Proceedings of a workshop held in Nairobi, Kenya 4 - 6 December 2017

Editors

W. Kasolo, A. B. Temu, S. Mkomwa

February 2018
# Table of Contents

Table of Contents .................................................................................................................. 2  
Preface ..................................................................................................................................... 3  
EXECUTIVE SUMMARY ........................................................................................................ 4  
1. INTRODUCTION .................................................................................................................. 5  
2. OPENING SESSION: SETTING THE SCENE .................................................................... 7  
3. STATE OF SCIENCE IN CONSERVATION AGRICULTURE ............................................. 11  
   3.1 Highlights from the presentations ................................................................................. 11  
   3.2 Discussion .................................................................................................................... 12  
4. BUILDING THE SCIENTIFIC BASE OF CA ..................................................................... 15  
   4.1 Background .................................................................................................................. 15  
   4.2 Principles of CA .......................................................................................................... 15  
   4.3 The Science of CA ...................................................................................................... 16  
   4.4 Agreement on Training levels ...................................................................................... 17  
5. CURRICULUM DEVELOPMENT PROCESS .................................................................... 19  
   5.1 DACUM Primer and justification to develop a curriculum ........................................... 19  
   5.2 Curriculum Objectives and Teaching Modules ........................................................... 23  
   5.3 Conclusion on CA Curriculum ...................................................................................... 26  
6. DEVELOPMENT OF TEACHING AND LEARNING RESOURCES .............................. 27  
   6.1 The need for a teaching manual .................................................................................. 27  
   6.2 Chapters of the Manual ............................................................................................... 28  
   6.3 The way forward ......................................................................................................... 30  
7. WORKSHOP CLOSING SESSION .................................................................................... 31  
Annex 1: List of Workshop Participants .............................................................................. 33  
Annex 2: Workshop Programme ......................................................................................... 35  
Annex 3: Summary on CA Science and practice in Africa by Method Kilasara ................. 37  
Annex 4: Summary on CA Science and practice in Africa by James Kung’u ..................... 39
Preface

Conservation Agriculture (CA) is a venerable, old age practice by farmers world-wide that rests on three pillars, namely minimum mechanical soil disturbance, continuous soil cover and crop rotation (diversification). There are many global efforts and activities to research, assemble and share knowledge on CA. There are also many successful stories on CA and current indications are that it ranks high as one of the ways of adapting agriculture to climate change. It is considered as an essential component of the recently coined Climate Smart Agriculture (CSA).

Within Africa the leading institution in developing, synthesizing and sharing knowledge on CA is The African Conservation Tillage Network (ACT) www.act-africa.org. It is a not-for-profit organization that was conceptualized in Harare Zimbabwe in 1998 and with headquarters in Nairobi. It promotes CA through various actions including gathering and sharing of knowledge. This has earned ACT the reputation as a major platform for stimulating and facilitating adoption, lessons gathering and networking stakeholders dedicated to improving agricultural productivity and sustainability of Africa’s farming systems. This way, ACT is adding value to local, national and international efforts in CA. At the first Africa Congress on Conservation Agriculture held in 2014 in Lusaka, ACT established the International Conservation Agriculture Advisory Panel (ICAAP - Africa) icaap.act-africa.org with the purpose of helping ACT to access, interpret and understand policy, scientific, economic and technical issues that may have a bearing on the Network’s priorities, strategies and activities, and to make judgements about their relevance, potential and application.

The African Network for Agriculture, Agroforestry and Natural Resources Education (ANAFE), is a pan African Network of 146 colleges and universities teaching tertiary agriculture and natural resources education. Established in 1993, ANAFE provides leadership in enabling these teaching institutions to deliver quality and contextually relevant tertiary agricultural and natural resources education in Africa. Over the years, ANAFE has grown into a powerful education network and a game changer in agriculture, agroforestry and natural resource education. ANAFE has deep experience in the areas of curriculum development and reviews, capacitation of educators and development of learning materials relevant to Africa by African educators.

At a meeting of minds early in 2017, ACT and ANAFE leaderships agreed to develop a memorandum of understanding which materialized in May 2017. They also developed the idea of a partnership to advance CA into an area of teaching and learning primarily at colleges and universities. This partnership materialized in the form of a workshop of educators, researchers and development experts in agriculture to pull together CA knowledge and develop a curriculum and learning resources. This proceedings from the workshop heralds the beginning of a career development in Conservation Agriculture, and a long-term partnership between ACT and ANAFE.

Eng. Saidi Mkomwa
ACT Executive Secretary

Dr. Wilson Kasolo
ANAFE Executive Secretary
EXECUTIVE SUMMARY

This workshop was jointly convened in Nairobi on 4th to 6th December 2017 by the African Conservation Tillage Network (ACT) and the African Network for Agriculture, Agroforestry and Natural Resources Education (ANAFE). The 29 participants from 11 countries were specially selected to ensure the presence of top experts in Conservation Agriculture (CA), top educators in agriculture and natural resource management sciences, and in curriculum development. The focus of the workshop was on Conservation Agriculture in Africa. The main objectives were;

a) To familiarize participants on the state of science, innovations and adoption rates for Conservation Agriculture;

b) To analyse the need for Conservation Agriculture Education and the challenges involved;

c) To agree on and initiate a process towards the development of an effective Conservation Agriculture curriculum;

d) To agree on and initiate a process to develop a teaching and learning manual that would deliver the curriculum under c) above; and

e) To develop a way forward in achieving these objectives.

Participants acknowledged that CA is a practice whose adoption rate is growing at an estimated 10 million ha annually worldwide. The three principles guiding CA are minimum soil disturbance (interpreted as minimum or no tillage), land cover all year round (through mulching and cover crops) and crop rotation. Therefore, CA is ecosystem-based agriculture that is both productive and climate smart. Despite these good attributes, CA is hardly taught in Africa.

Workshop participants agreed on the need to provide CA education at different levels, starting with educators in Agriculture and Natural Resource sciences, relevant policy makers, farmers, extensionists and entrepreneurs. To achieve this, participants initiated a process for the development of a model curriculum on Conservation Agriculture that would be adapted to the different needs at different scales. The model curriculum will be available by March 2018.

Further, participants developed the outline of a teaching manual and launched a competitive process for prospective authors to develop the contents. It was agreed that the manual would be based on existing knowledge and would be available in 2018.

Another key outcome of the workshop was a decision of the participants to form the Education Chapter of Conservation Agriculture and therefore actively support ACT and ANAFE in their efforts to advance knowledge and learning through research and practice.

This workshop was the first of its kind. The thirst to learn more about CA and the enthusiasm to take it into the classroom was great. The new curriculum and learning resources will be available for use in 2018.
1. INTRODUCTION

The idea of holding a workshop on Conservation Agriculture (CA) curriculum emerged from a meeting between the Executive Secretaries of The African Conservation Tillage Network (ACT) and The African Network for Agriculture, Agroforestry and Natural Resources Education (ANAFE). As implied in the names of these networks, ACT is leading Africa in the transformation of conventional agriculture to more environmentally friendly and productive practices dubbed Conservation Agriculture, while ANAFE provides leadership in improving the relevance and quality of learning in agriculture and natural resources. The meeting unveiled the complementarity of the two networks, opening an opportunity for collaboration. It was realized that while the practice of Conservation Agriculture is growing rapidly in Africa, the science and innovations behind the practice are still to be captured and included in learning in colleges and universities teaching agriculture. This gave birth to a collaborative arrangement between ACT and ANAFE. The two networks signed a memorandum of understanding and launched a process to develop a CA curriculum and teaching resources. This workshop was planned as the first major collaborative activity, financed by ACT and jointly implemented under ANAFE leadership.

Conservation Agriculture is a sustainable agriculture production system comprising a set of farming practices adapted to the requirements of crops and local conditions. The practice protects the soil from erosion and degradation, improves its fertility and biodiversity, and contributes to the preservation of the natural resources, water and air, while optimizing yields. It is based on three interlinked principles as defined by FAO (www.fao.org/ag/ca): i) Avoiding or minimizing mechanical soil disturbance (sowing seed or planting crops directly into untilled soil); ii) Enhancing and maintaining a permanent mulch cover with organic matter on the soil surface (use crop residues - including stubble and cover crops to protect the soil surface; and iii) Diversifying species (using diverse cropping systems and crop species in different associations, sequences and/or rotations). These ecological underpinnings enhance the provisioning of ecosystems services, besides other benefits.

The Vision of ACT is to be a premier network of excellence in promoting sustainable agriculture and ecosystem management for improved livelihoods and wealth creation in Africa, and its mission is to enhance agricultural productivity, sustainable land management and environmental conservation through promotion of Conservation Agriculture principles and practices in Africa.

ACT’s work is to inspire, facilitate and challenge for mutual sharing of information and knowledge on experiences or lessons on promotion of CA in Africa. These efforts enable farmers, entrepreneurs, policy makers, researchers, learners and academicians and other stakeholders to access and share information and knowledge on CA, thereby contributing to better and more appropriate policies and programmes in the efforts to scale-up CA in Africa. The ACT thematic areas of focus are:

   i) Adoption and scaling up of conservation agriculture;
   ii) Sustainable land management and climate change resilience;
   iii) Capacity building and partnerships;
   iv) Communication, information and knowledge management;
   v) Entrepreneurship and business development; and
   vi) Network management and support functions.
ACT’s partnership strategy provides the basis of collaborating with agricultural-based organizations or institutions explicitly to promote Climate Smart Agriculture. ACT strongly believes in growth of partnerships for enhancing its effectiveness in scaling up adaptation and adoption of CA and natural resource management sectors.

ANAFE is a pan African Network of 146 tertiary agricultural and natural resources education institutions (universities and colleges). It is registered in Kenya, Tanzania and Niger as an international organization. ANAFE is a leader in enhancing regional capacity for delivery of quality and relevant tertiary agricultural and natural resources education and training to contribute more effectively to the improvement of livelihoods, economic growth and environmental sustainability in Africa. This is being achieved through ANAFE’s overall strategy of integrated Tertiary Agricultural Education (TAE) that articulates logical and relevant progression at all TAE educational levels from Certificate to doctoral level and linking them to local communities and farmers.

