CONSERVATION AGRICULTURE

A Curriculum Guide for Africa

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African Network for Agriculture, Agroforestry & Natural Resources Education

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ACT African Conservation Tillage Network

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ACRONYMS AND ABBREVIATIONS

AGB	Above-Ground Biomass
ACT	African Conservation Tillage Network
ANAFE	African Network for Agriculture, Agroforestry and Natural Resources Education
AUC	Africa Union Commission
BGB	Below-Ground Biomass
CAADP	Comprehensive African Agriculture Development Programme
CBD	(United Nations) Convention on Biodiversity
FC	Field Capacity
IPM	Integrated Pest Management
ISFM	Integrated Soil Fertility Management
MEA	Millennium Ecosystem Assessment
MST	Minimum Soil Tillage
NEPAD-AU	New Partnership for Africa's Development – African Union
SOM	Soil Organic Matter
STISA	Science, Technology and Innovation Strategy for Africa
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change

ACKNOWLEDGEMENT

This curriculum is a product of a close partnership between the African Conservation Tillage Network (ACT) and the African Network for Agriculture, Agroforestry and Natural Resources Education (ANAFE). The curriculum is being developed as a compliance response to the Lusaka Declaration of the first Africa congress on Conservation Agriculture, which in its 6th resolve urged *"ACT is to establish a quality-assurance system for accredited agricultural training institutions to provide CA training certificates. Furthermore, ACT will collaborate with relevant stakeholders for the harmonization of CA training curricula"*. Furthermore, in its eighth resolve, the declaration requested *"Agricultural training institutions to take up CA as an integral part of their training programmes and take part in farmer sensitization and training efforts".*

The impetus to develop this curriculum arose from an intensive workshop held in Nairobi Kenya from 4th to 6th December 2017 for researchers, educators and practitioners of Conservation Agriculture. The workshop participants came from African Conservation Tillage (ACT) Secretariat; ANAFE Secretariat; Capacity Development Resources (CDR), School of Agriculture, Policy and Development, University of Reading, UK; School of Environmental Studies Kenyatta University; Land Resource Management & Agric Technology (LAR-MAT), University of Nairobi, Kenya. Others were Nsuka University, Nigeria; Botswana College of Agriculture; Mekelle University, Ethiopia; Sokoine University of Agriculture, Tanzania; College of Agriculture Makerere University, Uganda; Zambia Virtual University; Egerton University, Kenya; Ekiti State University, Nigeria; Rongo University, Kenya; Copper belt University, Zambia; University of Limpopo, South Africa; University of Swaziland; Uyole Agricultural Research Institute, Tanzania; Gwebi College of Agriculture, Zimbabwe and Kenya Agricultural and Livestock Research Organization Njoro, in Kenya.

ACT and ANAFE are grateful to all individuals and their institutions for the excellent contributions they made towards the development of this curriculum. We also express our gratitude to Prof. August B Temu, former Deputy Director General of the World Agroforestry Centre (ICRAF), who led the curriculum development process and is the lead author of this curriculum. In addition, we make special mention of Prof. Amir Kassam, International Conservation Agriculture Advisory Panel for Africa (ICAAP-Africa) Chair for his contribution.

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ACT Executive Secretary

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PREFACE

Africa's agriculture is in great need of reform to minimize and eventually eliminate land degradation, improve yields per unit area, reduce the drudgery especially for smallholder farmers, sustain productivity and profitability and enhance environmental conservation. These aspirations are elaborated in the Comprehensive Africa's Agricultural Development Programme (CAADP) adopted by the African Union Commission. The companion document dubbed STISA (Science Technology and Innovation Strategy for Africa) emphasises modernization of agriculture while relegating traditional practices to history. Our ambitions to make big gains in agriculture are unlikely to be achieved any time soon because we are dealing with millions of smallholder farmers whose traditional practices (even where effective) are largely ignored or underrepresented in what is called innovations. Conservation Agriculture requires low investment, minimises labour and is close to current smallholder practices. Yet its impact has been shown to be huge on both production and ecological sustainability. Here is an opportunity to enhance its practice by providing expertise through education and training.

This curriculum is a first step in the development and further adoption of CA in Africa. The curriculum structure is versatile, enabling agricultural learning institutions to select and use modules or topics that enhance their current agricultural curricula. The goal is to support agricultural learning institutions to impart the science and innovations in CA to enhance productivity while meeting the conservation and sustainability needs, with a special focus on smallholders. Thus, this curriculum is a source of ideas that can be adopted and adapted to meet the specific needs of farming communities and of teaching institutions. Educators and researchers are expected to further develop the ideas contained herein to strengthen the science and innovations in Conservation Agriculture.

This is a fresh front for African Agriculture!

1. INTRODUCTION

To farmers and agronomists, Conservation Agriculture (CA) is an age-old practice that was until recent times being replaced by intensive monocultures, mechanization and heavy use of fertilizers and pesticides. Interestingly, over the last 30 years or so CA has been reclaiming its place as a sustainable and ecologically friendly farming practice. The turnaround is partly due to increasing pressure on agricultural science and technological innovations to guarantee that gains in production and productivity do not jeopardise the future productivity of the land or destroy biodiversity, leading to environmental degradation. Further, the widely held triple bottom-line of sustainable ecological, economic and social gains is a key characteristic of Conservation Agriculture, therefore promoting its adoption. For this Curriculum Guide, the following FAO definition and description of Conservation Agriculture (CA), as accepted by the CA Community of Practice are used (www.fao.org/ag/ca):

FAO defines Conservation Agriculture (CA) as an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. CA is characterized by three linked principles, namely:

1. Continuous no- or minimal mechanical soil disturbance (i.e., no-till sowing or broadcasting of crop seeds, and direct placing of planting material in the soil; no-till weeding, minimum soil disturbance from farm operations, harvest operation or farm traffic, in special cases limited strip or band seeding disturbing less than 25% of the soil surface);
2. Maintenance of a permanent organic soil mulch cover, especially by crop biomass, stubbles and cover crops; soil cover less than 30% is not considered as CA; and
3. Diversification of crop species grown in rotations, sequence or associations through rotations or, in case of perennial crops, associations of plants, including a balanced mix of legume and non-legume crops.

