# TECHNICAL REPORT:

INTERNATIONAL TRAINING ON RAINWATER HARVESTING, ORGANIC FARMING, PERMACULTURE AND AGROFORESTRY

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## List of abbreviations and acronyms

| | |
|---|---|
| AOCC | African Orphan Crops Consortium |
| BDBA | Billion Dollar Business Alliance |
| COPD | Chronic Obstructive Pulmonary Disease |
| HoPPA | Household Protocol Application |
| ICRAF | International Centre for Research in Agroforestry |
| ICS | Integrated Carbon Sequestration |
| IFAD | International Fund for Agricultural Development |
| KEFRI | Kenya Forestry Research Institute |
| KFS | Kenya Forest Service |
| KIOF | Kenya Institute of Organic Farming |
| SDI | Spatial Data Infrastructure |
| SNV | Netherlands Development Organisation |
| SSA | Sub Saharan Africa |
| WaMPA | Watershed Management Protocol Application |
| WHO | World Health Organisation |

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# 1. Background

## 1.1 Introduction to the training

The Integrated Carbon Sequestration Project – ICSP , with the support of International Fund for Agricultural Development (IFAD – Sudan), subcontracted the World Agroforestry (ICRAF) based in Nairobi - Kenya to organize a 10-day training for 16 delegates drawn from State agencies of the Sudan Government that included; the Ministry of Agriculture, Forest National Corporation, Rainwater Management and the Integrated Carbon Sequestration Project in Sudan. Meta Meta based in Wageningen – The Netherlands, provided technical support to the course. The course took place in Kenya from 15th to 26th of September 2019.

Course Objectives:

The following were the course objectives:

- To be acquainted with up-to-date know-how of the importance, central ideas, challenges and benefits linked to agroforestry, silviculture, permaculture, organic farming and water harvesting – both direct rainfall and floods;
- To understand and analyze the interlinkages between permaculture, agro-forestry, and silvipasture systems, while acknowledging the roles organic farming, water harvesting – both direct rainfall and floods, and irrigation techniques play in improving food security, water and land productivity as well as livelihoods;
- To develop the knowledge and skills necessary for application of different practical methods, technologies and applications in agroforestry, silviculture, permaculture and organic farming;
- To acquire practical knowledge and skills in the field of catchment management and water harvesting (rainfall and floods) - including area-based approaches, decision-making tools, green infrastructure and road water harvesting;

- To provide participants with practical experiences, including digging bunds, planting vetiver, designing artificial wetlands, water dowsing and (sand) dam design.

The trainers used the following methods training to achieve the course objectives:

- The use of PowerPoints presentations, which were done by ICRAF scientists at their Global headquarters in Nairobi
- Delegates were guided to various field tours of the ICRAF laboratories, the Kenya Institute of Organic farming, the Kenya Forestry Services, the Kenya Forestry Research Institute, Yatta and Mwala locations of Machakos county, Embu and Laikipia counties. During the field visits, farmers and extension agents were given time to explain their activities relating to the training and in one case, a practical conducted on ground water prospecting and planting of vetiver grass.
- Group work: Participants were given topics to discuss in groups, after which each group presented in plenary the recommendations, which were documented and shared with relevant government officials in Sudan.

## 1.2 Brief highlights on ICRAF and the ICS Project

This training was officially opened by the Eastern and Southern Africa Regional Coordinator, Dr. Peter Gilruth who gave a brief history, ongoing activities and the future plans for ICRAF. He emphasized on the need for water harvesting including floods and smart agriculture for improved global food security. Dr Gilruth welcomed the delegates to Kenya and urged them to gather as much technical and social knowledge during the training. He wished them well for the entire period of their stay in Kenya. Dr Gilruth urged the delegation to take full advantage of being at ICRAF and Kenya and to explore avenues of future collaboration with ICRAF and other places they would visit.

The Sudan delegates were led by Madam Isra Mamoon, who gave a robust highlight of their team – in respect to their disciplinary orientation and the state agencies each of them represents. She also dwelt at length on the ICS project with special reference to its interlinkages with agroforestry.