ANAFE’s mission is “to work with member institutions to improve the quality, relevance and effectiveness of tertiary education, research and extension in Agriculture, Forestry, Agroforestry, and other Natural Resources for sustainable socioeconomic transformation in Africa” and its vision is “a continent with quality and relevant tertiary agriculture and natural resources education, research and extension for profitable agriculture and sustainably managed natural resources”.

The major areas of focus for ANAFE are:

i. Promoting sustainable agriculture and management of natural resources through skilling of managers, entrepreneurs, farmers and other stakeholders

ii. Enhancing the appeal and relevancy of agriculture and natural resources management education and training, through curricula reviews, development of contextual learning materials and improving programmes delivery and environments.

iii. Retooling lecturers, researchers and development workers with relevant skills and knowledge for socioeconomic transformational initiatives in Africa through agriculture and sustainable natural resources management.

iv. Empowering youths and women to engage in sustainable agriculture and agribusiness

v. Improving Institutional governance and learning environment

The objective of this workshop was to launch a curriculum development process, and to initiate the development of learning resources to support the curriculum. The expected outputs of the workshop were:

i. A synthesis of the state of knowledge, science and practices of CA

ii. Span of possible job positions/employment for graduates with CA competence

iii. Modules and Topics to be included in CA curriculum

iv. Agreement on the content of CA learning resources and how to develop them

v. The way forward for CA development
The workshop started with introductions and characterization of all participants. The 29 participants included 22 men and 6 women representing Kenya (11) Tanzania (5) Uganda (1) Nigeria (2) Zambia (2) Malawi (1) South Africa (1) Zimbabwe (2) Ethiopia (1), and United Kingdom (1) Swaziland (1). Among them were 10 agriculturists, 4 foresters, 4 agroforesters, 1 animal scientist, 4 soil scientists, 2 water experts, 2 ecologists, 1 engineer and 3 environment scientists. Of these, 14 were educators while 13 were researchers and 2 were development workers. Those with conservation agriculture experience were 13 while 7 had limited exposure and the rest (10) had only heard about it. Universities represented included: Rongo University, University of Nairobi, Kenyatta University and Egerton University (all in Kenya). Others were Makelle University (Ethiopia), Makerere University (Uganda), Copperbelt University and Zambia Virtual University (Zambia), Sokoine University of Agriculture (Tanzania), University of Swaziland (Swaziland), University of Limpopo (South Africa), Nsuka University and Ekiti State University (Nigeria), University of Limpopo (South Africa). Other Institutions were Uyole Agricultural Research Institute (Tanzania) and Gwebi College of Agriculture (Zimbabwe).

In his welcome remarks, **Engineer Saidi Mkomwa** (Executive Secretary of ACT) set the stage by highlighting the work of ACT and the principles of Conservation Agriculture (CA). The pillars of CA are three: Minimum soil disturbance, continuous soil cover and crop rotation and diversification. He highlighted the benefits of CA as higher productivity, up to 60% labour saving and enabling mitigation and adaptation to climate change. He provided statistics showing that CA adoption rates are rising and pointed out that in more than 20 countries in Africa CA is the core component of Climate Smart Agriculture (CSA) on 2.68 million hectares, and 95% of the farmers are smallholders with land area not exceeding 1 ha.

He indicated that Africa has invented its own aspects of CA as exemplified by Zai Pits/basins for water catchment and ripping or sub-soiling to overcome soil compactions. However, due to limited access to information and technical support, among other constraints, the full benefits of CA are yet to be achieved. Eng. Mkomwa pointed out the lack of well-equipped extensionists to support farmers as a key constraint in the adoption of CA. He however expressed optimism about the ACT – ANAFE partnership, indicating that it was a very important step towards the teaching of CA by education institutions which will lead to availability of expertise at different levels. “I am thrilled to see top African brains here ready to engage in this workshop”
Dr. Wilson Kasolo presented ANAFE’s work in the areas of curriculum development, writing of learning resources and support to graduate students to undertake research in various aspects of agriculture, forestry, agroforestry and natural resources management. He highlighted the large membership of ANAFE (146 colleges and universities in 36 countries in Africa) and the administrative structure that provides for 4 regional chapters of ANAFE known as RAFTs (Regional Agricultural Forums for Training and national chapters (NAFTS) which enable ANAFE to implement its programmes at different scales. He further highlighted the strengths of ANAFE especially in:

- Enhancing the appeal and relevancy of agriculture and Natural Resources Education and training through curricula reviews/development and reaching materials development;
- Retooling lecturers with pedagogy, andragogy, research and knowledge on emerging issues;
- Promoting good practices in agriculture and sustainable management of other natural resources;
- Empowering the youth and women to engage in sustainable agriculture and sustainable use of other natural resources;
- Enhancing institutional capacities for delivery of quality training programmes; and
- Improving Institutional governance and learning environments

Dr. Kasolo cherished the emerging partnership with ACT as a major milestone in building a firm base for transformation of agriculture on the African continent. He hoped that the joint efforts will expand to enable this to happen. In conclusion Dr. Kasolo stated ‘We have done it for the last 24 years and we can do it even better now’. ANAFE is determined to build credible capacity for Conservation Agriculture at all scales.

Prof James Kung’u (ANAFE Board member and Chair of the Eastern and Central African chapter of ANAFE (ECA-RAFT) warmly welcomed the participants to the meeting on behalf of the Board Chair. He focused his comments on the need for African academia to take the role of first hand authors and not just ‘good collaborators’ in publications. He said through ANAFE “We are able to identify the problems and tailor make curricula that solve our African problems”. For this, he was proud to be a member of ANAFE! He congratulated the leaders of ACT and ANAFE for the move to collaborate on Conservation Agriculture and assured them that ANAFE is well connected with a wide network across the continent. He encouraged the workshop participants to ensure that an effective curriculum is generated by the workshop.
Dr. David Kamau, Director of Environment Systems at Kenya Agricultural and Livestock Research Organization (KALRO) formally opened the workshop on behalf of Dr. Joseph Mureithi who is an ACT Board Member and KALRO’s Deputy Director General. In his statement he highlighted the emerging importance of CA. He indicated the commitment of Kenya Government to CA and other practices for alleviating poverty.

He pointed out that KARLO recognizes CA as one of the options that national governments and other stakeholders use to address the challenges in Kenya and Africa – food security, poverty and natural resources degradation. He also indicated that the Government of Kenya is aware of the importance of strengthening the resilience of livelihoods to enable communities to cope with climate natural and manmade shocks such as droughts, floods and macro-economic crises.

He further pointed out that a number of national, regional and international organizations have embraced CA as an option for addressing the above the challenges, giving the following as examples of CA and CSA initiatives in Kenya:

- Kenya Climate Smart Agriculture Strategy 2017 -2016
- Kenya Government has incorporated CA into National Agricultural Investment Plans (INIPs)
- Kenya Climate Smart Agriculture Programme 2015-2030
- Kenya Climate Agriculture Project (P154784), with World Bank, USD 250M
- Kenya Cereal Enhancement Programme – Climate Resilient Agricultural Livelihoods Window (KCEP – CRAL), with IFAD and EU, which targets to reach 10,000 farmers

Dr. Kamau praised the focus on increasing knowledge of educators for quick delivery. Noting that the few farmers practicing CA are benefiting a lot from the practice, he wondered why farmers in Africa are slow in adopting CA despite its merits, and identified the following barriers:

- Promotion and support of tillage-based farming by national governments
- Poor quality and under standardized CA
- Poor access to CA services (for direct seeding, weed management etc.) to production inputs and produce markets
- Limited access to information and hands-on skills on CA
- Poor access to financial services
- Socio-cultural, peer pressure
- Uncoordinated and unregulated extension services
- Weak and unsystematic research in CA
- Weak participation of tertiary agricultural education institutions in the process

He called for the need to widen research in CA, introduce it into learning institutions, and using the Malabo Declaration for CA and the Lusaka declaration for ACT to promote CA, build partnerships and human capacity in CA. He said that partnership building is emphasized in the ACT 2013-2022 strategic plan, which identifies capacity building as one of the six thematic areas. Strengthening institutional, individual and corporate private sector players and farming communities’ capacities in the uptake and use of CA is essential. ACT already works in
partnership with national agricultural research institutions and academia across Africa, commonly identified as future conservation agriculture centres of excellence (CA CoE).

He shared the case of Brazil where a systems approach was applied in the effort to green cerrado (Brazilian savannas) http://www.economist.com/node/16886442. EMBRAPA (Brazilian Agricultural Research Corporation) did four things to make the soils more useful. In a sequence, these were: (1) poured industrial quantities of lime (pulverized limestone or chalk) onto the soil to reduce levels of acidity (approx. 5 tons/ha/yr.), then bred varieties of rhizobium, a bacterium that fixes nitrogen in legumes and which works especially well in soil of the cerrados thereby reducing the need for fertilizers; (2) imported brachiaria grass from Kenya, cross bred it with braquiarinha variety enabling them to raise 20-25 tons/ha of animal feed that expanded the beef industry (reducing the period of raising slaughter bulls from 4 years to 20 months. Currently they are experimenting on genetically modifying brachiaria to produce a larger-leafed variety called braquiarao; (3) turned soybeans (a temperate crop) into a tropical crop through cross breeding; and (4) invested in and pioneered no-till agriculture. Currently they are introducing forest, agriculture and livestock integration systems. He concluded: ‘We too can borrow a leaf from the EMBRAPA for the promotion of CA’ in Africa.

Turning to capacity, he stated that Curriculum development is a great step forward. He thanked ACT, ANAFE and NORAD for the workshop which marks a great transformation for Africa. Wishing participants success in their deliberations, he declared the workshop formally opened.

