



## Workshop Report

### CTCN Training Workshop on Technologies to Enhance and Monitor Soil Carbon for African Countries

12-14 December 2018, ICRAF Nairobi, Kenya



The Climate Technology Centre and Network (CTCN) organized a three-day capacity development event on technologies for soil carbon enhancement in African Countries in partnership with the International Centre for Research in Agroforestry (ICRAF), a CTCN consortium partner. The workshop brought together representatives from 14 countries, including the National Designated Entities (NDEs) of the CTCN and representatives from the Ministries of Agriculture, for a total of 26 participants from Botswana, Ethiopia, Kenya, Lesotho, Malawi, Mozambique, Namibia, Uganda, Rwanda, South Sudan, Swaziland, Tanzania, Zambia, and Zimbabwe.



The workshop was organized as part of CTCN activities to strengthen capacities of National Designated Entities (NDEs) – CTCN and technology focal points in the countries for the United Nations Framework Convention on Climate Change (UNFCCC). The overall objective of such event was to expose NDEs and other stakeholders to technologies having strong potential for low emission development and climate resilience.

According to the latest report from the Intergovernmental Panel on Climate Change (IPCC), we are heading with the current global efforts to a 3°C increase in global temperature by the end of the century. This call for increased efforts toward low carbon development, and to achieving Nationally Determined Contributions (NDCs). In this context, soil carbon storage can play a key role in climate mitigation. However, African countries are fast depleting their soil carbon due to accelerated agricultural development, deforestation and soil degradation. This trend is in turn reducing land resilience capacities to extreme climate events as carbon in soil is essential to soil health and fertility. Carbon sequestration is thus critical to achieving climate targets, and countries would benefit from using technologies that contribute to sequester carbon in the soil at a much faster rate.

Agriculture is a prominent topic in the national priorities related to climate change, both in adaptation and mitigation. In their NDCs, countries priorities include a number of sub-sectors such as livestock, manure and grassland; croplands, fertilizer management, agricultural residues and rice paddies. Examples of cropland mitigation and adaptation strategies included nitrogen efficiency, alternate wetting and drying in paddy rice, carbon sequestration, agroforestry, and conservation agriculture.

The objective of this workshop was therefore to share experiences and best practices related to agriculture from around the globe and inspire country's development programs for greater integration of those technologies into their national efforts in meeting their adaptation and mitigation of climate change.

The training covered the following topics:

- Understanding soil carbon: basic concepts of carbon sequestration, challenges in enhancing soil carbon storage
- Technologies having potential to enhance soil carbon stock in Africa: Enhancing inorganic carbon and soil organic carbon (conservation agriculture with and without trees, agroforestry, social forestry, plantation management, potential of genomics for organic carbon sequestration, agroecological approaches - improving vegetation cover, pasture management, cross-slope barriers, mulching, green manuring, crop residues, agroforestry/agricultural residues, organic agriculture (OA)/ micro-dosing, area closures and reserves.
- Advance approaches to monitoring and visualizing soil carbon stock
- Technology adoption, scaling and impacts
- Matching soil enhancement technological potential with country NDCs

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## **Acronyms and Abbreviations:**

|        |   |
|--------|---|
| CTCN   | Climate Technology Centre and Network                     |
| GCF    | Green Climate Fund  |
| GDP    | Gross Domestic Product                                    |
| GEF    | Global Environment Facility                               |
| FAO    | Food and Agriculture Organization of the United Nations   |
| INDC   | Intended Nationally Determined Contributions              |
| NAPs   | National Adaptation Plans                                 |
| NDAs   | National Designated Authorities                           |
| NDCs   | Nationally Determined Contributions                       |
| NDEs   | National Designated Entities                              |
| TEC    | Technology Executive Committee                            |
| TNAs   | Technology Needs Assessments                              |
| UNFCCC | United Nations Framework Convention on Climate Change     |
| SDGs   | Sustainable Development Goals                             |
| IPCC   | International Panel on Climate change                     |
| ICRAF  | International Centre for Research in Agroforestry         |
| CGIAR  | Consortium of International Agricultural Research Centres |

## Workshop Background

*‘Nation that destroys its soil destroy itself’* Franklin D Roosevelt 1937.

Land degradation, desertification and drought are widespread global issues that threaten the future of our environment. SDG 15.3 focus is to combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods and strive to achieve a land degradation- neutral world by 2030. Desertification already affects around 45% of the African continent indicating an urgent need for action. Failure to act on this threat has serious negative impacts on GDPs and sustainable development opportunities. A recent study shows that an annual loss of 280 million tons of cereal crops in Africa is caused by the degradation of 105 million hectares of cropland per year due to erosion induced NPK loss. This translates to 110 billion USD per year (FAO).

Nourishing more people while nurturing the planet will be a monumental challenge. The United Nation Food and Agriculture Organization (FAO) estimates that to feed another two billion people in 2050, food production will need to increase by 50 percent globally and to nearly double in developing countries. The situation is complicated further by the impact of climate change on agriculture, while agriculture is also a major greenhouse gases emitter.

In his opening remarks, Rajiv Garg, CTCN African region manager noted that; “... *the increased need for food can be achieved by transforming food and agriculture systems, shifting to more sustainable and diversified consumption and production, improving governance and securing the political will to act. The use of climate technologies, can, without a doubt, accelerate the attainment of these goal.*”

In East, Central and Southern Africa, agriculture, together with forestry and land use, is a major sector to address climate change challenges. It is no surprise that agriculture is among the key sectors prioritized by these countries’ NDCs, both for climate change adaptation and mitigation. Support to climate-smart agriculture is embedded across CTCN’s Technical Assistance portfolio. Since the inception of CTCN in December 2013, developing countries have submitted 226 requests for technical assistance, of which agriculture, forestry and land use form a significant proportion. ICRAF, a CGIAR Center, is well versed in pooling such knowledge together and making knowledge available to technicians and planners on soil carbon enhancing technologies and approaches.

The objective of this workshop was therefore to present technologies and practices that can be used for increased soil carbon sequestration, adapted to the needs and circumstances of each country. The three-day workshop helped the 14 countries represented to identify and plan the scale-up of priority technologies and practices specific to the agriculture sector. This would help them to better implement their NDCs by transiting to low carbon development while building their climate resilience.

In his inaugural speech, ICRAF Director General, Tony Simons, also urged the participants to rethink the issue of dependence on overseas development aid for Research and development. He called for an innovative approach to project financing as the world is shifting from development aid assistance to a more blended financial mechanism. This approach strives to harness resources from the private sector, governments, academic, non-governmental organizations and other institutions. He also stressed for more action geared towards achieving the SDG 15 on the life on earth in the face of changing environment and land use.

The National Designated Entity to Kenya, Dr. Kelvin Khisa affirmed that sustainable agricultural systems are faced with increasing pressure of land degradation and climate change, soils have become one of the

most endangered natural resources of the world. FAO estimates that each year, an estimated 25–40 billion tons of fertile soil are lost globally. Hence, improving soil health through sustainable land management practices should be a common goal for any nation. He thanked CTCN and ICRAF for organizing the workshop that will build countries capacity to enhance its Agriculture sector and build their climate resilience

### **Workshop Objective**

The objectives of this workshop were as follows:

- Expose the NDEs and representatives from Ministries of Agriculture to the global carbon cycle, basic concepts of soil carbon sequestration and challenges in enhancing soil carbon storage;
- Present the latest technologies having potential to enhance soil carbon stock in Africa, and provide an overview of the state of art soil carbon monitoring tools and approaches at field, farm, district/province and national levels;
- Discuss possible assistance needed from countries for increasing soil carbon sequestration based on their national climate priorities, especially their Nationally Determined Contributions (NDCs).

### **Workshop participants**

The workshop brought together National Designated Entities (or their nominees) and Representatives of Ministry of Agriculture from 14 Southern and Eastern African countries. The Ministry of Agriculture representatives constituted senior soil scientists or research officials in the agriculture sector. These official selected interact in one way or another in the sector policy dialogue and the knowledge gained through the workshop would see them champion policy reforms in their countries. The workshop was facilitated by Key Technology Experts from CGIAR Centers/other knowledgeable institutions with a high mastery of the discussion areas.

### **Overview of CTCN Mandate and Services**

The CTCN is the operational arm of the Technology Mechanism of the UNFCCC. It was established through a COP decision during the 16<sup>th</sup> session of the Conference of Parties (COP) in Cancun in December 2010.

The CTCN is mandated by the Parties of UNFCCC to promote accelerated, diversified and scaled-up transfer of climate technologies in developing countries for climate change mitigation and adaptation, consistent with the national priorities of the requesting countries. The CTCN implements this mandate through three core functions: 1) Provide technical assistance; 2) Foster collaboration and access to information and knowledge to accelerate technology transfer; and 3) Strengthen networks, partnerships and capacity building for climate technology transfer.

