# Climate-Smart Agriculture Manual for Agriculture Education in Zimbabwe

**Ngara, Todd**

*Publication date:*
2017

*Document Version*
Publisher's PDF, also known as Version of record

# Climate-Smart Agriculture Manual

## for Agriculture Education in Zimbabwe

# Climate-Smart Agriculture Manual

## for Agriculture Education in Zimbabwe

**Edited By**

**Todd Ngara**

UNEP DTU Partnership

Climate Technology Centre & Network
UN City, Marmorvej 51
DK-2100 Copenhagen, Denmark
+45 4533 5372
www.ctc-n.org
ctcn@unep.org

ISBN 978-87-93458-21-5

Design:
Magnum Custom Publishing
New Delhi, India
info@magnumbooks.org

A digital copy of this report can be downloaded from http://www.ctc-n.org/



This document may be cited as: Climate-Smart Agriculture Manual for Zimbabwe, Climate Technology Centre and Network, Denmark, 2017

# Contents

# List of Tables, Figures, and Boxes

## List of Tables



## List of Figures

## List of Boxes

# Abbreviations

| | |
|---|---|
| ACARN | Advisory Committee on Agricultural Resilience in Nigeria |
| ACRE | Agriculture and Climate Risk Enterprise |
| AEZ | Agro-ecological Zone |
| AfDB | African Development Bank |
| AGRITEX | Agricultural Technical and Extension Services |
| ANAF | Aquaculture Network for Africa |
| ANAFE | Agriculture, Agroforestry and Natural Resources Education |
| CA | Conservation Agriculture |
| CAFOD | Catholic Agency for Overseas Development |
| CAMPFIRE | Communal Areas Management Programme for Indigenous Resources |
| CBD | Convention on Biological Diversity |
| CBI | Crop Breeding Institute |
| CCAFS | Climate Change Agriculture and Food Security |
| CFS | Climate Field Schools |
| CGIAR | Consultative Group on International Agricultural Research |
| CI | Climate Information |
| CIAT | International Center for Tropical Agriculture |
| CIMMYT | International Maize and Wheat Improvement Center |
| CIS | Climate Information Services |
| COMESA | Common Market for Eastern and Southern Africa |
| CRS | Community Resilience and Sustainability |
| CSA | Climate-smart Agriculture |
| CSC | SADC Climate Services Centre |
| CSIS | Climate Services Information Systems |
| CSP | Concentrated Solar Power |
| CTCN | Climate Technology Centre and Network |
| CTDO | Community Technology Development Organisation |
| DAPA | Decision and Policy Analysis Program |
| DRSS | Department of Research and Specialists Services |
| DTMA | Drought Tolerant Maize for Africa |

| | |
|---|---|
| EA | Environment Africa |
| EC | Energy Conservation |
| EE | Energy Efficiency |
| EM | Energy Management |
| EMA | Environmental Management Authority |
| EMS | Energy Management System |
| ENSO | El Niño Southern Oscillation |
| ESCOs | Energy Service Companies |
| EU | European Union |
| FAO | Food and Agriculture Organization |
| FAWEZI | Forum for African Women Educationalists Zimbabwe Chapter |
| FEWS NET | Famine Early Warning Systems Network |
| FNI | Integrated Food, Nutrition and Income Security Programme |
| FPH | Fish-protein Hydrolysate |
| FPI | Fish-protein Isolates |
| FTS | Fertiliser Tree Systems |
| GERPMI | Gender-Responsive Economic Policy Management Initiative |
| GFCS | Global Framework for Climate Services |
| GHGs | Greenhouse Gases |
| GIEWS | Global Information and Early Warning System |
| GiHUB | Green Innovation Hub |
| GRP | Gender-responsive Pedagogy |
| HAP | Household Air Pollution |
| HFP | Homogenised Fish Protein |
| IBLI | Index-Based Livestock Insurance |
| ICRISAT | International Crops Research Institute for the Semi-Arid Tropics |
| ICT | Information Communication Technologies |
| IFAD | International Fund for Agricultural Development |
| IITA | International Institute of Tropical Agriculture |
| ILRI | International Livestock Research Institute |
| ILUP | Participatory Integrated Land-use Planning |
| INDCs | Intended Nationally Determined Contributions |
| IPCC | Intergovernmental Panel on Climate Change |
| IRENA | International Renewable Energy Agency |

| | |
|---|---|
| LEAP | Livelihoods, Early Assessment and Protection |
| LPG | Liquefied Petroleum Gas |
| MAP | Mean Annual Precipitation |
| MoAMID | Ministry of Agriculture, Mechanisation and Irrigation Development |
| MSD | Meteorological Services Department |
| NACOF | National Climate Outlook Forum |
| NAMAs | Nationally Appropriate Mitigation Actions |
| NAPs | National Adaptation Plans |
| NCCRS | National Climate Change Response Strategy |
| NDEs | National Designated Entities |
| NDVI | Normalized Difference Vegetation Index |
| NGOs | Non-governmental Organisations |
| NMHS | National Meteorological and Hydrological Services |
| NPP | Net Primary Production |
| NTFPs | Non-timber Forest Products |
| NUST | National University of Science and Technology |
| OPV | Open Pollinated Varieties |
| PPP | Public-private Partnerships |
| PV | Solar Photovoltaics |
| PVGIS | Photovoltaic Geographical Information System |
| RARP | Rural Agro-dealers Restocking Programme |
| RAS | Recirculation Aquaculture Systems |
| RE | Renewable Energy |
| REDD+ | Reducing Emissions from Deforestation and Forest Degradation |
| RET | Renewable Energy Target |
| RUFORUM | Regional Universities Forum for Capacity Building in Agriculture |
| SADC | Southern Africa Development Community |
| SADC | Southern African Development Community |
| SARCOF | Southern Africa Regional Climate Outlook Forum |
| SAZ | Standards Association of Zimbabwe |
| SDGs | Sustainable Development Goals |
| SEU | Significant Energy Users |
| SFM | Sustainable Forest Management |
| SIRDC | Scientific and Industrial Research and Development Centre |

| | |
|---|---|
| SMS | Short Message Systems |
| SNV | Netherlands Development Organisation |
| UDP | UNEP DTU Partnership |
| ULKRS | University Lake Kariba Research Station |
| UMP | Uzumba-Maramba-Pfungwe |
| UNCCD | United Nations Convention to Combat Desertification |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UNIDO | United Nations Industrial Development Organization |
| UN-REDD | United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation |
| WFP | World Food Programme |
| WII | Weather Index-based Insurance |
| WMO | World Meteorological Organization |
| ZAIP | Zimbabwe Agriculture Investment Plan |
| ZFU | Zimbabwe Farmers Union |
| ZimASSET | Zimbabwe Agenda for Sustainable Socio-Economic Transformation |
| ZINWA | Zimbabwe National Water Authority |
| ZPWMA | Zimbabwe Parks and Wildlife Management Authority |

# Foreword by the Government of Zimbabwe

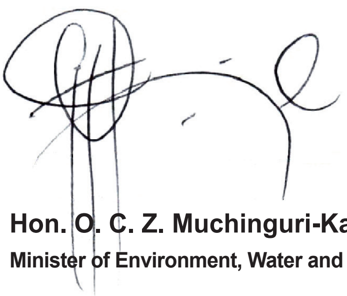
Zimbabwe views climate change as a direct threat to its socio-economic development with the potential of reversing the hard earned developmental gains achieved since independence. According to observations and scientific studies, climate change has resulted in an increase in the average temperature and high inter and intra-seasonal rainfall variability and in extreme cases flooding and droughts for Zimbabwe. This has largely affected water resources availability for agricultural purposes and inevitably reduced agriculture production which supports over 70% of the country's rural population for their livelihoods mainly through rain-fed agricultural systems. The impacts of climate change on agriculture production have rendered a significant proportion of households food and nutrition insecure and consequently having to rely on food aid while climate projections show that conditions will worsen.

There is growing drive the world over to increase climate action through scaling up both climate change mitigation and adaptation interventions. The Government of Zimbabwe in partnership with its stakeholders have prioritised national actions that build climate resilience, lower the country's greenhouse gas emissions (GHGs), and contribute to sustainable development. In this regard, we have actively welcomed innovations and programmes such as Climate-smart Agriculture (CSA). CSA practices are expected to sustainably increase productivity and resilience (adaptation), reduce GHGs (mitigation), and enhance achievement of national food security as well as sustainable development goals. CSA is widely expected to contribute towards achieving the objectives of the Paris Agreement to "hold" the temperature increase below 2°C and enhance climate change adaptation.

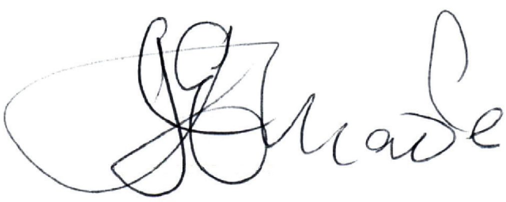
CSA practices have since been identified in Zimbabwe's National Climate Policy, National Climate Change Response Strategy (NCCRS), Intended Nationally Determined Contribution (INDC), Zimbabwe Agriculture Investment Plan (ZAIP) and the Draft Comprehensive Agriculture Policy as a priority intervention as the country steps up efforts to tackle climate change. Furthermore, CSA training was identified as a sustainable mode to enhance CSA adoption in the country hence the development of this Manual. As Ministries, we are grateful that this timely Manual will be a robust resource material primarily for agriculture colleges in Zimbabwe and extension officers working in various parts of the country. The graduates of the colleges of agriculture will be better prepared to carry out farmer trainings and outreaches to promote new climate-smart principles and practices.

The use of this manual is expected to transform the country's agriculture sector into a sustainable production system by maximising the climate opportunities and reducing climate change related risks on the agriculture sector.

The Government of Zimbabwe would like to thank the Climate Technology Centre and Network (CTCN) for the technical assistance to develop this manual, Green Impact Trust – the request proponent, UNEP-DTU Partnership lead implementer of the technical assistance, VUNA for providing additional support towards delivering the manual and all those who made it possible to have this manual produced.



**Hon. O. C. Z. Muchinguri-Kashiri**
**Minister of Environment, Water and Climate**



**Hon. Dr. J. M. Made**
**Minister of Agriculture, Mechanisation and Irrigation Development**

# Foreword by CTCN

In the past 30 years, Zimbabwe has seen the frequency and length of dry spells during its rainy season increase, while the frequency of rainy days has declined. As the country relies heavily on rain-fed agriculture, climate change poses a serious threat to food and livestock production. 'Climate-smart agriculture' represents an approach to transforming and reorienting agricultural development in response to such climate change pressures. Given that Zimbabwe's agricultural colleges are considered centres of excellence in promoting best practices in agriculture, the Zimbabwean Ministry of Environment, Water and Climate, together with the Green Impact Trust, recognised the importance for these colleges to incorporate a new curriculum based on transitioning to climate-smart technologies. They therefore requested the Climate Technology Centre and Network's technical assistance to mainstream climate-smart considerations and solutions into the agricultural educational system in order to reinforce the country's resilience to climate change among other benefits.

The Climate Technology Centre and Network (CTCN), the implementation arm of the United Nations Framework Convention on Climate Change (UNFCCC) Technology Mechanism, promotes the accelerated transfer of technologies for energy-efficient, low-carbon and climate-resilient development. As nations around the world seek to fulfil their development goals in an increasingly sustainable and environmentally sound manner, the CTCN aims to serve as a trusted partner by providing expert policy and technology support. At the request of nationally-selected representatives (National Designated Entities, or NDEs), the Centre harnesses the expertise of its global network of over 350 finance, NGO, private sector, and research institutions, along with CTCN hosts, UN Environment and the United Nations Industrial Development Organization (UNIDO), to deliver tailored assistance and capacity building in a broad range of sectors including agriculture, energy, transport, water and waste management.

In response to Zimbabwe's request, the CTCN collaborated with Zimbabwean NDE, the UNEP-DTU Partnership, and other key national counterparts including the Ministry of Environment, Water and Climate; the Ministry of Agriculture, Mechanisation and Irrigation Development; and Zimbabwe's universities and agriculture colleges, to develop the *Climate-Smart Agriculture Manual for Agriculture Education in Zimbabwe*. This manual will be complimented by a capacity building process, including training of trainers, which will enable broader dissemination to agriculture students and extension workers across the country. We are deeply grateful to all of our partners for their work and for Zimbabwe's tireless involvement and support in the undertaking of this initiative.

My sincere hope is that this manual will contribute to the further integration of a climate-smart approach in agricultural education and that future Zimbabwean extension workers, agriculture entrepreneurs and smallholder farmers will be better equipped to increase productivity and incomes, build resilience to climate change, reduce greenhouse gas emissions where possible, and ultimately, enhance the achievement of Zimbabwe's national food security and development goals.

Sincerely,

**Jukka Uosukainen**
**Director, Climate Technology Centre and Network**

# Acknowledgements

The Government of Zimbabwe and the CTCN would like to specially thank and acknowledge the Zimbabwean CTCN NDE, Mr. Elisha N. Moyo and the UNFCCC Focal Point, Mr. Washington Zhakata and the Deputy Director of MoAMID Mr. Francis Borgia Vengai for technical coordination and strategic guidance for the *Climate-smart Agriculture Manual for Agriculture Education in Zimbabwe*.

The Government of Zimbabwe and the CTCN would also like to thank the following individuals for reviewing the Manual:

| | | |
|---|---|---|
| CIAT- CCAFS | : | Dhinesh Dhanush |
| AIT (Thailand) | : | Victor Shinde, Peeyushi Soni, Sanyogita Andriyas |
| CSIR (South Africa) | : | Julia Mambo, Miriam Murambadoro, Sasha Naidoo, Emma Archer |
| CATIE (Costa Rica) | : | Andreas Oswald, Bastiaan Louman |
| CARE (Denmark) | : | Karl Deering |
| UDP | : | Astrid Solvej Lund Andersen, Kenneth Gondwe, Kelly Dorkenoo, Natacha Chater Cure |
| Genetics Analytics | : | Manyewu Mutamba, Kurauone Murwisi |
| MEWC | : | Kudzai Ndidzano, Elisha Moyo, Veronica Jakarasi, Emily Matingo, Tatenda Mutasa, Washington Zhakata. |

In addition, the Ministries of Agriculture, Mechanisation and Irrigation Development; and Environment, Water and Climate would like to thank the following:

- Climate Technology and Centre Network for providing the funds for the development of the Climate-smart Agriculture Manual;
- UDP for leading the development process;
- Green Impact in their capacity as project proponent;
- Academic institutions and agriculture colleges for their input;
- National Project Co-ordinator for taking a lead on logistics for project workshops; and
- Agriculture experts from allied institutions and NGOs for their constructive comments.

Gratitude also goes to VUNA, a DFID-funded regional Climate-smart Agriculture (CSA) programme implemented by Adam Smith International for co-financing the Manual's development. VUNA works in five countries in Eastern and Southern Africa to build climate resilience of smallholder farmers by contributing CSA evidence, promoting enabling environments for smallholder farmers, and innovating agricultural business models. Read more about Vuna at www.vuna-africa.com.

