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CGIAR RESEARCH PROGRAM ON Water, Land and Ecosystems

East Africa Soil Carbon Workshop

Science to Inform Policy

TECHNICAL REPORT

Nairobi, Kenya, 17-18 April 2018

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With contributions from

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Acronyms and abbreviations

CA	Conservation agriculture
CASA	Soil Carbon Network for Sustainable Agriculture in Africa
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CIFOR	Centre for International Forestry Research
CIMMYT	International Maize and Wheat Improvement Center
CIRCASA	Coordination of International Research Cooperation on Soil Carbon Sequestration in Agriculture
ECOWAS	Economic Community of West African States
FIR	Far-Infrared
GSOC	Global soil organic carbon
GSP	Global Soil Partnership
ICRAF	World Agroforestry Centre
ISFM	Integrated Soil Fertility Management
LDSF	Land Degradation Surveillance Framework
MIR	Mid-Infrared
MRV	Monitoring, reporting and verification
NIR	Near-Infrared
RAB	Rwanda Agriculture Board
SLM	Sustainable land management
SLU	Swedish University of Agricultural Sciences
SOC	Soil organic carbon
SOM	Soil organic matter

Contents


DAY 1

Introduction and rationale

Global soils contain about 2344 billion tons of organic carbon. This is the largest terrestrial pool of organic carbon. Small changes in soil organic carbon (SOC) stocks could result in significant impacts on the global carbon balance. Trapping carbon in the soil contributes to reducing greenhouse gas (GHG) emissions from agriculture. Managing our soils better can also help us to adapt to a changing climate by improving soil health, soil productivity (and crop yields) and agro-ecosystem resilience. However, not all soils are the same.

Geography, climate, and land use play a crucial role in how much carbon soils can potentially absorb, or how much they lose. While expectations are high – especially for degraded soils of sub-Saharan Africa – that soils can play crucial role in mitigating climate change, details on the where, how, and potential costs are missing.

The ***East Africa Soil Carbon Workshop – Science to Inform Policy*** brought together 28 participants from 11 countries: Ethiopia, Kenya, Uganda, Rwanda, Tanzania, South Africa, Madagascar, Germany, France, Netherlands, and Sweden (10 women and 18 men). Participants included decision makers, practitioners and implementers, and researchers in the fields of biophysical and social science. The aim was to exchange state-of-the art knowledge; review and discuss latest methods, metrics and tools for assessing SOC and mapping & monitoring SOC dynamic hotspots; and to discuss entry points for shaping gender-sensitive policies towards a green economy where carbon sequestration in soils is a recognized component. During group work sessions, the participants discussed and developed key messages that are relevant for policymaking on SOC sequestration in East Africa and beyond. This report summarizes contributions from participants, lessons learnt and action points.

Workshop objectives

- Review and discuss latest methods, metrics and tools for assessing SOC, and mapping & monitoring SOC dynamics and sequestration potentials.
- Identify knowledge gaps that limit our understanding of SOC dynamics in the East Africa region.
- Review and discuss existing policies and actions related to SOC sequestration.
- Develop key recommendations on the next steps for SOC interventions, policymaking, action campaigns and investment opportunities for East Africa.

Workshop presentations in a nutshell

Workshop Theme 1 – Evidence for, and testing of, promising SOC management practices

Presentation: **Avoided losses versus true sequestration: Evidence from CIAT's long-term trials in Western Kenya**

Presenter: **Rolf Sommer (CIAT)**

SOC dynamics observed in two CIAT long-term trials in Western Kenya highlighted that despite some efforts to conserve and improve soil fertility and agricultural productivity – implementing components of conservation agriculture (CA) and integrated soil fertility management (ISFM) – top-SOC could not be increased. The contrary: almost all treatments in these two trials lost significant amounts of carbon over time. CA and ISFM could avoid losses, i.e. slow down the trend of carbon losses over time as compared to conventional farmers' practices. On the other hand, land use history, visible through different contents of SOC at the onset of the two trials, was the major driver of losses. The insights from these trials highlight the complexity of the issue of sequestering carbon – vs. "merely" avoiding losses – and associated difficulties in assessing carbon sequestration potentials in a predictive fashion, when detail knowledge of land use history is usually unavailable.