The Facilitator, Prof. August Temu illustrated the workshop programme to emphasize main outputs of the various sessions as follows:

**Day 1**
Session 1: Recognizing participants, sharing experiences; familiarization with the work of ACT and ANAFE, agreeing on workshop objectives, workshop process and outputs
Session 2: Understanding the principles and practices of Conservation Agriculture, the state of research and innovation and adoption
Session 3: Organizing the science of CA, recognizing strengths and weaknesses, and identifying knowledge gaps

**Day 2**
Session 1: Agreeing on the training needs and level of training curriculum
Session 2: Identifying the job positions and tasks of graduates with CA expertise
Session 3: identifying the subjects that need to be learned

**Day 3**
Main focus is on development of learning resources
- Setting thematic areas (chapters) for development of learning resources
- Agreeing on modus operandi for development of learning resources and the division of labour. Setting terms of reference for authors and deadlines for submission of manuscripts.
- Decision on the way forward
3. STATE OF SCIENCE IN CONSERVATION AGRICULTURE

3.1 Highlights from the presentations

Two presentations were made regarding assessment of the science of CA. The first presentation by Prof James Kung’u provided an overview on CA in Africa. The second presentation by Prof. Method Kilasara was focused on meta-analysis of existing CA related literature with focus on SSA.

The presentations highlighted the following aspects.

- Defining CA as is a system of integrated management of soil, water and biological resources for efficient productivity.
- The three main practice pillars of CA: minimum soil disturbance, cover crop, and diversification.
- History and spread of CA in world
- Benefits of CA to the farmers that included: reduced production costs, increased yields and consequently enhanced food security, quality water and adaptation to climate change effects, among others
- The drivers of CA included drought, erosion, cost of production, and climate change among others
- Challenges of practicing CA that included maintaining continuous cover especially during the dry season when livestock graze on the residues, management of pests.
- Challenges such as weak communication on CA innovations resulting in slow adoption of CA
- A mindset among farmers and some professionals that assumes that modern agriculture is superior, and the CA is old and only for smallholders.

Summaries of the assessment reports are presented as Annexes 3 and 4.

The third presentation was a global overview of CA by Prof. Amir Kassam. Amir Kassam who is Chair, International Conservation Agriculture Advisory Panel for Africa (ICAAP-Africa), Moderator, Global Conservation Agriculture Community of Practice (CA-CoP) and Visiting Professor, University of Reading, UK. He explained the drivers of adoption of CA as:

- Erosion: North America, Brazil and China
- Drought: China, Australia, Kazakhstan and Zambia
- Cost of production: global
- Land/ecosystem degradation: global
- Ecosystem services: global
- Climate change A&M: global
- Sustainable intensification: global
- Pro-poor: developing regions

The spread of CA is farmer-led but needs policy and institutional support, especially for smallholders.
He noted that the challenges with respect to soils are: Loss of organic matter, destruction of biological life processes, Loss of pores and structure which leads to soil compaction, erosion and degradation. The benefits of CA are that it is regenerative, self-repairing & self-protecting. It contributes to the maintenance of the ecological foundation of production systems, soil health and biology, healthy plant root system relationships, enhanced biodiversity, ecosystem and societal services, integration (including with pasture, livestock, trees), maximum efficiency and resilience (including profitability). The CA principles are universally applicable through locally formulated practices.

Prof Kassam shared the following diagram which served as a useful summary of how CA works and the areas of science, innovation and practice.

He concluded that:

- CA can sustainably mobilize greater crop and land potentials with increased efficiency and resilience.
- CA offers greater output and profit to smallholders and larger-scale farmers, with less resources, and minimum land degradation.
- CA is increasingly seen as a basis for sustainable production intensification and ecosystem services, as well as for climate-smart agriculture.
- Integration of CA into education is an imperative because the achievement of responsible sustainability of agriculture for the society and the planet depends on it.

3.2 Discussion

Participants noted that there are many publications and books on Conservation Agriculture. Many of them emphasize the application of innovations that enhance productivity and
conservation and they draw experiences from around the world. However, few of the publications emanate from scientifically designed research, so despite obvious increases in yields. For instance, quite often the yield data are compared with past (preceding season yields, that is before CA was applied, or with neighbouring farmers using conventional farming. Further, while many case studies report increased yields and incomes for farmers adopting CA innovations, few studies show scientifically designed experiments that compare conventional agriculture with CA to determine the significance of productivity differences. Further, the ecosystem conservation benefits are often stated but rarely quantified. These aspects of science require improvement.

The following areas were discussed and agreed:

i. **Crop type**: Do CA innovations depend on the type of crop being cultivated? The response was generally not, but we cannot avoid some cases where some crop combinations can attract pests

ii. **Diversified crop rotation**: How is the rotation managed to ensure effectiveness? The rotation is kind of mimicking nature and is also for pest management. System diversification through rotation, associations and sequences also ensures continuous land cover. Obviously different plant combinations will yield different results and it is hard to generalize.

iii. **The place of livestock**: Is livestock considered as peripheral in CA? No, livestock is incorporated in CA. An example was given (by Prof. Amir Kassam) to show how CA pays with time. When the CA project started, farmers were running away from the farm and looking for off-farm work. The land was unproductive. But, at the end of the project, through CA efforts, land regained its productivity and usability, farmers were coming back to their farms. However, livestock integration may be difficult in certain situations but overall, CA increases livestock carrying capacity.

iv. **Scientific credibility**: In an attempt to compare results of CA research findings for studies carried out in Africa, only 4 out of 450 publications analyzed were found to be scientifically robust and amenable to meta-analysis. This does not necessarily mean that the publications are any less useful. The correct interpretation is that the magnitudes of improvement over conventional agriculture in terms of say yield increases, biodiversity/ecosystem conservation or reductions in greenhouse gas emissions must be based on scientific metrics, with means and standard deviations that provide confidence limits. This ensures that confounding factors such as changes in weather patterns, human and livestock interventions, are eliminated or reduced to the minimum. Undoubtedly, more work is needed to strengthen the science content in CA. While CA is farmer led, researchers need to step in and apply scientific methods, especially in standardizing management protocols and applying effective experimental designs to facilitate comparison of results among the different CA options and also between CA and conventional agriculture.
v. **Optimizing CA, and the tradeoffs:** We can now control weeds in many different ways. Healthy soils promote fertility and water retention. Standards have not been set because of the very wide variety of practices used and the species involved. There are no clear tradeoffs, but it does take time to get CA established. For instance, it takes several years to build up the soil organic matter to a point where water retention is effective, and the revitalization of the soil is activated resulting in increased crop performance. This period is a cost some farmers cannot afford.

vi. **Below ground processes are not well articulated in CA.** Mycorrhiza is good for mobilizing phosphorus and has more roles in the ecosystem. It requires carbon to function it is a source of sugar that is a centre for soil aggregates – stable soil structure. It is like an underground ‘internet’ where plants and trees communicate with each other. When soil disturbance is stopped, living creatures in the soil come back.

The diagram (above) shared by Prof Kassam was adopted as a good framework from which to develop learning in Conservation Agriculture.
4. BUILDING THE SCIENTIFIC BASE OF CA

Participants were divided into three groups. Each group was tasked to study available literature and discuss the rationale and the scientific principles behind Conservation Agriculture. The findings were presented and debated at a plenary session. Later it was agreed to appoint a small team of eight persons to tease out the science of CA. The team produced the following results.

4.1 Background

As the world population grows, so does that of Africa, which is expected to reach over 2 billion by 2050. Africa’s ability to feed her future population is dependent on among other things, how current food production technologies can be transformed to increase productivity and sustainability. With over 80% of agricultural production in the hands of smallholders, there is a need for the farming innovations to be easily adopted, affordable, achievable within a short period of time and with long lasting results.

Conservation Agriculture is a practically proven ecosystem-based farming system that is underpinned by three basic. This system of production and conservation has elements that meet the adoption criteria indicated above. Although this innovative farming approach is used by farmers worldwide, its adoption in Africa (though growing) is far from adequate to address the food security and the environment gaps. The main challenge is a huge shortfall in expertise. Few communities have the necessary knowledge and skills to enable rapid adoption of this labour-saving innovation. Currently it is not taught at academic institutions and therefore there is very limited extension capacity in this area. Much extension work is undertaken by agricultural projects often funded by NGOs.

In order to build up expertise in this area it is necessary to explore the scientific base of the practices, develop a fitting curriculum, relevant learning resources and capacity to deliver CA education. Therefore, defining the practice in a scientific lexicon is essential.

4.2 Principles of CA

Currently, Conservation Agriculture is based on the three main principles underpinning the practice, namely minimum soil disturbance, permanent soil cover and crop diversification. These are briefly illustrated as:

   4.1.1 Avoiding or minimizing soil disturbance by mechanical tillage.

Whenever possible, farmers are advised to seed or plant directly into untilled soil, in order to maintain Soil Organic Matter (SOM), soil structure, and overall soil health

   4.1.2 Enhancing and maintaining permanent mulch cover on the soil surface.

Use of crops, cover crops, or crop residues to protect the soil surface conserves water and nutrients, promotes soil biological activity, and contributes to integrated weed and pest management.
4.1.3 Diversification of species.

Utilizing both annuals and perennials in associations, sequences, and rotations that can include trees, shrubs, pastures, and crops (some or all of which may be Nitrogen-fixing legumes). All will contribute to enhanced crop nutrition and improved system resilience.

These CA principles are applied based on locally formulated and adapted practices. To achieve the sustainable intensification, these CA practices need to be complemented by additional best management practices, especially:

- Use of well-adapted, high-yielding varieties, and good-quality seeds
- Enhanced crop nutrition, based on healthy soils
- Integrated management of pests (insects, diseases, and weeds)
- Efficient water management
- Careful management of machines and field traffic to avoid soil compaction

The focus of CA is soil and landscape health. The approach is designed to achieve optimal economic, environmental and social benefits by enhancing productivity, ecosystem services, efficiency and climate smart compliance.

4.3 The Science of CA

Basing on the above description, FAO (2007) defined CA as “A concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment”. Given this understanding, participants discussed the best way to understand the defining principles in a scientific context. The main scientific domains covered by conservation Agriculture are Biophysical, Socio-economic, Ecological and Engineering.