CA principles are universally applicable to all agricultural landscapes and land uses with locally formulated and adapted practices. These interlinked CA practices are applied along with other complementary good agricultural practices including integrated crop, soil, nutrient, water, pest, labour, farm power and mechanization management as appropriate. Thus in practice, CA covers all land-based systems including rainfed and irrigated cropland systems, horticulture, orchards, plantations, rice-based systems, agroforestry, crop-livestock-tree systems, pasture-livestock systems, and organic systems. Currently, Africa spends US

$35 billion annually to import food. At its current rate of growth, Africa's population will more than double by 2050, meaning the demand for food will also double. The threats of climate change (particularly shifts in weather patterns, rising frequency of droughts and floods and incidences of pests and diseases) threaten Africa's future food security and nutrition. The good news is that Conservation Agriculture is superior to conventional agriculture and is poised to meet these challenges. By eliminating or minimizing tilling, maintaining soil cover all year round and rotating crops (and growing useful trees) CA is by design water conserving, nutrient efficient, builds up soil organic carbon and can prolong the growing seasons. These and other benefits make it a prime area for investment in African agriculture.

Sadly, the above narrative contrasts with current agricultural education in Africa, which emphasizes conventional agriculture. The latter emphasizes improved seed, ploughing and harrowing of land, use of inorganic fertilizers, managing weeds and diseases with agrochemicals and irrigation. Although few smallholder farmers in Africa can afford such expensive inputs, current college and university curricula are dominated by these elements. Through complex business models, African governments find themselves subsidizing farmers to buy agricultural machinery, seed, fertilizers and agrochemicals that do not necessarily alleviate the food shortage. Africa's extension personnel know more and promote conventional agriculture than CA. This is awkward as the farmers are more familiar with CA through practice and they know that it is more resilient.

In 2017, Africa had about 1.4 million hectares of land under CA and this was expanding at 4.5% annually. This is low compared to the global statistics, which show 157 Million ha of CA and growing at 7% annually. Africa has invented *Zai* plots (micro basins) that are effective in catching and retaining water for crop irrigation and also developed subsoiling techniques that help to overcome hard pans and improve rooting. Africa's potential to catch up and accelerate the adoption of CA will be further enhanced through inter alia, the re-orientation of agricultural education to emphasize CA. This is exactly the purpose of this curriculum: to produce the required experts to drive CA innovations and extension. Complementary to the CA knowledge, policy moves are necessary to drive CA forward in Africa.

Country	CA Area (ha)
South Africa	439.00
Zambia	316.00
Mozambique	289.00
Malawi	211.00
Zimbabwe	100.00
Kenya	33.10
Tanzania	32.60
Ghana	30.00
Tunisia	12.00
Morocco	10.50
Sudan	10.00
Madagascar	9.00
Uganda	7.80
Algeria	5.60
Lesotho	2.00
Swaziland	1.30
Namibia	0.34
Total	1,509.24

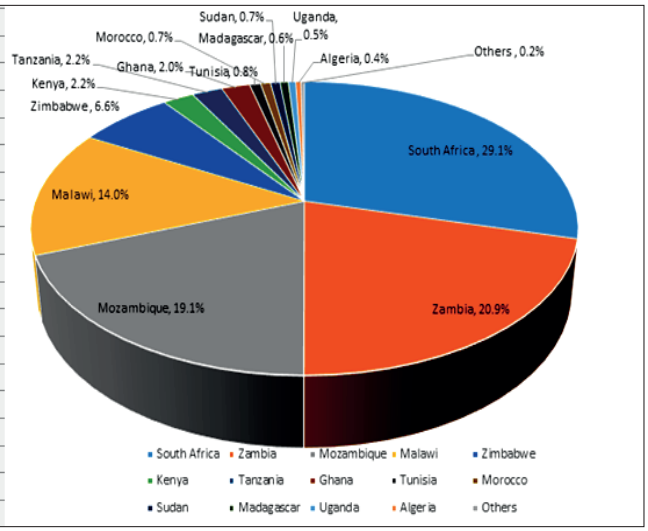


Figure 1: CA adoption status in Africa, 2017, Source, ACT.

2 HOW CONSERVATION AGRICULTURE RESPONDS TO DEVELOPMENT NEEDS

Conservation Agriculture practices are hinged on three interlinked principles: minimizing or avoiding soil disturbance, maintaining a permanent soil cover with mulch, and crop diversification through rotations and associations. The combined effects of these practices when applied along with other complementary good agricultural practices lead to benefits including: increased productivity, improved biodiversity and a number of ecological benefits. These results contribute to agricultural and human developments and environmental amelioration and protection. Table 1 shows the potential of CA to contribute to the achievement of 9 Sustainable Development Goals (SDG) and 22 targets.