Presentation: **Analysis of carbon sequestration potential in selected land use systems in Uganda**

Presenter: **Patrick Musinguzi (Makerere University)**

Clear evidence was provided for high SOC levels translating into higher grain yields, the more so when P and K nutrient deficiencies are taken care off by application of fertilizer (significant yield response to the amount of fertilizer added). The presentation also highlighted that losses of SOC are to be expected when pristine forest land is converted into farmland, with perennial and grassland systems loosing less than annual systems. In turn however, if traditional Banana-bases (mono) cropping systems were enriched by adding agroforestry species, this lead to an increase of SOC. Likewise, reducing tillage was also observed to improve SOC levels in annual cropping systems. Prof Musinguzi concluded with the remark that despite empirical knowledge available for Uganda about changes of SOC in response to the adoption of certain land management practices, understanding and, especially, quantifying drivers of SOC still remains a challenge.

Presentation: **Soil organic carbon sequestration in Ethiopia**

Presenter: **Ambachew Demissie (Hawassa University)**

Prof Demissie stressed the importance of deforestation and associated environmental degradation in Ethiopia, causing soil erosion and loss of soil fertility (including a loss of SOC). In addition, in the absence of sufficient fuel wood, use of cow dung and crop residues for fuel instead of return to farm lands, excessive tillage and overgrazing of grasslands leads to more soil degradation. Agroforestry, afforestation, and temporary area enclosure from grazing are important pathways for soil restoration. Increasing carbon in soils by such means has been proven to also increase crop yields of wheat, maize and cowpea.

Presentation: **Literature review – SOC sequestration in East Africa**

Presenter: **Sylvia Nyawira (CIAT)**

Two literature reviews on SOC sequestration East-African cropland and agricultural systems were funded by AgriFoSe2030 and implemented by CIAT scientists and two consultants in 2017. Results from these reviews showed the current gap in quantifying observations-based SOC sequestration potentials in the region due to the limited availability of data. Implementing agronomic management practices, such as crop residues and manure, showed the potential to increase SOC sequestration in the region. However, to quantify the long-term impacts of such management practices on SOC, more long-term experiments covering large cropland areas are still needed. There is a need to move from sampling specific research hotspots to larger landscapes, including blind spots, where little to no sampling had been done so far, because sampling only a few spots limits our understanding of SOC dynamics in the region and the quantification of the sequestration potentials. The workshop participants noted that in future a systematic protocol, detailing the aspects to consider in the literature studies, should be established to come-up with conclusive results from such reviews.

Presentation: **Evidence (?) of increased soil organic carbon sequestration under conservation agriculture**

Presenter: **Leonard Rusinamhodzi (CIMMYT)**

While conservation agriculture (CA) clearly has the potential to sequester SOC, published results for sub-Saharan African land use systems are inconclusive, with a significant number of published cases witnessing no measurable increase. Tillage often reduces SOC contents relative to no-till in the topsoil, while increasing carbon thereunder (mixing of soil in the plough layer). Many factors influence SOC dynamics under CA, such as actual amounts of aboveground biomass/residue inputs and associated crop rotations implemented, root development and rhizodeposits, baseline SOC content, soil bulk density and porosity, climate, landscape position, and erosion/deposition history. Furthermore, methodological constraints hamper our ability to clearly delineate SOC sequestration: For instance, baseline values are often unavailable, but are required to show if a system is indeed sequestering carbon. Similarly, bulk density data are necessary for equivalent mass calculations of carbon for an unbiased comparison of land use systems, but are often not reported/measured. Yet, even though CA may not qualify as a key option for SOC sequestration, without doubt it improves soil health and fosters associated ecosystem services while boosting crop yields.