# Authors of the Climate-smart Agriculture Manual

| Chapter | Name | Institution |
|---|---|---|
| Introduction | Todd Ngara | UNEP DTU Partnership |
| 1. Institutional arrangements and policy engagement | Juliet Gwenzi | University of Zimbabwe, Department of Physics |
| 2. Climate information services | Dorah Mwenye | Department of Research and Specialist Services, Zimbabwe |
| 3. Weather index-based insurance as a CSA strategy | Todd Ngara | UNEP DTU Partnership |
| 4. Gender and social inclusion | Sophia Huyer and Mary Nyasini | Climate Change Agriculture and Food Security (CCAFS) |
| 5. The landscape approach | Todd Ngara | UNEP DTU Partnership |
| 6. Soil and water management in climate-smart agriculture in Zimbabwe | Temba Nkomozepi | Independent Consultant, Harare, Zimbabwe |
| 7. Crop production | Catherine Ziyomo | Agriculture Research Trust, Zimbabwe |
| 8. Climate-smart agriculture in livestock and rangeland management in Zimbabwe | Irvine Mpofu | Chinhoyi University of Technology, Department of Animal Production and Technology |
| | Walter Svinurai | Marondera College of Agriculture Sciences and Technology, University of Zimbabwe |
| 9. Sustainable forest management and agroforestry | Elizabeth Mujuru | Bindura University, Department of Environmental Science, Zimbabwe |
| 10. Fisheries and aquaculture in Zimbabwe | Mzime-Ndebele Murisa | Chinhoyi University of Technology, Department of Freshwater and Fisheries Sciences |
| | Maxwell Barson | University of Zimbabwe, Department of Biological Sciences |
| | Nyasha Mabika | University of Zimbabwe, Department of Biological Sciences |
| 11. Energy management in agriculture | James Madzore | Scientific and Industrial Research and Development Centre (SIRDC), Zimbabwe |
| | Benson Zeyi | Scientific and Industrial Research and Development Centre (SIRDC), Zimbabwe |
| | Raul Polato | Padua University, ETIFOR Srl – Forests Ideas Responsibility, Italy |
| 12. Climate-smart Agriculture in Zimbabwe—the way forward | Raymond Zvavanyange | Independent Consultant, Harare, Zimbabwe |
| | Desire Nemashakwe | Green Impact, Harare, Zimbabwe |
| | Todd Ngara | UNEP DTU Partnership |

# Introduction

## Introduction and background

In Zimbabwe, the frequency and length of dry spells during the rainy season have increased in recent years—the consequences of which include increased heat and water stress on natural ecosystems, agricultural crops and livestock, which ultimately affects agriculture communities that depend on agro-based livelihoods negatively. In addition, Zimbabwe continues to use an agro-ecological map from 1960 which divides the country into five agro-ecological regions, in spite of the fact that some of these natural regions may have changed over time. This poses a threat to agriculture, economic growth and development as the climate continues to change.

On the other hand, Zimbabwe continues to depend on rain-fed agriculture, which poses a serious threat to food and livestock production. According to the Ministry of Agriculture, Mechanisation and Irrigation Development (MoAMID), in November 2015, at the launch of the National Climate Change Response Strategy, the country had only about 200,000 hectares of crop production under irrigation against a potential of five million hectares. Introduction and transition to climate-smart agricultural technologies in the Zimbabwean agricultural education system is vital, as agricultural educational institutions are centres of excellence, promoting best practices, especially to new smallholders. This would go a long way in helping Zimbabwe in securing food and nutrition security. About 70 per cent of Zimbabweans reside in rural areas where they rely on rain-fed agriculture for livelihoods. Unfortunately, the unreliable and intermittent rainfall patterns have resulted in low agricultural output and productivity, and food and nutrition insecurity.

Cognisant of the negative impacts of climate change on agriculture, MoAMID organised a National Curriculum Workshop on 25-26 July 2015 to review the courses offered in all government-run agricultural colleges. The workshop acknowledged that there is an urgent need to mainstream education in Climate-smart Agriculture (CSA) by offering national diplomas in all agricultural colleges, including Mazowe Veterinary College.

It was evident that there is a pressing need to provide adequate and effective training on climate change issues to agricultural extension workers so that they acquire expertise to impart CSA to rural farmers and build resilience to climate change. In addition, it was felt that there is also a need to mobilise support to ensure that this service provision is added into the mandate for extension workers.

Most farmers lack adequate knowledge of climate-smart agriculture and sustainable environmental practices, which further increases their vulnerability, as well as the risks to agriculture and the environment. Many smallholders continue to follow environmentally harmful practices, i.e., cutting down trees, slash and burn, flood irrigation and forest degradation. There is also widespread use of and dependence on synthetic fertilisers and harmful chemicals in crops and soils, which hinders the soil's capacity to retain moisture and nutrients.

The problems the country is facing in the agricultural sector mainly stem from climate change, unsustainable farming methods and the lack of training for extension officers on enhancing productivity, climate change adaptation and mitigation—i.e., climate-smart agriculture. The current agricultural education syllabus does not focus on climate-smart agriculture. With the country's low adaptive capacity, there is an urgent need to address agricultural education so as to develop sustainable solutions vis-à-vis food production, nutrition security, and economic growth and development.

In view of the above, the Ministry of Environment, Water and Climate, as the National Designated Entity (NDE) for the Climate Technology Centre Network (CTCN), requested CTCN for technical assistance to develop a Climate-smart Agriculture Manual for Professional-Level and University-Level Agricultural Education in Zimbabwe. This collaborative initiative involves MoAMID as the co-custodian of the CSA Manual, the Green Impact Trust as the request proponent, and the UNEP-DTU Partnership as the lead implementer. In addition to developing the CSA Manual, the project will also provide training to agriculture (extension) workers in the form of Training-of-Trainers after the launch of the CSA Manual.

### Projections for Zimbabwe's climate

Climatologically, Zimbabwe has an extremely variable rainfall distribution, which will be exacerbated by climate change. This will inevitably impact on agriculture and the availability of water to sustain human activities. These future climate change impacts are likely to aggravate the harmful effects of poor land-use practices, especially deforestation, soil degradation and water pollution. Communities that have been made vulnerable by economic hardship and disease will find it even harder to cope. Several studies (IPCC, 2014a) on the impacts of climate change in southern Africa (Zimbabwe included) show that from 2050 until the end of the century the following phenomena are likely to be observed (Konrad Adenauer Stiftung, 2015):

- A modest decrease in the total amount of rainfall (IPCC, 2014b) and changes in the onset and cessation of rainy seasons
- More frequent and prolonged mid-season droughts
- Reduced groundwater recharge
- Erratic spatial rainfall distribution across Zimbabwe
- Temperature increase between 1°C and 3°C, which is greater than the global average increases

These climate changes are likely to result in:

- Reduced water supply for domestic and agriculture uses
- The expansion and contraction of Natural Regions V and I respectively (Mugabe et al., 2013)
- Degradation of natural resources, especially soil, water, natural vegetation, crops and livestock
- Reduced food security because of negative impacts on agriculture

## Climate change impacts on agriculture

Zimbabwe's agricultural activities are threatened by climate change impacts on rainfall, as discussed in the previous section. Furthermore, poor land-use practices in the form of unsustainable soil and water management, compromised biodiversity and unsuitable choice of crops are resulting in degradation of the resource base within which agriculture is anchored. Climate change and variability will accelerate food insecurity, which is gaining traction insidiously in Zimbabwe.

It is predicted that increasing temperatures will result in more frequent occurrences of heat stress and increased infestations of pests and outbreaks of diseases, thus eroding the productivity of crops and livestock, as well as increasing expenditure on pesticides, herbicides and veterinary drugs. In addition, there are likely to be shifts of between four and six weeks in the onset and cessation of the rainy season (Mugabe, 2013, Lesolle, 2012). This implies shifts in planting and harvesting dates, as well as changes to the length of the growing season and to the types of crops and livestock that are suitable to these changes. This will result in increased demands for irrigation and increased strain on groundwater resources to support crops and livestock, especially in areas where water is climatologically scarce.

Livestock and wildlife will suffer equally from a lack of good pastures and vegetation due to erratic rainfall and heat waves associated with high temperatures. The frequency of fires, both natural and anthropogenic, is likely to increase due to a combination of dry vegetation and high temperatures.

Wheat, maize and horticultural growing areas will shift in tandem with changes to the agro-ecological zones mentioned above. The IPCC predicts maize yield losses of between 18% and 30% in southern Africa by 2050 (IPCC, 2014a) and also mentions the possibility of sorghum yields declining. Areas suitable for maize cultivation are projected to decrease by 2080. One study predicts that the south and west of Zimbabwe will become less suitable for growing sorghum and maize, while the north, central and eastern areas will support sorghum and cotton (Brown et al., 2012). Crops such as groundnuts, roundnuts and cassava could benefit from enhanced $CO_2$ levels (IPCC, 2014b), while areas suitable for sorghum and cotton cultivation are likely to increase by 2080.

## Need for climate-smart agriculture

Climate-smart Agriculture is defined by the Food and Agriculture Organization (FAO) as agriculture that sustainably increases productivity, enhances the resilience of livelihoods and ecosystems, reduces and/or removes greenhouse gases (GHGs) and enhances the achievement of national food security and development goals. The ravages of climate change and variability on agricultural production made it imperative for the government to call for the introduction of CSA practices into the tertiary education curriculum and agricultural extension advisory services—hence the need for the CSA Manual.

CSA includes proven practical techniques such as mulching, intercropping, conservation agriculture, crop rotation, integrated crop-livestock management, agroforestry, improved grazing and improved water management. It also involves the introduction of innovative practices such as more dependable weather forecasting, early-warning systems and climate-risk insurance. The climate-smart agriculture concept reflects the ambition of further integrating agricultural development and climate responsiveness. The concept aims to achieve food security and broader development goals in circumstances of a changing climate and increasing food demand. Increased planning is vital in order to address trade-offs and synergies between the three pillars of productivity, adaptation and mitigation (Vermeulen et al., 2012). By addressing challenges in the environmental, social and economic dimensions across productive landscapes, CSA practices coordinate the priorities of multiple countries and stakeholders in order to achieve more efficient, effective and equitable food systems. While the concept is new and still evolving, many of the practices that make up CSA already exist worldwide and are currently used by farmers to cope with various production risks. Mainstreaming CSA calls for critical analysis of successfully completed, on-going practices and their relationship with current and future institutional and financial enablers.

The role of higher and tertiary education in CSA includes research and development, networking and capacity-building. Capacity-building relates to both technical skills and knowledge diffusion. Tertiary institutions in Zimbabwe also participate in the provision of training materials for various stakeholders.

## CSA Manual approach and structure

Climate change impacts agriculture in different ways. The type of impact dictates the nature of the entry point when introducing CSA interventions. The three CSA pillars (productivity, adaptation and mitigation) can be handled at different levels—technological, organisational, institutional and political—hence the need for ease of identification, for which it is prudent to classify the entry points under three thematic areas: (a) enabling environments, (b) systems approaches, and (c) practices. Thereafter each entry point under each thematic area is analysed in terms of productivity, mitigation and adaptation potential. The ensuing chapters or entry points in this Manual follow this approach.

Planning and implementing CSA interventions entail grasping as well as identifying challenges and opportunities, proposing plans and solutions, implementing, and ultimately monitoring and evaluating. For example, in this regard, Climate Change Agriculture and Food Security (CCAFS) CSA analyses projects in four steps, viz. (Westermann, 2016):

i. Situational analysis: understanding the status of CSA endeavours and the vulnerabilities of prevailing contexts across several levels, i.e., environmental, administrative and political.

ii. Targeting and prioritisation: this implies streamlining an extensive list of potential practices, policies and services to a range of options that can attract financial support.

iii. Programme support: focusses on developing materials and plans for training and scaling up of interventions.

iv. Monitoring and evaluation: involves monitoring and evaluation of CSA plans and the development of tools and strategies to implement progress, evaluate impacts and enhance learning to improve project implementations and outcomes.[1]

In line with the discussion above, the arrangement of the chapters in the CSA Manual is as follows:

**Section I: Enabling environments**

- Institutional arrangements and policy engagement
- Climate information services
- Weather index-based insurance
- Gender and social inclusion

**Section II: System approaches**

- Landscape management

**Section III: Practices**

- Soil and water management
- Crop production
- Livestock and rangeland management
- Sustainable forest management and agroforestry
- Fisheries and aquaculture
- Energy management
- Climate-smart Agriculture in Zimbabwe—the way forward

## Mandate of the CTCN

The UNFCCC's CTCN assistance in the development of the Zimbabwe CSA Manual is consistent with its mandate to promote accelerated, diversified and scaled-up transfers of environmentally sound technologies for climate change mitigation and adaptation in developing countries, in accordance with their sustainable development priorities. As defined by the Intergovernmental Panel on Climate Change (IPCC), climate technologies cover any piece of equipment, technique, practical knowledge or skills for performing a particular activity that can be used to confront climate change. The United Nations Environment Programme-Technical University of Denmark Partnership [UNEP DTU Partnership (UDP)]—a member of the CTCN Consortium—is taking the role of lead implementer for this technical assistance. In the case of Zimbabwe, this assistance consists of technical expertise and recommendations related to specific technology needs associated with the development of the CSA Manual.

1 www.csa.guide

## References


1. Brown, D., Chanakira, R., Chatiza, K., Dhliwayo, M., Dodman, D., Masiiwa, M., Muchadenyika, D., Mugabe, P. and Zvigadza, S.2012. *Climate Change Impacts, Vulnerability and Adaptation in Zimbabwe.* IIED Climate Change Working Paper 3, October 2012: http://pubs.iied.org/pdfs/10034IIED.pdf, accessed August 2017.

2. Intergovernmental Panel on Climate Change (IPCC) 2014a. *Climate Change 2014a: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report.* IPCC, Geneva: www.ipcc.ch/report/ar5/syr/, accessed April 2017.

3. IPCC 2014b.Working Group II to the Fifth Assessment Report of Chapter 22: Africa. IPCC, 2014: *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.*

4. Konrad Adenauer Stiftung, 2015. *Climate Change in Zimbabwe.*

5. Lesolle, D. 2012. *SADC Policy Paper on Climate Change: Assessing the Policy Options for SADC Member States*: www.sadc.int/files/9113/6724/7724/SADC_Policy_Paper_Climate_Change_EN_1.pdf, accessed August 2017.

6. Mugabe, F.T., Thomas, T. S., Hachigonta, S. and Sibanda, L. eds. 2013. *Zimbabwe: In Southern African Agriculture and Climate Change: A Comprehensive Analysis.* Research monograph, International Food Policy Research Institute, Washington, DC: http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/127792, accessed August 2017.