In Table 1, each of the key practices is presented to tease out the areas of science involved.

<table>
<thead>
<tr>
<th>Principles of CA</th>
<th>Practices</th>
<th>Areas of Science</th>
</tr>
</thead>
</table>
| No/Minimal soil disturbance | • Direct seeding  
• No-till seeding  
• No till weeding  
• Controlled traffic  
• Integrated weed management | Tools and Mechanization, Soil physics, Water management, Herbicides, Allelopathy, Weed sciences, Cropping systems, Soil compaction, Soil microbiology and Restoration science |
| Soil cover | • Crop residues/mulching  
• Cover crops  
• Crop combination  
• Fallowing | Soil biology, Soil fertility, Soil and water management, Soil chemistry, Pest management (Biological control), Soil temperature management, Carbon sequestration, Carbon management, Soil organic matter Biodiversity, Soil erosion control and Restoration science |
| Crop rotation and diversified | • Intercropping  
• Crop rotation  
• Agroforestry  
• Mixed cropping | Nutrients cycling, germplasm management, Pest management, Crop/tree/livestock interaction, Soil fertility, |
In addition to the scientific areas listed under the three principles, there are cross-cutting areas and principles. These are presented in table 2.

Table 2. Cross-cutting areas and preconditions

<table>
<thead>
<tr>
<th>Cross cutting issues</th>
<th>Pre-Conditions for CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agro climatology, Social cultural aspects, Yields enhancement, Policy and institutional aspects, Ecosystem/Agric-ecology, Information management, Capacity building, Extension, Collaboration and networking</td>
<td>Landscape characterization, Socio-economic analysis, Policy and institutions. Soil characterization, diagnostic CA suitability assessment, Tenure aspects, Human capacity, Indigenous/local knowledge, Project design and management</td>
</tr>
</tbody>
</table>

This rich discussion led to a need to find a science-based (complementary to practice-based) definition of conservation agriculture. The purpose is to form a base upon which the sciences covered by CA can be taught. Participants agreed that for educational purposes the following definition would hold:

“Conservation agriculture is an ecosystem-based approach to land/farm management”.

4.4 Agreement on Training levels

Workshop participants discussed the different levels of training on the basis of needs. It was posited that currently CA is not formally taught at any level, all the way from certificate to degree level. The challenge is that there has not been a curriculum or learning resources properly developed for use in teaching. Thus, most educators/trainers are also unfamiliar with this area. Thus, the training needs are among educators, agricultural graduates responsible for extension services, entrepreneurs as well as farmers. Considering the above, participants agreed that a model curriculum should be designed to be adaptable so that users can customize it to their specific needs. The subsequent sections of this proceedings details the process followed and the results regarding the development of a model curriculum on Conservation agriculture.

It was further agreed that given the importance of making business in CA the developed curriculum must address aspects of financial literacy and entrepreneurship.
Figure 6 Exciting Group discussion session

Figure 7. The unstoppable participants go flip charting

Figure 8. Charting out the future of CA
5. CURRICULUM DEVELOPMENT PROCESS

5.1 DACUM Primer and justification to develop a curriculum

Dr Wilson Kasolo guided participants through the principles applied by ANAFE in the curriculum development process. He illustrated the DACUM (Developing A Curriculum) process. DACUM is a framework for planned and logically organised teaching and learning, geared at developing specific competencies and skills for carrying out identified tasks. Developed in British Columbia in 1968 for hospitals and tourism industry training, the process is highly participatory whereby the stakeholders are able to define job requirements accurately. The process begins with analysis of stakeholders and their interests, followed by planning, training needs assessments, development of a curriculum, implementation & evaluation.

Dr Kasolo pointed out the attributes of a good curriculum as one that is based on:

- A review of existing information, based on training needs assessment and stakeholder consultations, and
- A clearly defined, training paradigm, with clear objectives and clear occupational profiles.

Participants noted that these two criteria have not been strictly followed, but there is enough evidence to show that although CA is growing in popularity (as manifested in rising adoption) a concomitant training capacity in the area is badly needed. Thus, the workshop is a robust beginning for addressing this need. More investigations and research will be undertaken by education institutions in this respect.

A point was raised regarding justification for developing a curriculum on any subject. It was noted that when an area of practice begins to attract many practitioners as CA is currently doing, the need for establishing the scientific underpinnings is crucial. Two examples were shared. The first regarded the development of agroforestry in the eighties under the International Council for Research in Agroforestry and later in the nineties as the International Centre for Research in Agroforestry (ICRAF). In the eighties the practices were documented, benefits listed but despite the many experiments, the science was yet to be clarified. Agroforestry was regarded as an interesting practice, beneficial and well worth disseminating. The development of agroforestry curricula in early nineties especially in Africa and Asia enhanced scientific studies through special project studies, and MSc and PhD dissertations. In the nineties and thereafter, more scientific research underpinning the structure and benefits of agroforestry were revealed and today it is a cutting-edge science and practice promoted for higher productivity, greater economic and ecological benefits and effective in mitigating and adapting to climate change.

The second example was on the establishment of the global hype of adopting Jatropha as an oil plant, which gripped the world for almost ten years around 2000 and 2010. A promotion of Jatropha curcus as a plant that produced oilseeds highly potent to meet future global oil needs replacing the fossil fuels went viral globally. This practice was promoted without the usual scientific rigour to understand the scientific principles involved. The results were huge investment losses as the plants did not deliver due to very poor yields while farmers already planted large areas and oilseed factories were already assembled but had nothing to process.
Allowing science to take a backstage was very costly. Using these two relevant examples, participants unanimously agreed that the next step for CA is education and research.

After thorough discussions and clarifications on the technical aspects of developing a curriculum through the DACUM process participants embarked on the elements of the process that could be achieved at the workshop. These included:

- A decision on the levels of curriculum
- Identification of possible job areas
- A breakdown of the job areas to competences (i.e. knowledge, skills and attitude)
- Determine the learning areas that will build up the competences.

### 5.1.1 Level of curriculum

Observations were made that currently the key persons involved in CA are farmers and extension personnel. The farmers are being guided by persons who have direct contacts with CA practitioners and CA activities at various projects around the world. These persons have been ‘trained’ by exposure. There are also some brochures and a training manual jointly developed by ACT, CTA and IIRR. These are the main driving forces behind the rising adoption of CA. Considering the situation, workshop participants agreed that the most immediate need is to train educators and trainers, so they can in turn train extension personnel. Further, educators will eventually do and produce researchers and the system will start stabilizing, become dynamic and expand in all directions. This further strengthened the earlier decision to develop a ‘model’ curriculum that can be adapted to different needs and levels. The subsequent priority areas will be short courses for educators, so they can incorporate the CA ideas into current programmes in agriculture (back-door approach to curriculum adoption) and later into fully fledged CA topics or courses as needs arise.

Simultaneously, the research in CA will be growing alongside special projects and graduate students, as earlier indicated,

### 5.1.2 Possible job areas and learning profiles

Workshop participants worked in groups to identify the jobs areas for graduates with competency in CA. In Tables 3, 4, 5 and 6 the identified job areas, tasks, and competencies are presented. The key subject areas are also listed. Please note that the subject lists only indicate the areas identified at the workshop and do not in any way represent a full curriculum.

The principle applied is that any job area can be divided up into tasks. And each task requires certain competencies. A competence is defined as possessing the right knowledge, acquiring the skills (to apply the knowledge to practice) and having the right attitude (willingness to use the knowledge and skill to solve problems. In short:

\[
\text{Competence} = \text{Knowledge} + \text{Skill} + \text{Attitude}
\]
### Table 3. Learning profile for Agricultural Extension Officer

<table>
<thead>
<tr>
<th>Main Tasks</th>
<th>Competences needed</th>
<th>Learning areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community mobilization, Technology transfer, training on CA, collecting and managing statistics</td>
<td>CA technologies</td>
<td>Agricultural production, Soil sciences, soil and water management, farming systems, cropping systems, livestock systems, Pest management, Conservation and biodiversity.</td>
</tr>
<tr>
<td></td>
<td>Extension planning and production management</td>
<td>Climate change and its mitigation and adaptation</td>
</tr>
<tr>
<td></td>
<td>Conservation of natural resources</td>
<td>CA technologies</td>
</tr>
<tr>
<td></td>
<td>Communication skills</td>
<td>Mechanisation, Agronomy and conservation Animal/crop integration</td>
</tr>
<tr>
<td></td>
<td>Training capacity</td>
<td>CA innovations, fitting in diverse conditions</td>
</tr>
<tr>
<td></td>
<td>Data management</td>
<td>Hands on practical training for farmers</td>
</tr>
<tr>
<td>Subjects: CA tools and mechanisation, germplasm, soil physics, water management, agrochemicals, allelopathy, cropping systems, introduction to soils, soil biology, soil fertility, soil and water management, soil chemistry, soil temperature, carbon management, soil organic matter, restoration science, integrated pest management, ecology biodiversity, soil erosion control, nutrient cycling, crop tree/livestock interaction, human nutrition and health, marketing, value chain development, enterprise diversification, agro-climatology, nutrient management, Social cultural aspects, policy and institution frame works, extension methods, collaboration and networking, capacity building, information management, ecosystem/agro-ecology, cost benefit analysis.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 4 Learning profile for Farm/Natural Resource Manager

<table>
<thead>
<tr>
<th>Main Tasks</th>
<th>Competences needed</th>
<th>Learning areas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Agronomy, conservation</td>
<td>Nature conservation techniques</td>
</tr>
<tr>
<td></td>
<td>Nature conservation and biodiversity</td>
<td>Biodiversity indices and management, restoration science and practice</td>
</tr>
<tr>
<td></td>
<td>Land tenure</td>
<td>Land ownership and governance</td>
</tr>
<tr>
<td></td>
<td>Strategic planning</td>
<td>Strategic and operational planning</td>
</tr>
<tr>
<td></td>
<td>Resource mobilization</td>
<td>Different resources and sources, systematic resource planning and accounting</td>
</tr>
<tr>
<td></td>
<td>Financing mechanisms</td>
<td>Labour streamlining, productivity management</td>
</tr>
<tr>
<td></td>
<td>Human resource management</td>
<td></td>
</tr>
</tbody>
</table>
Human nutrition & health, Value chain, Enterprise diversification, Crop/system modelling, Seed science/Germplasm. Climate change mitigation and adaptation.