Workshop Theme 2 – Methods, metrics and scaling

Presentation: **Mapping hotspots for SOC sequestration potentials at multiple scales – a case study in Western Kenya**

Presenter: **Mats Söderström (SLU; CIAT)**

The delineation and mapping of hotspots of SOC sequestration – i.e. areas where it can be assumed that significant amounts of carbon could be sequestered in a short period of time – requires revisiting the concept itself, including the identification of suitable indicators. Defining realistic upper (saturation) boundaries of SOC contents seems a useful concept, whereas soil texture (above all clay content) is a prime candidate against which such boundaries can be defined. A hotspot pinpoints the difference between such boundary and measured/actual carbon contents. First attempts of applying such approach for a watershed in Western Kenya produced some promising results. Input datasets of different scales yielded similar predictions. There is also scope for bypassing tedious field sampling and analysis of soils in the lab by use of mobile proximal sensing equipment.

Presentation: **To what extent did we change our soils? A global comparison of natural and current conditions**

Presenter: **Jetse Stoorvogel (Wageningen University)**

Dr. Stoorvogel showed a novel model-based approach (S-World) that was applied to derive global soil properties, mainly soil organic matter and carbon, under current and natural conditions to quantify the human-induced changes on these properties. S-world uses basic information of land use, vegetation, topography, precipitation and temperature to quantify soil properties. Quantitative assessments of soil organic matter and carbon under the two vegetation conditions revealed substantial changes associated with land cover and land use changes. Revisiting the concept of "window of opportunity", in the context of soil properties, shows that while land use is a clear driver of soil carbon losses, the potential to sequester more carbon is much stronger when considering other variables like soil type, topography and climate. The introduced S-World methodological framework can be used for making future possible trajectories. However, quantifying global soil properties remains a challenge due to the limited information on land management practices, such as manure application, tillage, etc.

Presentation: **Toward next generation SOM models**

Presenter: **Marc Corbeels (CIRAD)**

The majority of widely available and used soil organic matter (SOM) models are using a set of SOM pools that describe organic matter breakdown by first-order kinetic equations, with varying (chemical) decomposition constants. This poses a challenge as a) these theoretical pools cannot be measured directly but need to be approximated, and b) over-parameterization is common. Also, models that have been developed based on a limited range of climatic and soils conditions are now used globally. Hence, SOM models are more uncertain than most would have thought. Next-generation models are developed with a stronger emphasis on microbes and their crucial role in SOM stabilization, but also considering physical protection of SOM from breakdown (importance of soil aggregates). There are also attempts to add SOC saturation principles to these models, and to improve algorithms that describe SOM dynamics in deeper soil layers, including the movement of dissolved organic matter or OM transport by physical or biological means. These new attempts should improve our ability to predict the impact of a changing climate on soil organic matter and carbon dynamics. Open, accessible, and usable data are still a bottleneck, and more extensive datasets are needed to develop and test models for more reliable, robust simulations. This will require collaborative networks for data sharing and data-model integration and inter-comparison.

Presentation: **Need for spatially explicit, robust assessments of soil organic carbon**

Presenter: **Leigh Winowiecki & Tor-Gunnar Vågen (ICRAF)**

Indicators for the assessment and monitoring of ecosystem health should be science-based, rapidly quantifiable, applicable at multiple scale, and representative of the complex landscape processes. The Land Degradation Surveillance Framework (LDSF) addresses the issue. It is a systematic field-based assessments of multiple variables at the same geo-referenced location. Implemented in numerous regions of Africa, LDSF data now allow deducting biophysical drivers and processes of land and soil degradation. For instances, density plots of $\delta^{13}C$ help understanding vegetation patterns and changes in response to land use change. Also, data show that soil erosion is a major cause of the loss of SOC in African landscapes. Very-high resolution mapping (5 m) of various soil properties in combination with socio-demographic data allow for deducting also socio-economic and social impacts and feedback loops. Open access/data sharing (e.g. via dashboards or data-driven networks), archiving and data standardization are still issues that require much closer attention.