7. Vermeulen, S.J., Campbell, B. M., and Ingram S.J.I., 2012. *Annual Review of Environment and Resources* 37: 195 -222

8. Westermann O., 2016. *Climate Smart Agriculture* 101, 2016

# Section I. Enabling environments

# 1. Institutional arrangements and policy engagement

## Abstract

Climate change has intensified the challenges faced by rain-fed agricultural systems. As a result, there is growing recognition of the need to harmonise protection of the environment, investment in smallholder agriculture and improving food production and productivity, while reducing carbon emissions and vulnerability to the impacts of climate change. Achieving sustainable food production calls for a paradigm shift that allows institutional arrangements and the creation of synergies focused on championing the components of Climate-smart Agriculture (CSA). While the Ministry of Agriculture, Mechanisation and Irrigation Development (MoAMID) and the Ministry of Environment, Water and Climate are the major players in the promotion of climate action, there is often a disconnect between these sister institutions, coupled with conflict between farmers and policymakers. A coordinated, legally binding institutional framework for the enforcement of CSA interventions is required given the need for greater coordination and integration among institutions. The instrument is designed to remove bottlenecks while ensuring concerted effort that maximises established synergies while minimising trade-offs between institutions and actors. The CSA policy should therefore be premised on a framework that is clear, scalable and inclusive, taking advantage of the entry points that already exist in the CSA technologies and practices undertaken by a number of state and non-state actors. These include the Department of Research and Specialists Services, the Agricultural Research Council, International Maize and Wheat Improvement Center (CIMMYT), Scientific and Industrial Research and Development Centre (SIRDC), Consultative Group on International Agricultural Research (CGIAR), Non-governmental Organisations (NGOs) and other similar research institutions. These actors have worked on a variety of CSA practices, such as drought-tolerant germplasm, the introduction of drought-tolerant maize varieties and livestock production. The absence of a legal framework guiding CSA operations has seen research institutions offering piecemeal training in the adoption of new technologies, taking into account local innovations and strengthening knowledge sharing at the individual level. This chapter highlights the CSA practices that can be used as entry points for the formulation of CSA policy and the governance of institutional arrangements.

**Key words:** climate-smart agriculture, entry points, inclusive, institutional arrangements, policy

## Key messages

By the end of this chapter, the reader should be able to:

i. Identify key institutions that can champion CSA and its implementation using existing policy instruments that recognise CSA as a technology for improving food security;
ii. Identify all existing entry points for CSA implementation and establish the capacity needs to improve the design and implementation of the programmes;
iii. Identify and list institutional arrangements that can be established in the implementation of CSA; and
iv. Recommend policy statements for input into the national CSA legal/policy framework.

## 1.1 Introduction

There is growing recognition of the need to reconcile environmental protection with smallholder agriculture by reducing carbon emissions, improving food production and productivity, and reducing vulnerability to the predicted impacts of climate change—in other words, CSA (Meinzen-Dick, et al., 2012). While advocating all these changes, policy and institutional arrangements need a paradigm shift to allow the creation of synergies that focus on and champion the components of CSA without creating bottlenecks. Zimbabwe has a number of policies and strategies relevant to climate change, some of which support CSA. The National Climate Change Response Strategy (NCCRS), and Zimbabwe's Intended Nationally Determined Contribution (INDC), pay particular attention to the inclusion of fully fledged CSA programmes that are sustainable and also foster resilience among smallholders. In particular, the INDC highlights the need for legislation to regulate CSA activities and promote the adoption of complementary technologies. The Comprehensive Agriculture Policy Framework (2012-2032) recognises the use of climate-smart technologies for sustainable food production in Zimbabwe. Other policy instruments in place, such as the Food and Nutrition Security Policy, the Zimbabwe Agriculture Investment Plan, the National Environmental Policy and Strategies (2009), the National Policy and Programme on Drought Mitigation, the Draft Disaster Risk Management Policy and Strategy, the Technology and Innovation Policy (2012), the Southern African Development Community (SADC), the Common Market for Eastern and Southern Africa (COMESA) and the Food and Nutrition Frameworks, only recognise the existence of climate change without describing how mainstreaming of the subject can be achieved. Lately, the National Climate Policy, which awaits government approval, has been developed to support CSA activities as recommended in the INDCs. These policies could be harmonised so as to give CSA its place and foster easy but fruitful collaboration among state and non-state institutions.

The Ministry of Agriculture, Mechanisation and Irrigation Development and the Ministry of Environment, Water and Climate are the major players in the promotion of climate action, but there is often conflict between farmers and policymakers, coupled with disconnection between sister institutions. CSA will require significant coordination and integration in order to reach landscape levels (Meinzen-Dick, et al., 2012; Williams et al., 2015). Sustainability, reducing vulnerability and increasing resilience call for major shifts in the way these institutions and actors interact (Steinecker, 2012). Legislation focused on CSA implementation is required to coordinate institutions and actors. Questions that should be addressed when setting the tone for climate-smart policy development include the following (Box 1.1):

***Box 1.1 Questions for climate-smart policy development***

Using the Economics and Policy Innovations for Climate-Smart Agriculture (EPIC) projects in Malawi and Zambia as examples: http://www.fao.org/climatechange/epic/projects/en/:

a. What policies supporting agriculture exist in Zimbabwe, and do they recognise climate change?
b. What entry points exist for Zimbabwe to support CSA through harmonised CSA policies?
c. What are the costs, benefits and barriers to the adoption of climate-smart practises by individual institutions?
d. What are the major components of a scalable strategic framework for the development of a CSA policy that recognises the strengths and differentiated ability levels of the different institutions and their involvement in the success of CSA?
e. Major institutions and players for the successful implementation of CSA in Zimbabwe need to be identified.

## 1.2 Mainstreaming CSA into national policies and programmes

CSA contributes to a wide range of developmental goals, especially for smallholders. It needs to be implemented using a cross-cutting, cross-sectoral approach to agriculture and food security and other aspects of sustainable development, poverty reduction and general development. CSA policies and programmes, as with all cross-sectoral development programmes, should be aligned with all levels of government. This calls for an understanding of the structure and functioning of each level of government. Comprehensive capacity-building needs to be developed, since in many developing countries local-level capacity development is not taken into account in decentralisation processes.

To create an enabling environment for the development and mainstreaming of CSA in the national development plan, appropriate institutions with effective and transparent governance structures are necessary. These institutions ought to coordinate the division of sectoral responsibilities and the associated mandates of national local institutions that will incorporate CSA practices into legal and regulatory frameworks. Regulations need to be adapted to country environments and accompanied by other supporting incentives if CSA interventions are to be successful in influencing behaviour by providing additional attractions in advocating CSA.

Civil society, the private sector and financial institutions play important roles in implementing CSA in their respective ways. These entities should jointly make a concerted effort to work with key national line ministries, development agencies and donors through an efficient stakeholder consultation process for the advancement of CSA practices.

Often, training and programmes promoting technology are designed to intervene at community level or sometimes with cooperatives. These require groups or individuals to cooperate with government programmes or market agents. A detailed understanding of how institutions or actors operate and interact is vital in the development of CSA policy development or the harmonisation of available policies in order to ensure that CSA technology-oriented programmes are inclusive (IIED, 2012). Grouping institutions according to their strength in CSA implementation and expertise allows strong synergies to be brokered using top-down, bottom-up and horizontal participatory processes and models. Research and higher education institutions will play a pivotal role in the development of CSA models, providing a balance among several institutions that are key to CSA implementation. The models identify the kinds of synergies and collaborations that could best bring out institutional strengths while compensating for institutional weaknesses in addressing climate change through CSA. Cooperatives offer the potential for smallholders to join together to gain bargaining power, but they often exclude certain actors through social biases such as gender and ethnicity (Mwangi, Markelova, and Meinzen-Dick, 2012).

In order to strike partnerships and introduce equity that promote productivity, resilience and carbon sequestration in CSA, no single sector or type of institution should be regarded as inclusive. Poorly designed interventions may fail to reach the intended recipients and therefore not address the pillars of CSA holistically. In creating synergies, inclusiveness should be an end in itself, rather than a means of achieving some of the goals of CSA. Once affirmative commitment exists, the coherence, coordination and integration of institutions in CSA should become the priority and focus of all institutions in order to avoid pitfalls that cause disconnection in CSA implementation.

## 1.3 Opportunities for mainstreaming CSA in policies and programmes of Zimbabwe

Achieving the necessary levels of success for CSA will require a concerted effort to maximise any synergies established and minimise trade-offs between institutions and actors. Therefore institutions and incentives should be put in place to achieve climate-smart transitions. This could be illustrated by examples from other developing countries. For example, in Nigeria, the Federal Ministry of Agriculture and Rural

Development has established the Advisory Committee on Agricultural Resilience in Nigeria (ACARN) to support the country's efforts in increasing the resilience of the agriculture sector. ACARN has developed a comprehensive National Agricultural Resilience Framework, which supports short-and long-term efforts to increase resilience, reduce vulnerability and improve food security.

Initiatives like those listed in Box 1.2 could be designed in such a way so as to include all interested institutions. Given a legislative framework, each partner would have to work to maximum capacity for best results, while also acknowledging shared ownership. In Box 1.2, the institutions are shown working towards improving food and nutrition security using climate-smart technologies. Therefore a legally binding framework would provide room for institutional reforms that can be adopted to promote the governance of CSA issues. As an example, providing free of charge weather and climate data for CSA programmes whilst partners improve observation networks provides a good cost and benefit situation for partners as well as communities.

***Box 1.2 Role of institutions in improving food security using climate-smart practices***

The Food and Agricultural Organization (FAO) and Community Technology Development Organisation (CTDO) worked together in some districts in Zimbabwe improving the livelihoods of communities through the provision of seed and indigenous small livestock. CTDO was the implementing agency. Livestock became a livelihood backup in the face of drought.

The Meteorological Services Department (MSD) worked together with Oxfam in the project "Strengthening weather and climate information dissemination" in Masvingo and Matebeleland provinces. MEWC is currently working with Oxfam, Plan International, Safire and the University of Zimbabwe in the project "Scaling up Climate adaptation in Zimbabwe, with a focus on rural livelihoods". These projects could have run concurrently.

Netherlands Development Organisation (SNV) has partnered with the Catholic Agency for Overseas Development (CAFOD) and Environment Africa (EA) in implementing the Integrated Food, Nutrition and Income Security Programme (FNI). In the project, households are able to increase and diversify production of crops and small livestock through use of climate-smart technologies.

## 1.4 Role of institutions in scaling up CSA

Policies and programmes are unlikely to be effective unless their implementation is supported by sound institutions. It is therefore important to enhance institutional capacities in order to implement and replicate CSA strategies. Institutions are vital to agricultural development as well as the realisation of resilient livelihoods. They are not only a tool for farmers and decision-makers, but are also the main conduit through which climate-smart agricultural practices can be scaled up and sustained (FAO, 2013).

The focus in this chapter is on institutions at three different levels, i.e., (i) building local institutional frameworks, (ii) strengthening the key role of meso-level institutions, and (iii) enhancement of the national institutional capacity to implement policy decisions. Other important formal institutions may include regional or supranational institutions in different contexts. Non-traditional actors may also include market and private-sector actors, such as insurance and agro-advisory companies, or other similar outfits.

### 1.4.1 Building local institutional frameworks

Support to climate change adaptation and mitigation among smallholders hardly works when it is imposed from outside: local institutional frameworks for the adoption of climate-smart agricultural practices at the

district and community levels must play a facilitating role. This means that institutional frameworks that support farmer-driven adoption and adaptation must be encouraged (Agrawal et al., 2009). Supporting such frameworks usually not only involves developing new institutions but also creating synergies between existing institutions to implement policies effectively.

### 1.4.2 Buttressing the role of meso-level institutions

Meso-level institutions, like local governments and local state agencies, are vital for energising national institutions to support communities in climate change adaptation and mitigation. On the other hand, they have limited access to funding, which is often monopolised by national-level institutions or stuck in administrative bottlenecks (Christoplos et al., 2014). Therefore, a vital but often trivialised institutional entry point is the strengthening of the mandate and access to funding of local governments and other institutions at the meso-level.

### 1.4.3 Working to enhance national institutional frameworks

Efforts to support CSA are stymied by a lack of the appropriate institutions, institutional capacity and coordination at the appropriate levels. As incentives, farmers need enabling conditions to make transformations on the ground, which ought to be facilitated by institutions and policies. State institutions are particularly important for the production and dissemination of information related to CSA strategies, i.e., technology options, climate variability and value chain conditions. In any case, national institutions take the lead in providing safety nets and insurance schemes for farmers. Some options for enhancing institutional efficiency include building human knowledge and capacities, strengthening institutional procedures, integrating climate change and CSA into strategic plans and policies e.g., Nationally Appropriate Mitigation Actions (NAMAs), National Adaptation Plans (NAPs), Intended Nationally Determined Contributions (INDCs), strengthening institutional and sector collaboration both horizontally and vertically, and analysing options for deconcentration and decentralisation (Anyonge et al., 2013).

## 1.5 Role of higher and tertiary education institutions and civil-society organisations in promoting CSA

Climate has changed over the years without an equal change in agricultural systems. Several CSA interventions have been proposed and implemented through a wide spectrum of models from the global to local scales. However, the success of new technologies and training programmes hinges to a large extent on the support offered by research and academic institutions, as well as on NGOs.

Several tools can be used to highlight the role of higher and tertiary institutions in promoting CSA. The tools become a checklist against which an institution is measured for its potential in promoting CSA.

### 1.5.1 Crop suitability

The agricultural systems of smallholders in Zimbabwe have been modified by climate change (Gwenzi and Mupuro, 2015). Multiple stressors have resulted in the loss of significant crop production (Gwimbi, 2009; Mapfumo et al., 2010). A business-as-usual approach among farmers in terms of crop production cannot overcome the challenges of extreme weather and climate shocks. Universities and research institutions working together with NGOs and extension staff and using participatory approaches have room to experiment, study weather and climate patterns, analyse and advise locals of the most suitable crops for an area using CSA practices. This leaves room for farmers to participate fully in the whole experimental process until the results become available from which they are able to decide on the most suitable crops for their area (Box 1.3). Such projects give smallholders ownership of the process and outcomes. Farmers are given an equal opportunity to choose from among many crop varieties, both indigenous and hybrids.

Potential universities that can articulate the programme should promote both local partnerships and private partnerships without prejudicing the smaller players. This can be accomplished in partnership with development agencies and NGOs.

***Box 1.3 Training of research institutions for crop suitability***

Biodiversity International, in collaboration with the Consultative Group on International Agricultural Research (CGIAR), has launched a programme in which they train research institutions in determining crop suitability. The materials have been developed jointly by the Walker Institute, University of Reading, UK, and the Decision and Policy Analysis (DAPA) programme at International Center for Tropical Agriculture (CIAT). Analogue tools that allow the researcher to identify, connect and map sites with statistically similar climates across space and time in order to answer crop suitability questions are used. The idea is to answer questions such as "Where in the world can I find a future (or present) climate comparable to the future (or present) climate of my location of interest?" This can be used to initiate the borrowing of similar concepts to develop locally specific adaptation and mitigation options that are pro-poor but fulfil the major goals of CSA in agricultural policy and planning. In 2015, the Community Technology Development Organisation (CTDO), together with the University of Zimbabwe, had initial training in using the tools. The success of such a programme can be used to influence policy.