Table 1: Conservation Agriculture as a response to SDG Goals and Targets

SDG Goal 1. End poverty in all its forms everywhere	
SDG TARGETS	**HOW CA CAN CONTRIBUTE**
1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions	CA addresses the needs of smallholders to achieve more productivity with less inputs. This builds up rural enterprises.
1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters	CA innovations are particularly designed to reduce the negative effects of climate change by building up resilience and adaptation

Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture	
2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons	Crop diversification and rotation will lead to Improved nutrition (e.g. fruits and vegetables)
2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment	CA is primarily geared to support smallholder farmers to raise productivity without the need for heavy technological inputs. This reduces their dependency on loans and is friendly to the environment.
2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	CA enhances resilience, ecosystem functionality and risk aversion
Goal 3. Ensure healthy lives and promote well-being for all at all ages	
3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	CA's production system minimises or eliminates the dependence on agrichemicals, making food safer.
Goal 5. Achieve gender equality and empower all women and girls	
SDG TARGETS	**HOW CA CAN CONTRIBUTE**
5.2 Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws	CA contributes to knowledge and livelihood strategies for women and youth and provides opportunities for women and youth engagement in enterprise development

Goal 6. Ensure availability and sustainable management of water and sanitation for all	
6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	• CA improves water use, quality and soil conservation • Innovations in CA enable restoration of farming ecosystems and reduce dependency on natural forests for ecosystem services • CA practices capture and conserve water
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	
Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	
8.1 Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries	CA provides employment opportunities across the agricultural value chains
8.2 Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors	CA anchors sustainable economic growth at local levels, and helps to create employment, especially for rural people. Scientific research into sustainable farming systems, policies that support conservation and entrepreneurial innovations in processing naturally produced foods and fibre and key tenets of CA.
8.3 Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services	
9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including. by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending	

Goal 12. Ensure sustainable consumption and production patterns	
SDG TARGETS	**HOW CA CAN CONTRIBUTE**
12.2 By 2030, achieve the sustainable management and efficient use of natural resources	CA will substantially reduce the pressure on forest resources, sequester carbon, reduce greenhouse gas emissions and improve ecosystem functionality
12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment	
Goal 13. Take urgent action to combat climate change and its impacts	
13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in al1 countries	CA has the capability to contribute to effective risk management, particularly those arising from climate change
13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	
Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	
15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	CA's primary goal is precisely to strengthen ecologically friendly approaches at farm level and this cascade up to national and global levels. Among the benefits are • Efficient management of soil and water resources • Reduced soil erosion • Raised water retention capacity • Ecological sustainability • Increased biodiversity • Reduced desertification
15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world	
L5.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development	
I5.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species	

It is important when teaching Conservation Agriculture to demonstrate how best to achieve these goals and targets. It is noteworthy that the goals and targets also respond to the challenges identified in agreements and protocols relating to the United Nations Framework Convention on Climate Change (UNFCCC), United Nations Convention on Biodiversity (CBD) and United Nations Convention to Combat Desertification (UNCCD). Very similar goals and targets are identified by the Comprehensive Africa's Agricultural Development Programme (CAADP) and the accompanying Science Technology Innovation Strategy for Africa (STISA).

3 JOB AREAS FOR CONSERVATION AGRICULTURE EXPERTS

Graduates with Conservation Agriculture knowledge and skills are expected to apply their knowledge in farming, extension, training and research. Thus, they may take job positions such as Farmers, Farm managers, Agronomists, Agro-mechanics, Extension Officers, Trainers for farmers or technicians, Conservators, Ecologists and Natural resource Managers. They are expected to understand:

- The local, regional and global implications of farming practices on livelihoods (especially food, nutrition and health), ecosystems (especially biodiversity conservation), water (volume and quality), greenhouse gas emissions (and their impact on climate) and overall long-term development aspirations of communities.

- The interaction between crops, livestock and trees in farming systems and be able to balance farming productivity with landscape restoration.

Obviously, a Conservation Agriculturist is a highly versatile person with a wide range of knowledge and skills on wise use of land and its resources.

It is important to note that the purpose of this curriculum is not to separate conservation agriculture from conventional agriculture. Rather, it seeks to enhance the knowledge and skills of (among others) farmers, agronomists, soil specialists, irrigation experts, mechanization engineers, agricultural economists and policy makers to appreciate and apply the knowledge currently available on CA to tap its benefits.

It is therefore important that currently serving officers in agriculture attend refresher courses where CA will be a focal point. This curriculum can therefore be adapted to fit into short courses in Conservation agriculture, targeted at different stakeholders according to identified needs.

Another important consideration is the capacity to evaluate an agricultural production system regarding whether or not it meets CA criteria and indicators. By being able to score farming practices and farms we can establish the tendency towards CA and thereby map whole agricultural landscapes showing the stages of transition.

This curriculum is therefore versatile in its application, and is intended to fulfil the following objectives:

- Strengthening human resource competencies in CA,
- Mainstreaming CA into agricultural science and innovations,
- Enhancing the adoption of good CA practices and innovations and
- Enhancing the contribution of CA to food security and wealth creation.

Whereas the curriculum is primarily intended for Africa, it is freely available for use globally. Like any other discipline, it will be revised periodically to include new concepts and knowledge.

Figure 2: Job creation through less arduous and rewarding Conservation Agriculture-based production

4 CONSERVATION AGRICULTURE CURRICULUM

4.1 Guidance on Modules

This curriculum is organized in 9 modules that are logically linked. For institutions aspiring to produce CA specialists they can adopt all the nine modules. However, as pointed out earlier the user of this curriculum may be institutions that are already teaching various aspects of agriculture and may therefore already be teaching some of the modules or topics. It is therefore advised that they mainstream CA into the existing curriculum by identifying the topics they consider useful in meeting their needs. Table 2 shows how the modules are related.

Table 2. Learning Modules in Conservation Agriculture.