Presentation: **Metrics of soil health relevant to quantifying SOC critical levels for ecosystem service functions and carbon sequestration potentials**

Presenter: **Andrew Margenot (University of Illinois) and Keith Shepherd (ICRAF)**

Even though SOC is a commonly accepted and fundamental indicator of soil health, thresholds and ranges of what constitutes a satisfactory SOC level are not available, and are likely to be context-specific (e.g., edaphic and climate variables). Upper limits of SOC (i.e., C saturation) are driven by texture, whereas limits can be distinguished further based on predominant clay minerals (1:1 vs. 2:1 phyllosilicates, vs. allophanic). To improve comparability and standardization, an index of SOC is suggested, which reads [actual level – lower limit] / [upper limit – lower limit] (0 to 1 scale). Near-infrared (NIR) and mid-infrared (MIR) spectroscopy is a well-established method for measuring and monitoring soil characteristics and essential functional properties, including total SOC and SOC fractions proposed to represent pools of differing turnover rates (e.g., light fraction vs clay-associated). Far-infrared (FIR) spectroscopy could offer additional analytical benefits that yet remain to be fully explored and is increasingly possible with the advent of commercially available, sensitive FIR detectors. Targeting carbon sequestration may in some cases entail trade-offs with other ecosystem service function of soils, e.g. the supply of nutrients for crop production which relies on the breakdown of organic matter ("hoarding vs. using" dilemma).

Workshop Theme 3 – Monitoring, reporting and verification (MRV)

Presentation: **How does tillage intensity affect soil organic carbon? A systematic review protocol**

Presenter: **Thomas Kätterer (SLU)**

A systematic review protocol was developed for analysing the effect of agricultural practices on SOC in the boreo-temperate agricultural systems based on data presented in the literature. A systematic map was presented containing meta-data from 735 long-term (>10 years) field experiments. Several reviews are presently conducted based on this dataset focusing on specific agricultural management practices. Results from a recently published review on tillage effect on SOC were presented. Higher SOC stocks were observed in the top soil (0-30 cm) under no-tillage compared to high-intensity tillage systems. However, the inclusion of the subsoil resulted in very minor differences between no-tillage and high-intensity systems. When assessing the benefits of implementing improved management practices, besides SOC there is also a need to consider yields, which have been reported to decrease in average under the no-tillage systems. Strict procedures for conducting meta-analysis and review studies allow for making reliable conclusions. Future literature reviews and meta-analysis conducted in the East Africa region would greatly benefit by using such systematic review protocols in their analysis.

Presentation: **Monitoring, reporting and verification of soil organic carbon**

Presenter: **Herintsitohaina Razakamanarivo (Laboratoire des RadioIsotopes/Antananarivo University)**

Monitoring, Reporting and Verification (MRV) of SOC was discussed within the current framework set by UNFCC. An example of the REDD+ activities in Madagascar showed that above- and below-ground biomass are included in the MRV of carbon stocks, while soils are omitted due to their complexities. Several needs still have to be met to develop a MRV approach of SOC sequestration in the region. They include: organizing freely available datasets, improving our knowledge on SOC sequestration, and the need to have robust *ex-ante* tools for designing adequate programs or policies. The e-learning course on "*the national greenhouse gas inventory for agriculture*", provides more details on the MRV process. The setup and aims of the "*Soil Carbon Network for Sustainable agriculture in Africa (CASA)*" was highlighted, a network that brings together 11 African French-speaking countries and France. Workshop participants discussed the possibility of East-African countries to be included into CASA and benefit from trainings, data-exchange and research collaboration between the participating institutes.

Workshop Theme 4 – Soil carbon and gender

Presentation: **Gender matters in land restoration / Gender matters in climate policies that have an effect on carbon**

Presenter: **Markus Ihalainen (CIFOR)**

Two examples outlined how gender analyses can be conducted prior to implementing agroforestry and soil enhancing practices. For such analysis, a holistic consideration of the physical, social, economic, financial and natural factors that have an impact on human capitals would need to be considered. Gender should form a key component of analyses assessing the cost & benefits of different management interventions, which are aimed at improving SOC sequestration. In addition, innovations and practices related to SOC need to be informed by a gender analysis that highlights differentiated needs and preferences as well as constraints and opportunities. By not including gender, there is a considerable risk that women farmers or female resource managers will not implement the proposed management practices when recommendation collide with vital aspects of women's livelihoods that are easily overlooked. The outlined examples provide insights for soil carbon experts and social scientists to collaborate in ensuring that gender issues are well addressed in policies aimed at enhancing mitigation through SOC sequestration. Excellent research is always gender-sensitive!