### 1.5.2 Coordinate reform and define new investment for maximum positive impact

The success of CSA hinges on research institutions that are capable of efficiently coordinating research that has positive impacts on sustainability, resilience and food security. Higher and tertiary educational institutions should coordinate and drive the CSA vision and all its aspects in a strategic and scalable manner. A good example that local universities can copy is the TEAM-Africa concept: the Tertiary Education for Agriculture Mechanism for Africa. TEAM-Africa has established a network of African universities called the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) and the African Network for Agriculture, Agroforestry and Natural Resources Education (ANAFE). Among its key mandates is to engage in an analytical exercise that projects the rapidly changing locus of labour demand in Africa's food and agricultural systems. Similar ideas can be downscaled to country and local scale to promote good governance, policy formulation and skills in CSA.

### 1.5.3 Knowledge-sharing and networking

Universities, research institutions, extension workers and NGOs are in a good position to bring different stakeholders together, such as farmer communities, corporate organisations and government, including its agencies. Knowledge sharing and network platforms can take the form of master farmer and farmer field schools. These have been used mostly by extension staff to train farmers in agronomic practices. In recent years, the emergence of Climate Field Schools (CFS) (Stigter and Ofori, 2014) has boosted farmers' responses to climate change, for example, in Indonesia. CFS are schools without walls where farmers, researchers and extension staff meet, share experiences, identify problems, experiment, analyse and discuss the outcomes. The farmers learn by doing. Having a training component, the CFS trainer allows the cascading of information, knowledge and technology to grassroots levels, as training at these levels is carried out by lead farmers who have become role models for others. In Uzumba-Maramba-Pfungwe (UMP), to the northeast of Zimbabwe, farmers are now able to analyse locally measured data, giving them better understanding of local weather patterns. As a result, they now plan farm activities, including CSA practices, using local data. CSA policy formulation should consider CFS as an important tool for information dissemination, together with social gatherings and Roving Seminars. Most knowledge sharing initiatives

tend to provide farmers with overly technical information that is not easily understandable. The standalone CSA, while borrowing from several other policies in existence, should specifically support simplification of language and translation to community languages through the support of institutions of higher learning. The legislation should improve village governance and by-laws promoting CSA through prioritisation of the practice within the broader adaptation and mitigation programmes that already exist in an area. CSA policy harmonisation or development should be allowed to reach out to existing infrastructure which is easily accessible to smallholder famers.

### 1.5.4 Monitoring, advocacy and policy support

Extension staff need to actively monitor the impacts of climate change on agriculture, and progress in the implementation of CSA in close collaboration with scientists and farmers. Where governance structures are decentralised, extension officers play an important advocacy role to ensure that climate change remains high on every agenda and that funds are allocated to CSA programmes. They also have a role in explaining CSA practices to smallholders. The extension officers should be seen as the nodal points bringing together and facilitating multiple stakeholders to discuss and address complex CSA problems and situations. In light of the above, CSA advisory systems encompassing the institutions and actors involved in the provision of extension and closely related services should be set up to govern the operation of the system at the grassroots level.

## 1.6 Application of CSA in Zimbabwe

### 1.6.1 Seed production

The Department of Research and Specialist Services of Zimbabwe has fully supported CSA activities and collaborated with the International Maize and Wheat Improvement Center (CIMMYT) by providing oversight of drought-tolerant germplasm and seed production. Working together with the Crop Breeding Institute (CBI), the department has offered training to crop-breeding specialists and farmers. Through their work, drought-tolerant Open Pollinated Varieties (OPV) such as ZM309, ZM401 and ZM521 and hybrids such as ZS263 and ZS265 have been launched in the market. The seeds are distributed by the Champion, ARDA and Agriseeds companies.

### 1.6.2 Drought Tolerant Maize for Africa (DTMA)

In the last five years, CIMMYT and the CGIAR's Research Programme on Maize have bred and tested heat-tolerant varieties of maize suited to the local environment. In the 2015/16 season, CIMMYT conducted on-farm variety trials of heat-tolerant maize in Zaka and Chiredzi Districts, Masvingo, where farmers were able to harvest where all other varieties had failed. These varieties are expected to improve the country's food security. Smallholder Marutsvaka, who participated in the on-farm variety trials, says: "In the past, I harvested nothing, as my crops were literally burnt by the scorching heat. During the 2015-2016 growing season, I realised almost 200 kilograms of white grain."

Seed varieties which have been successfully tested and released on the market through seed houses include ZM309, ZM401, PAN3M-41 and SC301. These are distributed by Seedco and Pannar. Syngenta has also launched a drought-tolerant maize variety, MRI514. SIRDC also launched Sirdamaize 113, suitable for areas of marginal rainfall. Used in combination with good agricultural practices, they have performed better than other hybrid seeds. The Seed Services Institute has tried and tested high-yielding sorghum varieties (DC 75, and NS 511). Also being promoted are pearl millet varieties (PMV 3 and Okoshana), which are early maturing varieties, requiring only 75 days to mature.

### 1.6.3 Conservation agriculture

To date CSA has been promoted using methods such as Conservation Agriculture (CA). The FAO and other development partners supported more than 20,000 households in over 15,000 districts to implement CA between 2005 and 2010 (Marongwe et al., 2011). Yields were observed to increase progressively over the years, and the physical structure of the soil also improved. Since then there has been increased adoption of CA due to the benefits. Being labour-intensive, the method is not suitable for the elderly. Entry points for a fully-fledged CSA programme in Zimbabwe already exist from the work already done. Indigenous farming methods similar to CA technologies should be identified and used as entry points in CSA policy formulation. The active involvement of government systems in both research and extension will ensure sustainability. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has a number of CSA projects which promote CA in order to capitalise on soil moisture enhancement complemented by micro-dosing. Capacity-building of extension professionals in the approaches that can be used to implement CSA at the grassroots level can easily follow from CA training, though they need broadening to include a wide range of CSA concepts . There is a need to address the differences arising from different agro-ecological zones so that solutions are not prescriptive but rather flexible.

### 1.6.4 Capacity-building

Farmer Field Schools exist in a number of districts, some of which have been converted to CFS. This is another entry point which properly crafted policies should promote. CTDO, together with the Agromet Group (University of Zimbabwe), have collaborated in four districts (UMP, Goromonzi, Chiredzi and Tsholotsho) using the concept of CFS. Extension officers were trained in weather and climate issues, as well as the use of weather data, in response to farming and developing the agrometeorological advisories needed by smallholder farmers. In the project "Strengthening Weather and Climate Information Dissemination", the Meteorological Services Department (MSD) trained Agricultural Technical and Extension Services (AGRITEX) officers in the interpretation of weather and climate information for better dissemination to grassroots levels.

## 1.7 Recommendations

Previous CSA-aligned projects and programmes had flaws which could be corrected in a new CSA era. The lack of a water-tight system and standards to govern the implementation of programmes can result in the exclusion of some institutions and participants. Sustainable CSA interventions require a standalone CSA legal framework and policy that is inclusive. Such a policy can be developed through the harmonisation of existing entry points and recognition of the following:

- The practices and benefits in existing policies scattered around different ministries;
- The levels of awareness required to bring CSA issues to the forefront;
- Identifying all institutions (large and small) which have the capacity to champion CSA and cluster them according to function, highlighting potential synergies;
- Identifying key agricultural technologies and production systems across all sub-sectors that would be showcased as climate-smart; and
- Promote good CSA governance that allows enforcement of climate-smart agriculture interventions.

## 1.8 Conclusions

Successful CSA adoption will require a legal instrument (policy) that promotes it and offers a clear, scalable, inclusive, and standalone framework for CSA implementation. The instrument should clearly identify key institutions, supporting actors and possible synergies, highlighting the costs and benefits of implementation. Any policy formulation or improvement should consider existing programmes and plans and the coherence and integration between agricultural development and processes that achieve sustainable food security.

Policy instruments for CSA should be inclusive and support growth, as well as providing a framework for access to markets and knowledge sharing, locally and globally.

## References


1. Agrawal A, Kononen M, Perri N., 2009. *The role of local institutions in adaptation to climate change.* World Bank, Social Development Working Paper No 118. Washington DC. World Bank Group

2. Anyonge T, Jonckheere S, Romano, and Gallina A, 2013. *Strengthening Institutions and Organisations. Synthesis Report.* Rome, Italy: International Fund for Agricultural Development.

3. Christoplos I, Aben C, Bashaasha B, Hoa Sen LT (2014) *Towards "Good Enough" Climate and Disaster Governance: Emerging lessons from Zambia, Nepal, Viet Nam and Uganda.* DIIS Report 2014:21 Copenhagen, Denmark.

4. FAO, 2013. *Climate-Smart Agriculture Source Book.* Rome: Food and Agriculture Organization of the United Nations

5. Gwenzi, J., & Mupuro, J. (2015). *Variability of Rainfall and Extreme Events over Northeastern Zimbabwe.* Journal of Applied Science in Southern Africa (JASSA).

6. Gwimbi, P. (2009). *Cotton farmers' vulnerability to climate change in Gokwe District (Zimbabwe): impact and influencing Factors*. JÀMBÁ: Journal of Disaster Risk Studies, 2(2), 81 - 92.

7. IIED. (2012*). Climate change impacts, vulnerability and adaptation in Zimbabwe:* Working Paper no. 3. December 2012.

8. Mapfumo, P., Chikowo, R., & Mtambanengwe, P. (2010*). Lack of resilience in African smallholder farming: exploring measures to enhance the adaptive capacity of local communities to pressures of climate change.* Climate Change Adaptation in Africa (CCAA): International Development Research Centre (IDRC).

9. Marongwe, L. S., Kwazira, K., Jenrich, M., Thierfelder, C., Kassam, A., & Friedrich, T. (2011). An African succes: the case of conservation agriculture in Zimbabwe. *International Journal of Agricultural Sustainability, 9*(1), 1 - 9.

10. Meinzen-Dick, R., Bernier, Q., Haglund, E., Markelova, H., & Moore, K. (2012). *Identifying the Institutions for Climate-Smart Agriculture.* Paper presented at the International Research Workshop on Institutions for Inclusive Climate-Smart Agriculture. Collective Action, Property Rights and Institutions (CAPRi) and Climate Change, Agriculture and Food Security Programs of the CGIAR. http://www.capri.cgiar.org/wks_0912.asp., Nairobi, Kenya.

11. Mwangi, E., Markelova, H., and Meinzen-Dick, R. (2012). *Collective action and property rights for poverty reduction.* Philadelphia: University of Pennsylvania Press.

12. Steinecker, C. (2012). *CARE's approach to climate-smart smallholder agriculture: a report prepared for CARE International.* Nairobi: Poverty, Environment and Climate Change Network.

13. Stigter, C. K. J., & Ofori, E. (2014b). *What climate change means for farmers in Africa: a triptych review. Left Panel: Increasing climate variability and a response approach for African farmers.* African Journal of Food, Agriculture, Nutrition and Development (AJFAND), 14(1), 8445 - 8458.

14. Wilk, J., Andersson, L., & Warburton, M. (2013). *Adaptation to climate change and other stressors among commercial and small-scale South African farmers*. Regional, 13, 273 - 286. doi: 10.1007/s10113-012-0323-4

15. Williams, T. O., Mul, M., Cofie, O., Kinyangi, J., Zougmore, R., Wamukoya, G., . . . Campbell, B. (2015*). Climate Smart Agriculture in the African Context*. Unlocking Africa's Agricultural Potentials for Transformation to Scale.

# 2. Climate information services


## Abstract

This chapter addresses the issue of Climate Information Services (CIS) in light of the emerging body of knowledge and evidence on climate change, agriculture and food security. Climate information services encompass the entire process of procuring climate data for storage, and processing it into specific end-products for use by different clients within climate-sensitive sectors such as agriculture and health. Climate information services contribute to CSA by ensuring the sustainable production of food and income generation, thus enhancing adaptation, increasing resilience to climate change, and developing opportunities to reduce greenhouse gases. An understanding of climate information services and the contribution of the various actors in the value chain is of importance for students in tertiary institutions and practising extension agents. The key concepts in CIS, agro-meteorological tools and extension methods, supported by a set of interactive activities and case studies are presented in this chapter. The chapter concludes by giving policy and institutional recommendations for the provision of effective climate information services in Zimbabwe.



**Key words:** agro-meteorology, climate information services, climate-smart agriculture, extension, tertiary education


## Key messages

i. By the end of this chapter, the reader should be able to explain the relationship between CSA and CIS;
ii. Outline the contribution of climate information and extension to the pillars of CSA;
iii. Identify key meteorological service tools for CSA, give examples and assess their importance; and
iv. Recommend areas for improving the dissemination of climate information.

## 2.1 Introduction

Climate Information Services, which involve the generation and dissemination of climate information and its relevance to CSA, are discussed in this chapter. Climate change is one of the contributing factors to low productivity in the agricultural sector. Increases in temperature, rainfall variation, and the frequency and intensity of extreme weather events are adding pressure to global agricultural systems, (OECD, 2015). Zimbabwe is no exception to these global experiences, being particularly vulnerable, as it depends heavily on rain-fed agriculture. Notable changes include shifts in the onset of rains and increases in the frequency and intensity of heavy rainfall events, the proportion of low rainfall years, high-intensity rainfall events and the frequency and intensity of mid-season dry spells (Brown et al., 2012). Climate variability also threatens natural processes that sustain fodder for livestock and moisture for crops and also promote sustainable development in general.

According to FAO (2013), sustainable agriculture can be achieved through CSA. Provision of climate information services is one of the requirements needed to achieve CSA objectives. Climate information services are being addressed to enable vulnerable communities to reduce the risks associated with climate, particularly extreme events, which are now increasing in frequency (WMO, 2011), as well as allowing different sections of the economy to make informed decisions. Of particular interest, this chapter helps students in tertiary education and practising extension agents to improve their understanding of the importance of climate information services to CSA in order to communicate climate information effectively. Finally, the chapter focuses on the guiding concepts of climate services and the contribution of climate services to CSA, agro-meteorology and agriculture extension in Zimbabwe.