The CTCN relies on a growing network of expert organizations working on climate technologies worldwide (research institutions, private companies, non-profit organizations, etc.) to support countries mitigate and adapt to climate change. In order to implement technical assistance projects, the CTCN selects Network members through a competitive bidding process. At present, CTCN network includes more than 400

members from around 80 countries to support activities on technical assistance and knowledge sharing on climate technologies. The list of network members can be accessed on the CTCN website on the link <https://www.ctc-n.org/network/network-members>

Therefore, the CTCN acts as a matchmaker, to help countries identify technologies and barriers to those technologies, and to provide solutions to remove these barriers based on the expertise available worldwide. Network members can also engage and collaborate with countries and with other network members through exchanging knowledge and information, contributing to capacity building activities, etc.

Since it was established, the CTCN received over 200 requests for technical assistance from 85 countries all over the world. CTCN technical assistance supports countries on the following:

- Technology identification and selection, based on country and stakeholder needs, to inform decisions of government and private actors in their climate technology choices.
- Technology feasibility, piloting and deployment, to ensure they are appropriate to national context and markets.
- Policy, planning and law, to ensure the mainstreaming of climate technologies issues into national planning processes.
- Project readiness and facilitating financing, through networking with donors and investors to increase country capacities to access funding for their climate technology priorities.
- Training, awareness raising and experience sharing on proven and innovative climate technologies.
- Research and development, to support and catalyze technology innovation.

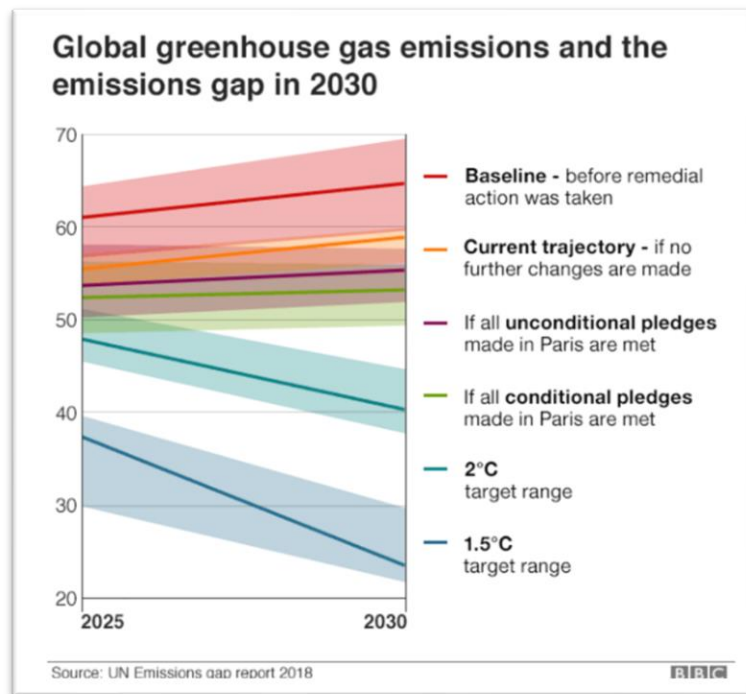
There are three ways to access CTCN technical assistance:

- Fast Technical Assistance: international expert advice (remotely or through short in-country mission), duration of up to 2 months
- Technical Assistance: one request per country per year, within CTCN funds availability, assistance worth max USD 250,000
- Technical Assistance through GCF Readiness: can be coupled with CTCN regular TA. Support to the country to access GCF readiness funds (Max \$1M/country/year.)

As part of its capacity building activities, the CTCN also works with developing countries through the Vision to Concept programme, to enhance the skills of national project proponents in preparing GCF concept notes for future submission to the GCF. The concept notes to be developed are based on the project visions identified as priorities in the country's climate change process (NDCs, GCF country programme, TNAs, NAPs, etc.).

## Summary of the Sessions

### Session I: Understanding Soil Carbon



This session presented soil sequestration in the context of climate change mitigation. In order to achieve the Paris Agreement's goal of containing global temperature rise to well below 2°C by 2100, significant emissions are needed. The latest climate reports show that we are off this mark. In Africa, agriculture is among the key sector that can be targeted to achieve this goal.

In addition to reducing emissions, ensuring carbon sequestration in soils and biomass presents an opportunity to mitigate climate change. There is a difference between geologic and biological sequestration (ocean and terrestrial sequestration).

Nearly 90% of the technical mitigation potential of agriculture comes from soil carbon sequestration and this potential is mainly untapped. At the global level, the IPCC Third Assessment Report estimates that ~100 billion metric tons of carbon over the next 50 years could be sequestered through forest preservation, tree planting and improved agricultural management.

Many agricultural mitigation options, including increasing the levels of soil organic matter particularly those that involve soil carbon sequestration, also benefit adaptation to climate change, food security, and development (FAO 2009). Carbon can act as a marker of soil health as it contributes to increase soil fertility, reduce erosion, retain water better, and enable stronger resilience to extreme weather variations.

Regenerating soils presents a win-win solution for mitigating climate change and for food security, as it enables to:

- Restore soils to sequester carbon back where it belongs, in the soils and in the plants: this is the most efficient and safest climate mitigation strategy (no need for geoengineering)
- Restore soils to enhance food security: adding 1 ton of soil carbon per hectare per year increases crop yield by 20 to 70 kg per hectare of wheat, 10 to 50 kg per hectare of rice and 30 to 300 kg per hectare of maize. This means an increase of 24 to 40 million metric tons in grain production at the global level

Technologies to enhance soil carbon include but not limited to afforestation, reforestation, agroforestry, biochar, climate smart agriculture, agroecological approaches, carbon farming, among others discussed in

the session's summaries below. There are other non-agricultural methods that include bioenergy and bury, fertilizing the ocean, rock solutions, direct air capture and storage.

There are however challenges in adopting of soil carbon sequestration practices and there is a need for incentivizing their deployment at various levels, including through flexible and adaptable regulatory frameworks and large-scale testing and demonstration projects to resolve technical and integration uncertainties and reducing costs. Addressing these three challenges will also help increase public acceptability of the technologies and practices.

## Session II: Technologies having the potential to enhance soil carbon stock in Africa

### *Application of Biochar*

Biochar is a charcoal produced from plant matter, used as soil manure and stored in the soil as well as a means of removing carbon dioxide from the atmosphere. Biochar is made by the pyrolysis of biomass (*pyro* means fire and *lysis* means decomposition). It is made by heating organic material under conditions of limited or no oxygen.



The session gave an overview of the biochar production, conversion and use. There are practices that can be adopted to sustain this concept which include: sustainable biomass production for bioenergy or biochar, production through improved fallows (IF), and production under evergreen agriculture with fertilizer trees. The use of biochar on land can largely improve soil conditions including enhancing water retention,

absorption of soil nutrients, increasing soil fertility, reducing acidity, improving micro fauna activity and root growth.

Bioenergy-biochar systems have multiple benefits: energy security, improved livelihoods and gender equity, resource recovery, improved agricultural productivity and climate change mitigation and adaptation. It is worth noting that biochar sequesters approximately 50 per cent of the carbon that would otherwise be released.

To support the adoption of biochar, there is need for co-designing for cleaner inclusive bioenergy/biochar systems and application of transdisciplinary processes.

The session highlighted case studies and lessons from the application of this concept in African countries in Tanzania, Kenya, and Ghana among others.

The key lessons learnt presented are as follows;

- There is need for gender responsive demand driven technologies adoption for sustainable biomass production
- Knowledge and capacity are needed on charcoal and biochar systems as low carbon emitter and context biochar performance
- Development of policy framework including standards and regulations is needed for climate smart charcoal for energy and biochar

The following question was also discussed: is biochar considering the reality for Africa? African landscapes are facing devastating levels of deforestation. Kenya for instance had recently banned logging even in private owned tree plantations address the reduction of its forest cover. The situation is similar across the African continent. Will recommendation of biochar send the wrong message? The increased use of biochar could contribute to reducing forest cover if done in an unsustainable manner. These practices therefore need to be assessed depending on the circumstances and resources of each country. The value added of biochar technologies also need to be further demonstrated through research and testing on the ground.

### ***Agroecological approaches and Agroforestry, Social Forestry, Plantation Management***

Agroecology is an integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of food and agricultural systems. It seeks to optimize the interactions between plants, animals, humans and the environment while taking into consideration the social aspects that need to be addressed for a sustainable and fair food system.

Agroecology presents an opportunity toward a transition to sustainable food systems and presents incentives for increasing sequestration of carbon in the soil. This session presented the principles and pillars for a sustainable food system. Application of Agroecology practice leads to improving food productivity and nutrition quality, fuel and water security, and increasing income from high value products while ensuring resource conservation and contributing to mitigation and adaptation to climate change. The session thus discussed how agroecology can contribute to increased sequestration of carbon in the soil.