Table 5. Learning profile for Educator/Researcher

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Competencies</th>
<th>Learning Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitating learning, Undertaking research, Publishing/communicating science, Innovating, advising policy makers, monitoring and evaluating projects and programmes</td>
<td>Teaching and learning skills</td>
<td>Agricultural and NRM sciences and technologies, Biometrics and data management, Teaching and learning principles and practices, Policy making strategies and processes, CA innovations, scientific writing and publishing,</td>
</tr>
<tr>
<td></td>
<td>Research skills</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Innovating skills</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Policy formulation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Science writing skills</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monitoring tools</td>
<td></td>
</tr>
</tbody>
</table>

Subjects: CA tools and mechanization, farming systems, crop/system modeling, agro-climatology, tree and crop germplasm. CA soils fertility (organic matter, physics, biology, chemistry, temperature), soil erosion control, nutrient cycling agrochemicals, water management, allelopathy, cropping systems restoration science, integrated pest management, carbon management, Above ground and below ground biodiversity, ecosystem/Agro-ecology, crop tree/livestock interaction, human nutrition and health, value chain development, enterprise diversification, Social cultural aspects, policy and institution framework, collaboration and networking, capacity building, information management, Social cultural aspects, policy and institution framework, Pedagogy and Andragogy, information management.

Table 6. Learning profile for Agronomist/Agro-mechanic

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Competencies</th>
<th>Learning Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil health &amp; fertility, Crop &amp; livestock production, procurements, Soil &amp; water mgmt., Equipment choice &amp; Customizing, CA equipment, Fabrication, Integrated pest management and Sustainable land use management.</td>
<td>Soil health analysis</td>
<td>Soil analysis and characterization, Erosion management, cropping systems, rotation, agroforestry, animal science and production, animal nutrition, water quality and irrigation systems, farm mechanization for Conservation agriculture, pest and disease management, ecosystem-based farming, biodiversity values and systems, landscape restoration, entrepreneurship and agribusiness development. Field studies.</td>
</tr>
<tr>
<td></td>
<td>Crop production and productivity, crop rotation and agroforestry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Enabling livestock productivity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Managing irrigation systems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Analysing technology efficiency</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Identification and characterization of pests</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Designing sustainable landscapes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improving innovations and business</td>
<td></td>
</tr>
</tbody>
</table>

Subjects: Soil fertility – temperature, physics, chemistry and biology, Soil erosion control, Compaction, Seed science and Germplasm management, Water, Herbicides, Allelopathy, Weed
5.2 Curriculum Objectives and Teaching Modules

The following curriculum objectives were agreed:

i. Mainstreaming CA into agricultural science and innovations

ii. Strengthening human resource competencies in CA

iii. Enhancing the adoption of good CA practices and innovations

iv. Enhancing the contribution of CA to food security and wealth creation

Nine teaching modules were developed as illustrated hereunder:

**Module 1. Introduction to Conservation Agriculture**

At the end of this module the learner will be able to:

- Describe the state of agriculture in a given area or country
- Link agriculture with the state of food security and nutrition
- Explain the impact of agricultural practices on environment
- Explain the history and principles of conservation agriculture

**Module Synopsis:** Situation Analysis, Conventional agriculture, Food security, Socio-economic and cultural aspects, Environmental sustainability, History and Principles of CA, Potential of CA in enhancing productivity and conservation.

**Module 2. Land Resource Characterization**

At the end of this module the learner will be able to:

- Describe the roles of biophysical elements in agricultural production
- Characterize an area with respect to agricultural productivity
- Recognize and quantify elements of land and ecosystem degradation
- Explain the role of CA in reducing negative impacts of farming
- Manage soils for sustainable productivity
- Design systems that ensure water capture and efficient use

**Module Synopsis:** Physical environment (Climate, Soils and soil health, Landscape, Water harvesting, quality and efficient use of water); Agro ecological zonation (Description, Potential and Limitations); State of Agriculture (Land degradation – soil erosion, compaction, loss of biodiversity, deforestation, salinity, loss of nutrients, Water scarcity,Declining ecosystem services and productivity) Role of CA in land amelioration and quality; CA suitability assessment; Tenure issues (land, trees); Indigenous knowledge; CA Project design.
Module 3: Agro-ecosystems and Biodiversity Management

At the end of this module the learner will be able to:
- Explain the benefits of below- and above-ground biodiversity
- Select and design diverse cropping systems that enhance biodiversity
- Determine and apply safe agrochemicals for pest management
- Apply suitable combination of inorganic and organic fertilizers

Module Synopsis: Agro-climatology; Importance of biodiversity; below and above ground biodiversity. Monoculture systems; Mixed cropping systems; Rotational systems; Relay cropping; Agroforestry (tree-crop- livestock interactions); Roles of inorganic fertilizers and agrochemicals on biodiversity

Module 4: CA Practices, Innovation and Technologies

At the end of this module the learner will be able to:
- Identify weaknesses and strengths of a farming system
- Develop suitable CA interventions
- Promote the application and scaling up of CA interventions by farmer
- Monitor and evaluate the effectiveness of CA interventions

Module Synopsis: Characterization of farming practices; Participatory Design of CA interventions (social, economic, cultural and biophysical conditions); Crop management (Land preparation: vegetation clearing for mulch, No or minimum till. No till weeding, controlled traffic, Planting: direct seeding, integrated pest management, Allelopathy); Adoption and up-scaling of CA innovations; Commercialization of CA technologies; Monitoring and Evaluation.

Module 5: Conservation Agriculture in Crop and Livestock Production

At the end of this module the learner will be able to:
- Identify, establish and manage suitable species for soil mulch and cover crops
- Identify, establish and manage suitable species for fodder
- Identify, establish and manage the integration of livestock into CA crop farming systems
- Apply suitable apply IPM to manage pests in farming systems

Module Synopsis: Systems modelling, Germplasm management; Animal feeds and fodder production, Biomass management for crop and animal production, Pest management (Weeds, insect pests, birds, rodents etc., and diseases) IPM (Push and pull, Chemical, Biological, cultural etc.); Resistant cultivars/species.

Module 6: Soil and Water Management in CA

At the end of this module the learner will be able to:
- Apply suitable soil erosion control measures
- Soil fertility management (Nutrients cycling)
- Measure and manage water cycles in cropping systems (Determine and describe water cycles in a cropping system)
- Apply effective water harvesting and storage (Apply appropriate water harvesting and storage technologies)
- Guide water conserving measures in irrigation (Practice suitable water irrigation practices in a farming system)

**Module Synopsis:** Restoration science - Soil physics, soil chemistry and soil biology under CA, Soil erosion control, Soil fertility management, Soil water management, Water harvesting and storage, Water use efficiency, Irrigation, Nutrient cycling, Mulching, carbon management, SOM, Crop rotation, Perennial soil cover.

**Module 7: CA and Climate change**

At the end of this module the learner will be able to:
- Describe the causes and consequences of global warming
- Explain the impact of conventional agriculture in global warming and how to reduce it
- Assess the impact of CC on agriculture
- Design and apply CS mitigation and adaptation measures

**Module Synopsis:** Climate variability and climate change, Causes of global warming, Contribution of agriculture to global warming, GHG emissions (cropping systems, fertilizer, livestock), Impact on agriculture, Adaptation measures, Mitigation measures, Clean Development.

**Module 8: Economics of CA and Entrepreneurship**

At the end of this module the learner will be able to:
- Analyze the profitability/benefits of CA
- Promote the development of CA tools and products-based enterprises
- Harness and use green energy options
- Develop markets for CA products

**Module Synopsis:** Cost-benefit analysis of CA, Enterprise development and diversification, Value chain (value addition), Marketing, CA service provision, Green energy, Ecosystem services valuation.

**Module 9: Cross Cutting Aspects**

At the end of this module the learner will be able to:
- Develop inclusive strategies in projects
- Support development of CA supportive policies
- Train farmers and extension personnel
- Undertake studies and publish results in appropriate media
Module Synopsis: Social and cultural aspects, Human nutrition and health, Youth and gender, Policy, legislation and institutions, Capacity development, Sustainable mechanization (compaction), Research needs for CA, Communication and information management, Collaboration and networking.

5.3 Conclusion on CA Curriculum

Using the data generated in section 4.3, and taking advantage of training materials currently available, workshop participants concluded that an innovative model curriculum on Conservation Agriculture can be developed. This task was assigned to the Secretariat of ANAFE. Workshop participants further agreed to assist in reviewing the curriculum and committed themselves to start using it as soon as it is read.
6 DEVELOPMENT OF TEACHING AND LEARNING RESOURCES

6.1 The need for a teaching manual

To be effective, a good curriculum requires supportive learning resources. Currently, there are many publications on Conservation Agriculture, but most of them are at the practical level, either reporting on projects/investigations or as instruction manuals to support practitioners. There is a need to develop a manual that will support the impending curriculum. Prof Amir Kassam indicated that he introduced ‘Rethinking agriculture and implementing a solution’, a three-month module that is given at Reading university (UK). At the same university, the course takes the following structure:

i. Introduction to CA (why CA, land resource management, returning to soil health, ecologically sustainability, opportunities and challenges, sustainability, poverty)
ii. What are CA farming system (role of CA practices, cover crops) in reference to CA practices
iii. Sustainable mechanization for CA, approaching from value chain perspective
iv. CA based agribusiness development and services
v. CA adoption and dissemination (diagnostic and design)
vi. Policy and institutional support (creating enabling conditions), service provision, private people partnership, research support, innovation and extension
vii. CA as climate smart agriculture (climate mitigation and adaptation)
viii. Socio-economic aspect of CA system (impact and benefit-efficiency)
ix. CA based Tree livestock system (Complex systems)
x. Ecosystem management and services in CA
xi. Irrigated CA base system