*Figure 1: ICS Project Team Leader giving an overview of the project*

### 1.2.1 Questions/ comments

Q1. What's the current seedling rate in Sudan?

A. 80%

Q2. What tree species are you focusing on in your project?

A. Acacia, Eucalyptus, Balanites and Ziziphus tree species

Q3. Where is the project site?

A. North of Sudan

Q4. Which are the main food crops in Sudan?

A. Sorghum and millet

## 2. Powerpoint presentations and plenary discussions

The course combined theoretical and practical sessions. Theoretical sessions focused on soil health and its interlinkage with agroforestry and sustainable ways to conserve the tree germplasm. In addition, the main agroforestry practices in Eastern Africa capitalizing on benefits of trees were discussed. These also included regeneration and management of trees and shrubs. Water harvesting techniques operational across East African countries were covered along with Watershed Management Protocol Application (WaMPA), the Household Pond Protocol Application (HoPPA) and an app for designing pond reservoir potential and dimensions.

### 2.1 Soil Health by Dr. Ermias Betemariam

Dr. Ermias who is a lead soil health specialist stressed that Sub Sahara Africa may have the highest food security risk to feed its growing population with a possibility of the demand of the cereals tripling. He reiterated that food, fiber and fuel production to achieve food and energy will place increased pressure on land and in turn lead to agricultural soils being degraded. Dr. Ermias stressed that the main gaps in soil health are lack of information on crop nutrient requirement and low declining soil fertility. However, these gaps could be addressed through generation of evidence by monitoring progress and learning adaptive management techniques, engaging in target multiple benefits practices that sequester carbon, enhance productivity and biodiversity, and stimulating better communication between scientists, businesses, public and private enterprises, policy makers and the public. Dr. Ermias noted that there is need to close the gap between the current farm yield and the yield potential on the existing cropland, intensify on the number of crops grown per year as well as incorporate the use of technology in integrated soil fertility and water management as well as plant generic improvement.

#### 2.1.1 Resource Documents on Soil Health

1. Precision Soil and Plant Health Measurement: Driving Agricultural Transformation ppt.
2. AfSIS Technical Specifications: Soil Health Surveillance Manual.
3. Africa Soil Information Service (AFSIS)

4. ICRAF Soil- plants spectral diagnostic laboratory: Sample submission and services request form

## 2.2 Orphan Crops Genomics by Dr. Prasad Hendree

Orphan crop genomics was handled by Dr. Prasad who began by giving a brief definition of the orphan crops terminology. He defined this as under-researched, under-investigated and under-represented crops in the scientific and donor community, which have been preserved for thousands of years by farmers, communities and farming societies. These crops are believed to be highly nutritious, climate resilient and stress tolerant. He stressed on the use of DNA – Marker based production of quality seed for good crop, good harvest, good market, new value chains, new products and good remuneration.

### 2.2.1 Resource Documents on AOOC

1. African Orphan Crops Consortium (AOCC), a public- private partnership for promoting food and nutritional security in Africa through genomics ppt.

2. AOCC Website by ICRAF

3. Supporting human nutrition in Africa through the integration of new and orphan crops into food systems: placing the work of the AOCC in context. Working paper.

4. AOCC: Status of developing genomic resources for African orphan crops. Article

## 2.3 Agroforestry practices in Eastern Africa By Eric Otieno

In this presentation, Eric focused on the benefits accrued from agroforestry as well as intercropping different trees with crops. He gave a specific example of Gliricidia sepium as an excellent biomass producer, soil improver, nitrogen fixer as well as a nutrient recycler. He also briefly talked about the Regreening project aimed at reversing degradation by bringing back trees on landscapes. Land degradation was mentioned as a serious concern in Africa hence the need for national agroforestry food-energy security programme that requires cross-sectoral coordination and goodwill with an 'all-in' spirit of collaboration.