Workshop Theme 5 – Policies and actions

Presentation: **The international SOC initiatives – CIRCASA**

Presenter: **Cristina Arias-Navarro (INRA)**

The presentation introduced and discussed the EU-funded *Coordination of International Research Cooperation on Soil Carbon Sequestration in Agriculture* (CIRCASA) project, which brings together various organizations, projects and initiatives working on SOC. A growing trend in ongoing research on SOC sequestration in agriculture, both at the international and interdisciplinary point of view, acted as the key driver of initiating this project. The project goals and the various working packages of the 3-year project were outlined and discussed. A clear gap was noted in the involvement of national organizations, where the representation of the East Africa region is only limited to very few non-governmental research organizations.

Presentation: **The 4 per 1000 – Soils for Food Security and Climate initiative**

Presenter: **Cristina Arias-Navarro & Viridiana Alcántara (BLE, Germany)**

The presentation highlighted the governing structure and four pillars of the 4p1000 initiative and addressed common misconceptions. Example on-going projects supporting 4p1000 from Uruguay, Germany and the members of Economic Community of West-African States (ECOWAS) were presented. The 4p1000 initiative aims to increase success of these projects by a project assessment through the scientific technical committee of the initiative and enhanced networking with and awareness raising of funding agencies. The East-Africa region is yet to be more actively involved in the implementation of the 4 per 1000 initiative. Workshop participants representing national research organizations expressed interest in closer collaboration and participation in major meetings and workshops – such as the forthcoming 4p1000 meeting in Johannesburg later this year, but stressed the importance that without some humble funds to support attending meetings, such collaboration would be extremely difficult to implement.

Presentation: **Unlocking the potential of SOC, what's next after GSOC17?**

Presenter: **Liesl Wiese (GSP)**

The East-Africa region is well represented in the development of global SOC maps as part of the Global Soil Partnership (GSP). The global map still is to overcome the lack of continuity at country boundaries associated with the independent, country-led mapping exercises, maps of which were then stitched together. GSP is currently working towards releasing a new version of the GSOC map that addresses some of the data limitations. GSP is also in the process of developing two sets of guidelines related to SOC. The first are guidelines for soil organic matter management which will be launched in August this year during the World Congress of Soil Science in Brazil. The second are guidelines for measuring, mapping, monitoring and reporting on SOC for which the working group is currently being developed. The talk highlighted the many digital soil mapping training workshops which have been conducted since the inception of GSP. Such workshops only provide for one participant per country, while countries generally have a need for more national expertise.

Presentation: **CCAFS' Koronivia response**

Presenter: **John Recha (CCAFS)**

The presentation outlined the six key sections of the Koronivia Joint Work on Agriculture and how CCAFS has been addressing them in the past. CCAFS supports NDCs and the national policies through assessing the countries' SOC stocks and the hotspots for preventing loss and improving sequestration.

Presentation: **Vi-Agroforestry's Sustainable Farming Carbon Credits project**

Presenter: **Miriam Nalianya (Vi-Agroforestry)**

The non-governmental organization *Vi-Agroforestry* supports an approximate 30,000 farmers in adopting sustainable agricultural land management practices (SLM) in Western Kenya. Their *Sustainable Farming Carbon Credits* project has been made possible by the World Bank's funded Kenya Agricultural Carbon Project, which runs from 2009-2030. Farmer groups receive carbon credits for above and below-ground carbon sequestration through the implementation of SLM practices. Since 2009, about 184,447 tons of CO_2 emissions have been offsets though carbon sequestration. Maize productivity of the farmers participating in the project improved by 30-50 %. In summary, carbon offsetting through providing payments for carbon sequestration is possible through coordinated projects that include well-organized services delivery structure and proper monitoring.