To kick off the discussion, draft contents (list of possible chapters) was presented and workshop participants were asked to discuss it in groups and provide feedback. The list of possible chapters was as below.

i. Principles and practices of CA
ii. Poverty, food security and nutrition
iii. Ecosystem mgmt. and biodiversity conservation
iv. Landscape characterization and CA design
v. Farming system and crop and livestock mgmt.
vi. Soil and water management for productivity
vii. Climate change mitigation and adaptation (include water management)
viii. Entrepreneurship
ix. Case studies

Participants were asked to work in groups to modify and expand this list. In the subsequent discussions, the following points were raised:

- Add an introductory chapter that brings out the challenges, picking on some areas in chapters 4, 5 and 6. (history, green revolution, poverty and food security)
- A chapter on ‘Scaling up CA’ may be needed
- Consider a chapter on ‘Characterization for CA design’
• Consider a section on ‘Challenges of ecosystem management’
• Instead of landscape management better to use ‘land use management’
• Add a section on ‘Physical and biological characterization of soil and water management’
• Include a section on ‘Socioeconomic aspects’ (policy issue, tenure)
• In chapter 7 CA should address issues of climate change
• Embed case studies under each chapter instead of putting them at the end, and ensure that they are relevant to the chapter content
• Introduce landscape characterization.
• Replace ecosystem management with ‘Agroecosystems’
• Add organic agriculture, germ plasm evaluation
• Add green energy (wind, solar to drive machinery)
• Add Climate change and adaptation
• Add CA and SDGs
• Add CA and entrepreneurship.

It was agreed that a small team of volunteers be asked to consider all the proposals and develop the list of chapters. These were circulated among participants for their inputs and also to indicate interest to author parts of the manual. The following principles were agreed:

a) That the manual chapters be matched with curriculum modules to reinforce coherence
b) For each module/chapter there should be a set of objectives to be achieved
c) Prospective authors should be asked to develop the full list of contents for each chapter before being allowed to proceed with write up.
d) ANAFE will pay an honorarium to each author
e) Each chapter will be reviewed by experts on the subject and a general language/flow editor.

6.2 Chapters of the Manual

After several iterations the small team tasked to develop the manual content agreed to apply a participatory approach, using the prospective authors. So, all participants were invited to submit the contents they think would fulfil the objectives of each chapter, as illustrated below:

Chapter 1. Introduction to Conservation Agriculture

At the end of this module the learner will be able to:
• Describe the state of agriculture in a given area or country
• Link agriculture with the state of food security and nutrition
• Explain the impact of agricultural practices on environment
• Explain the history and principles of conservation agriculture

Chapter 2. Land Resource Characterization

At the end of this module the learner will be able to:
• Describe the roles of biophysical elements in agricultural production
• Characterize an area with respect to agricultural productivity
• Recognize and quantify elements of land and ecosystem degradation
• Explain the role of CA in reducing negative impacts of farming
• Manage soils for sustainable productivity
• Design systems that ensure water capture and efficient use

Chapter 3. Agro-ecosystems and Biodiversity Management

At the end of this module the learner will be able to:
• Explain the benefits of below- and above-ground biodiversity
• Select and design diverse cropping systems that enhance biodiversity
• Determine and apply safe agrochemicals for pest management
• Apply suitable combination of inorganic and organic fertilizers

Chapter 4. CA Practices, Innovation and Technologies

At the end of this module the learner will be able to:
• Identify weaknesses and strengths of a farming system
• Develop suitable CA interventions
• Promote the application and scaling up of CA interventions by farmer
• Monitor and evaluate the effectiveness of CA interventions

Chapter 5. Conservation Agriculture in Crop and Livestock Production

At the end of this module the learner will be able to:
• Identify, establish and manage suitable species for mulching
• Identify, establish and manage suitable species for fodder
• Apply suitable apply IPM to manage pests in farming systems

Chapter 6. Soil and Water Management in CA

At the end of this module the learner will be able to:
• Apply suitable soil erosion control measures
• Soil fertility management (Nutrients cycling)
• Measure and manage water cycles in cropping systems (Determine and describe water cycles in a cropping system)
• Apply effective water harvesting and storage (Apply appropriate water harvesting and storage technologies)
• Guide water conserving measures in irrigation (Practice suitable water irrigation practices in a farming system)

Chapter 7. CA and Climate change

At the end of this module the learner will be able to:
• Describe the causes and consequences of global warming
• Explain the impact of conventional agriculture in global warming and how to reduce it
• Assess the impact of CC on agriculture
• Design and apply CS mitigation and adaptation measures

Chapter 8. Economics of CA and Entrepreneurship

At the end of this module the learner will be able to:

• Analyze the profitability/benefits of CA
• Promote the development of CA tools and products-based enterprises
• Harness and use green energy options
• Develop markets for CA products

Chapter 9. Cross cutting aspects

At the end of this module the learner will be able to:

• Develop inclusive strategies in projects
• Promote the development of CA supportive policies
• Train farmers and extension personnel
• Undertake studies and publish results in appropriate media

6.3 The way forward

It was agreed that ANAFE will ensure a rigorous editing of the manual. A suggestion to try a mock process (on line CA material development) was suggested but it was agreed to remain flexible on process. To reach the youth, it was agreed to consider various exciting audio and visual electronic products in addition to making CA a market driven approach. Technologies developed under CA should be less labour intensive to attract the youth. It was noted that recently ANAFE produced a curriculum on Evergreen Agriculture (EVA). It would be interesting to integrate CA and EVA, to deliver them in the same university. The small working group also proposed the following timetable for developing the manual (sent to participants after workshop was closed)

Work plan for CA Teaching Manual development

<table>
<thead>
<tr>
<th>S/No</th>
<th>Activity</th>
<th>Due date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Receipt of formal expressions of interest and Chapter(s) Outlines from interested participants</td>
<td>December 31, 2017</td>
</tr>
<tr>
<td>2</td>
<td>Review of Chapter outlines, and selection of Authors</td>
<td>January 5, 2018</td>
</tr>
<tr>
<td>3</td>
<td>Communication of the results of authors selection, and preparation and signing of contracts by selected authors</td>
<td>January 12, 2018</td>
</tr>
<tr>
<td>3</td>
<td>Authors submit draft materials to the ANAFE Secretariat</td>
<td>February 28, 2018</td>
</tr>
<tr>
<td>4</td>
<td>Reviews of manuscripts</td>
<td>March 31, 2018</td>
</tr>
<tr>
<td>5</td>
<td>Incorporation of Reviewers comments in the draft chapters by authors</td>
<td>April 30, 2018</td>
</tr>
<tr>
<td>6</td>
<td>Final Editing and Publishing</td>
<td>May 30, 2018</td>
</tr>
</tbody>
</table>
7 WORKSHOP CLOSING SESSION

The facilitator, Prof. August Temu thanked participants for their lively and focussed contributions, and proposed that the participants at this first workshop on CA education in Africa agree to form the **Education Chapter on CA**. This was unanimously endorsed. He thereafter, invited the various leaders to make closing remarks as hereunder.

Dr. Wilson Kasolo thanked all the participants for their contributions. He was satisfied that the workshop achieved its objectives, and that the curriculum which will be completed by a small team will be shared widely for comments and improvements before it is finalized. He invited all participants to contribute to the subsequent processes on the curriculum and the teaching manual. Regarding the workshop he was grateful to all participants for their enthusiasm and very active contributions in the whole workshop process. He called on all of them to become the champions of CA. He thanked all administrative staff of ACT and ANAFE for their sterling services which enabled the workshop participants to concentrate on the CA agenda. Finally, he was grateful to ACT and especially Eng. Saidi Mkomwa for his strong commitment and bold decision to work with ANAFE. He promised to consolidate the ACT-ANAFE partnership.

Prof James Kung’u in his capacity as the Chair of the Eastern and Central African Chapter of ANAFE (ECA-RAFT) thanked the facilitator Prof. August Temu, and Prof. Amir Kassam for the leadership in the workshop process, and in exposing CA respectively. He expressed enthusiasm to initiate CA teaching at Kenyatta University (Kenya) beginning in 2018. He wished all participants safe travel back home and wished them good health during the forthcoming festive season and Happy New Year 2018.

Prof Yorekun Olesegun, Chair of the Southern Africa chapter of ANAFE (SA-RAFT) and representing the Chair of ANAFE Board thanked the facilitator for an efficiently managed workshop, Engineer Saidi Mkomwa for the new partnership with ANAFE and Dr. Wilson Kasolo for the overall leadership of ANAFE. He envisioned a huge success as the ACT-ANAFE collaboration moves forward. He urged all participants to meet the agreed deadlines with regard to commitments made at the workshop. Finally, he thanked Prof August Temu for guiding and directing the workshop so well.

Professor Amir Kassam on behalf of International Conservation Agriculture Advisory for Africa (ICAAF) said that CA contributes to better land management, poverty alleviation and food security. He pointed out that there is a big responsibility ahead of us to improve living conditions for farmers, indicating that while CA community of practice for education already is established, there is the need to make CA the true sustainable agriculture of the future. He thanked participants for their contributions.

Engineer Saidi Mkomwa expressed his satisfaction that all workshop objectives were achieved. He praised the synergy realized by ACT and ANAFE. He said that ACT is a CA network and
it belongs to all. Tracing the history of ACT, he said that it started with two staff in Nairobi in 2008 and currently has 22 permanent staff. CA work is booming but the main task is to mainstream it into the government systems, including education and development institutions. He revealed that ACT and its partners have developed lots of resources accessible at the Knowledge sharing platform (website www.act-africa.org), open source resources of CA and CA knowledge hub. He pointed out that mechanisation and agribusiness are important for ACT. He also highlighted the need to expand the international and national platforms to include all who are interested.