Discussion were made on the need to rethink our food systems in the face of climate change. An interesting topic in this regard, was the issue of moralization of food systems. There is need to manage the interaction of these two systems (climate change and food systems) to enable a shift towards a sustainable system. The

transformative effect of transdisciplinary collaboration is seen as a support mechanism to achieve the transition goal.

Technologies embedded in Agroecology were discussed and different scenarios explored. They included, Agroforestry, and Farmer managed natural regeneration-FMNR (the concept and benefits) among others. There is a need to further broaden the Agroecology concepts to fit in the fast-evolving agricultural systems. There is great need for interaction between science, policy, social and economics spheres to ensure success of interventions. In adopting such approaches in agriculture, it is essential to consider the socio-economic aspects of these approaches, as they are at least as important as the technology/practices aspects.

For example, the approach of the Zero Budget Natural Farming (ZBNF) was presented, as a method increasingly used in India that follows a number of rules including: minimum tillage of the soil, land preparation, no industrial inputs (but can include naturally-derived pesticides), mulching to protect soil surface including intercropping and land cover, and management of soil moisture to increase water holding capacity. All these aspects can be tools that contribute directly to increasing the quantity of carbon stored in the soil, while increasing the soil health, quality and productivity.

The question of the benefits and challenges of putting a price on carbon in Africa was also discussed. On a local context where land tenure or land rights are not formalized, schemes such as carbon trading, which is meant to offer a positive incentive towards climate change mitigation, could be interpreted otherwise. The issue of who gains and who losses become the question. Lack of understanding of local issues can exacerbate existing equity problems.

### ***Organic agriculture***

FAO (1999) defines organic agriculture (OA) as “a holistic production management system which promotes and enhances agroecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, considering that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfill any specific function within the system.” Organic agriculture holds important Climate change mitigation potential. Organic farms typically have lower energy use and lower green-house gas (GHG) emissions than conventional farms. Other organic farming advantages include; sustainability over the long term, reduced exposure to pesticides and chemicals, building of healthy soil, erosion control, support in water conservation and water health, supports animal health and welfare, encourages biodiversity

A key challenge is to generate enough biomass for organic soil management in semi-arid areas. Therefore, soil rehabilitation and sustainable resource management must be key priorities, apart from improving agricultural productivity.

When it comes to economics of organic farming, yield production is relatively low compared to conventional farming. A case example of Europe shows the yields of organic farms are around 20 % lower on average than those of conventional ones. However, higher prices make up for this yield difference (Neubert 2016). A recent study shows 32 percent more revenues for organic farms than for conventional crops (Despain 2017).

Is organic farming sustainable? Organic farming requires more land than conventional farming, to produce the same quantity of food. Globally, there is pressure to increase food production due to rapid population

growth especially in African countries. The way forward is to think solution that will ensure an integrated approach that will meet this current and future food production needs.

### ***Area Closures and reserves***

The aim of area closures is to prevent further degradation of the ecosystems, advance re-vegetation /forest regeneration, and restore the overall ecological conditions of the area. Area closure is known to improve ground vegetation cover, which in turn enhance better soil conditions, microclimate conditions and water percolation. This also contributes to enhanced CO<sub>2</sub> sequestration due to improved vegetation.

Area closure can qualify for carbon credit programs. A cost benefit analysis conducted on area closure showed that the practice has a positive net present value (NPV) and that its benefit-cost ratio (BCR) varied between 4.6 to 54.3; i.e. a dollar investment will bring at least 4 dollars through carbon credit (PWA 2014).

The inception of this practice can be challenging due to loss of livelihoods options as a result of changing access to resources. A suitable approach is to ensure the engagement and support of concerned households. Communities can for example practice beekeeping and small-scale irrigation to help offset potential short-term losses of income from closed off land while at the same time making themselves more resilient to climate change. Good community engagement and awareness raising on the value of area closures both for the environment and for their livelihoods is crucial for success of the practice. Land tenure issue should be well checked to ensure equity in initiative implementation.

### ***Climate Smart Agricultural Practices***

Climate-smart agriculture (CSA) is an approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate. CSA aims to tackle three main objectives: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; and reducing and/or removing greenhouse gas emissions, where possible.

This session presented various practices under climate smart agriculture. They included; agroforestry, mulching, green manure and use of animal manure. Animal farming is a big source of GHG emissions, however locking the manure in the soil prevents the gases from escaping to the atmosphere. Mulching is a simple, low-cost, low-tech solution for improving agricultural productivity, resilience, and carbon sequestration hence has a high adoption rates among smallholder farmers.

Techniques on enhancing soil organic carbon by use of cross-slope barriers was also presented in this session. Cross-slope barriers technique reduces runoff velocity and soil loss, thereby contributing to soil, water and nutrient conservation. This is achieved by reducing steepness and / or length of slope. This technique involves the use of terracing systems, stone lines on low slopes and vegetative strips. To reap maximum benefit, farmers are encouraged to harness synergies of using more than one technique.

### ***Conservation Agriculture with and without trees***

Soil is a living body, essential to sustain life on earth. This session thus focused on techniques that enhance the protection of the upper 0-20 cm of soil since it is the most active zone, but also the most vulnerable to erosion and degradation. The table below summarizes these techniques. And the three key principles of conservation agriculture: minimum soil disturbance, permanent soil cover, crop rotation/ intercropping

Conservation Agriculture with tree is preferred as it maximizes the farm benefits. In addition, a single young tree can absorb 11.8 Kgs of CO<sub>2</sub> per year which is important in achieving climate change mitigation goals.

Trees can represent an investment in the ecological structures, including to increase net carbon storage. Agroforestry is actually very important worldwide. Globally nearly half of agricultural land has more than 10% of tree cover, and a third has more than 20% of tree cover. It has such enormous potential for increasing carbon in soil. However, the selection of species to be used is important, depending on their various possible impacts of the soil and their interaction with the chosen crops.

| Principle                    | Practice        | Biophysical Benefits  | Farm Benefits   |
|------------------------------|-----------------|---|---|
| Minimum soil disturbance     | Minimum tillage | <u>Improved soil physical properties</u>                                    |   |
|                              | Zero-tillage    | <ul style="list-style-type: none"> <li>• Texture &amp; structure</li> </ul> | <ul style="list-style-type: none"> <li>• Reduced erosion</li> </ul>         |
| Permanent soil cover         | Live mulch      | <ul style="list-style-type: none"> <li>• Aeration</li> </ul>                | <ul style="list-style-type: none"> <li>• Enhanced WH capacity</li> </ul>    |
|                              | Crop residue    | <ul style="list-style-type: none"> <li>• Soil moisture regime</li> </ul>    | <ul style="list-style-type: none"> <li>• Enhanced soil fertility</li> </ul> |
| Crop rotation /intercropping | Crop rotation   | <u>Improved biological properties</u>                                       | <ul style="list-style-type: none"> <li>• Enhanced productivity</li> </ul>   |
|                              | Intercropping   | <ul style="list-style-type: none"> <li>• Microbial activities</li> </ul>    | <ul style="list-style-type: none"> <li>• Enhanced Profitability</li> </ul>  |
|                              | Both            | <ul style="list-style-type: none"> <li>• Organic matter (manure)</li> </ul> |   |

### Session III: Advance Approaches to Monitoring and visualizing Soil Carbon stock

#### *Spectroscopic Approaches and Living Soils Labs demonstrations*

Soils are the largest carbon reservoirs of the terrestrial carbon. Soils contain 3 times more carbon than vegetations and 2 more times than the carbon present in the atmosphere. Land use change and soil degradation are major processes for the release of CO<sub>2</sub> to the atmosphere. The increase of GHGs in the atmosphere is now recognized to contribute to climate change. Carbon in the soil is also a good indicator of soil fertility and health. The sustainable use and management of land and soils is also linked to many areas of sustainable development. There is therefore an urgent need to stop land degradation and nutrient depletion and to establish frameworks for sustainable land and soil management systems. The organic carbon content (SOC) in the soil has been proposed to be used as indicator of the soil health level. Soil spectroscopy is thus key for Land Health Surveillance.

The session outlined the decisions and process that inform design of soil carbon measurements projects. The key message in this presentation was the value of information analysis to better link our measurement systems to decisions. A practice that the World Agroforestry Centre under the CGIAR Program on Water Land and Ecosystems, is advocating. Through this approach, knowledge gathered through research is made available to decision makers, bridging the disconnect that exist between research work and decision making.