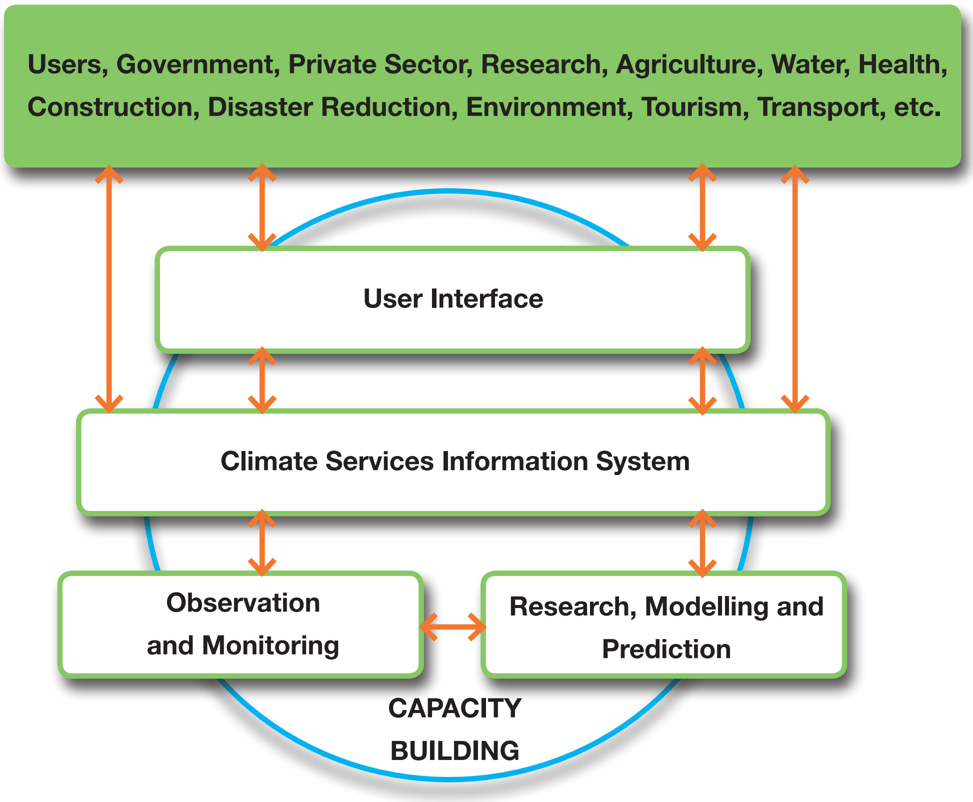
## 2.2 Guiding concepts under the theme of Climate Information Services

### 2.2.1 Climate Information Services

Climate information services cover the whole process of obtaining climate data, storing it, and processing it into specific products that are required by different users in climate-sensitive sectors such as agriculture, disaster-risk reduction and health, among others. In short, it is the packaging and dissemination of climate information to specific users. According to WMO, 2011, climate services encompass a range of activities that deal with generating and providing information based on past, present and future climate, and on its impacts on natural and human systems. A climate information service is one of the five components of the Global Framework for Climate Services (GFCS) (Figure 2.1). The major goal of GFCS is to enable better management of the risks of climate variability and change at all levels through the development of science-based climate information and prediction services and their incorporation into planning, policy and practice (WMO, 2011).

As a component of the GFCS, Climate Services Information Systems (CSIS) has a role in producing and distributing climate data and information according to the needs of users and agreed standards. The CSIS is the principal mechanism through which information about climate (past, present and future) is routinely collected, stored and processed to generate products and services that inform decision-making processes across a wide range of climate-sensitive activities and enterprises. It is the means by which research outputs and technological developments are transformed into improved operational climate information (http://www.wmo.int/pages/prog/wcp/wcasp/documents/workshop/pune2015PPT/day1/Session1-Global-Framework-for-Climate-Services-GFCS.pdf).

*Figure 2.1 Global framework for climate services pillars and priority areas*




*Adapted from: www.gfcs-climate.org/*

## 2.2.2 Climate Outlook Fora

There are several regional centres that provide climate services across the world. Climate Outlook Fora provide a platform for the dissemination of climate information at various levels to address the different needs of communities (WMO, 2011). Users may obtain information from a range of global, regional and national sources, as indicated in Table 2.1.

In the Southern Africa Development Community (SADC), the SADC Climate Services Centre (CSC), formerly the World Meteorological Organization (WMO) Drought Monitoring Centre, has the responsibility for the provision of climate services to member states. One of its activities is to coordinate the Southern Africa Regional Climate Outlook Forum (SARCOF). SARCOF builds into the National Climate Outlook Forum (NACOF) at the country level. This enables the generation of consensus over regional climate seasonal forecasts.

***Table 2.1 User Interface Platform of Global Framework for Climate Services***

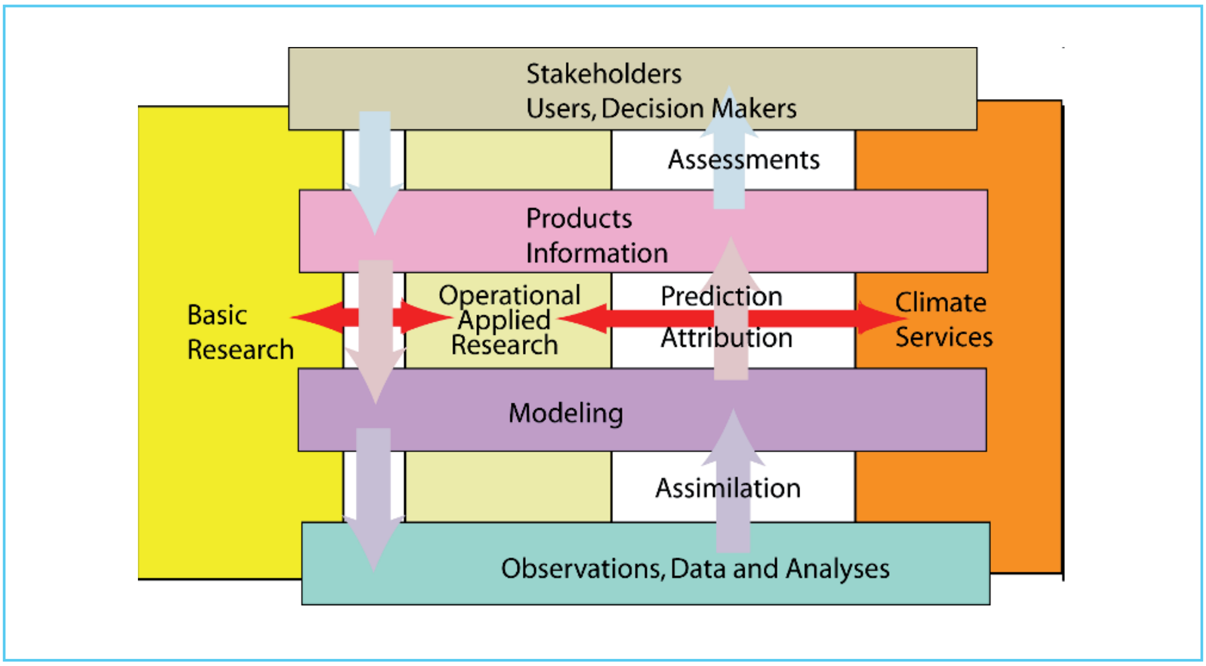
| Institutions/organisations | Mechanism |
|---|---|
| Global level | |
| UN systems | UN delivering |
| International climate research | |
| Sectoral research institution | |
| Universities | |
| NGOs and others | |
| Regional level | |
| Regional development institutions | Regional outlook fora e.g., SARCOF |
| Regional climate centres | |
| Universities, NGOs and others | Sector specific outlook fora |
| National level | |
| National development ministries | National communication fora |
| National research institutions (*in Zimbabwe research institutions currently do not play a significant role in the user interface platform)* | NACOF: National Climate Outlook Forum |
| National Meteorological and Hydrological Services (NMHS) and other related agencies | |
| Universities | |
| NGOs and others | |

*Source: Sivakumar, 2015*

### 2.2.3 Climate information generation system

The process of generating climate information globally is rather complicated, as indicated in Figure 2.2.

***Figure 2.2  Climate generation information systems***




*Source: Sivakumar, 2015*

**Activity 1.** *Can you compile a simple diagram from your understanding of climate generation for Zimbabwe? One of the identified problems in figure 2.2 is that end users are at the receiving end. Explain why this is a problem? What are other regional climate outlooks on the African continent?*

## 2.2.4 Climate-smart agriculture

CSA was defined earlier in the scene-setting chapter. CSA addresses climate change by systematically integrating climate information into the planning of sustainable agricultural systems (FAO, 2013). The major aim of this integration is to ensure sustainable livelihoods in the face of climate change (see https://csa.guide/csa/what-is-climate-smart-agriculture). CSA is knowledge-intensive and therefore requires access to information to enable stakeholders and farmers to make informed decisions. Under CSA, systems that are based on seasonal rainfall need to adapt and build resilience to climate change. It is within this context that this chapter discusses the relevance of climate information systems.

## 2.2.5 Extension

Agricultural extension is a form of a rural advisory service that can be implemented by any organisation in the public or private sector to provide information and advice to farmers and rural actors (Salas et al., 2014). In brief, extension is defined as a series of embedded communicative interventions. This definition is adopted here as it includes various actors in the value chain of climate information, from generators to users of information.

## 2.3 Contribution of climate services to CSA

This section discusses the contribution of climate information services and extension to CSA.

### 2.3.1 Contribution of climate information services

CARE (2014) highlights the following contribution that climate information makes to CSA:

- **Productivity.** Effective climate services are part of the enabling environment for the transition to CSA. Adequate and timely weather information can help farmers make decisions on the timing of agricultural activities and the variety of crops to be planted, thus increasing productivity. Climate information provides a basis for flexible planning adapted to a range of climate possibilities. It supports decision-making on which options to invest in, and when and how much to invest. For example, a farmer may decide to grow a high-yielding maize variety, given a forecast of a good season for rainfall. The farmer may decide to diversify and add the value of the harvested maize to other projects such as poultry and piggery in order to increase income. According to a presentation (AGRITEX, 2013), farmers need the following type of data (Box 2.1) in order to make informed decisions.

> ***Box 2.1 Farmer's needs (Source: AGRITEX, 2013)***
>
> - *The expected start and end of rainfall patterns, as well as distribution*. Simplified forecasting can help farmers understand better the concepts 'normal', 'below normal' and 'above normal'.
> - *Probability of extreme events, dry and wet spells*. This information should be made available at the beginning of the season.
> - *Probability of having certain quality of season*, which can be calculated using historic data.
> - *Future weather patterns and their implications*.
> - *Risks in producing different crops (for informed decision-making)*, planting dates and choice of crops and varieties.
> - *Basketful of livelihoods options*.

- **Adaptation through risk management.** The effective use of climate information services contributes to resilience by enabling farmers to manage the negative impacts of weather-related risks in poor seasons better, while also taking greater advantage of average and better than average seasons. A climate information system is the key to understanding climate as a major influence on livelihoods, life, ecosystems and development. It allows effective adaptation, which involves developing a range of adaptation options with the flexibility to switch from one strategy to another or to combine strategies. It helps actors to adjust their plans as climate stressors and shocks unfold.
- **Mitigation.** Climate information services can contribute to CSA by providing information that supports the more efficient use of fertilisers so as to reduce emissions of greenhouse gases into the atmosphere.
- **Contribution of agricultural extension to CSA.** Agricultural extension plays a key role in CSA mainly because adaptation to climate change requires changes in knowledge, attitudes, resilience, capacities, people's skills and extension systems. Agricultural extension contributes directly or indirectly to the three pillars of CSA. According to Singh and Grover (2013), agricultural extension

roles include: technologies and management information; capacity development; facilitating brokering and implementing policies and programmes; coordination; infrastructure/institutions; training; use of technology demonstrations; yield crop forecasting; and feedback role. However, there are known challenges in respect of the dissemination and uptake of various CSA technologies. These include financial and operational resources; low ratios of extension officials to farmers; clientele socio-cognitive factors, and institutional arrangements that are not responsive to climate change.

The challenges are amplified by the current extension services, which are staffed mostly by natural scientists, including agronomists and engineers. These scientists have limited resources to support farmers and also have limited skills in communicating climate information or addressing social challenges. According to Salas et al., 2014, although a strong interdisciplinary vision is required, it is not readily available in traditional extension systems. Moreover, there is a lack of adequate capacity at different levels with which to carry out the actions and changes needed to diversify in the interests of stakeholders. Other challenges include the lack of an enabling environment, including policies and the technical and financial conditions to increase productivity and resilience. The lack of capacity to adapt and to seek opportunities to mitigate emissions from greenhouse gases has also been reported. Lastly, the relevant information that is available is confined to the scientific literature, little being done in terms of operational activities to reduce greenhouse gases, for example.

## 2.4 Practice: application of the theme in the Zimbabwean context

Understanding approaches and appreciating tools for communicating climate information and advisory services is important in the adoption of CSA practices.

### 2.4.1 Agrometeorological tools for CSA

#### 2.4.1.1 Climate and weather

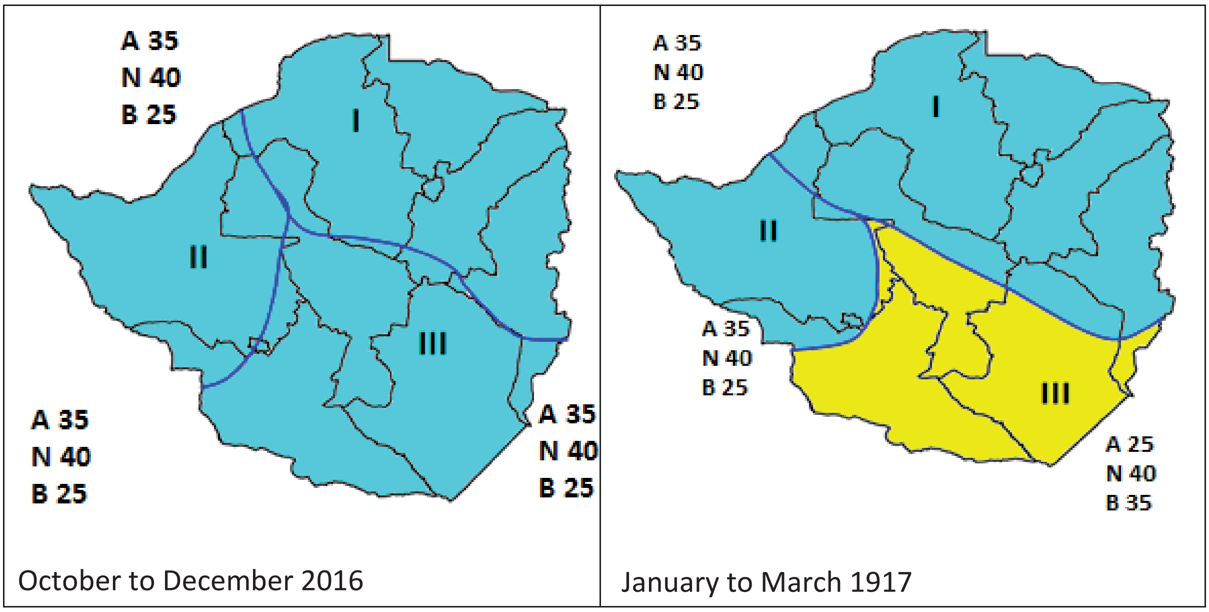
According to WMO (2011), weather is the state of the atmosphere at a given time and place with respect to variables such as temperature, moisture, wind, and barometric pressure. Climate refers to average weather in terms of the mean and its variability over a certain time-span and a certain area. Climate change is a change in the climate that persists for an extended period of time (WMO, 2011). Whereas climate variability is any deviation in the long-term statistics of climate elements over a short period of time, which can be a day, intra-seasonal, inter-seasonal or related to differences in climate from decade to decade.

The Zimbabwe Meteorological Services Department is responsible for the provision of a range of weather and climate information for farmers (real-time weather data and short-, medium- and long-range forecasts), that provide the basis for tactical and strategic adaptation at different levels of operational detail. When and if properly tailored to farmers' needs and expectations, these products are extremely valuable in the implementation of CSA. The products in most cases have to be used concurrently to ensure that users maximise the benefits. Climate forecasts are useful in giving an indication of what the climate may look like in the near future, whilst projections are for the long term, (Salas et al., 2014), as discussed below.