Discussing and distilling information and actionable items

During two break-out sessions, workshop participants reviewed and discussed evidence and gaps, and distilled action points using some guiding questions (see Appendix 2). On day 1, the following groups were formed:

- Group 1: Evidence/data/existing knowledge on SOC
- Group 2: Mapping and monitoring (at field and national scale)
- Group 3: Biophysical modelling

Break-out group 1: Evidence/data/existing knowledge on SOC

- The crucial importance of maintaining long-term trial experiments was pointed out: these are the only systematic evidence that we have in terms of tracing the dynamics of SOC long-term and associated benefits in terms of soil health and agricultural productivity. The group also discussed the challenge to secure funding for these trials.
- Relating SOC dynamics to management practices remains difficult as often major C inputs are not well quantified / easily quantifiable.
- Measuring SOC in chronosequences was seen as a good – yet not ideal – alternative to long-term trials, with the challenge that impacting factors often cannot be captured in their entireness leading to fuzziness of the data set and unknown compounding factors.
- The value of open access of data was appreciated by all group members. Yet, this is by far not common practice in the national system of the East African countries.
- It was noted that benefits of CA depend much on the scale of implementation; for instance, smallholder farmers may see little benefit in the cost-saving aspect of no-till, when opportunity costs for tillage are very low (tillage by hand done by family members). Carbon sequestration is most likely not a factor triggering spontaneous adoption of CA by farmers, rather incentive mechanisms may have to be put in place.
- To increase awareness and action of regional (county) policy makers and governments in terms of supporting soil carbon conserving farming practices, a bottom-up approach was discussed as a good option, where farmer representatives voice their needs directly. This however requires strong evidence ("seeing is believing") with pilots (e.g. long-term trials!) available and farmer-field-days or exchange visits to showcase results.
- Policy makers will be more easily convinced if they have clear, brief, and easy-to-understand evidence, e.g. on the costs and benefits (e.g. SOC-yield relationships), the short-term investments and concrete actions required. Scientists need to make sure that a consistent message is provided in terms of the principles of SOC management (managing the organic matter inputs).

- Broadly speaking, any practice or technology that leads to an increased input of organic matter into the soil should be considered in the carbon sequestration debate. In mixed crop-livestock smallholder farms, forages have a big role to play as they can alleviate the pressure on organic resources and allow retaining or adding manure, compost or crop residues.
- Biophysical/economic modelling of agro-ecosystems and practices that improve SOC was considered an important component for spelling out site-specificity of promoted technologies.

Break-out group 2: Mapping and monitoring (at field and national scale)

- Members acknowledged the range of different methods for mapping C stock, e.g. random forest statistics used to create the SOC map for Rwanda (Kabirigi), or multi-variate adaptive regression splines for Western Kenya (Söderström).

Issues/challenges around mapping & monitoring:

- The importance of good quality high resolution data and the relevance of co-variates was discussed. It was noted that despite the efforts to derive fine scale and high resolution data the quality of these data-sets still remains a major challenge.
- The methods applied in data collection are often not standardized. They are developed for different purposes and they contain different units and scales.
- It was noted that there are a wide-range of existing global datasets. However, they are often hard to access and in most cases the data sets are at a risk of being misused or misinterpreted.
- In developing the GSOC map, different methods were used by different countries which makes it difficult to compare different country maps. Ideally, better/ more efficient coordination and joint training is required to ensure that a single methodology is used across countries.
- While the Land Degradation Neutrality Target Setting under UNCCD has a monitoring component, details on its implementation remain scarce. The monitoring component is not yet implemented in Rwanda and in other East Africa countries its implementation is project-based and therefore short-term.
- The practical use of (different) guidelines is a challenge and needs to be more consistent.
- There is not sufficient national capacity in EA to implement the necessary mapping and monitoring (expertise, computing). There is a need for more training, as well as creation of regional networks also for standardizing methodologies.

Requirements for policy makers

- Produce SOC trends and predictions/scenarios related to soil and land management practices or maps of hotspots (e.g. areas going out of production if not restored).
- Derive messages that inform investment options that pay off in the relatively short term (5 yrs).
- Link to practical interventions with demonstrated evidence of change.

Break-out group 3: Biophysical modelling

- Biophysical SOM/SOC models have not been widely used in the past in East Africa, but they are recently gaining usage.
- Blind use (no calibration or validation) of models is an issue, which may lead to the wrong interpretation of the model-based results or wrong results.
- Low availability, limited data sharing and poor data quality is hindering wider application of models. Limited human power in East Africa adds to the issue.
- The group reiterated that absence of the large role of microbes in SOM decomposition and stabilization (mechanisms of protection in available models) is a serious concern.
- The group agreed that models add value to the debate – globally and regionally – and can/should be used for making a convincing case for influencing policies.