Discussion arose on the issue of applying emerging technologies to increase the reproducibility and reduce costs of soil carbon measurements in Africa. To facilitate and ensure monitoring on a regular basis, SOC stocks should be measured using a method that is cost-effective and can cover a high variety of soils types. Innovative methods that can rapidly and inexpensively characterize SOC, such as IR spectroscopy have produced good results for the prediction of SOC content.

In this context ICARF researchers have been promoting the idea of the rural soil-plant spectral diagnostic lab. With just two instruments that can run off battery packs, most soil and plant analysis required for agronomic purposes are covered.

The participants visited the living soils labs where demonstration was made on spectroscopic methods of monitoring and visualizing soil carbon stock.

### ***Geospatial Tools for Soil Health Monitoring***

Geospatial tools are among the advanced soil health monitoring techniques currently available. The session started by evaluating the participants perception on applicability of geospatial techniques in soil health monitoring. The first question was on the availability of geospatial tools in terms of accessibility and ease of use. The second was on their robustness and accuracy and the third, on the importance for scientists to display and communicate evidence /data in a user-friendly way to decision makers.

In response to these questions, the main issues raised by the participants demonstrated availability of the tools in terms of general access. The ease of use was however rated negative as there is a belief for the need of specialized skills which lacks in the African countries. The participants felt that the tools are not robust enough and their use is mainly focused on regional or wide geographical coverages and thus not down scaled to the farmer level. In addressing the last question, there was unanimous agreement that information acquired using this technology should be shared to the end users and not just be an intellectual exercise.

The session demonstrated the use of this technology. Participants were given the opportunity to have a hands-on experience. The demonstration gave an overview of the Malawi land health program that has recently launched the country soil health dashboard. After this the participants gave their feedback on what they could use such a dashboard for, what steps need to be taken to ensure evidence/data is incorporated into decision making and what additional datasets would be useful to explore alongside soil health.

### **Session IV: Technology Adoption, Scaling and Impacts**

This session gave an overview of adoption of various interventions and the barriers to adoption. Adoption rates of NRM initiatives tend to be lower than for commodity-based technologies. An example, agroforestry interventions (e.g. FMNR) versus hybrid maize seeds. The session thus gave an overview of the prerequisites for successful scaling and the necessary strategies/approaches. Among the successful scaling up approaches is the use of theory led comparisons that are thoughtfully designed to test certain hypotheses or generate lessons to inform the design of larger interventions.

The issue of evaluating interventions impacts was discussed. Several methods for impact evaluations were presented. The use of Experimental Design-Randomized control trials (RCTs) and quasi experimental designs –constructed controls was highlighted due to their effectiveness.

### **Session V: Matching Soil Enhancement Technological Potential with country NDCs**

This session was designed to help the participants to reflect on the country priorities relevant for carbon sequestration in soil (including for climate change mitigation through the agriculture and forestry sectors, and for adaptation of the agriculture sector).

The objective of the sessions was to brainstorm how the technologies and practices would best help the realization of the priorities contained in the NDCs. Through this session, country representatives sketched

some ideas for possible technical assistance to further deploy technologies and practice increasing potential for carbon sequestration in soil. that they could request for CTCN Technical Assistance.

- Soil health mapping and measurements information systems
- Farming practices for soil carbon sequestration
- Practices for restoration of degraded lands
- Forest restoration and afforestation
- Use of biomass energy
- Technology need assessment in the agriculture sector
- Upscaling of climate smart Agriculture

## **Conclusion**

The workshop covered a wide array of sustainable agricultural practices, taking the overall angle of soil carbon sequestration. The importance of integrating indigenous techniques and modern approaches would accrue more benefits to our ecosystems, a concept that was replicated through various interventions presented during the workshop. Emphasis was also made on the huge untapped potential of soil carbon sequestration in the agriculture sector. An area that presents a win-win solution for mitigating climate change and for increasing resilience (carbon rich soils constitutes healthy soils, increases soil fertility, reduces erosion, retains water better, enable stronger resilience to extreme weather variations, etc.).

The last session of the workshop gave the NDEs an opportunity to identify possible Technical Assistance areas that would need CTCN support. Among the main area of interest for technical assistance was on modern information system for mapping and monitoring aspects of soil including soil carbon. This included Soil Spectroscopic analysis and geospatial tools for soil health monitoring. To leverage on this event's experience a training manual will be developed covering the topics of focus during the workshop. The will facilitate knowledge sharing and possible replication of the event in other regions.

## Annex 1; Workshop Program

### CTCN Capacity Development Workshop for National Designated Entities (NDEs) from Africa Jointly with ICRAF

#### Technologies to Enhance and Monitor Soil Carbon

12-14 December 2018, ICRAF Conference Room, Nairobi, Kenya

#### Agenda

##### Objectives

- Expose the NDEs to the global carbon cycle, basic concepts of soil carbon sequestration; and challenges in enhancing soil carbon storage;
- Present the latest technologies having potential to enhance soil carbon stock in Africa;
- Expose the NDEs to the state of art soil carbon monitoring tools and approaches at field, farm, district/province and national levels;
- Provide access to knowledge resources to NDEs and make these available for CTCN website for wider knowledge-sharing.

##### Participants (30)

- National Designated Entities (or their nominees) and Representatives of Ministry of Agriculture from Botswana, Ethiopia, Kenya, Lesotho, Malawi, Mozambique, Namibia, Rwanda, South Sudan, Swaziland, Tanzania, Uganda, Zambia, Zimbabwe;
- Key Technology Experts from CGIAR Centers/other knowledgeable institutions
- Representatives from the Host Country Government, CTCN and ICRAF

##### Methodology

- Plenary presentations, discussions and interactive exercises
- Lab exposures and hands-on experience
- Group-based methodologies for enhanced learning
- Country Team Work on potential for enhancing Soil Carbon

|              |   |
|--------------|---|
| <b>DAY-I</b> | <b>12 December 2018: ICRAF</b>  |
| 08:30-09:00  | Registration (at ICRAF main entrance gate)  |
| 09:00-10:30  | <b>Opening session: Facilitator: Mehmood Ul Hassan, ICRAF</b> <ul style="list-style-type: none"><li>- <i>Inaugural address: Rajiv Garg, CTCN</i></li><li>- <i>Special Address: Prof. Anthony Simons, Director General, ICRAF (or representative)</i></li><li>- <i>Key note address: Dr. Kelvin Khisa, NDE/Govt of Kenya Representative, KIRDI</i></li><li>- <i>Introductions and Expectations: Dr. Mehmood-UI-Hassan, ICRAF</i></li><li>- <i>Brief Overview of CTCN: Agathe Laure, CTCN</i></li></ul> |

|              |  |
|--------------|--|
|              | <ul style="list-style-type: none"> <li>- Objectives of the Program: <b>Dr. Mehmood-Ul-Hassan, ICRAF</b></li> <li>- Group Photo: <b>Elizabeth Mwangi, CTCN/ICRAF (To be Taken</b></li> </ul>  |
| 10:30-11:00  | Tea/Coffee   |
| 10:30-11:30  | <p><b>Session 1: Understanding Soil Carbon: Dr. Mehmood-Ul-Hassan, ICRAF</b></p> <p><i>-Basic concepts of carbon sequestration</i></p> <p><i>-Challenges in enhancing soil carbon storage: interactive group exercise</i></p>  |
| 11:30-12:30  | <p><b>Session 2: Technologies having potential to enhance soil carbon stock in Africa</b></p> <p><b>2(a): Enhancing Inorganic Carbon</b></p> <p><i>-Application of Biochar: Dr. Mary Njenga, ICRAF</i></p> <p>Q&amp;A and discussion</p>   |
| 12:30-13:30  | Lunch  |
| 13:30-15:30  | <p><b>Session 2: Technologies having potential to enhance soil carbon stock in Africa</b></p> <p><b>2(b): Enhancing Soil Organic Carbon</b></p> <p><b>1. Agroecological approaches (Improving Vegetation Cover, Pasture Management, etc.): Prof. Fergus Sinclair, ICRAF</b></p> <p>Q&amp;A and discussion/Group Work</p> |
| 14:30-15:30  | <p><b>2. Agroforestry, Social Forestry, Plantation Management: Prof. Fergus Sinclair, ICRAF</b></p> <p>Q&amp;A and discussion/Group Work</p>   |
| 15:30- 16:00 | Tea/Coffee   |
| 16:00-17:00  | <p><b>Session 2 (b): Enhancing Soil Organic Carbon</b></p> <p><i>3. ICRAF Lab Tour: Understanding the Potential of genomics for Organic Carbon Sequestration: Dr. Prasad Hendre, ICRAF</i></p>   |