#### 2.4.1.2 Seasonal forecasts

The seasonal forecast, also referred to as the long-range (climate) forecast, is important as it assists strategic planning by users in climate-sensitive sectors such as agriculture, water and disaster risk reduction. Seasonal forecasts provide the expected rainfall performance for the season in terms of the total of accumulated amounts for sub-seasons. The sub-seasons for the three homogeneous rainfall regions that Zimbabwe has been divided into are OND (October, November, and December) and JFM (January, February and March) (Figure 2.3). The forecast is probabilistic in form and gives the outcomes for three scenarios: **above normal, normal** and **below normal**.

***Figure 2.3 Seasonal forecasts for Zimbabwe, 2016/2017 season (A–above normal rainfall; N–normal; B–below normal)***




*Source: Meteorological Services Department, 2016*

### 2.4.1.3 Medium-range weather forecasts

These forecasts are useful in giving the weather conditions expected for the next seven to ten days (Box 2.2). The forecast will assist in carrying out various agricultural activities such as planting, fertiliser application, weeding, spraying and mulching, i.e., tactical decisions. The forecast also helps farmers cope with increasing rainfall variability by adjusting decisions on the timing of planting at short notice.

### 2.4.1.4 Short-range weather forecasts

These forecasts are issued to cover one to three days. This assists in decisions which may be immediate such as chemical spraying, fertiliser application and frost protection. Delays in responses may limit the effectiveness of the operation, particularly if certain weather conditions are expected in the next few hours.

**Activity 2.** *What advice would you give to a farmer under the following scenarios?*

1. *The three-day forecast indicates strong winds and morning rain/showers, and the farmer wants to spray.*
2. *The 10-day forecast indicates heavy rains from 2–10 February, and the farmer would like to apply top-dressing fertiliser.*
3. *In a certain ward in Chiredzi, a farmer wants to plant maize seed in February, since the area experienced a late start to the season.*
4. *Discuss the importance of short-term, medium-term and long-term forecasts in agriculture.*

***Box 2.2 Use of SMS platform in disseminating weather forecasts in semi-arid regions of Zimbabwe***

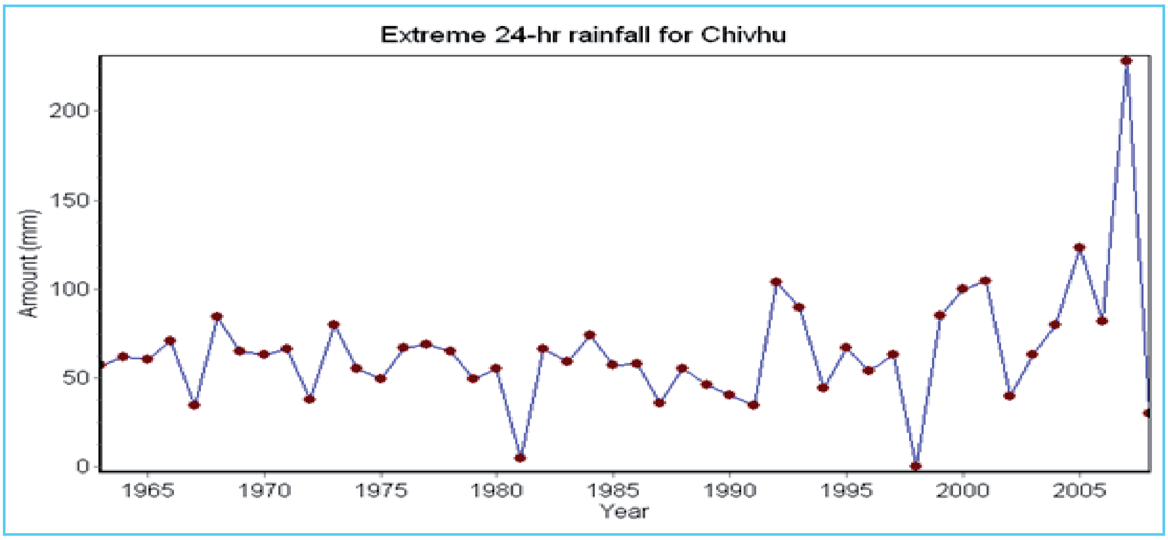
This is a project implemented by Oxfam, MSD and AGRITEX on climate change adaptation in Zimbabwe from 2012 to 2015, aimed at strengthening the dissemination of weather and climate information amongst extension staff and farmers. In summer, 10-day weather forecasts and in winter three-day weather forecasts were received through Short Message Systems (SMS) facilitated through private and public partnerships. This project helped enhance the farmers' ability to interpret weather data and make informed decisions not only in agriculture but also in respect of disaster risk reduction in livelihoods (Mubaya et al., 2016).

**Activity 3.** *Identify and discuss other projects on climate information services initiated in Zimbabwe.*

### 2.4.1.5 Probability of extreme events

An extreme weather or climate event is one that shows a deviation from the norm. For example, an increase in the number of rainy days where the total amount received in 24 hours exceeds 50 millimetres. Due to climate variability and change, there is an observed increase in the severity and frequency of extreme events (WMO, 2011; Mubaya et al., 2016). Figure 2.4 shows an upsurge of extreme events and the severity and frequency of heavy rainfall in excess of 24 mm recorded at Chivhu in Zimbabwe.

***Figure 2.4 Highest 24-hour maximum rainfall received every year for Chivhu for the period 1962–2010***



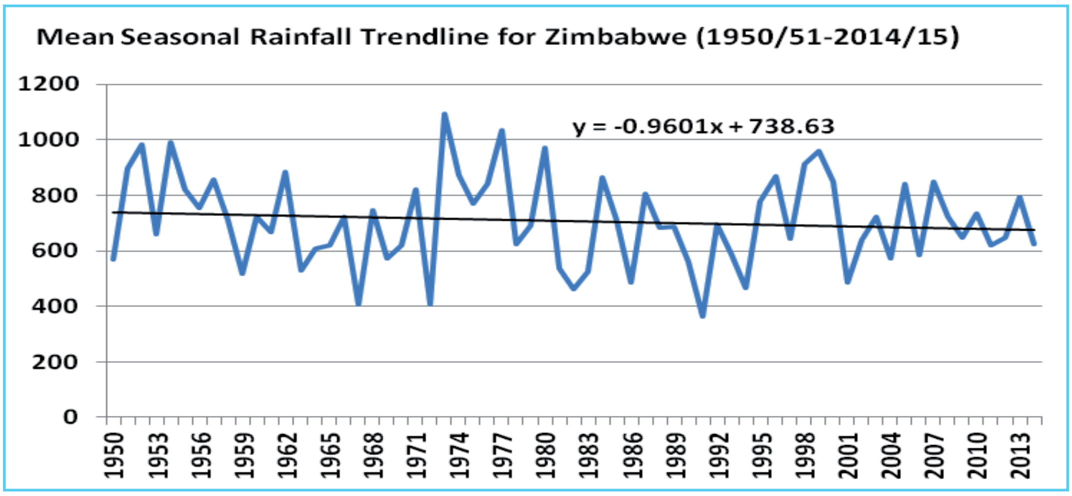

*Source: MSD, Zimbabwe, 2015*

### 2.4.1.6 Inter- and intra-seasonal variability

Rainfall performance varies between seasons (inter-seasonal variability), as well as within a season (intra-seasonal variability), as shown in Figure 2.5. Inter-seasonal variability is usually observed through several factors such as seasonal totals, onset, cessation, and season length. These differences in the seasons are sometimes linked to the status of the El Niño Southern Oscillation (ENSO), which has three phases: El Niño, La Niña and neutral. However, it should be stressed that the ENSO is just one of the factors that affects rainfall performance across seasons. Other factors include sea surface temperatures, teleconnections,

prevailing winds during the winter season, and prior heating from September to November and the Indian Ocean Dipole.

***Figure 2.5 Inter-seasonal rainfall variability for Zimbabwe 1951 to 2014***

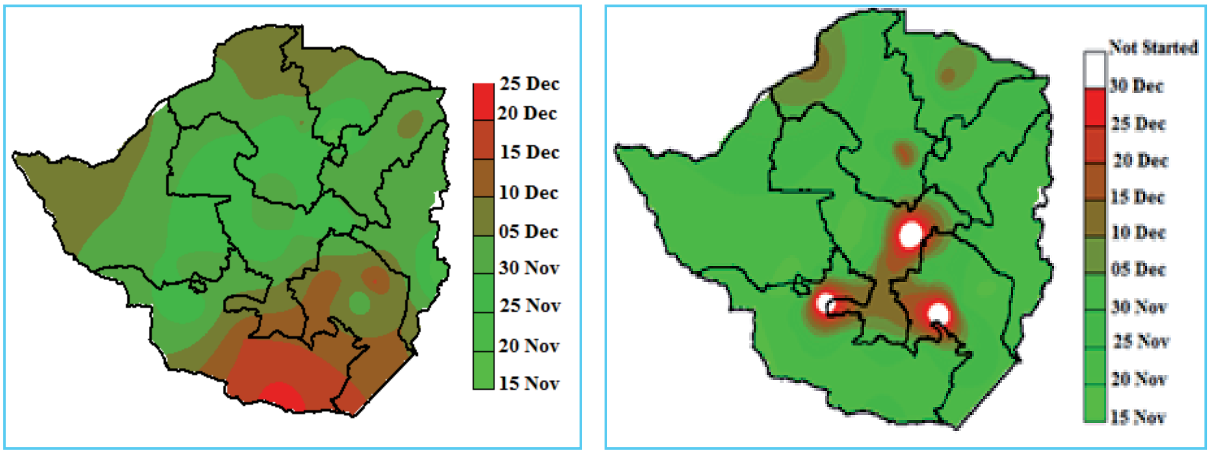



*Source: MSD, 2015*

### 2.4.1.7 Start, end, and length of growing season

As an institution, AGRITEX adopts the following definitions of the start and end of the season, which are dependent on soil type. The start of the season is *"any day after the 10th of November when an area receives 20 mm or more of rains in 3 days or less provided there is no dry spell of 10 days or more in the next 20 days".* The end of the season is *" any last day before end of April when an area receives 15 mm of rain provided there are no rains of 2.95 mm or above in the next 20 days*" (AGRITEX, 2013). The length of the rainfall season can be calculated by subtracting the date of the start of season from date of the end of season. The length of the growing season goes beyond the length of the rainfall season, as it takes into consideration the soil/water balance, which at this time of the season should be at zero, provided there are no effective rains within the last 20 days. Season length is important in crop variety selection in CSA. Inter-seasonal variability is shown in onset of rains for two seasons 2013/2014 and 2014/2015 (Figure 2.6).

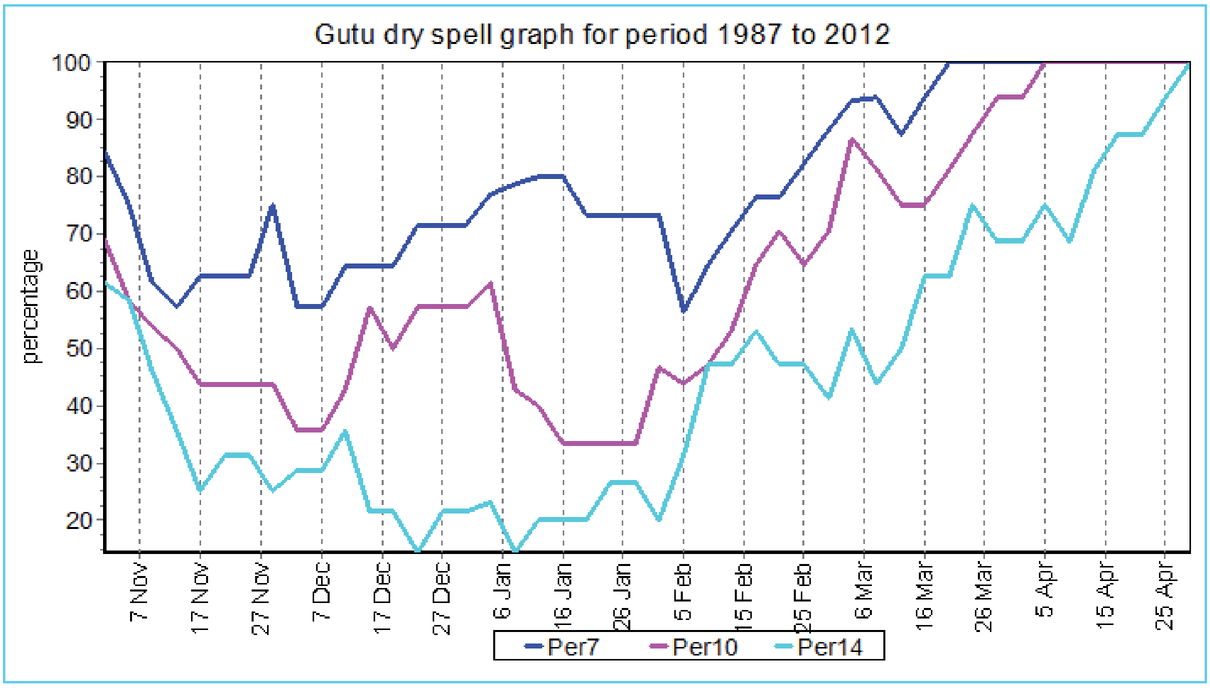
***Figure 2.6 Comparison of mean onset of rainy season (2013/14) with 2014/2015 season***
***Source: MSD, 2015***



#### 2.4.1.8 Dry and wet spells

A dry spell is a period of days with little or no precipitation and is therefore a collection of dry days, where each day will have received less than 2.95 mm or 5 mm, depending on the threshold adopted for record-keeping and analysis. Alternatively a dry spell is also defined as a period when the weather has been dry for an abnormally long time, though shorter than and not as severe as a drought. The lengths of the dry spells have significant consequences, particularly at critical growth stages such as the reproductive stage (silking, ear formation, cob development). Such information will assist the farmers to make informed decisions in CSA practices. In contrast, a wet spell is when 100 mm is received in five days. Figure 2.7 shows the probability of the occurrence of dry spells in Gutu, Zimbabwe. There is an increased chance of the occurrence of 7–14 day dry spells within 30 days from any day in the growing season for Gutu (Mubaya et al., 2016).