On day 2, three parallel groups reviewed the summaries from day 1 and included lessons learnt from theme 4 and 5 (day 2). Based on these discussions, some major action points were formulated on how science can inform policy.

DAY 2

Action points – Science to Inform Policy

1. Agronomic long-term trials are essential tools for monitoring changes of slow variables like soil carbon, and to deduct rigorous evidence of the impact of agricultural land use on soil carbon, soil health and agricultural productivity. Given the limited data availability in East-Africa, existing long-term trials should therefore be better supported.
2. Methods for quantifying SOC should be standardized. The Global Soil Partnership (GSP) and the Intergovernmental Panel on Climate Change (IPCC) seems the right platform to address this issue through ensuring that the guidelines and methods for SOC monitoring are well outlined and detailed by their regional and country representatives.
3. Research scientists and policy makers need to collaborate more closely to a) make research, tools and maps more demand-driven, and b) illustrate how model based results, including ex-ante, forecasting or uncertainty assessments, can be used for informing the policy and decision making processes.
4. Soil carbon initiatives and projects, such as CASA, CIRCASA and 4 per 1000, should motivate and support increased participation of target countries and organizations.
5. Open access of primary data, methods and maps is an issue. East African countries should support open access by endorsing data sharing of their national research centres. International donors should demand open data access in projects that they fund.
6. East African research organizations – including CGIAR centres – and institutions of higher learning need to organize more frequent networking events and specific workshops offering adequate knowledge exchange and training on latest methods, tools and models.

Appendix 1 - Workshop Agenda

Nairobi, 17-18 April 2018

DAY 1

Time	Session	Speaker
8:30-8:40	Welcoming and setting the agenda	**Sylvia Nyawira** (CIAT)
8:40-9:00	Introduction of participants	
	Evidence for, and testing of, promising SOC management	
9:00-9:20	Avoided losses versus true sequestration: Evidence from CIAT's Long-Term Trials in Western Kenya	**Rolf Sommer** (CIAT)
9:20-9:40	Analysis of carbon sequestration potential in selected land use systems in Uganda	**Patrick Musinguzi** (Makerere University)
9:40-10:00	SOC sequestration in Ethiopia (Tentative title)	**Ambachew Demissie** (Hawassa University)
10:00-10:30	TEA / COFFEE	
10:30-10:50	SOC sequestration in Rwanda	**Michel Kabirigi** (RAB)
10:50-11:10	Literature review – SOC sequestration in East Africa	**Sylvia Nyawira** (CIAT)
11:10-11:30	Evidence of increased soil carbon sequestration under conservation agriculture	**Leonard Rusinamhodzi** (CIMMYT)
11:30-11:50	Overall discussion - Theme 1	
	Methods, metrics & scaling	
11:50-12:10	Mapping hotspots for SOC sequestration potentials at multiple scales – a case study in Western Kenya	**Mats Söderström** (Swedish Univerisity of Agricultural Sciences, SLU; CIAT)
12:10-12:30	To what extent did we change our soils? A global comparison of natural and current conditions	**Jetse Stoorvogel** (Wageningen University)
12:30-13:40	LUNCH	
13:40-14:00	Toward next generation SOM models	**Marc Corbeels** (CIRAD)
14:00-14:20	Scaling SOC assessments	**Leigh Winowiecki** & **Tor-Gunnar Vågen** (ICRAF)
14:20-14:40	Metrics/Indicators of soil health that are relevant in quantifying SOC critical levels	**Andrew Margenot** (Illinois University) **Keith Shepherd** & **Ermias Betemariam** (ICRAF)
14:40-15:00	Overall discussion - Theme 2	
15:00-15:30	TEA / COFFEE	
15:30-17:00	Breakout groups - addressing evidence, methods, metrics and scaling	