### 2.3.1 Resource Documents on Agroforestry

1. Agroforestry for land restoration and sustainable livelihood ppt

2. Agroforestry in the dry lands of Eastern Africa: A call to action. Working paper

## 2.4 Enhanced Water Management and Water Productivity by Dr. Abraham Mehari

Dr. Abraham Mehari, a research scientist at ICRAF and seconded from Meta Meta Research of Netherlands, presented on methods of enhancing water productivity. He reported that there are three assessment methods;

i. Field based method that involve measurements and interviews
ii. Modelling method that involves the use of CropWat and AquaCrop models
iii. Remote sensing that involves the use of flying sensors and satellites.

Dr. Mehari introduced the participants to flying sensors, whose benefits were highly realized in a Smart Water for Agriculture project funded by the Dutch embassy and implemented by SNV. He reiterated that with the flying sensors, water, nutrients, pest and disease stress can be detected 10 days before the naked eye is able to detect. Though the flying sensors record improved water productivity, validation through field data is very important. The need for soil and moisture conservation techniques at crop, field and basin levels was highly emphasized.

Dr Mehari noted that there is need for policies that generate revenue and at the same time promote efficient water management. For example, in Nijmegen, the local government together with the water board provides a subsidy of 4.55 Euros per $m^2$ for citizens and companies using permeable surface systems instead of impermeable systems. In Pimanpira, Ecuador, upstream farmers are paid 0.5 to 1 US$/ha by the community in Pimanpira to improve groundwater recharge. This was agreeably a good way to improve the communities' income.

### 2.4.1 Resource Documents on Water Productivity

1. Agricultural water management and productivity ppt

2. Smart water for agriculture - farmer case study, video

3. Accelerating farmer-led irrigation development , technical paper – smart water for agriculture project

2. Green water management handbook: rainwater harvesting for agricultural production and ecological sustainability

3. Modifying forestry and agroforestry to increase water productivity in the semi – arid tropics. Article

## 2.5 Agroforestry bioenergy (charcoal and charcoal briquettes) by Dr. Mary Njenga

Agroforestry bioenergy was presented by Dr. Mary Njenga, who made a brief presentation on making tree-based energy sustainable in Sub Saharan Africa. She noted that charcoal is mainly used in urban areas where consumption is higher than the rate of urbanization with a 3% average charcoal demand growth rate as documented by GEF, 2013. Dr. Njenga further reiterated that in rural SSA, firewood is predominant for cooking and heating and optimal benefits can only be achieved if negative health and environmental impacts are addressed in each component of the woodfuel system.

She went ahead to emphasize that 4.3 million people die from illnesses associated with smoke in the kitchen (Lim and Vos 2012). These include pneumonia, stroke, ischaemic heart disease, chronic obstructive pulmonary disease (COPD), lung cancer and headaches (WHO Fact sheet). From this, she said that a rationale for cleaner biomass cooking systems has been developed which focuses on reduced gas emissions and high calorific value. She insisted on the adoption of the currently available low emission cookers in the market.

### 2.5.1 Resource Documents on Agroforestry Bio-energy

1. Making tree-based energy sustainable in Sub-Saharan Africa ppt

2. Innovative biomass cooking approaches for Sub-Saharan Africa. Article

3. Sustainable rural bioenergy solutions in Sub-Saharan Africa: A collection of good practices. Handbook

4. Implications on livelihoods and the environment of uptake of gasifier cook stoves among Kenya's rural households. Article

## 2.6 Role of agroforestry in climate change by Dr. Rose Akombo

Dr. Rose Akombo is Head of Climate Change Response Programmes in Kenya Forest Service (KFS). She gave a presentation on the overview of KFS, current ongoing activities and highlights of achievements in the last strategic plan period. KFS strategic goal is to conserve, develop and manage forest resources sustainably for the provision of forest goods and services in perpetuity. In order to effectively provide leadership, coordination and technical advice for forest development, Dr. Akombo noted that KFS has established 10 forest conservancy areas and 47 county offices.