Module 1. Introduction to Conservation Agriculture Describes conventional agriculture especially with regard to meeting the food, nutrition and conservation needs of society. Explains the origin of CA and showcases the principles of CA and their strengths. Makes the case for transition into Conservation agriculture. Explains the similarity to organic farming.	**Module 2. Natural Resource Characterization** Underpins the importance of climatic, biophysical and socio-economic analyses as the baselines for choosing agricultural practices. This helps to anchor CA in realistic local conditions and culture. It also provides analysis on the risks in agriculture and mitigation measures.
Module 3: Agro-ecosystems Biodiversity and Climate Change Analyses existing farming systems their productivity and challenges. Introduces the concepts of biodiversity conservation (above- and belowground), ecosystems and their values, effects of fertilizers and agrochemicals on water and living organisms; organic and inorganic farming benefits and challenges. Addresses climate change mitigation and adaptation measures, Green energy, ecosystem services.	**Module 4: CA Practices, Innovations and Technologies** Traces the history of CA with local and global examples. Introduces principles and innovations in CA (minimum till, soil cover, crop rotation, and diversification) and their applicability in local conditions. Analyses profitability, conservation, challenges of upscaling CA and trends in the adoption of CA locally and globally. Covers CA mechanization, Water cycles, water harvesting and efficient utilization, irrigation systems, recycling, pollution and cleansing methods and tools.
Module 5: Economics and Business of CA Tools the learner in economic analysis of complex systems and underpins the full value chain approach. Also strengthens knowledge and skills in entrepreneurship and innovations in CA. Proposes niche markets for eco-products and compensation for ecological products and services. Provides strategies for CA extension to accelerate adoption.	**Module 6: Cross Cutting Aspects** Strengthen the concept of inclusive strategies in CA projects. Policy formulation, legislation and knowledge dissemination as critical considerations. CA project planning, social and cultural aspects, youth, gender, institutions and capacity development. Research needs for CA, Communication and information management, Collaboration and networking.

4.2 Elaboration of Modules

Important Note: The list of learning resources presented under each module indicated is only indicative. It is neither comprehensive nor up to date. Educators are advised to search for more and up to date resources. Additionally, they should as far as possible select materials that are relevant/suitable for the social, cultural and geographic circumstances they work in.

Module 1. Introduction to Conservation Agriculture:

Preamble

This module provides the history of Conservation Agriculture and describes the features that distinguish Conservation Agriculture from conventional agriculture. It then presents a global portrait of the various practices of local communities universally accepted as constituting CA. The learner is exposed to the virtues of CA. Then it describes the extent of adoption to demonstrate the popularity of the practice. Finally, the module analyses the country's agricultural practices, paying attention to local communities, private sector and public institutions with the goal of understanding policy aspects and the niches for Conservation Agriculture. This sets the stage for contextual understanding of prospects for CA in the country and its contribution to food, nutrition and conservation.

Learning Objectives

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

- Explain the history and principles of conservation agriculture,
- Enlist the benefits of CA practices,
- Explain the extent of adoption of CA locally and globally and why,
- Describe the state of agriculture in the country and
- Explain the impact of agricultural practices on food security and environment, and
- Describe organic farming.

Module Synopsis

- History and extent of Conventional Agriculture: Basic tenets of conventional agriculture, soil management, water management, soil organic matter management, the push for enhanced productivity through monocultures
- Principles of CA: The three basic features of CA, justification and evidence of performance
- Comparative analysis of CA with conventional agriculture: Listing the merits and demerits, challenges and opportunities
- Adoption rates for CA: Adoption rates in different countries and regions, impediments to adoption
- Situation Analysis with respect to Food security: Drivers of productivity (food demand globally) and environmental sustainability challenges.
- Socio-economic and cultural aspects: Contextual understanding of local communities, cultures and impact on farming.
- Potential of CA in enhancing productivity and conservation: Strengths of CA, areas requiring more scientific research.
- State of agriculture and environment in the country of study. A thorough analysis of the country's state of agriculture.
- Organic Farming and certification

Learning Resources:

i) Kassam, A., Friedrich, T., Shaxson, F. and Pretty, J. (2009). The spread of Conservation Agriculture: justification, sustainability and uptake. *Int. J. Agric. Sust.* 7(4):293-320.

ii) Derpsch, R. and Friedrich, T. (2009). Global overview of Conservation Agriculture adoption. Innovations for Improving Efficiency, Equity and Environment, New Delhi: http://www.fao.org/ag/ca.

iii) Hobbs, P. R. 2007. Conservation agriculture: what is it and why is it important for future sustainable food production? J Agric Sci 145: 127–137.

iv) What is Organic Farming? http://www.infonet-biovision.org/res/res/files/488.OrgFarm.pdf

Indicative duration

40 lecture hours with extensive reading assignments

Practicum

Laboratory: None

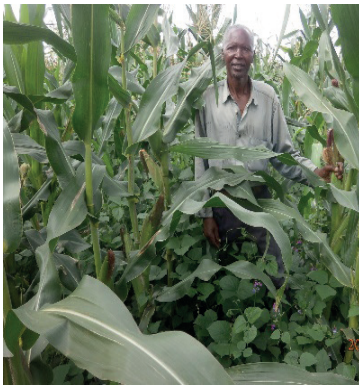
Field work: Visits to farming areas to study the distinction of CA from conventional agriculture

Assessment methods:

Continuous assessments tests (30%) and final examination (70%).