***Figure 2.7 Probability of 7-day, 10-day and 14-day dry spell occurrence in Gutu for the period 1987-2012***

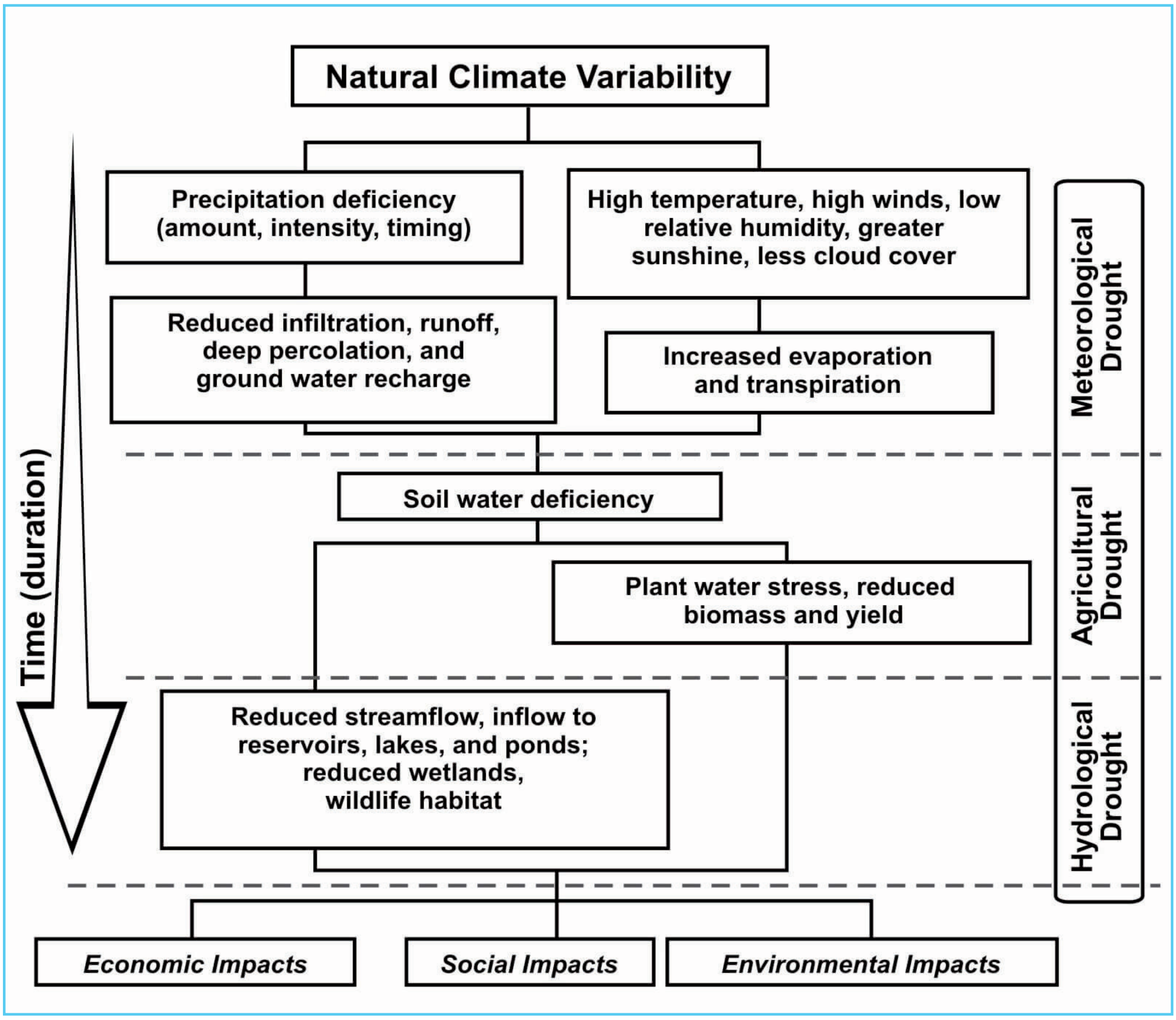



*Source: MSD, Zimbabwe, 2015*

#### 2.4.1.9 Drought

Drought is defined as a period in which a region has a deficit in its water supply. The definition of drought is region-specific and can be categorised into three main types: meteorological, hydrological and agricultural. Socio-economic droughts have been reported in some cases. The different types of droughts cause social, economic and environmental impacts as indicated in Figure 2.8. Meteorological droughts take into account deficiencies in measured precipitation. CIS provides information on annually measured precipitation and compares it to what is determined as normal and gives precautionary advice to farmers. For hydrologists, droughts are monitored by checking stream flow and lake, reservoir, and aquifer water levels, which is important in recommending appropriate soil and water management techniques in CSA. Agricultural droughts occur as a result of water deficits that impact negatively on crop production.

***Figure 2.8 Types of droughts and related impacts over time***




*Source: National Drought Mitigation Centre http://drought.unl.edu*

### 2.4.1.10 Traditional indicators

Use of traditional indicators of climate and weather is common in most areas of Zimbabwe. Indicators used include the observation of animals, insects, wind direction and tree phenology to indicate both good and bad seasons. The indicators may not have a direct influence on CSA, but it is necessary to acknowledge indigenous knowledge systems in weather and climate forecasts.

**Activity 4.** *Discuss the indigenous indicators used in forecasting weather and climate in your area.*

## 2.5 Agriculture extension for CSA

Several extension approaches are cited in the literature; the major categories including the group extension approach, the mass media extension approach and the individual/household extension approach. Extension approaches and methods have their advantages and disadvantages, meaning that there is no best approach to extension (Speranza, 2010). The choice of a particular extension approach is determined by the target audience, the available resources and the capacity of the facilitator, amongst other factors. For the purposes of the discussion, extension approaches and methods are grouped into two sections:

traditional methods, and innovative approaches for climate-smart agriculture. Traditional extension methods within the mass media approach include use of radio, print media such as newspaper and pamphlets, and audio visual aids. In the group extension approach, there are demonstrations of agricultural practices, field days, farmer days, master farmer training, training workshops and meetings, study circles, exchange visits and farmer field schools. The individual extension approach involves house visits or individual farm visits.

### 2.5.1 Innovative extension approaches and methods

Innovative approaches should be centred on clear statements of the limits and limitations of alternatives, rewards to communities for their knowledge inputs and building capacities to assess related parameters, and the integration of agriculture and socio-economic development (http://www.fao.org/3/a-bl361e.pdf). Salas et al., 2014 discussed a number of new initiatives in extension that respond to the challenges of climate change, including science field shops, building climate-smart farmers, data-driven agriculture, plant clinics and plant heath approaches, a citizen science approach, sustainable crop intensification, participatory video, farmer to farmer extension, participatory scenario planning, index-based scenario approaches and climate field schools, amongst others. WMO, 2014 cites other innovative approaches, including Livelihoods, Early Assessment and Protection (LEAP) for early warning, and roving seminars for communicating climate information.

**Activity 5.** *Discuss the relevance of innovative extension approaches for climate-smart agriculture in any communal area of your choice*.

### 2.5.2 Information communication technology

Information Communication Technologies (ICT) are effective delivery mechanisms and knowledge sharing methods that can improve access to information and awareness about CSA practices (Westermann, Thornton and Forch, 2015). ICT provides information on meteorological data, advisory services, early warning systems for disaster prevention and control, market prices and agricultural statistical data gathering. ICT technologies include radio, TV, telephones, computers, mobile phones, internet and social media. Farmers also play an active role in the dissemination of Climate Information (CI) within their communities through ICT. In every rural household there is at least one mobile phone, which is often used by many people. When farmers and extension agents receive climate information, they relay it to other farmers by SMS (Speranza, 2010). This creates a multi-branching distribution chain. Instant information is usually disseminated through this channel (Salas, 2014). Through their networks of social relationships, they facilitate access to climate information for other farmers (see case study in Box 2.3 illustrating the institutional benefits of ICT in Senegal). The same case study reports that use of ICT is constrained in extension due to the high costs of investment, the lack of competition and the lack of relevant skills for effectively using ICT.

***Box 2.3 Case study of ICT***

Findings from a project implemented by ICRISAT in Senegal, in collaboration with the national meteorological agency and a number of local stakeholders, including farmers, indicated the benefits of ICT at different levels:

- Within the context of more frequent and extreme weather events and climate shocks, enhanced early-warning systems provide a key opportunity to curb the erosion of progress.
- It allowed farmers to base farm management decision-making on tailored and salient climate information throughout the cropping cycle.
- It helped farmers reduce climate risks and avoid regular food insecurity.
- Downscaled seasonal rainfall and long-term weather forecasts reached around seven million people in Senegal, helping smallholders to make better-informed decisions about agricultural management in a changing climate.
- The services allowed farmers to improve their adaptive capacity and increase farm productivity.

In addition, institutional behavioural change was observed in the Senegalese Ministry of Agriculture, which considered climate information services as an input to their annual agriculture action plan (Westermann, Thorton and Forch, 2015).

### 2.5.3 Data-driven agriculture

This is an approach in which technical decisions made on farms or recommended by extensionists are supported by the analysis of large amounts of observational data (Salas et al., 2014). Farmers' data describing the management of crops, yields and crop status are pooled and combined with weather records and soils data at field level to finely determine the actual conditions in which the crop grew and the production it achieved. The idea takes advantage of every bit of data generated on farms, climate stations and research and plant breeding plots, which are analysed to guide farmers in making decisions. The information generated can be used by different stakeholders. The main risk with this data-driven approach is the misuse of farmers' data, as it needs to be compiled at some point. Data privacy and farmers' willingness to share their data can also be a challenge. Data-driven agriculture can take time to reach the critical amounts of data that allow analysis.

In Zimbabwe, data-driven approaches are employed every season through surveys undertaken by the government, such as the First and Second Round Crop and Livestock Surveys. For CSA practices, crop and livestock data should be supported by weather-related data that includes rainfall, wind speed and direction, temperature and evaporation rates to enable farmers to make informed decisions.

## 2.6 Role of higher and tertiary institutions in climate-smart practices

The role of higher and tertiary education in climate information services includes research and development, networking, capacity-building and the facilitation of extension methods such as learning platforms and support to communities. Capacity-building relates to both technical skills and knowledge in respect of climate-smart agriculture and related subjects. Tertiary institutions in Zimbabwe participate in research and the provision of training materials for various stakeholders. Tertiary educational institutions provide the necessary environment for learning and knowledge exchange and also support community initiatives (Hiepe and Kals, 2010).

## 2.7 Policy implications

Policies provide an enabling environment to ensure that stakeholders provide climate services, reconcile differences and create the necessary institutional infrastructure to work together (FAO, 2013). At the national level, climate change policies are expressed through national and regional strategies and plans, including National Adaptation Plans, Nationally Appropriate Mitigation Actions and Intended Nationally Determined Contributions (INDCs). Policies facilitate the promotion of incentives and programmes of climate services that enhance the adoption of CSA, such as research and extension, reduction of tariffs on ICT and public/ private partnerships to ensure effective communication of climate information.

## 2.8 Conclusion and recommendations

Sources of climate information are many. It is therefore imperative to have well-coordinated systems at all levels of communication. This is especially the case with regard to the value attached to climate information as a resource for planning and decision-making. The uncertainties in climate change show that there is no one-size-fits-all recommendation for CSA, and practices should be site-specific in response to real-time climate information. There is a need to move from limited sources of information to robust networking which caters for all stakeholders with an interest in climate change. The need for multiple extension methods for dissemination cannot be overemphasised. It is therefore recommended that:

- Actors, including providers of information and users of information, should bridge the gap between the content, scales, format and lead time that meet farmers' needs in order to increase agricultural productivity at the grassroots level;
- Climate information services should be accessible to all actors in the value chain for effective communication. The packaging of information in terms of content and language to meet the expectations of users is advisable;
- Climate information services should support farmers with skills in CSA, since most past projects on CSA have not used climate information;
- CIS should provide the knowledge to understand patterns of variability in the current and projected climate, seasonal forecasts, hazards impacts, mitigation methods, land-use planning, risk management, and resource management to achieve the three pillars of CSA;
- Climate information services should be an integral component of CSA at all levels within the multi-stakeholder set up and should be connected to the broad agenda of agricultural development, thus ensuring farmers' involvement in the design and delivery of climate information systems; and
- Development of the National Framework for Climate Services, which will assist in coordinating and funding activities under climate services, is needed.

**Activity 6.** *Can you recommend other areas for improving the dissemination of climate information and advisory services?*

## Acknowledgements

Thanks are extended to the following: Department of Agricultural Technical Extension Services for staff time and material. Meteorological Services Department, Chinhoyi University of Technology; and UNEP-DTU Partnership for funding. Green Impact and Department of Climate Change in the Ministry of Environment, Water and Climate for facilitating the process.

## References


1. AGRITEX (2013) *Department of Agricultural Technical Extension Services training reports.*

2. AGRITEX (2013*) Proceedings of the Training Programme on Interpretation and Use of Seasonal Climate Forecasts for Agricultural Extension Workers in Zimbabwe.*

3. Brown D., Chanakira R., Chatiza,K., Dhliwayo,M., Dodman,D., Masiiwa,M., Muchadenyika D., Mugabe,P., and Zvigadza S. (2012) *Climate change impacts, vulnerability and adaptation in Zimbabwe, Working Paper Series* no. 3, IIED pp. 3-10.

4. CARE (2014) *Facing uncertainty: the value of climate information for adaptation and risk reduction and resilience in Africa.* www.careclimatechange.org p. 5.

5. FAO (2013) *Climate smart agriculture Source book.* Rome Italy Food Agriculture Organisation of United Nations, pp. 4-10.

6. Hiepe C., and Kalas P. (2010) Module 17. *Capacity development for climate smart agriculture.* https://csa.guide/csa/what-is-climate-smart-agriculture, accessed February 2017, pp. 478.

7. MSD (2016) *Meteorological Services Department reports.*

8. Mubaya C.P., Ndebele –Murisa M., Mutopo, P. and Ngepah N. (2016). *Community experiences: weather and climate information dissemination in farming systems in Zimbabwe.* Chinhoyi University of Technology, Zimbabwe, pp. 8-25.

9. *National Drought Mitigation Centre.* http://drought.unl.edu, accessed November 2016.

10. OECD (2015) *Trade and agriculture directorate. Organisation for economic co-operation and development.* www.oecd.org/agriculture. September,2015

11. Salas S, Kossi, R., David S edit (2014). *Compendium of climate smart agriculture and extension, supporting agricultural extension towards climate smart agriculture:* an overview of existing tools, pp. 5-43.

12. Singh I., Grover J. (2013*). Role of extension agencies in climate change related adaptation strategies.* International Journal of Farm Sciences 3(1): 144155, 2013, p. 145.

13. Silvakumar M. (2015*). The global framework for climate services: communicating climate change science.* SBSTA-34. Research dialogue World Meteorological Organisation. www.wmo.int, accessed November 2016, p. 5.

14. Speranza, I.C. (2010) *Resilient adaptation to climate change in African agriculture,* German Development Institute, pp. 157-227.

15. Westermann, O., Thornton, P., and Forch, W., (2015). *Reaching more farmers: innovative approaches to scaling up climate smart agriculture,* https://csa.guide/csa/what-is-climate-smart-agriculture, p. 22.

16. WMO (2011) World Meteorological Organisation Climate Knowledge for Action: *A Global Framework for Climate Services – Empowering the Most Vulnerable.* The Report of the High-Level Taskforce for the Global Framework for Climate Services, WMO-No 1065, pp. 8-9.

17. WMO (2014) *Appendix to the agriculture and food security exemplar to the user interface platform of the global framework for climate services – GFCS.* World Meteorological Organisation Weather, Climate and Water, pp. 4-18.

# 3. Weather index-based insurance as a CSA strategy

**Abstract**

Weather Index-based Insurance (WII) is used as a mechanism to enhance agricultural and rural development, as well as providing an alternative method for financing disaster reduction. The index also contributes to the three pillars of CSA, as described in the introduction to this Manual. This chapter also discusses the advantages and disadvantages of using the index. WII can be applied at three socio-economic levels: micro, meso and macro. In many developing countries, laws and regulations are not designed to encourage the development and use of WII. However, the chapter also presents two case studies from Ethiopia and Kenya to illustrate the use of the index in the areas of arable agriculture and livestock respectively. The chapter ends with a comprehensive discussion of the pros and cons of using weather index-based insurance.