As reported, the organization has in the last strategic plan period;

i. Increased the forest cover in Kenya from the 6.99% to the current 7.2% equivalent to 4,195,051.20 ha.
ii. Increased state forest reserves area from 1.9 million ha to the current 2.5 Million ha.
iii. Rehabilitated a cumulative total of 1,567,306.9 hectares of natural forests countrywide.
iv. Developed a total 81 out of 149 participatory Forest Management plans
v. Facilitated the establishment of over 2,416 Forest-based enterprises
vi. Recruited 515 additional forest rangers to strengthen protection in the five water towers
vii. Cumulatively established a total of 40,034 ha of industrial forest plantations
viii. Facilitated the establishment of 73,450 ha of private plantation forests and 12,450 ha of trees and commercial woodlots on farmlands
ix. Facilitated the growing of 150 hectares of bamboo on private farms
x. Developed and implementing KFS third Strategic Plan for the period 2017-2022.

This clearly gave an insight of the techniques that could be adopted in Sudan by a corporation of similar status.

### 2.6.1 Resource Documents Kenya Forest Service

1. KFS overview ppt

2. Agroforestry for mitigating climate change in Viet Nam. Paper

3. Meeting climate change and food security challenges in fragile states. Practical note

3. Achieving mitigation and adaptation to climate change through sustainable agroforestry practices in Africa. Paper

## 2.7 Mapping of Agroforestry by Dr. Muhammad

Dr. Muhammad is a Scientists based at the Geoscience laboratory. He gave an overview of what the geoscience lab at ICRAF performs. Dr. Muhammad specifically emphasized that the Geoscience laboratory has a huge data bank on geospatial related science, which involves mapping of landscapes, spatial data infrastructure, solutions development and capacity development. These were detailed as follows:

*Table 1: Summary of Services provided by Geoscience lab at ICRAF*

| Geoscience Lab Sub Thematic areas | Services provided |
|---|---|
| **Mapping of Landscapes:** | • Survey framework<br>• Surveys using mobile data collection<br>• Data Analysis<br>• Modeling of land use land cover |
| **Spatial data Infrastructure (SDI)** | • Data<br>• Metadata<br>• Catalog and Search<br>• Modules Layer, Maps, Docs, Project etc. |

| | |
|---|---|
| **Solution development** | • Mobile apps.<br>• Decision support Systems |
| **Capacity Development** | • Data collection and mapping<br>• Data analysis |

### 2.7.1 Resource Documents on Geoscience Lab

1. Geo Science Lab: ICRAF. Ppt

2. The Land Degradation Surveillance Framework (LDSF). Website

3. The Land Degradation Surveillance Framework: Field Guide. Book

## 2.8 Watershed Management Protocol Application (WaMPA) by Eng. Maimbo Malesu

Engineer Malesu leads the Water Management Unit at ICRAF East and Southern Africa region as a Programme Coordinator. He began by emphasizing on the need of GIS in watershed management. His presentation focused on Assessment and mitigation of catchment degradation trends in East and Southern Africa using the Watershed Management Protocol Application (WaMPA). Eng. Malesu gave a case study of Mwache catchment in Kenya, where the WaMPA tool was used for watershed characterization, field data collection, soil and water sampling analysis, analysis of the acquired data and synthesis.

The key message of this presentation was that water management needs to be integrated and be inclusive. It requires coordination and strategies adapted to all levels of water governance and should give due consideration to cross-sectoral approaches in addressing the synergies and trade-offs between the goals of food production, protection of water, land and biodiversity as well as energy use through enhanced dialogue, collaboration, coordination and policy coherence.

### 2.8.1 Questions/ Comments

C1. A similar application has been developed for natural resource management resources

### 2.8.2 Resource Documents on Watershed management

1. Assessment and mitigation of catchment degradation trends in East and Southern Africa using the Watershed Management Protocol: A case study of Mwache Catchment in Kenya. Ppt

2. Success factors for land and water management in Africa. Blog

3. Participatory watershed management: Lessons from RELMA'S experience in Eastern and Southern Africa. Working paper

4. Maintain the sustainability of PES program: Lessons learnt from PES implementation in Sumberjaya, Way Besay watershed, Indonesia. Book Chapter.