| <b>DAY-II</b> | <b>13 December 2018</b>  |
|---------------|--|
| 08:30-09:30   | <p><b>Session 2 (b): Enhancing Soil Organic Carbon</b></p> <ol style="list-style-type: none"> <li>1. <i>Organic agriculture</i> (Dr. Mehmood Hassan)</li> <li>2. <i>Area Closures and reserves</i> (Dr. Mehmood Hassan)</li> </ol> <p>Q&amp;A and discussion</p>   |
| 09:30-10:30   | <p><b>Session 2 (b): Enhancing Soil Organic Carbon</b></p> <ol style="list-style-type: none"> <li>3. <i>Cross-Slope Barriers: (Dr. Christine Lamanna)</i></li> <li>4. <i>Mulching, green manuring, crop residues, agroforestry/agricultural residues: Dr. Christine Lamanna, ICRAF</i></li> </ol> <p>Q&amp;A and discussion</p>          |
| 10:30-11:00   | <b>Tea/Coffee Break and Group Photograph</b>   |
| 11:00-12:00   | <p><b>Session 2 (b): Enhancing Soil Organic Carbon</b></p> <ol style="list-style-type: none"> <li>5. <i>Conservation Agriculture with and without trees: Alex Oduor, ICRAF</i></li> </ol> <p>Q&amp;A and discussion</p>  |
| 12:00-13:30   | Lunch  |
| 13:30-15:30   | <p><b>Session 3: Advance Approaches to Monitoring and visualizing Soil Carbon stock (and other soil quality parameters)</b></p> <p>(a) <i>Spectroscopic Approaches (Ermias Betemariam/ Eric Towett, ICRAF)</i></p> <p>(b) <i>Sub-national/national/continental (Dr. Tor Gunner/Dr. Leigh Winowiecki, ICRAF);</i><br/> <b>Q&amp;A</b></p> |
| 15:30-16:00   | Tea/Coffee Break   |
| 16:00-17:00   | <b>Session 3 (c): Visit to ICRAF's Living Soils Labs: Eric Towett</b>  |

|                |  |
|----------------|--|
| <b>DAY-III</b> | <b>14 December 2018</b>  |
| 08:30-09:30    | <b>Session 3 (d): <i>Geospatial Tools for Soil Health Monitoring</i>: Tor Gunner, ICRAF</b>  |
| 09:30-10:30    | <b>Session 4: Technology Adoption, Scaling and Impacts (Dr. Judith Odoul, ICRAF)</b><br><b>Q&amp;A and discussion</b>  |
| 10:30–11:00    | <b>Tea/Coffee Break</b>  |
| 11:00-13:00    | <b>Session 5: Matching Soil Enhancement Technological Potential with country NDCs facilitated by: Mehmood Hassan, ICRAF</b><br><br><b>a. Prioritization Exercise in country teams</b><br><b>b. Plenary Presentations by countries and discussion (continued)</b> |
| 13:00- 14:00   | Lunch  |
| 14:00-15:30    | <b>c. Plenary Presentations by countries and discussion</b>  |
| 15:30- 16:00   | Tea/Coffee Break   |
| 16:00 -17:00   | <b>Session 6: Evaluation, closure, and departures</b>  |

## **Annex 2; Final Session Guide**

### **CTCN Capacity Development Event for National Designated Entities (NDEs) from Africa**

#### **Jointly with ICRAF**

#### **Technologies to Enhance and Monitor Soil Carbon**

#### **Final session guide**

CTCN aims to expose developing Nations to technologies having potential to contribute towards low emission development and achieving Nationally Determined Contributions (NDCs). Of focus for this workshop is soil carbon enhancing technologies for carbon sequestration.

**1. Based, on your NDC and relevant climate change/ agriculture policy, what are the identified country priorities relevant for carbon sequestration in soil (including for climate change mitigation through the Agriculture and forestry sectors, and for adaptation of the agriculture sector).**

**2. What is currently preventing the realization or achievement of these identified priorities. or in other words, what are the barriers? (economic, technical and institutional kind of barriers)**

**3. From the knowledge gained through this workshop what will be your main recommendations (next steps) in each of these fields for your country**

**4. Within these recommendations, and based on the challenges, propose 2 to 3 ideas for possible technical assistance to further deploy technologies and practice increasing potential for carbon sequestration in soil.**

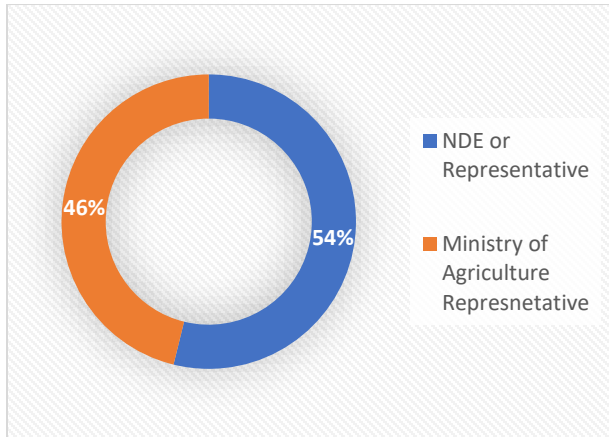
### Annex 3; Participants List

|    | Name                 | Email  | Institution   | Country          |
|----|----------------------|--|---|------------------|
| 1  | Penny Lesolle        | plesolle@bitri.co.bw;<br>plesolle@gmail.com    | NDE-Botswana  | Botswana         |
| 2  | Lefa Thamae          | lefathamae@gmail.com                           | NDE-Lesotho   | Lesotho          |
| 3  | Lyson Kampira        | lkampira@ncst.mw;<br>lkampira@yahoo.com        | NDE- Malawi   | Malawi           |
| 4  | David Batali         | db_oliver@ymail.com                            | NDE, South Sudan  | South Sudan      |
| 5  | Bafana Simelane      | bafanasim@gmail.com                            | Swaziland Meteorological Service                                      | Swaziland        |
| 6  | Maxwell Otim Onapa   | m.onapa@uncst.go.ug                            | Uganda National Council for Science and Technology                    | Uganda           |
| 7  | Ben Makayi           | benmakayi2004@gmail.com                        | Ministry of Higher Education - Zambia                                 | Zambia           |
| 8  | Elisha N. Moyo       | enmoyo@gmail.com;<br>moyo_elisha_n@yahoo.co.uk | Ministry of Environment, Water and Climate-Zimbabwe                   | Zimbabwe         |
| 9  | Jonathan Kamwi       | mutauk@yahoo.co.uk                             | NDE-Namibia   | Namibia (NAM)    |
| 10 | Gerald Kafuku        | kafukugm@gmail.com<br>gkafuku@costech.or.tz    | NDE -Tanzania   | Tanzania         |
| 11 | Kelvin Khisa         | kelvinnamukhasi@gmail.com                      | NDE - Kenya   | Kenya            |
| 12 | Austin Phiri         | phiriaustin534@gmail.com                       | Ministry of Agriculture   | Malawi (MWI)     |
| 13 | Sikhumbuzo Maseko    | masekosikhumbuzo1@gmail.com                    | Ministry of Agriculture   | Swaziland (SWZ)  |
| 14 | Joseph Katuahupira   | josephath_tjeripo@yahoo.co.uk                  | Ministry of Agriculture, Water and Forestry                           | Namibia (NAM)    |
| 15 | David Akodi,         | akodidavida@yahoo.com                          | National Agricultural Research Organization (NARO)                    | Uganda (UGA)     |
| 16 | Kebonyethata Dintwe  | kebonye.dintwe@gmail.com                       | Ministry of Agriculture   | Botswana (BWA)   |
| 17 | Godfrey Chikwenhere- | chikwenherepasu@gmail.com                      | Ministry of Lands, Agriculture, Water, Climate and Rural Resettlement | Zimbabwe (ZWE)   |
| 18 | Geophrey Kajiru      | gjkajiru@gmail.com                             | ministry of Agriculture   | Tanzania (TZA)   |
| 19 | Maria Cheko Manussa  | smanussa@hotmail.com                           | ministry of Agriculture   | Mozambique (MOZ) |
| 20 | Selebalo Ramakhanna  | sramakhanna@gmail.com                          | Ministry of Agriculture   | Lesotho (LSO)    |
| 21 | Tezera Giref         | tezck7@gmail.com.                              | NDE- Ethiopia Rep   | Ethiopia         |