1 Avoiding or minimising mechanical soil disturbance

2 Enhancing & maintaining permanent mulch cover on the soil surface



3 Diversification of species

Figure 3: Principles of Conservation Agriculture

Module 2. Natural Resource Characterization

Preamble

All too often agriculture is taught with food security as the only goal. The epitome of this module is to broaden the scope of the learner, with respect to the overall landscape conditions and including the social, cultural and environmental aspects of agriculture. This holistic approach brings in the interaction of various resources and values (locally and globally), that is, placing food security and nutrition in context of many other goals of society. Multiple use concepts will strengthen the learner's understanding of needs beyond those of the individual farmer or community. Thus, efficiency is no longer solely with respect to inputs to production or productivity but is tied to conservation and sustainability values. This also expands the understanding of the factors of production.

Learning Objectives

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 soils and productivity
- Explain the social and cultural aspects of society in relation to agriculture
- Recognize and quantify elements of land, soils and ecosystem degradation
- Manage soils for sustainable productivity
- Explain the role of CA in reducing negative impacts of farming
- Analyse systems and tools for water capture and efficient use
- Explain integrative planning and implementation of agricultural enterprises

Module Synopsis

- The Physical environment: Latitude, altitude and soil types, Soil health parameters and in relation to different crops and uses. Landscapes and limits to different uses. Soils analysis, classification and mapping;
- Factors affecting Soil quality, soil productivity and degradation soil erosion, compaction, salinity, loss of nutrients (leaching);
- Agro ecological zonation: Description, Potential and Limitations;
- People, population growth and analysis, social and cultural aspects in relation to agriculture and food, economic aspects of food production, Indigenous knowledge;
- Water harvesting, quality and efficient use of water; Water use and scarcity, water harvesting and conservation, irrigation management, water retention in different soils;

- Land Tenure issues, tree tenure;
- Climate, State of Agricultural productivity (Land degradation–loss of biodiversity, deforestation, declining ecosystem services).
- Millennium Ecosystem Assessment (agricultural aspects): The performance of agriculture
- Organic agriculture

Learning Resources:

i) Millennium Ecosystem Assessment report 2005. https://www.unpei.org/sites/default/files/PDF/ecosystems-economicanalysis/MEA-A-Toolkit.pdf

ii) Kassam, A., Basch, G., Friedrich, T., Shaxson, F., Goddard, T., Amado, T., Crabtree. B., Hongwen, L., Mello, I., Pisante, M. and S. Mkomwa. (2013). Sustainable soil management is more than what and how crops are grown. In: R. Lal and Stewart, R.A., (Eds) *Principles of Soil Management in Agro-ecosystems*. 2013. Advances in Soil Science. CRC Press.

iii) Rattan, L. 2013. Food Security in a changing Climate. Elsevier: Ecohydrology & Hydrobiology. www.Elsevier.com/locate/ecohyd

iv) FAO, 2012. Soil organic carbon accumulation and greenhouse gas emission reductions from conservation agriculture: a literature review. Integr Crop Manage 16, 89 p. Rome: FAO.

v) De Maria, I. C., Nabude, P.C., and Castro, O.M. 1999. Long-term tillage and crop rotation effects on soil chemical properties of a Rhodic Ferralsol in southern Brazil. Soil till Res 51: 71–79.

Indicative duration

40 lecture hours and extensive reading assignments

Practicum

Laboratory: Basic soil analysis and classification 20 hours

Field work: Field assessments of landscapes and soils and vegetation - 40 hours

Assessment methods

Continuous assessment tests 20% Field and lab work 40% and Final examination 40%

Module 3: Agro-ecosystems, Biodiversity and Climate change

Preamble

Conservation Agriculture requires that an agro-ecosystem is designed for sustained production and conservation. It must also meet the community aspirations. Whereas biodiversity is already imbedded in the basic principles of CA, there is a wide range of possibilities and opportunities to advance this area. Further, with the advent of climate change, CA must by design demonstrate better mitigation and adaptation capability. Can CA deliver in all these areas? This is precisely the question this module is intended to address.

Foremost CA should be understood as a system that mimics nature. Naturally occurring ecosystems are usually highly diverse and adaptive/resilient. This is generally more evident in the tropics compared to the temperate regions where the diversity is less. But the more diverse the ecosystem the harder it is to manage it, precisely because of the complex relationships that are sometimes difficult to map out. Here then is the challenge of CA.

It is estimated that the adoption of soil conserving farming practices on all the farmlands in the European Union (estimated as 103.7 million hectares including the annual cropland and the land under permanent crops), could reduce CO2 in the atmosphere by nearly 190 million tonnes. This reduction represents the 20% of the goals agreed on the 2030 framework for Climate and Energy of the EU. Clearly, widespread adoption of Conservation Agriculture would represent an enormous contribution to the overall sustainability of agriculture and to its environmental performance and climate action.

Learning Objectives

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

- Describe agroecosystems, their uniqueness, benefits and challenges
- Explain the meaning and benefits of below- and above-ground biodiversity
- Design diverse and productive cropping systems that enhance biodiversity
- Design and apply integrated pest management systems
- Explain safe use of agrochemicals (fertilisers and pesticides)
- Apply suitable combinations of organic and inorganic fertilizers
- 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 various species and agriculture as a whole
- Design and apply CC mitigation and adaptation measures that include CA

Module Synopsis

Agro-ecosystems: Classification of agroecosystems. Principles of agro-ecology, characterization of systems of production, land productivity mapping, competition for growth resources (light, water, and nutrients) and ecological succession. Species, energy use and nutrients balance. Agrochemicals and eutrophication.