Finally he thanked the facilitator (Prof A B Temu), Prof. Amir Kassam who travelled all the way from England), Dr. Wilson Kasolo (ES of ANAFE), the ACT team present, ACT and ANAFE administrators and all participants for their contributions toward the success of the workshop. He said the that the planned curriculum and book will be launched in South Africa in the second ACT/CA African conference in October 2018 and invited all to participate. He declared the workshop officially closed and wished all participants safe travel home.
## Annex 1: List of Workshop Participants

**Dates:** December 4 – 6, 2017  
**Venue:** Jacaranda Hotel, Westlands Nairobi

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Name of Participant</th>
<th>Designation and Institution</th>
<th>Email address and telephone</th>
</tr>
</thead>
</table>
| 1     | Dr. Wilson Kasolo   | Executive Secretary, ANAFE  | W.Kasolo@cgiar.org  
+254 207224135 |
| 2     | Eng. Saidi Mkomwa   | Executive Secretary, African Conservation Tillage (ACT) | saidi.mkomwa@act-africa.org  
+254 712252549 |
| 3     | Prof. August Temu   | Director, Capacity Development Resources (CDR) | Killemerly@gmail.com  
+254 767062427 |
| 4     | Josephine Oyoo      | ANAFE Admin and finance assistant | j.oyoo@cgiar.org  
+254 207224186 |
| 5     | Prof. Amir Kassam   | ICAAP-Africa Chair & Visiting Professor, School of Agriculture, Policy and Development, University of Reading, UK | amirkassam786@gmail.com |
| 6     | Mr. Peter Kuria     | African Conservation Tillage Network (ACT) | peter.kuria@act-africa.org  
+254 722 451 704 |
| 7     | Ms. Meaza Melham    | African Conservation Tillage Network (ACT) | Meaza.melkamu@act-africa.org  
+254 792 444592 |
| 8     | Monica Buyu         | African Conservation Tillage Network (ACT) | Monica.buyu@act-africa.org |
| 9     | Prof. James Kung'u  | Dean, School of Environmental Studies Kenyatta University | kungu.james@ku.ac.ke  
+254 722740719 |
| 10    | Prof. Geoffrey Kironchi | Lecturer, Land Resource Mgmt & Agric Technology (LAR-MAT) University of Nairobi | geokironchi@uonbi.ac.ke |
| 11    | Prof. Paul Kayode Baiyeri | Lecturer Nsuka University | paulkayodebaiyeri@yahoo.com |
| 12    | Prof. David Munthali | Prof. Emeritus (Agriculture), Botswana College of Agriculture | davidmuntali@yahoo.com |
| 13    | Prof. Emiru Birhane | Prof Ecology and Mycorrhiza Mekelle University | Emiru.birhane@gmail.com  
+251 191470336 |
| 14    | Prof. Method Kilasara | Professor of Agriculture Sokoine University of Agriculture | kilasaramethod@gmail.com; kilasara@suonet.ac.tz  
+255 754493 668 |
| 15    | Dr. Prossy Isubikalu | Lecturer College of Agriculture Makerere University | isubikalu@gmail.com |
| 16    | Prof. Yerokun Olusegun | Prof. of Agriculture, and VC, Zambia Virtual University | oyerokun1@yahoo.com |
| 17    | Prof. Samuel Mwonga. | Egerton University | smwonga@yahoo.com  
smwonga@egerton.ac.ke |
<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Affiliation</th>
<th>Email/Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Prof Sunday Fashina</td>
<td>Deputy Vice Chancellor, Department of Soil Science and Land Resources Management, Federal University Ekiti State University</td>
<td><a href="mailto:sundayfash2012@yahoo.com">sundayfash2012@yahoo.com</a>, 08060369936, 08023404597</td>
</tr>
<tr>
<td>19</td>
<td>Prof. Daniel Nyamai</td>
<td>Agroforestry Research Scientist and Head of Dept. Rongo University</td>
<td><a href="mailto:nyamai.kefri@gmail.com">nyamai.kefri@gmail.com</a>, +254 726438</td>
</tr>
<tr>
<td>20</td>
<td>Prof Exildah Kasumu</td>
<td>Copperbelt University, University of Zambia</td>
<td><a href="mailto:exildahkasumu@yahoo.com">exildahkasumu@yahoo.com</a>, +260 968277546</td>
</tr>
<tr>
<td>21</td>
<td>Prof Ali Aboud, Morogoro Tanzania</td>
<td>Sokoine University, University of Tanzania</td>
<td><a href="mailto:aoaboud2@gmail.com">aoaboud2@gmail.com</a>, +255 655717151</td>
</tr>
<tr>
<td>22</td>
<td>Ms. Paulina Mabapa South Africa</td>
<td>University of Limpopo, University of Limpopo</td>
<td><a href="mailto:Paulina.mapaba@ul.ac.za">Paulina.mapaba@ul.ac.za</a></td>
</tr>
<tr>
<td>23</td>
<td>Prof H. R. Mloza Banda</td>
<td>University of Swaziland, University of Swaziland</td>
<td><a href="mailto:mlozah@yahoo.co.uk">mlozah@yahoo.co.uk</a>, +268 78233057</td>
</tr>
<tr>
<td>24</td>
<td>Dr Tulole Bucheyeki</td>
<td>Zonal Director Research and Development, Uyole Agricultural Research Institute</td>
<td><a href="mailto:tlbucheyeki@gmail.com">tlbucheyeki@gmail.com</a>, <a href="mailto:tulole.bucheyeki@kilimo.go.tz">tulole.bucheyeki@kilimo.go.tz</a>, +255 782 237383</td>
</tr>
<tr>
<td>25</td>
<td>Mr. Remmy Mwakimbwala</td>
<td>Senior Agricultural Research Officer, ARI Uyole, Tanzania</td>
<td><a href="mailto:mwkimbwala@gmail.com">mwkimbwala@gmail.com</a>, +255 754578601</td>
</tr>
<tr>
<td>26</td>
<td>Dr William Matizha</td>
<td>Principal, Gwebi College of Agriculture, Zimbabwe</td>
<td><a href="mailto:gwebiagric@gmail.com">gwebiagric@gmail.com</a></td>
</tr>
<tr>
<td>27</td>
<td>Dr Jeffrey Jinya</td>
<td>Lecturer, Gwebi College of Agriculture, Zimbabwe</td>
<td><a href="mailto:jeffjinya@gmail.com">jeffjinya@gmail.com</a></td>
</tr>
<tr>
<td>28</td>
<td>Mr. Ngari Macharia</td>
<td>Senior Researcher, KALRO Njoro Kenya</td>
<td><a href="mailto:cngarimacharia@gmail.com">cngarimacharia@gmail.com</a>, +254 721488081</td>
</tr>
</tbody>
</table>
## Annex 2: Workshop Programme

### 4 - 6 December 2017

**Rapporteurs:** Prof Geoffrey Kironchi and Dr. Prossy Isubikalu

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:30</td>
<td>Arrival, Registration and briefing (Be seated at venue by 08:45)</td>
<td></td>
</tr>
<tr>
<td>09:00 – 09.20</td>
<td>Welcome Remarks and introduction of ACT</td>
<td>Eng. Saidi Mkomwa ACT Executive Secretary</td>
</tr>
<tr>
<td>09.20 – 09.40</td>
<td>Welcome remarks and Introduction of ANAFE</td>
<td>Wilson Kasolo ANAFE Executive Secretary</td>
</tr>
<tr>
<td>09.40 – 09.55</td>
<td>Participants introduction and Workshop programme overview</td>
<td>August Temu Workshop Facilitator</td>
</tr>
<tr>
<td>09.55 – 10.05</td>
<td>Welcome Remarks</td>
<td>ANAFE Board Member</td>
</tr>
<tr>
<td>10.05 – 10.20</td>
<td>Opening Remarks</td>
<td>Dr. Joseph Mureithi Deputly DG, KARLO</td>
</tr>
<tr>
<td>10.20 – 10.30</td>
<td>Questions and clarifications</td>
<td>All</td>
</tr>
<tr>
<td>10.30 – 11.00</td>
<td><strong>Group Picture followed by Coffee/Tea Break</strong> (Monica/Josephine)</td>
<td></td>
</tr>
<tr>
<td>11.00 – 11.30</td>
<td>The state of knowledge, science and practices of Conservation Agriculture: Literature collation and meta-analysis reports by consultants</td>
<td>Prof. James Kung’u Consultant</td>
</tr>
<tr>
<td>11.30 – 12.00</td>
<td>The state of knowledge, science and practices of Conservation Agriculture: Literature collation and meta-analysis reports by consultants</td>
<td>Prof. Method Kilasara Consultant</td>
</tr>
<tr>
<td>12.00 – 12.10</td>
<td>Global overview of Conservation Agriculture</td>
<td>Prof. Amir Kassam</td>
</tr>
<tr>
<td>12.10 – 12.20</td>
<td>Questions and clarifications</td>
<td>Facilitator</td>
</tr>
<tr>
<td>12.20 – 13.00</td>
<td>Group Work 1: Synthesizing the science and practices of CA</td>
<td>Group Chairs and rapporteurs</td>
</tr>
<tr>
<td>13.00 – 14.00</td>
<td>Lunch break (Monica/Josephine)</td>
<td></td>
</tr>
<tr>
<td>14.00 – 14.20</td>
<td>Group Work 1: Continued</td>
<td>Group Chairs and rapporteurs</td>
</tr>
<tr>
<td>14.20 – 14.40</td>
<td>Group Work 1: Presentations and general discussion</td>
<td>Rapporteurs</td>
</tr>
<tr>
<td>14.40 – 15.20</td>
<td>Curriculum development and course development: an overview of processes</td>
<td>Wilson Kasolo</td>
</tr>
<tr>
<td>15.20 – 15.30</td>
<td>CA curriculum development and implementation: An experience from South Africa</td>
<td>Mr. Klaas Mampholo Deputy Director, Land Use &amp; Soil Management, MOA, South Africa</td>
</tr>
<tr>
<td>15.30 – 16.00</td>
<td>Coffee/tea (Monica/Josephine)</td>
<td></td>
</tr>
<tr>
<td>16.00 - 16.30</td>
<td>Plenary: Agreeing on level of training and setting Curriculum objectives</td>
<td>Facilitator</td>
</tr>
<tr>
<td>16.30 - 17.00</td>
<td>Plenary: Identifying span of possible job positions for the training programme</td>
<td>Facilitator</td>
</tr>
<tr>
<td>17.00 – 17.30</td>
<td>Group Work II: Identifying Tasks to be performed under each possible job positions</td>
<td>Group Chairs and rapporteurs</td>
</tr>
<tr>
<td>17.30</td>
<td>Closure for the day and transport to Hotel</td>
<td>Monica/Josephine</td>
</tr>
</tbody>
</table>
## Day 2: Tuesday 5th December 2017
**Rapporteurs**: Ms. Paulina Mabapa and Prof Yerokun Olesegun