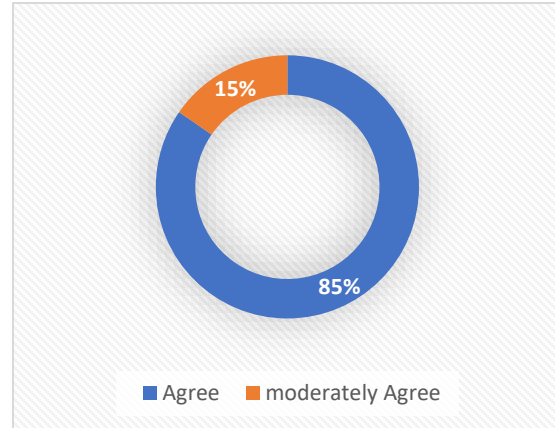
|    |                      |                            |   |                   |
|----|----------------------|----------------------------|---|-------------------|
| 22 | Agnes Ohide          | agnesimoya@gmail.com       | Ministry of Agriculture and food Security | South Sudan (SSD) |
| 23 | Gemechu Abera Beyene | gemechuabera593@gmail.com  | Ministry of Agriculture                   | Ethiopia (ETH)    |
| 24 | Apponnaire Twahirwa  | apotwahirwa@gmail.com      | Rwanda Environmental Management Authority | Rwanda            |
| 25 | Candida Chamusa      | candelladelis@gmail.com    | NDE representative                        | Mozambique        |
| 26 | Francis Nyambariga   | nyambariga.f2014@gmail.com | Ministry of Agriculture                   | Kenya             |
| 27 | Rajiv Garg           | gargr@un.org               | CTCN                                      | Kenya             |
| 28 | Agathe Laure         | agathe.laure@un.org        | CTCN                                      | France            |
| 29 | Mehmood Hasssan      | M.Hassan@cgiar.org         | ICRAF                                     | Kenya             |
| 30 | Elizabeth Mwangi     | E.N.Mwangi@cgiar.org       | CTCN/ICRAF                                | Kenya             |

## Annex 4: Synthesis of Participants Workshop Feedback

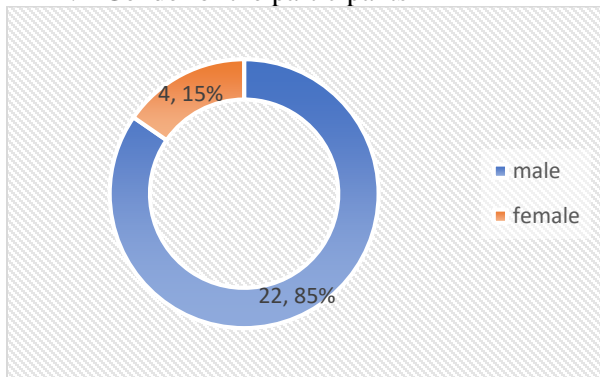
1. In what capacity the participants attended the workshop?



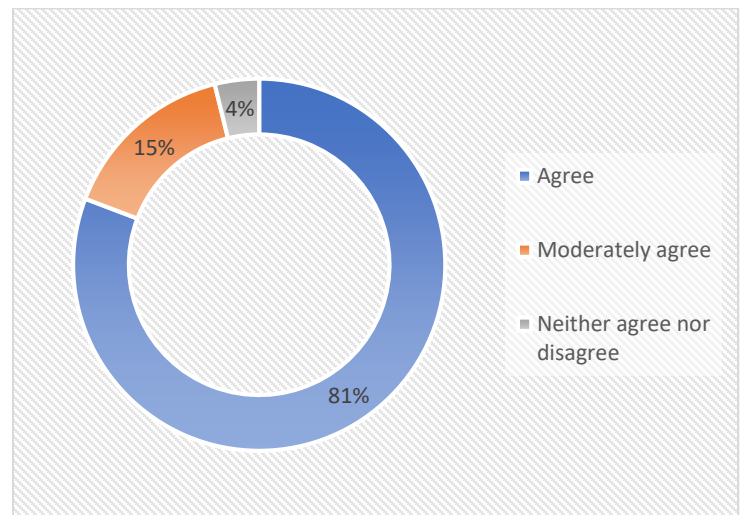
4. The workshop contributed to my understanding of the CTCN and its services



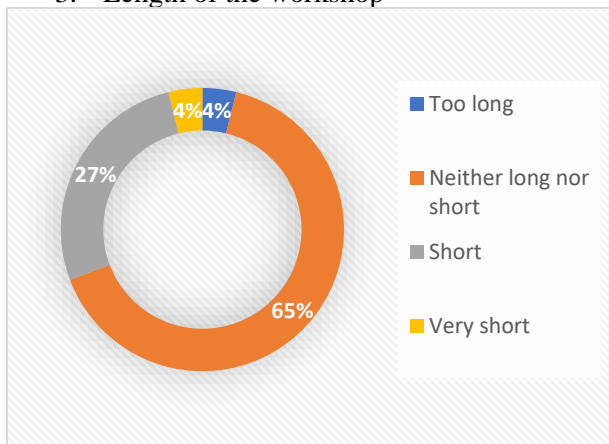
2. Gender of the participants



5. The workshop enhanced my understanding of how to match soil enhancement technological potential with the country climate priorities for better planning



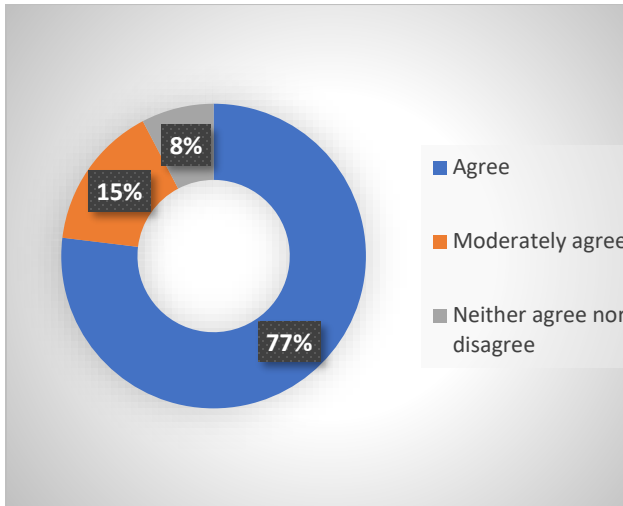
3. Length of the workshop



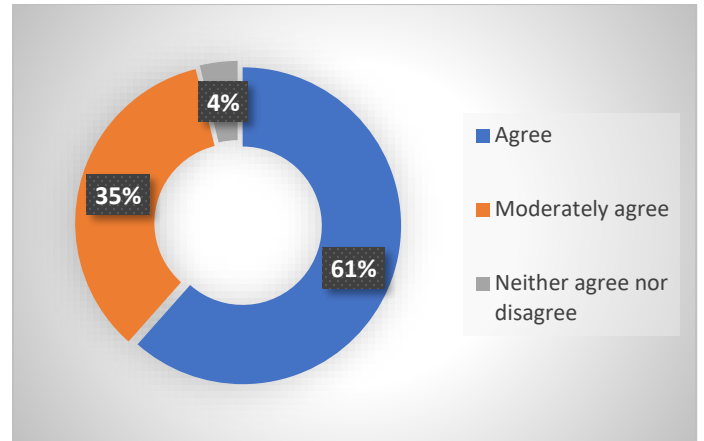


**6. The workshop increased my knowledge of soil carbon sequestration, through increased understanding of:**

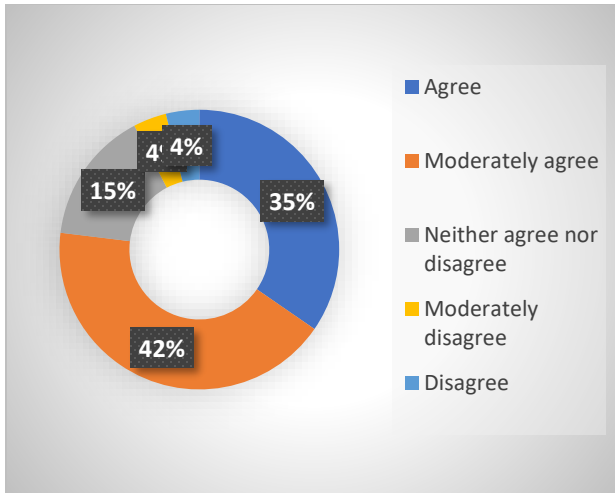
a) Basic concepts of carbon cycle and carbon sequestration – session 1



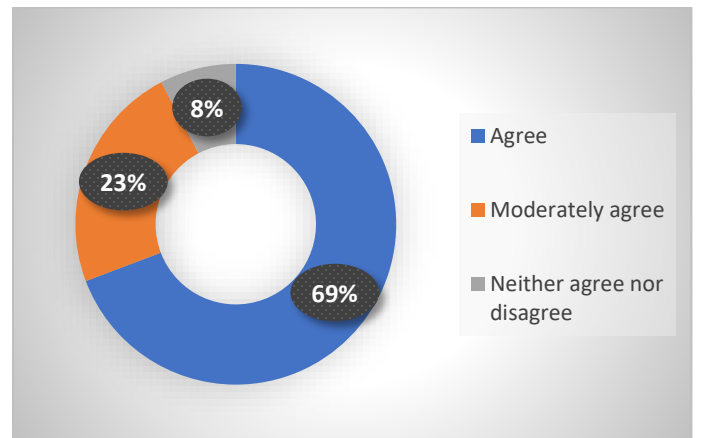
c) Agroecological approaches – session 2(b – 1)