Biodiversity: Below and above ground biodiversity, Measurement of biodiversity, Calculating Shannon and Simpson Indices of Biodiversity, The United Nation Convention on Biodiversity (CBD) and the roles of agriculture. Roles of inorganic fertilizers and agrochemicals on biodiversity;

Mixed cropping systems: Rotational systems; Relay cropping; Agroforestry (tree-crop-livestock interactions); integrated soil fertility management, integrated pest management;

Monoculture systems: Food security (availability, access, use and stability over time), how this translates into mass production and monocultures, Strengths and weaknesses of monoculture systems. Fertilisers and Agrochemicals, Pest management challenges. Food safety.

Climate variability and climate change: Causes of global warming, Contribution of agriculture to global warming, GHG emissions (cropping systems, fertilizers and livestock), Impact of climate change on agriculture, Adaptation measures, Mitigation measures, Clean Development. Agro-climatology.

Natural systems: forest systems, roles of trees in water management, energy exchange. Grasslands, desertification processes and mitigation measures.

Learning Resources:

i) Vandermeer, J.H. 2002. Tropical Agroecosystems. CRC Press, 3 Dec 2002.

ii) Melina, F., Laverty, Eleanor, J., Sterling, A. C., Cullman, G. 2008. Greenwood Press, Science. 203 pages

iii) Pisante, M. F., Stagnari, M., Acutis, M., Bindi, L., Brilli, V., Stefano, D., and Carozzi, M. 2015. Conservation Agriculture and Climate Change. https://www.researchgate.net/publication/265380313

iv) FAO, 1996. Global Climate Change and Agricultural Production. Direct and Indirect Effects of Changing Hydrological, Pedological and Plant Physiological Processes Edited by Fakhri Bazzaz and Wim Sombroek xii + 345 pp., ISBN 0 471 95763. ISBN 0 471 96927 3. Chicester, UK: Food and Agricultural Organization of the United Nations and John Wiley & Sons Ltd, 1996

v) FAO 2017: Climate Smart Agriculture Sourcebook. http://www.fao.org/climate-smart-agriculture-sourcebook/en/

Indicative duration

60 Lecture hours with extensive reading assignments

Practicum

Laboratory: Some analysis of soils and plant species (20 hours)

Field work: Extensive field visits especially to study diversity of agroecosystems and effects of climate change (3 weeks)

Assessment methods

Continuous assessment tests (20% Field study reports (30%) Final examination (50%)

Figure 4: Mixed cropping of maize with Dolichos lablab. Arusha Tanzania

Module 4: CA Practices, Innovations and Technologies

Important Note: Learners taking this module must study Module 1 first, which introduces Conservation Agriculture. Therefore, the introductory elements have not been repeated in this module.

Preamble

Whereas Conservation agriculture is recognized as an age-old practice, its documentation remains far from adequate. Its origin is very close to nature that is the traditional communities all over the world. The current literature on conservation agriculture is drawn from practices of several traditional communities and blended with more recent developments in agroforestry as well as concepts and practices in biodiversity conservation. Research in Conservation Agriculture has contributed significantly to current literature and strengthened the scientific base.

The recent thrust to make agriculture climate-smart is elevating the importance of conservation agriculture. All these have resulted in the synthesis of the driving principles of Conservation Agriculture to just three elements: *Limited or no tilling*, *Permanent Soil cover* and *Crop diversification and Rotation*. Despite the deceptive simplicity of these three principles, the actual design and practice of Conservation Agriculture are quite complex especially in implementation. This module captures the essence of CA, brings out the science and innovations involved and captures the short- and long-term benefits.

Learning Objectives

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

- Explain the principles and importance of Conservation Agriculture
- Compare CA with conventional Agriculture with regard to benefits and challenges
- Develop suitable CA interventions in a farming environment
- Train and Promote the application and scaling up/out of CA interventions by farmers
- Monitor and evaluate the effectiveness of CA interventions
- Develop or incorporate CA in projects
- Advice policy makers on CA

Module Synopsis

Overview: Characterization of farming practices: social, economic, cultural and biophysical conditions; policy situation, state of knowledge and skills, willingness to invest in CA. Economic and ecological challenges.

No-till or no-till seeding or planting and no-till weeding: Farm preparation innovations (vegetation clearing), CA planting techniques, weed management, surface water management, CA mechanization. Benefits of no till.

Permanent soil cover: Types of mulch, mulching configurations (spatial arrangements), Effects of mulch depth, microbial degradation of mulch, Soil water management, Drought tolerance, Soil carbon management, Soil pH tolerance management, Temperature management across the soil profiles, Fertility management. Soil microbial interactions, Optimising crop root systems to enhance capture of soil water and nutrients, Managing soil-borne pathogens, Cover crop types and management.

Diversified cropping system through rotations and associations: Selection of compatible species/varieties of annuals and perennials including legumes, plant-plant relations, minimizing competition for growth resources, allelopathy and commensalism, parasite management, Rhizosphere management (root morphology and physiology, soil air (N2, O2 and CO2), Flood and drought tolerance (part of water management), growth cycles management, mycorrhizal associations and management.

Agroforestry: Crop-livestock-tree associations, shade management, nutrient and water dynamics across seasons, fodder species selection and management, Evergreen Agriculture.

CA system management: No-till seeding and weeding interlinked with mulch cover and diversified cropping system, along with complementary Good Agricultural Practices including controlled traffic if necessary, integrated pest management, Integrated water management, Integrated Soil Fertility Management, labour and farm power management, and mechanization including cover crop management and harvesting systems.

Landscape restoration: Restoration science, wetlands, degraded landscapes, costs of conversion from conventional agriculture to CA. CA business models.