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Facilitator</th>
</tr>
</thead>
<tbody>
<tr>
<td>08.30 - 08.45</td>
<td>Synthesis of report of Day</td>
<td>Appointed participant/s</td>
</tr>
<tr>
<td>08.45 - 09.00</td>
<td>Group Work II: Presentations and discussions</td>
<td>Rapporteurs</td>
</tr>
<tr>
<td>09.00 - 10.00</td>
<td>Group Work III: Identifying required competences to undertake the identified tasks</td>
<td>Group Chairs and rapporteurs</td>
</tr>
</tbody>
</table>

### 10:00 – 10.30
- **Tea/Coffee break**
  - Monica/Josephine

### 10.30 - 11.45
- Group Work III: Presentations and discussion
  - Rapporteurs

### 11.45 - 13.00
- Group Work IV: Grouping Identified competence into generic modules
  - Group Chairs and rapporteurs

## Day 3: Wednesday 6th December 2017
**Rapporteurs**: Prof. Emiru Birhane Hizikias and Prof Exilda Kasumu

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Facilitator</th>
</tr>
</thead>
<tbody>
<tr>
<td>08.30 - 09.00</td>
<td>Synthesis report of Day 2</td>
<td>Appointed participant/s</td>
</tr>
<tr>
<td>09.00 - 10.00</td>
<td>Identification of teaching resources</td>
<td>Facilitator</td>
</tr>
<tr>
<td>10.00 - 10.30</td>
<td>The way forward for CA development (Discussion)</td>
<td>Facilitator</td>
</tr>
</tbody>
</table>

### 10.30 - 11.00
- **Coffee/Tea Break**
  - Monica/Josephine

### 11.00 - 11.30
- CA Teaching manual Development overview
  - Wilson Kasolo

### 11.30 - 13.00
- Agreeing on structure and format of the manual
  - Facilitator

### 13.00 – 14.00
- **Lunch Break**
  - Monica/Josephine

### 14.00 – 15.00
- Identification of Chapters in the manual
  - Facilitator

### 15.00 – 15.30
- Agreeing standards and quality of the manual
  - Facilitator

### 14.00 – 16.00
- Agreeing on timelines for the manual development
  - Facilitator

### 16.00 – 16.30
- Identification of Authors (Lead and co-authors)
  - Facilitator

### 16.00 – 17.00
- Agreeing on timelines
  - Facilitator

### 17.00 – 17.15
- Vote of thanks
  - Wilson Kasolo/ANAFE

### 17.15 – 17.30
- Closing Remarks
  - Saidi Mkomwa/ACT

### 17.30
- Closure/Departure/Transport to Hotel
  - Monica/Josephine
This work brings up existing current information on conservation agriculture (CA). It is based on synthesized collated information meant to provide an understanding of the genesis, scientific evidence, practices and development pathways of CA taking into account its opportunities and associated challenges. It start by exposing the origin of conservation agriculture and the salient features of the African land resources, pinpointing of their low productivity which is attributed to both the low potential of the resource base (soil and water) and to the wide spread land degradation which occurs upon long-term continuous tillage.

Conventional agriculture which is synonymous to industrial agriculture refers to farming systems which include the use of synthetic chemical fertilizers, pesticides, herbicides and other continual inputs, genetically modified organisms, concentrated animal feeding operations, heavy irrigation, intensive tillage, or concentrated monoculture production. Monoculture and intensive tillage (use of heavy machinery to till the land) or even continuous tillage using tools as simple as hand hoe, have degradative effects on soil quality, environmental quality, with a negative bearing to the ecological services and land productivity. This explains the deterioration of ecosystem services under continuous conventional tillage. CA was designed and promoted to address land productivity issues on sustainable manner. It is viewed as an effective means of addressing the low land productivity issues in SSA, as well as redressing the harmful effect of conventional agriculture. In essence, CA is an integration of interrelated practices that according to FAO (2014) involves simultaneous implementation of: (i) minimum soil disturbance, (including disturbed tillage area of less than 15cm width or 24% of the area); and (ii) crop residue cover of the soil (with a minimum of 30% soil cover at planting); and (iii) crop diversification (with greater than three crops in rotation). This study reports various research results from Africa and beyond, showing how CA can modify the soil bio-physical chemical characteristics which are responsible for maintaining soil and environmental quality with consequences of improving land productivity, hence crop yields. Reported results often compare the application of one or two components of CA with conventional agriculture, rarely do they cover the whole of the CA principles. There is substantial evidence of good performance of CA compared to conventional agriculture from such studies, and the contrary too. Positive results demonstrate ability of CA to positively influence soil characteristics that influence both soil health and land productivity, including increase in SOM content, increased infiltration, soil moisture retention and soil biology and beneficial soil microorganisms such as mycorrhizal population. The positive CA has often been noted semi-arid environment where productivity is often low with frequent cases of crop failure and the associated socio-economic consequences including famine. In these areas, CA can make the difference. Another positive aspect is the adaptability of CA to effects of climate change which are more severe in the semi-arid zones in SSA. This makes CA to be climate-smart compliant. The ability of CA to sequester carbon (contribution to the lowering greenhouse gas emission) and hence mitigation to climate change requires further studies to properly quantify the extent of C
sequestration in terms of input-output relationship under well-defined bio-physical settings. Among the bottlenecks of CA low productivity which occurs during the early years of its application. Results are also variable. In high potential areas, the duration is short, sometimes absence. In low potential areas, the period is variable, in some cases up to 10 years without conclusive results. Research should spearhead the process of CA adoption rather than sticking on the technical aspects only. This will happen if studies are designed to cover the whole CA components and include in them aspect that target the adoption pathways. Studies have shown many challenges that interferes with the adoption of CA. They include technical and socio-economic and institutional arrangement and policy matters. the set of landscape characteristics and outcomes of the contribution in terms of soil and environmental qualities and hence land productivity is necessary for making cases that can be used to promote CA adoption These are yet inadequate for SSA and calls for the need to have systematized full spectrum studies in well-defined bio-physical and socio-economic settings that involves not only the technical aspects but the adoption pathways. The study proposes many innovative research-and adoption initiatives which can accelerate the CA adoption process in SSA.

From the contrasting results with regard to effect of CA on crop yield and some soil quality parameters, a met-analysis procedure was undertaken based on publications from SSA. The purpose was to obtain a clear picture about effects of CA to maize yield and soil and environment qualities. This study could not be performed due to insufficiency in number of available publications.
Poverty and hunger in Africa are prevalent and will increase in absolute terms with population growth and continued land degradation. There is therefore need for sustainable agricultural strategies, such as conservation agriculture (CA) and integrated pest management (IPM). Among CA practices, intercropping holds the promise of providing benefits to smallholders through increased crop yields and income as well as improved resource use.

Food insecurity and malnutrition are two major challenges facing rural populations in many developing countries especially in sub-Saharan Africa (SSA). Sustainability of society in these countries hinges on the future of agriculture. The primary challenge is to feed a growing and more demanding population with reduced external inputs and minimal negative environmental impacts, all under more variable and extreme climate conditions. Conservation agriculture, a farming system that involves reduced or no-tillage, permanent soil cover and crop rotations to enhance soil fertility and crop yields is being promoted as a means to overcome continuing poor-profitability and soil degradation. In recent years a growing number of studies have been carried out in different parts of the world comparing conservation agriculture practices to conventional tillage-based practices. These studies have been conducted under a range of conditions (climate, soil, management, cropping system) gaining variable results on conservation agriculture responses. The aim of this desktop study was to review literature and carry out a meta-analysis to identify the state of knowledge, science and practices of conservation agriculture. Different research papers, text books and manuals on conservation agriculture were reviewed and the results compared and combined from different study and experiments in the hope of identifying patterns among study results, sources of disagreement among those results, or interesting relationships that may come to light in the context of the different studies are reported. The results of this meta-analysis show that reduced or no-tillage without mulch and/or crop rotation leads to reduced crop yields compared to conventional farmers' practices based on tillage. In contrast, crop grain yields are higher in no-tillage treatments compared to conventional tillage-based practices, when mulch was applied whether or not in combination with crop rotations. These outcomes suggest that for farmers to benefit from conservation agriculture they should be able to keep their crop residues as mulch on the soil surface. Additionally, crop rotation should be an integral component of their farming practice, which implies the change from continuous mono-cropping systems towards rotation systems that include different crops and preferably legumes. These two components of conservation agriculture are, however, for many smallholder farmers in sub-Saharan Africa the bottlenecks to adopting the approach. Crop residues have several other uses on the farm, in particular as feed for livestock. Legumes or other non-cereal crops in many cases gain limited interest, as ready markets for sale are often not available. Another important management factor with respect to the successful implementation of conservation agriculture practices is the use of chemical fertilizer. The results of this study demonstrate a clear response of crop yields to conservation agriculture with high nitrogen fertilizer application, and much less with low nitrogen fertilization. Crop yields are generally low in sub-Saharan Africa and organic residues in short supply. The use of
fertilizer to enhance crop productivity and organic residue availability is essential for smallholder farmers to engage in conservation agriculture. Our study did not differentiate rainfall regime as being better for successful implementation of conservation agriculture, as most of the published studies used in the meta-analysis did not report on rainfall distribution within the season. Considering the seasonal rainfall distribution would, however, help in assessing conservation agriculture practices for their resilience to future climate change. Conservation agriculture (CA) can sustainably address soil degradation and improve crop yields.

Figure 10. Workshop participants