## 2.9 Harvesting floods from roads by Dr. Abraham Mehari

The presentation by Dr. Mehari focused on roads for other uses other than only transport. He emphasized on making our roads as instruments for resilience, better water management, regreening as well as better health for humanity. He said that this could be achieved through road side tree planting hence the Green Roads Initiative. Dr. Mehari noted that roads positively impact on surface and subsurface hydrology and flood patterns as well as air quality. If the water is harnessed, it can contribute to improved water productivity and food security.

*Figure 2: Roadside water diversion in Malawi*

### 2.9.1 Questions/ Comments

Q1. Are you partnering with the ministry of Infrastructure?

A. We have partnered with the county governments which fully support the initiative especially the County Government of Kitui

Q2. Do you have initiatives in Sudan?

A. Not yet but we are looking for opportunities and this training could be a better platform for new partnerships.

### 2.9.2 Resource Documents Roads for Water

1. The green roads initiative. Ppt

2. Roads for water. Website

3. Experiences with road water harvesting in Kenya

## 2.10 Pond sizing application by Ms. Jackline Muturi

Ms. Muturi is a scientist at SNV. She reiterated that the water sizing application was developed by the Smart Water for Agriculture (SWA) project due to an identified gap in farmers' knowledge in sizing and costing of farm ponds. The SWA project thus developed an App that covers Machakos, Laikipia, Meru, Nakuru, Uasin Gishu and Narok Counties. With the use of this App, a farmer is able to determine pond storage capacity, pond dimensions (including both bottom and top width and length, and depth), liner dimensions (L X W) and estimated liner cost in Kenya Shillings. For the case of Sudan, this App would need some calibration considering the different eco-climatic zones in Sudan as well as biophysical factors.

### 2. 10.1 Questions/ Comments

C1. The APP cannot be used in many areas of Sudan due to small pieces of land

A. Change the shape and dimensions of the pond e.g. deepen the pond to reduce the space occupied.

C2. Other factors like the topology, location of the farm, movement of water among others need to be considered for the betterment of the app.

C3. The app can also be used for domestic purposes other than for irrigation as only indicated.

C4. Sudan is very rich in water but there is still a gap on water harvesting. Capacity building should thus be introduced to the extension officer who will in turn create awareness to the farmers.

### 2.10.2 Resource Documents for Pond Sizing

1. Mobile- based decision-making tools: Water pan sizing App. Ppt

2. Pond sizing App.

## 2.11 Water harvesting using HoPPA by Eng. Alex Oduor

Eng. Alex Oduor, the Programme Officer for Water Management at ICRAF, began by stating that farm ponds are essential for creating water independence at the household level given that they can be sited almost everywhere. He reiterated that run-off collection ponds are key to achieving higher agricultural productivity. This is the reason why The Billion Dollar Business Alliance's (BDBA) was launched in order to boost investments to scale up farm pond technologies – with Kenya aspiring to construct 1,000,000 smallholder ponds in next ten (10) years. Eng. Oduor provided the definition and design of the truncated pyramidal pond (in cross sectional 2D views or 3D view. He explained why the truncated shape guarantees pond stability in comparison with rectangular or square models. Eng. Oduor noted that ICRAF developed the Household Pond Protocol Application (HoPPA) whose objectives are:

i. To develop a platform for pond systems design and use by all practitioners;
ii. To improve the efficiency of runoff pond system and thus, increased crop yields

Eng. Oduor noted that one of the key features of the HoPPA is its potential for automation of flow mechanisms, water pumping, monitoring of crop performance, strengthening farm security.