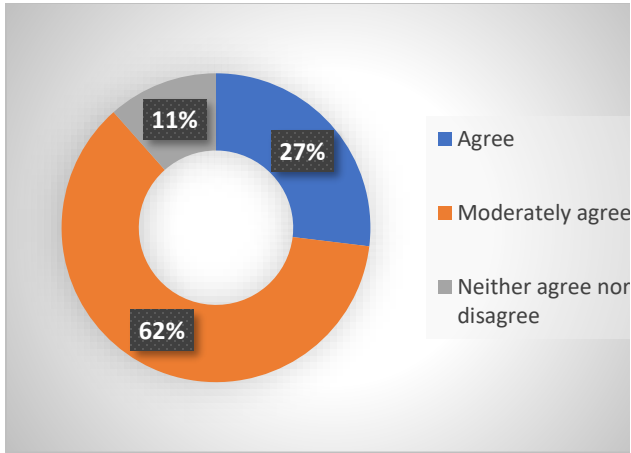
b) Application of biochar -session 2(a)



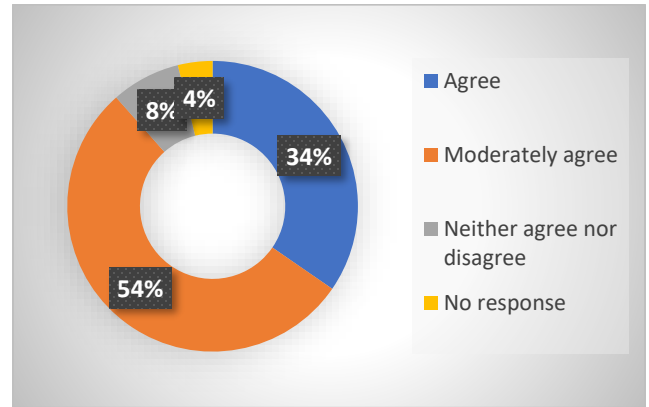
d) Agroforestry, social forestry, plantation management – session 2(b – 2)



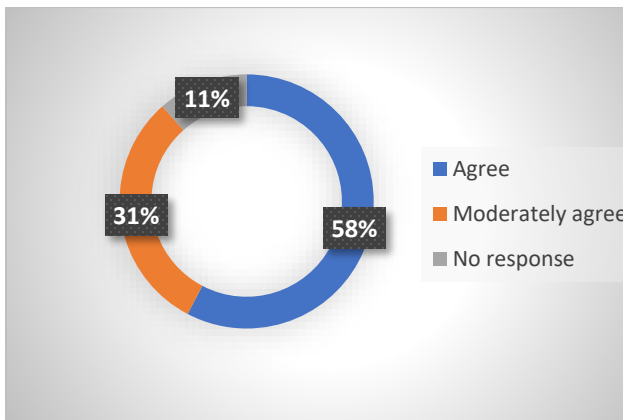
e) The potential of genomics for organic carbon – session 2(b – 3)



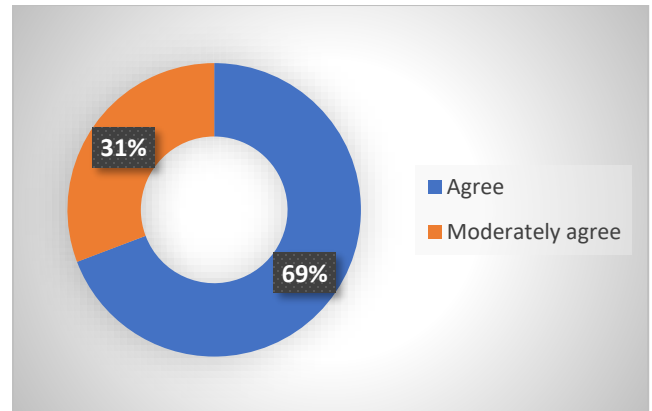
h) Cross-slope barriers – session 2(b – 6)



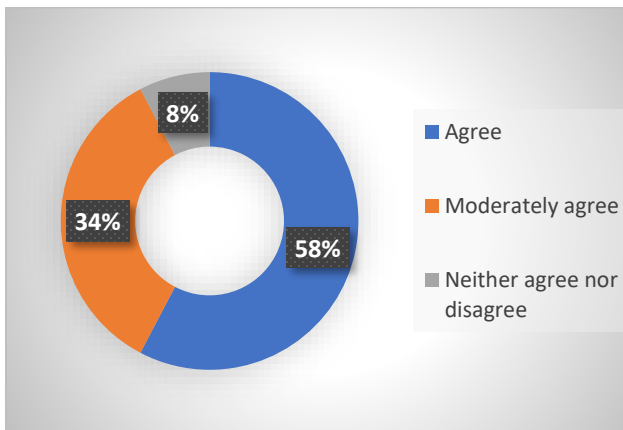
f) Organic agriculture – session 2(b – 4)



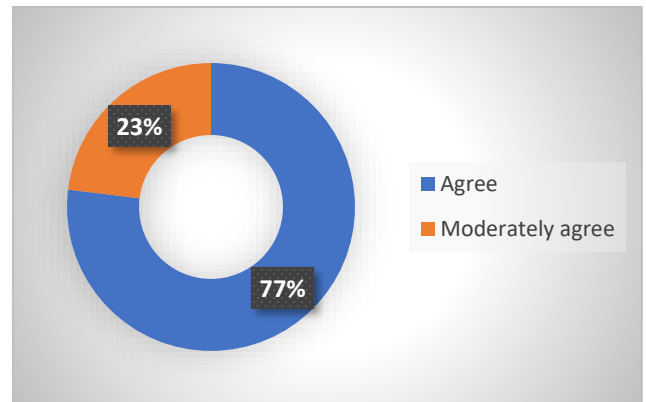
i) Mulching, green manuring, crop residues, agroforestry/ agricultural residues – session 2(b – 7)



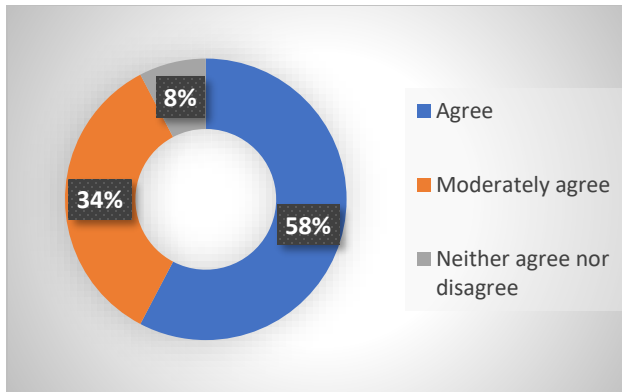
g) Area closures and reserves – session 2(b – 5)



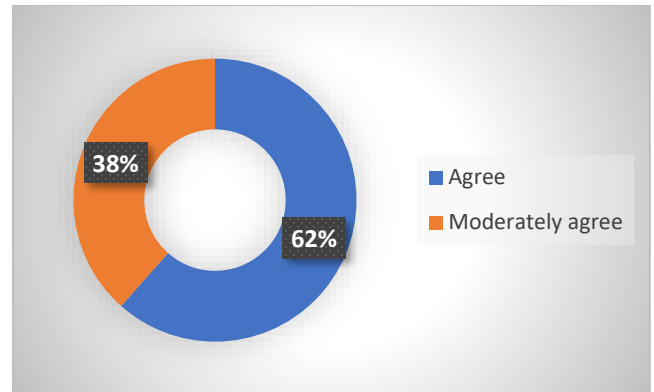
j) Conservation agriculture with and without trees – session 2(b – 8)



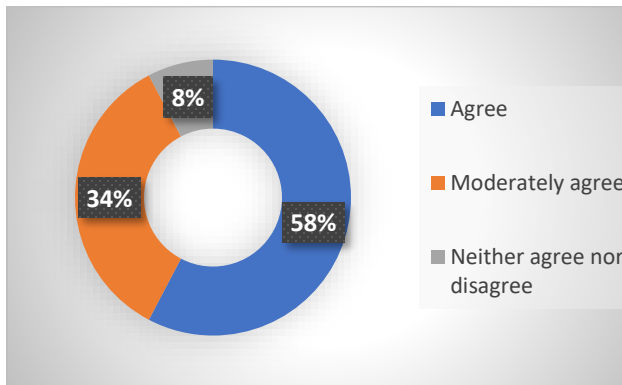
k) Advance approaches to monitoring and visualizing soil carbon stock – Spectroscopic approaches – session 3 (a)