Learning Resources:

i) Kassam, A., and Friedrich, T., 2011. Conservation Agriculture: Principles, Sustainable Land Management and Ecosystem Services.

ii) Kassam, A., Friedrich, T., Shaxson, F. and Pretty, J. 2009. The spread of Conservation Agriculture: justification, sustainability and uptake. Int. J. Agric. Sust. 7(4):293-320.

iii) FAO 2001. The Economics of Conservation Agriculture. Rome: FAO.

iv) Sapkota, T., Ba`rberi, M., Silvestri, A. 2012. Fifteen years of no till increase soil organic matter, microbial biomass and arthropod diversity in cover crop-based arable cropping

systems. Agronomy for Sustainable Development, Springer Verlag/EDP Sciences/INRA, 2012, 32 (4), pp.853-863.

v) Shaxson, T. F, Kassam A., Friedrich, T., Boddey, R., Adekunle, A. 2008. Underpinning Conservation Agriculture's Benefits: The Roots of Soil Health and Function. Integrated Crop Management Vol.6, FAO, Rome.

vi) Lalani, B. P., Dorward, D., Holloway, E., and Weuter, S. 2016. Smallholder Farmers' Motivation for Using Conservation Agriculture and the Roles of yield, Labour and Soil Fertility in Decision Making. *Agricultural systems* 146: 80-90.

vii) Rodrigo de Souza, W. 2011. Microbial Degradation of Lignocellulosic Biomass Institute of Biology, State University of Campinas (UNICAMP), Brazil.

Indicative duration

90 lecture hours and 60 hours of practicum

Practicum

Laboratory: 40 hours of mainly soil and plant analyses under different conditions

Fieldwork: 20 hours, complementing laboratory work and also experiences from preceding subject areas.

Assessment methods

Continuous assessment (30%) Practicum (30%) Final examination 40%.

Figure 5: Enhanced performance of sorghum under Faidherbia albida, Burkina Faso

Module 5: Economics and Business of CA

Preamble

In a world dominated by business and profit making it is hard to market innovations that are only socially and ecologically beneficial and businesswise non-profitable. Farmers' attraction to CA must primarily be driven by its profitability. This module traces the possible areas of savings in investment in CA to money making in the sale of CA products and service. In the long term, CA's contribution to the carbon sink and sustenance of land productivity are benefits that can also be monetized. All too often, farmers do not put value on their labour or time. However, reductions in labour allow farmers to use their spare time to relax, socialize, or undertake other income earning tasks. This is also part of the economic analysis. This module will have much more practical engagement with farmers and assignments to design and assess business and innovations and very limited classroom lectures. The learners have to be very creative.

Learning Objectives

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

- Analyze the profitability and benefits of CA
- Innovate in CA practices to improve efficiency and productivity
- Design and promote tools/equipment to ease CA work
- Develop and manage business enterprises involving CA products and Services
- Develop processes for refinement of CA products
- Harness and use green energy options
- Develop niche markets for CA products, and branding/patenting
- Promote investment in CA projects

Module Synopsis

Cost-benefit analysis of CA: Labour input analysis at different stages in the cropping season as compared with conventional agriculture – land preparation, planting, mulching, weeding and harvesting; savings in use of expensive agricultural machinery/tools; development of new mechanization tools that ease the farmers work such as the sub-soiler already being used to support direct sowing, savings arising from reduced use of inorganic fertilizers and pesticides; and irrigation savings/losses. There are also opportunities to access carbon and other funds for environmental services or products generated and access to niche markets for CA products. Enterprise development and diversification, value addition, Marketing, CA service provision, Green energy.

CA mechanization: Designing new labour-saving tools/machinery for CA, manufacture and marketing.

Innovations and entrepreneurship: Adoption and up scaling of CA innovations; Commercialization of CA technologies and products; Participatory design of CA interventions, Monitoring and Evaluation of CA farms and projects. Branding products, property rights.

Learning Resources:

Akpalu, W. and Ekbom, A. 2010. Bio-economics of conservation agriculture and soil carbon sequestration in developing countries. University of Gothenburg, Sweden.

Economics and Profitability of Conservation Agriculture http://www.fao.org/ag/ca/5.html

FAO, 2011. Payments for Environmental Services from Agricultural Landscapes http://www.fao.org/es/esa/PESAL/PESmaterials7.html.

World Bank, 1997. Expanding the Measure of Wealth: Indicators of Environmentally Sustainable Development. Washington DC: Environment Department, World Bank

Hobbs, P. R., 2007. Conservation agriculture: what is it and why is it important for future sustainable food production?, *Journal of Agricultural Science* 145: 127–137

D.S. White, R.A. and Labarta, E.J. 2005. Leguía Technology adoption by resource-poor farmers: considering the implications of peak-season labor costs

Agricultural Systems 85: 183-201

Waddington, S.R. and Karigwindi, J. 2001. Productivity and profitability of maize + groundnut rotations compared with continuous maize on smallholder farms in Zimbabwe. *Experimental Agriculture* 37 (1): 83-98

Varner, B.T., Epplin, F.M. and Strickland, G.L. 2011. Economics of no-till versus tilled dryland cotton, grain sorghum, and wheat *Agronomy Journal* 103 (5): 1329-1338

Uri, N.D. 1999. The economic benefits and costs of conservation tillage 1999. *Journal of Sustainable Agriculture* 15: 5-26

Mazvimavi, K. and Twomlow, S. 2009. Socioeconomic and institutional factors influencing adoption of conservation farming by vulnerable households in Zimbabwe. *Agricultural Systems* 101 (1–2): 20-29

FAO, 2001. Food and Agriculture Organization of the United Nations (FAO) The Economics of Conservation Agriculture. Food and Agriculture Organization, Natural Resources Management and Environment Department. FAO Corporate Document Depository

Indicative duration

30 lecture hours, 12 weeks field practicum

Practicum

Laboratory: largely workshop time to develop new tools, as may be needed.