All of these can be handled remotely using smartphones. Some automated systems are able to detect and communicate water levels, water losses, water temperature, and water quality by checking turbidity and initiating automated irrigation. The automated irrigation detects the soil moisture content in the farm area by use of sensors in the soil. Water is crucial to essentially all agricultural enterprises. However, the farm ponds are particularly useful for the following agricultural enterprises: High value crops; tree nurseries & transplanting; poultry production; bee keeping and fisheries.

### 2.11.1 Resource Documents on HoPPA

1. Household Pond Protocol Application (HoPPA): Kenyan Version of the HAFFIR. Ppt

2. Farm ponds become the source of livelihood for the youth of Myanyani – Machakos County. Blog

3. A farmer-led programme to enhance water management, food security, and rural economic development in the drylands of Burkina Faso, Mali, Niger, Ethiopia and Kenya: Kenya Drylands Development Programme (DryDev) Annual Report 2016.

## 3. Laboratory visits

The practical sessions were meant to provide the participants with an opportunity to visit and learn from selected state of the art laboratories, and bright field spots where ICRAF and its partners have successfully introduced water harvesting, agriculture and agroforestry techniques and practices.

### 3.1 Soil laboratory

At the soil laboratory, participants were briefed on the overall processes such as soil carbon monitoring, soil mineralogical determination, prediction of soil properties (physical, chemical and biological) and measurement of macro and micro nutrients and heavy metals in plant materials among others. They were also introduced to the various rapid and economical equipment in the laboratory.

### 3.1.1 Questions / Comments

Q1. How safe is it to use the machine with the direct exposure of the x-ray?

A. The rays are cancerous but the machine is designed in such a way that it cannot operate when the machine is not well covered and thus the operator is well protected.

## 3.2 Germplasm Laboratory

Here, the main activities are to ensure the supply of superior tree germplasm for research, to conserve material for the benefit of present and future generations, and to identify and make superior planting material available to smallholders to support their livelihoods and the sustainable use of tree diversity. Their focus is on indigenous trees.

### 3.2.1 Questions/ Comments

Q1. Do you assess the economic value of baobab?

A. Currently, that exercise is not conducted in the laboratory but the different value chain actors collaborating with the organization do that.

Q2. Are there any publications on the findings in the laboratory?

A. Yes. The results of all the laboratory work are documented in the ICRAF website.

Q3. How do you collect, process, clean and test the germination rate of the seeds?

A. There's a team of experts in the laboratory who go to the field and collect the required seeds. Orthodox seeds are dried at 150 °C and relative humidity of 6 -10% before storage. Seeds with an initial viability of between 40% and 90%, depending on the tree species, are accepted for storage. Periodic viability assessments are done every five to ten years during storage depending on the species.

Q4. What's the longest time the seeds can stay in the gene bank?

A. The seeds can stay over 50 years in the gene bank and still be good for planting.

## 3.3 Dendrochronology Lab

In this laboratory, participants were enlightened on how to use plant rings to unravel and better understand the past climates and tree growth. In principal, each ring represents a year in a tree's

life. One of the primary goals of this laboratory is to assess climate growth relationships and evaluate the effect of a changing climate on tree growth, agroforestry systems and forest development.

### 3.4 African Orphan Crops Consortium (OACC) Laboratory

From the AOCC Laboratory, the participants got an overview of the laboratory processes, the AOCC project, its objectives and current outputs, the 101 species AOCC is working on and as to why they are referred to as orphaned. They also got an overview of the opportunities for collaboration.

### 3.5 Living Soils Laboratory

In the living soils laboratory, participants were introduced to different ways of how to restore and sustain soil ecological functions by soil biota in agroecosystems as well as tools and approaches for scaling these up. The main elements are: Living Component of the soil, Interaction between trees and soil biota, Soil structure maintenance, Use of biochar in agriculture and InPaC-S methodology for scaling up.

#### 3.5.1 Questions/Comments

Q1. Between earthworms and termites, which one is better in aerating the soil?

A. The are different types of earth worms; litter, top soil and subsoil dwellers. The earth worms are far much better than termites in the sense that they improve the water infiltration rate and soil aeration. Earthworms also excrete a material that has high concentration of beneficial microbes that help decompose crop residue while others eat harmful nematodes thus decreasing the concentartion of harmful organisms in the soil.