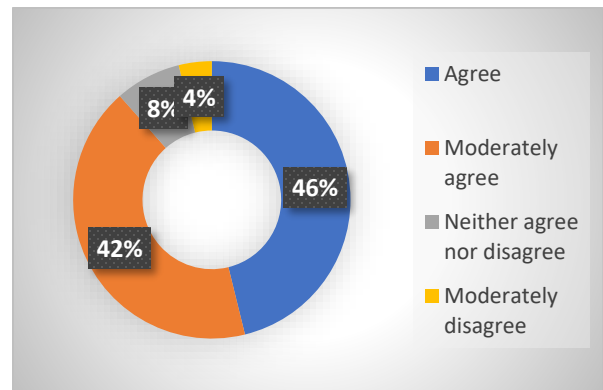
m) Advance approaches to monitoring and visualizing soil carbon stock – Spectroscopy Lab – session 3 (c)



l) Advance approaches to monitoring and visualizing soil carbon stock – soil carbon in landscapes at multiple spatial scales – session 3 (b)



n) Technology adoption, scaling and impacts – session 4



### 7. What did you specifically like?

- Acquiring new knowledge on soil and land health
- Session on digital soil mapping to monitor soil carbon
- Session on soil carbon sequestration techniques through remote sensing and GIS soil health dashboard
- Presentation on soil carbon in relation to the GHG emissions and the strategies that can help mitigate climate change related to soil carbon issue
- Agroecology approached and agroforestry
- Lab visits
- Zero budget natural farming

### 8. What specifically did you like least?

- Rushing over presentation due to time limitation
- The laboratories visit

- Session on climate smart agriculture from CA to CAWT
- Application of biochar
- Session on technology adoption and scaling up
- Having the workshop coinciding with COP
- The potential of genomics in soil carbon stock management

**9. What would you recommend for future trainings?**

- Allow more time to synthesize and discuss the concept presented
- More training on soil spectroscopy and how it works
- More presentation on countries specific experiences
- Allocate more days to the training
- Agroecological approaches
- Provide manual in simplified form to share with decision makers and farmers
- Training on organic certification and labeling
- Training in green skill set development for business development
- Soil surveying
- Soil fertility mapping including salinity
- Natural resources management
- Water management/ harvesting technologies

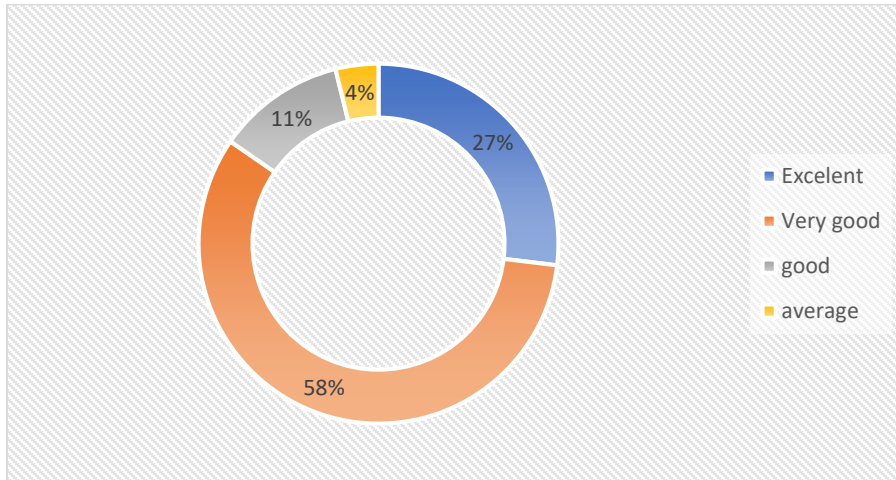
**10. What are the things will you do differently in your work based on what you learned by participating in the training workshop?**

- Work closely with other sectors of key importance in the NDCs to help them conceptualize technologies that can be adopted to achieve the goals of the NDCs and well as help to develop concepts notes for CTCN technical assistance
- Promote strategies that enhances soil carbon
- Being able to develop better concept notes for possible CTCN technical assistance
- Capacity building in efficient NDC implementation

**11. Would you, as an NDE/workshop participant suggest themes of future capacity development as areas where African countries need capacity to make progress on their NDCs?**

- Modern technologies on soil carbon monitoring
- Agroforestry
- Soil carbon sequestration approaches
- More capacity building in the conservational Agriculture
- Influence policy n soil carbon in Zimbabwe at all farming levels
- Green economy for Africa
- Climate finance opportunities and experiences sharing workshop because there are so many expectations from the NDAs
- Empowering farmers with knowledge and tools for soil fertility management

## 12. Overall workshop assessment



## 13. Elaboration on the choice of the workshop overall assessment above

- Well planned and organized presentation
- Supportive organizer who assisted accordingly when called upon
- Acquire new knowledge of main interest being technologies to monitor and enhance soil carbon
- Very knowledgeable presenter who are well versed in the subject matters
- Good networks developed
- The concepts can be practically applied, however some practices for instance biochar cannot be applied at large scale
- The sessions were well moderated and observed time
- The message on the increasing demand for food due to rapid population growth was compelling and clear and hence need to act accordingly to achieve food security

## **Annex 5: Last Session Analysis- Guide on Countries Technologies Prioritization**

**1. Based, on your NDC and relevant climate change/ agriculture policy, what are the identified country priorities relevant for carbon sequestration in soil (including for climate change mitigation through the Agriculture and forestry sectors, and for adaptation of the agriculture sector).**

- Agro-forestry;
- Grazing land/rangeland management
- Degraded land rehabilitation
- Conservation agriculture
- Catchment Management
- Fire management
- Wetland restoration (For the wetland to be able to perform its ecological services)
- Erosion control through terracing and contour banding
- Ecological pest management;
- Crop diversification (inter cropping; crop rotation)
- Organic farming
- Livestock selective breeding
- Urban forestry and agriculture
- Biodiversity and watershed conservation

**2. What is currently preventing the realization or achievement of these identified priorities. or in other words, what are the barriers? (economic, technical and institutional kind of barriers)**

- Low levels of awareness among policy makers right to the community level
- Lack of mainstreaming of the NDCs commitment and targets into existing development plans, policies, strategies and budgets
- Devolved governance system making implementation of initiatives difficult
- Long gestation period of some enterprises such as agroforestry
- Land tenures especial for the ASAL regions makes difficult to invest longer term initiatives like agroforestry
- Weak link between researchers and extensionists
- Land tenure systems challenges
- Poor planning and prioritization
- Lack of finance
- Lack of appropriate capacity building
- Lack of appropriate capacity on development of bankable project proposals.
- Shortage of skilled labor
- Lack technical assistance
- Lack of technology transfer
- Poor coordination among Government Ministries and departments

**3. From the knowledge gained through this workshop what will be your main recommendations (next steps) in each of these fields for your country**

- Degraded land restoration: A lot of top soil containing carbon and other nutrients is lost during erosion. Prevention of erosion is therefore recommended. The degraded land must be rehabilitated by employing a combination of techniques as presented

- Rangelands and Grazing land management: Pasture is also another technology that may be adopted by the country to sequester soil carbon and thus increase soil carbon stocks
- Agroforestry: Forestry has been recognized to reduce CO<sub>2</sub> emissions as well as enhancing carbon sinks. Forests are a large sink of carbon and their role in carbon cycles is well recognized. Awareness of the importance of soil carbon sequestration should be the starting point. Then the country should encourage farmers to invest in agroforestry by putting up incentives that will attract them (farmers) to practice agroforestry.
- Promotion of Efficient biomass energy production and utilization
- Sensitization of the communities about CSA and its benefit in carbon sequestration
- Develop and implement appropriate laws and policies on the land tenure systems
- Educate communities on alternatives energy saving cooking technologies
- Mapping the soil carbon problematic zones and advising the right agricultural technology
- Design and implement policy incentives for farm diversification
- Designing a credit system for soil carbon sequestration

**4. Within these recommendations, and based on the challenges, propose 2 to 3 ideas for possible technical assistance to further deploy technologies and practice increasing potential for carbon sequestration in soil.**

- Capacity building on mapping and rehabilitation of degraded land; Assistance in modern and cost-effective techniques for the restoration of degraded land.
- Creation of soil health information systems (SHIS)
- Capacity building on rangeland management
- Farmer training on the implementation of agroforestry.
- Biomass energy production and utilization technologies
- Support on development of strategies to create incentives for the community to engage in forest restoration
- Identification of water management technologies
- Soil carbon monitoring to develop a map of the key areas that need interventions and identification of the technologies relevant for the intervention
- Promotion of CSA practices including conservation of germplasm for land races and their wild relatives
- Review of the existing agriculture policies
- Strengthening capacity of the extension services to ensure climate action