Field work: 12 weeks to design and test tools that make CA work less arduous manually. Business incubation CA products. These involve intensive work with farmers. Learners choose one of 3 areas – CA tools design and testing, Business incubation or landscape restoration.

Assessment methods

Coursework assessment (10%), Practical work assigned as project/business design (60%), Final examination (30%)

Module 6: Cross Cutting Aspects

Preamble

This module is intended to equip the learner with knowledge and skills to become immediately effective after completion of the CA course. Four pathways are envisaged: i) Engagement with farmers in making CA innovations work – includes research ii) Promoting CA, particularly to access conservation-oriented funds and iii) Policy and institutions development and iv) Capacity building.

Research in CA is very crucial at this stage. While there have been many successful trials on CA, few have been designed to produce results that can be applied universally. Besides, precious few research projects have been designed to include the huge diversity of social and ecological conditions. More broad-based research initiatives are needed.

The roles of various components of society, especially men, women, youth indigenous communities, physically challenged persons in CA need to be analysed.

In most countries, the ministries responsible for Agriculture may have heard about

conservation agriculture, but precious few have any plans to include it in their policies or strategies. This is probably because it is poorly promoted to emphasize the ecological benefits, underplaying the business aspects. New thrusts are needed in this area.

Currently available extension services in Africa do not include conservation agriculture for two main reasons. First, the extension personnel have not been trained in this area. Second, the promotion of conventional agriculture is accompanied by resources that are hard to find in CA. These include knowledge products, germplasm, equipment and agrochemicals. A form of re-orientation is essential.

All too often, CA is promoted as an alternative to conventional agriculture. This perspective may be counterproductive. Rather, it should be an approach to improve conventional agriculture.

Learning Objectives

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

- Explain Conservation Agriculture initiatives and challenges around the world
- Undertake CA research and publish results in appropriate media
- Provide guidance on youth and gender aspects relating to CA projects
- Support development of supportive policies for CA
- Train farmers and extension personnel in CA

Module Synopsis

Global perspective: CA activities around the world, case studies, failures and successes

Research tooling: Design of CA experiments, social and cultural aspects, ecological considerations, productivity, profitability. Generating databases, publishing and communicating research findings. Policy analysis and development. Gender issues and mainstreaming. Youth challenges and their future in CA.

Capacity Development: Analysis of the state of knowledge, training needs assessment, design of training courses at different levels and for different clients, development and implementation of training courses. Monitoring and evaluating capacity.

Policy development and implementation: State of policy with respect to CA, challenges involved in linking CA to conventional agriculture, way forward at different levels from the farmer to the ministry responsible for Agriculture. Social and cultural aspects, Human Youth and gender, legislation and institutions.

Communication: Information management, Collaboration and networking at all scales. .

Learning Resources:

Kassam, A., Basch, G., Friedrich, T., Shaxson, F., Goddard, T., Telmo, J. C., Crabtree, B., Hongwen, L., Mello, I., Pisante, M., and Mkomwa, S. 2013. Sustainable Soil Management Is More than What and How Crops Are Grown. In: R. Lal and Stewart, R.A (Eds) *Principles of Soil Management in Agro-ecosystems*. Advances in Soil Science. CRC Press.

African Development Bank, 2011. Mainstreaming Gender Equality: A road to Results or a Road to Nowhere, Operations. Evaluation Department, May 2011, Tunis.

Dala-Clayton, B. and Steve Bass, S. 2009. The Challenge of environmental mainstreaming: Experience of integrating environment into development institutions and decisions, London.

DAC Network on Gender Equality, 2013. Gender equality, women's empowerment and development effectiveness: Policy and political dialogue on gender equality and women's empowerment at the country level, Issues brief 7, OECD Publishing, Paris.

European Institute for Gender Equality, 2013. Mainstreaming gender into the policies and the programmes of the institutions of the European Union and EU Member States – Good practices in gender mainstreaming, Luxembourg, 2013.

DFID, 2001. Achieving Sustainability: Poverty Elimination and the Environment. DFID Target Strategy Paper, London: DFID

Indicative duration

40 lecture hours with extensive reading plus 30 practical hours

Practicum

Laboratory: None

Fieldwork: Data collection based on the design of a research project or a training course development or a policy initiative (3 weeks)

Assessment methods

Continuous assessment (20%) Final Examination (40%) field research write up (40%).

4.3 A Note on Examinations Weighting

The proposed weighting of continuous assessment tests 20%, final examination 40% and field/laboratory work 40 % is deliberately tilted to favour the development of practical skills. Where there is no practicum then continuous assessment can be raised to 40% and final examination 60% or as deemed fit.

For the final assessment it is important to take into consideration the overall weighting of each module which in this curriculum is the overall duration time. When users of this curriculum only select certain topics to feed into existing courses, it is expected that the weighting will follow the overall content of the course and in relation to other courses in the curriculum.

Exposure to projects is very important. The students may carry out special studies in some aspects of Conservation agriculture as a way of strengthening their practical skills in the final year of study. Teaching institutions are expected to adapt these ideas to their regulations as they deem fit.

5 CONCLUDING REMARKS

This Curriculum Guide is a living /dynamic document which is expected to transform according to the institutional environment where it is applied in the light of experience, and as new information becomes available. The best way to improve it is to use it and determine its effectiveness and weaknesses. The authors recommend that it is fully reviewed within five years, basing on assessments by institutions that use it wholly or in part. That way, it will improve in terms of relevance and effectiveness. It is instructive to recognize that good practices that cannot be scientifically explained are just that … good practices. Let us use scientific methods to prove that indeed they are good because their results can be explained and repeated in similar conditions.

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