# 4. Field visits

## Field Visit Routes

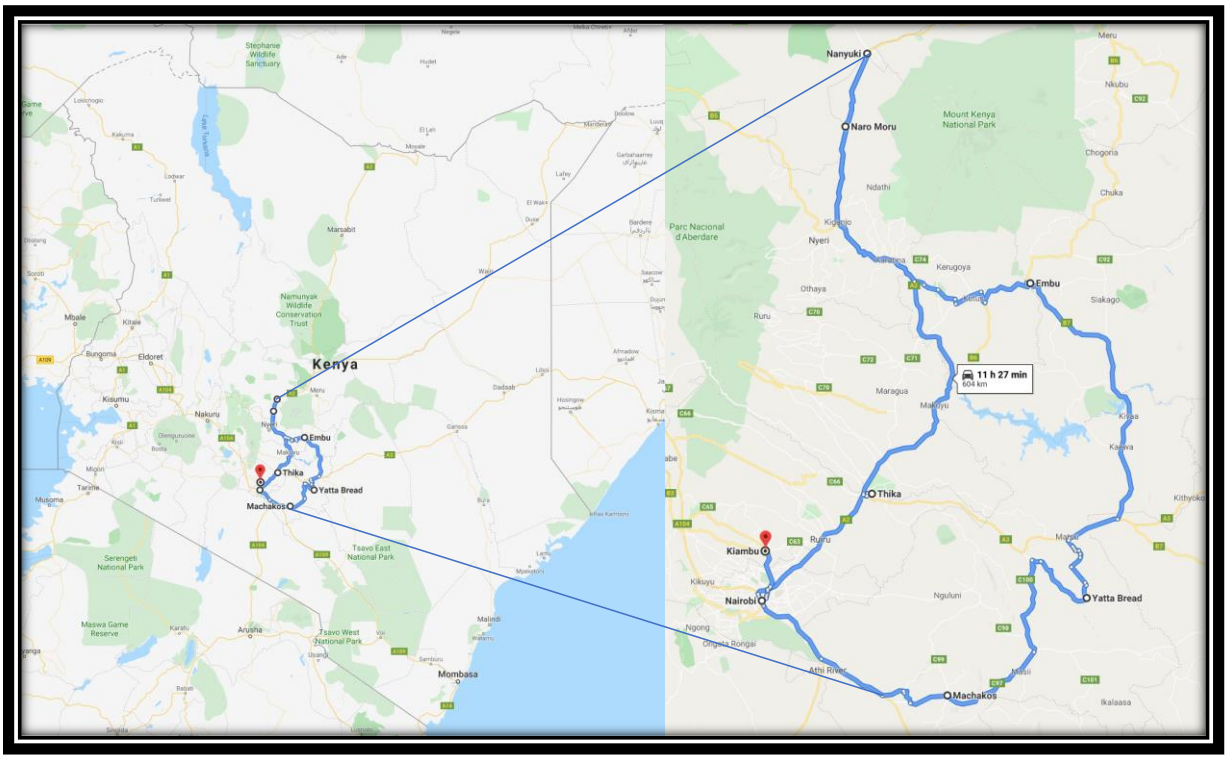


*Figure 3: Map of Routes used during Field Trips*

| Place Visited | From | To | Distance (Km) |
|---|---|---|---|
| **Kenya Forest Service - KFS** | Nairobi | KFS – Karura Forest | 13.3 |
| **Kenya Institute of Organic Farming** | Nairobi | Juja off Thika Highway | 38.2 |
| **Return to City Lodge Hotel** | Juja | Nairobi | 36.2 |
| **Visit to Agroforestry Farmers** | Nairobi | Kiambu | 10.8 |
| **Return to City Lodge Hotel** | Kiambu | Nairobi | 10.8 |
| **Organic farming, Permaculture, RWH** | Nairobi | Yatta – Bishop Masika | 164 |
| **Return to Kyaka Hotel** | Yatta | Machakos | 61 |