DAY 2

Time	Session	Speaker
8:30-9:00	Reviewing day 1 and action points from breakout groups	
	Monitoring, reporting and verification (MRV)	
9:00-9:20	How does tillage intensity affect soil organic carbon? A systematic review protocol	**Thomas Kätterer** (SLU)
9:20-9:40	Monitoring, Reporting and Verification of Soil Carbon	**Herintsitohaina Razakamanarivo** (Antanarivo University)
9:40-10:00	Overall discussion - Theme 3	
10:00-10:30	TEA / COFFEE	
10:30-11:00	**Soil carbon and gender**	**Markus Ihalainen** (CIFOR)
	Gender matters in land restoration / Gender matters in climate policies that have an effect on carbon	
	Discussion - Theme 4	
	Policies and actions	
11:00-11:20	The international SOC initiatives - CIRCASA project	**Cristina Arias-Navarro** (INRA)
11:20-11:40	The 4 per 1000 - Soils for Food Security and Climate initiative	**Cristina Arias-Navarro** & **Viridiana Alcántara** (Federal Office for Agriculture and Food [BLE], Germany)
11:40-12:00	Unlocking the potential of SOC, what's next after GSOC17?	**Liesl Wiese** (Global Soil Partnership)
12:00-12:20	CCAFS' Koronivia response	**John Recha** (CCAFS)
12:20-12:40	Vi-Agroforestry's Sustainable Farming Carbon Credits project	**Miriam Nalianya** (Vi-Agroforestry)
12:40-14:00	LUNCH	
14:00-15:00	Breakout groups - addressing networking, policies and action	
15:00-15:30	TEA / COFFEE	
15:30-16:00	Breakout groups - addressing networking, policies and action	
16:00-16:30	Wrapping up & Closure	

Appendix 2 - Break-out group questions

DAY 1

Break-out group 1: Evidence/data/existing knowledge on SOC

- Review, discuss and exchange knowledge (20 min).
    a. Discuss the value of the existing long-term and short-term experiments of SOC and the opportunities for improving them and having more.
- How can the existing evidence, data and knowledge be used to inform policy makers (20 min)?
    a. What evidence/data/knowledge is already useful to policy makers in particular for East Africa?
    b. How can this information be packaged to easily communicate to policy makers?
    c. What gaps are limiting the application of the existing evidence/data/knowledge by policy makers?
- What can we recommend based on the existing evidence/data/knowledge (30 min)?
    a. What technologies/methods can be used to improve SOC sequestration and what would be required for their implementation?
    b. What is the timeframe of implementation?
- Wrap-up (10 min).

Break-out group 2: Mapping and monitoring (at field and national scale)

- Review, discuss and exchange the existing knowledge (20 min)
- Describe the major challenges, current progress and gaps in mapping and monitoring SOC dynamics (30 min).
    b. Is there sufficient data?
    c. Is there consensus on the mapping and monitoring approaches? What is the practical use of the different guidelines available?
    d. Is there sufficient national capacity in terms of expertise and computing resources?
- What are the immediate mapping and monitoring requirements to inform policy makers (20 min)?
- Wrap-up (10 min).

Break-out group 3: Biophysical modelling

- Review, discuss and exchange the existing knowledge (20 min)
- What is the current capacity of SOC modelling within East-Africa (20 min)?
    a. Are the tools, i.e. the models and model inputs readily available? If model inputs are not readily available, can they be easily generated?
    b. Is there enough man power with the modelling skills in the region?
- Which gaps are there in the current generation of SOC/SOM models and what are they? What are the immediate needs to address them (20 min)?
- Are model-based projections/results/quantifications already used in the policy making process? If yes, list examples of where this is the case? If not, why (20 min)?
- Which added value could SOC modelling provide for policy-making and investment in East-African countries?

DAY 2

Three groups reviewing the summary of day 1 and distilling the action points for East Africa for their theme. The rest of the time the groups should discuss the same points.

- Review day-1 summaries and distil the action points for East Africa (group structures as on day 1).
- Scopes for taking forward the action points to global fora – Which and when?
- Is the East-Africa region well represented in the existing global fora? If not, what can be done to improve the representation?
- List examples of successful projects and initiatives for SOC preservation and enhancement in the East-African region. Which lessons can be learned and how can these examples be scaled up?
- Brainstorm on public and private investment opportunities for SOC sequestration. What is possible through international or bilateral cooperation and which actions are required at national level?
- Networking – where are we and what are and should be the goals?

Appendix 3 - Workshop participants

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