| Place Visited | From | To | Distance (Km) |
|---|---|---|---|
| **DRYDEV farmers – FMNR, RWH** | Machakos | Matuu | 80.3 |
| **Return to Kyaka Hotel** | Matuu | Machakos | 80.3 |
| **Field visit to Smart water Agriculture project** | Machakos | Nanyuki via Embu and Naro Moru | 296 |
| **Return to City Lodge Hotel for closing session** | Nanyuki | Nairobi | 195 |
| **Total distance** | | | 985.90 |

## 4.1 Nairobi and Kiambu Counties

The participants visited three sites in Nairobi. These included a farmer dealing with agroforestry in Limuru, the Kenya Forestry Services (KFS) and Kenya Institute of Organic Farming (KIOF). At KFS, the participants were introduced to different methods of tree propagation and selection for vast areas depending on the climatic conditions. With the neighboring Kenya Forestry Research Institute (KEFRI), the participants were also introduced to efficient charcoal producing kilns and commonly available residues for briquette making. Thereafter, at KIOF, they were ushered and guided through demonstration plots that majorly deal with production of horticultural crops using organic farming techniques. The participants were also trained on how to make organic pesticides using a mixture of water, marigold and ash.

## 4.2 Machakos County

At Yatta plateau, the participants were exposed to Operation-Mwolyo-Out, a locally initiated model that encompasses different components for eradication of poverty and sustainable agriculture. The main elements in the model are water harvesting structures like farm ponds, organic farming, permaculture and plantation of different fruit trees for sustainable development. The participants were encouraged about having a mindset change and in turn move to a self-reliant, self-sufficient, self-sustaining and resilient people-based development

rather than focusing on donors. The participants were also exposed to design and layout of soil moisture conservation techniques as well as water dowsing techniques using two copper rods or a Y-tree branch. The participants also learned about better methods of Farmer Managed Natural Regeneration (FMNR).

### 4.3 Laikipia County

In Laikipia county, participants visited the bright spots of Naro Moru where model farmers supported by ICRAF, MetaMeta and partners have significantly enhanced their income and livelihood. These model farmers have introduced simple land preparation and farming practices such as raising the field bunds to protect standing crops from unexpected torrential rainfall and flooding as well as reusing weeds as mulch to conserve and improve soil moisture. They also produce compost in-situ: this significantly reduces dependence on artificial fertilizers, cut production costs, promote organic farming and enhanced yields. The farmers have also highly focused on water harvesting (from Naro Moru river, direct rain fall and floods running off major earthen roads) techniques with several gaining some income through training of other farmers as well as fixing of the dam liners. Several demonstrations were also done on how to use the drones for monitoring crop performance.

Another site in the locality also demonstrated the use of biochar producing gasifier cookstoves as well as the use of the produced biochar for soil improvement. Biochar attracts and holds soil nutrients, it reduces fertilizer requirements - something common organic matter cannot do. As a result, fertilization costs are minimized and fertilizer (organic or chemical) is retained in the soil for far longer

## 5. Wrap up and closing ceremony

The wrap up session was conducted at the City Lodge Hotel within the Two Rivers Mall in Nairobi. This session was graced by Ambassador and Deputy Ambassador of Sudan Embassy in Nairobi as well as ICRAF Kenya Country Representative, Dr. Jonathan Muriuki. Eng. Malesu thanked all the participants for the successful training and lively discussions that transpired during the entire 10-day period. He looked forward to more collaborations with the Government of Sudan so as to

make Africa a great nation. The Sudan team leader thanked all the players who made the training a success and emphasized on how they will use the gained knowledge when they get back to Sudan. All the trainees were awarded with Certificates of participation.

# 6. Annex

## 6.1 Training Programme

The training programme is available here.

## 6.2 Photo gallery for the training

A few selected photos under the different sessions can be downloaded here.

All other photos taken during the training are here