**Key words:** climate resilience, climate risk, insurance, rainfall, smallholders, weather-based insurance index

**Key messages**

i. WII is used to facilitate agricultural and rural development, as well as providing an alternative method for financing disaster reduction;

ii. In many developing countries, the laws and regulations are not designed to encourage the development and use of WII; and

iii. The index can be used for both arable agriculture and livestock.

## 3.1 Background

Small-scale farmers and pastoralists in developing countries often find themselves in a poverty trap because they are not in a position to make investments in improved agricultural practices due to weather-related risks. Agricultural insurance, an attractive approach to managing such risks, usually involves direct measurement of the loss or damage incurred by farmers. However, field-loss assessments are not only expensive but also time-consuming, especially when there are a large number of smallholders or pastoralists who cannot afford the late insurance pay-outs by companies (Greatrex et al., 2015).

WII schemes help to ensure farmers' livelihoods, enabling them to invest in climate-smart agricultural technologies to achieve sustainable food security. As noted in the introduction to the Manual, the increasing frequencies of droughts, dry spells, storms and other extreme weather events in Zimbabwe are compromising the livelihoods of small-scale farmers. Given this background, banks become risk-averse, especially if they perceive that frequent droughts might lead to poor insurance servicing.

In the light of this scenario, WII becomes an attractive alternative to managing weather and climate risks since it is based on weather indices, such as rainfall thresholds. This form of insurance is more straightforward than conventional ones, generally not being contentious, since it is based on the measurable and spatial distribution of a single weather phenomenon, such as the amount of rainfall recorded over a given time at a particular site for a specific crop. If this amount falls below the agreed threshold, the company disburses the money in accordance with the contract. Transactions based on such easy and quick weather-based indices are of advantage to rural farmers, since they are not likely to sell assets in order to maintain their livelihoods in the event of the loss or damage specified in the contract.

In low-income countries, WII facilitates two broad purposes (IFAD and WFP, 2010):

- **WII for development**: a tool to bring about agricultural and rural development by helping households, financial service providers and input suppliers cope with low-to-medium episodes of covariate risks, for example, drought or excessive rainfall.
- **WII for disaster reduction**: provides an alternative method of financing disaster reduction assistance or relief programmes.

## 3.2 Contribution to CSA

**Productivity.** Index insurance, especially when associated with access to credit, allows farmers to take additional risks by investing in improved practices that increase productivity and food security, even in situations of adverse weather conditions.

**Adaptation through short-term climate risk management.** In most developing countries, rainfall varies in both seasonal totals and spatial distribution. Under such conditions, farmers are faced with the risk of livestock loss and reductions in crop yields. Under these conditions, index insurance is designed to contain such risks, thus making a significant contribution to farmers' resilience. In this regard, there is considerable interest in the potential role of insurance index in agricultural adaptation to climate change (Hellmuth et al., 2009). This scenario applies to Zimbabwe, as elsewhere.

**Adaptation through longer term climate risk management.** Climate change projections (IPCC Fifth Assessment, 2015) suggest that total rainfall is likely to decrease in Zimbabwe. Therefore, WII will become an increasingly important adaptation strategy.

**Mitigation.** This will depend on the degree to which insured farmers are able to invest in improved production practices (e.g., agro-forestry) that either enhance carbon sequestration or reduce greenhouse gas emissions.

## 3.3 Characteristics of WII

The usual features of a WII contract are:

- A specific functional meteorological station is taken as the reference.
- A trigger weather measurement is determined, e.g., the cumulative amount of rainfall in a specified period at which disbursements are triggered in accordance with the contract.
- A lump sum or incremental payment is determined, e.g., a specific amount of money per specified rainfall amount above or below the trigger.
- A limit to the measured parameter is set at which a maximum payment will be made.
- The period of insurance in the contract should coincide with the length of the growing period. It can be divided into phases, with each phase having its own trigger, increment and limit (WFP and IFD, 2010).

## 3.4 Advantages of WII

WII is best designed for a weather phenomenon that is assumed to occur over a widespread area in which there is a close relationship between weather parameters and crop yield. In arable agriculture, the best relationships typically involve a specific crop during a specified rainy season. So far, most WII endeavours have been based on rainfall deficits (spatial and temporal).

- WII insurance largely overcomes the problems of moral hazard and adverse selection. As a pay-out is determined by an objective index, such as the amount of water falling into a rain gauge or the state of vegetation recorded by a satellite, the need to verify losses through individual farm visits is eliminated, leading to significantly reduced administration costs. In addition, index insurance is more resistant to moral hazard and adverse selection, which again leads to lower premiums. In this case a pay-out does not depend on the state of the farmers' fields, so the farmers who benefit most are those who can keep their crops alive in a bad year.
- Index insurance has the potential to build up the resilience of smallholders, not only by paying out in bad years to help farmers survive and protect their assets, but also by helping to unlock opportunities to increase productivity in years without a pay-out, which might allow them to escape from the poverty trap or associated threats. For example, insurance can enable smallholders to obtain credit to buy inputs or make other agricultural investments (Janzen and Carter, 2013).

## 3.5 Disadvantages of WII

**Basis risk.** The lack of a link between on-farm losses and pay-outs that prevent moral hazard is one of the greatest challenges involving index insurance. By definition, a weather index does not insure a farmer's loss directly, and multiple farmers, who will typically have somewhat different losses, must be covered by the same index formula and data source. Farmers may receive a pay-out even when their crops survive, or they may experience losses when a pay-out is not triggered. This scenario is called "basis risk", a major drawback of index-based insurance.

**Technical capacity and expertise.** It is imperative to have technical capacity and expertise, especially during the initial design phase for new products in agro-meteorology and in the operationalisation of the process.

**Scarcity of credible weather data.** WII is a function of its availability, spatial coverage and temporal distribution, as well as quality of the weather data. These aspects can vary considerably both within and between countries, especially developing countries.

**Complex situations.** WII is less beneficial in complex situations, for example, localised risks such as heat waves or microclimates, e.g., in mountainous areas. The scope for WII is also limited where agriculture activities are compromised by other complex causes of crop loss such as pests and diseases.

## 3.6 Role of governments and donors

In agricultural insurance, and especially WII, investments by governments and donors are most effective in funding market development start-up costs. In comparison to traditional indemnity insurance, the biggest costs in WII are incurred in the product development phase.[2]

For long-term sustainability of WII, the role of donors is important to facilitate the development of insurance products. This role should include creating of an appropriate enabling environment and providing specific public goods. More specifically, donors can support governments in the development of markets in the following respects:

- Improvements in data systems and data collection.
- Improvements in the legal and regulatory environment.
- Capacity-building programmes on the use and advantages of weather insurance.

In some cases, governments may opt to provide financing for premium subsidies. The most common form of government support to agricultural insurance is actually by directly subsidising insurance premiums. Governments justify premium subsidies as a means of making crop insurance affordable, especially for small farmers. However, there are a number of drawbacks regarding direct insurance premium subsidies if they are not carefully designed. This occurs mainly when countries provide a single flat-rate premium subsidy, typically 50% of the full commercial price of insurance for all farmers, all crop types, and all regions at risk. These undifferentiated premium subsidies disproportionately benefit the larger farmers to the detriment of the small and marginal farmers, and they actively encourage farmers in the highest risk-rated regions to grow unsuitable high-risk crops. Therefore premium subsidy scales should be designed to differentiate between crop types, risk regions and size of cover.[3]

## 3.7 Levels of intervention and business models

WII can be applied at several socio-economic levels. Micro-level farmers can use agricultural insurance to cover themselves against the impact of adverse weather events. The premiums are either paid in full by clients or subsidised, depending on whether the objective is protective or promotional, while at the meso-level institutions (banks, NGOs, etc.) may use agricultural insurance to cover themselves from covariate risks. At the macro-level, a government, institution or international donor organisation might use agricultural insurance (especially index insurance) for a disaster relief fund.

2 Weather Index Insurance and Climate Change: Opportunities and Challenges in Lower Income Countries, Benjamin Collier, Jerry Skees and Barry Barnett, https://agriskmanagementforum.org/sites/agriskmanagementforum.org/files/Documents/Weather%20Index%20Insurance%20and%20Climate%20Change.pdf

3 Index-based Crop Insurance in Senegal: http://www.ifc.org/wps/wcm/connect/98e2c00041d405b5840c8400caa2aa08/Senegal+Ag.+Insurance+FINAL+REPORT_ENG+6MAY09.pdf?MOD=AJPERES

***Table 3.1 Models and potential benefits of WII***

| Policy-holder | Distribution model | Potential benefits of WII |
|---|---|---|
| **Micro** | | |
| Farmers, households | Farmers purchase index insurance either as a package (e.g., credit or technology) or as a viable stand-alone product | Allows farmer to avoid default and restart production<br>Provides income support in lean periods<br>Facilitates access to credit<br>Supplements other sources of household income that may be disrupted |
| **Meso** | | |
| Farmers' associations and NGOs | Meso-level institutions purchase index insurance to protect their own exposure and may draw up pay-out regulations that are good for farmers | Meso-level actors can develop links in the supply chain (e.g., contract farming) to facilitate risk management and open up market possibilities |
| **Macro** | | |
| Government or relief agencies | Government or relief agency is reinsured | Government receives liquidity early after disasters; relief agency funds the operations |

*Adapted from IFAD and IFP (2010)*

## 3.8 Improvements in the legal and regulatory environment

In many developing countries, governments do not fully recognise the role that insurance markets play in alleviating disasters associated with weather risks. On the contrary, they are inclined to focus on providing government aid in the wake of an extreme weather event. Unfortunately, the expectation among smallholders that such assistance will be forthcoming compromises the need for WII. It therefore, follows that in many developing countries, laws and regulations are not made to foster the development and use of WII. Without proper contract law and enforcement mechanisms, the market for innovations such as WII will hardly develop.

## 3.9 Supporting improvements in data systems and collection

In supporting the development of weather insurance markets, governments can have an immediate effect by easing access to existing relevant data. Reliable data is critical to the development of weather insurance markets. Weather stations that provide weather data must be equipped with recording instruments that are reliable, accurate, and should be proofed against deliberate human tampering. Quality data from weather stations should be archived so that historic weather data can be shared. However, the recent commercialisation of weather data by many developing countries does not augur well for the development of insurance products. The collection of weather data using government resources should be seen as a service to the country.

Other ancillary data that are relevant to the development of weather insurance, such as yield data and information on losses associated with extreme weather events, land use changes, input levels, and records of past disaster management activities or infrastructural changes, should be accorded a high priority by governments.

## 3.10 Case studies

In the previous sections of this chapter we have discussed the general theory of WII, but in order to contextualise the discourse to Sub-Saharan Africa, we now summarise some case studies in Ethiopia and Kenya that have more or less similar conditions to those in Zimbabwe.

### Case Study 3.1: Index-Based Livestock Insurance (IBLI): Kenya and Ethiopia

The International Livestock Research Institute (ILRI) project, kept livestock farmers out of the poverty trap by insuring their livestock against drought. The project faced the challenge of designing a commercially viable form of insurance for nomadic pastoralists in remote areas of Kenya and Ethiopia with poor communication and transport facilities. To overcome these challenges, the IBLI team mathematically connected livestock mortality data to the satellite Normalized Difference Vegetation Index (NDVI). This was found to be highly correlated with forage availability in the area.

Project partners included insurance entities, reinsurers, research outfits and NGOs, who assist in identifying and training local communities for the project. Since its inception in 2010, the IBLI project has covered more than 4,000 pastoralists. Project evaluation found that IBLI provides a development benefit from its pay-outs as participating households are less likely to sell livestock. Final assessment showed that the project reduced the total livestock mortality risk by 25–40%.

***Figure 3.1 Severe drought in Africa***

*Photo credit: Shutterstock*

## Case Study 3.2: Index-Based Agriculture Insurance

The Agriculture and Climate Risk Enterprise (ACRE) – East Africa Programme is said to be one of the largest index insurance programmes in low-income countries. It has also taken the lead in enrolling smallholders on the basis of mobile technologies (IFC, 2013). The project aims to scale up its activities to three million farmers across 10 countries in East Africa by 2018. Donor money is currently being used for feasibility studies and satellite "ground-truthing" using automatic weather stations, as well as start-up salaries during the early stages in each target country.

Essentially there are three pillars to ACRE's operations. The first is to have an extensive range of products based on different data sources, for example, automatic weather stations and remote sensing products. Secondly, ACRE would like to act as a go-between for intermediate insurance companies and reinsurers, as well as distribution channels. Thirdly, its links to the mobile money market in the form of the East African M-PESA scheme helps with rapid enrolment and rapid pay-outs on claims. This obviates the need to visit farmers physically, thus enabling the programme to reach more farmers than it would otherwise.

Project evaluation has shown statistically that insured farmers increased their earnings by 16% and also invested 19% more than their uninsured counterparts. The programme provides a strong example of the use of innovative technology solutions for the benefit of smallholders.

## Case Study 3.3: Climate proofing crops and livestock through smart insurance (Zimbabwe)

EcoFarmer is Zimbabwe's first micro-insurance product designed to insure inputs and crops against drought or excessive rainfall. In addition, the insured farmer receives daily weather information, farming techniques and marketing information. Gordon Mashiri, micro-insurance expert with the mobile company Econet Wireless in Zimbabwe, gave the interview below to a Spore correspondent at the CTA workshop on *Scaling-Up Climate-Smart Agriculture Solutions for Cereals and Livestock Farmers in Southern Africa*, in September 2016 in Johannesburg, South Africa.

**How does weather index-based insurance work?**

An insurance company devises an index or parameters for insurance purposes and monitors the weather for that particular season. Farmers who buy policies are informed of the rainfall patterns within their specific areas. Traditionally weather insurance indices cover a radius of approximately 15–20 km, but with satellite technology a specific policy can be provided for a specific farmer, even though the whole index will be the same for the region or country.

**How does this type of insurance help farmers adopt climate-smart solutions at an affordable cost?**

Weather index insurance is a risk management tool that has to be used in conjunction with other tools that are being adopted, such as conservation agriculture and good agronomic practices. Given the changes in climate, farmers need back-up cover to ensure they can retain their inputs and have something in reserve for subsistence during a period of adverse weather conditions.

**How have farmers responded to this insurance?**

Some farmers are aware of it but there is still a lot of work to be done to raise awareness about how weather index insurance works and about its benefits. Farmers need to understand that insurance is not a gamble but a fall-back plan. Its principles need to be understood by farmers, farmers' organisations and other actors in the agriculture value chain.

**Why are farmers not using a tool that can help them?**

Most programmes have been pilots and not commercialised. For those that have gone commercial, they have done so in specific regions with the assistance of donor organisations, and not all farmers have been exposed to them. We now need to scale up the products and invest in farmer education and understanding. Then we can roll insurance out to everyone.

**What is the significance of bundling in the provision of climate-smart agricultural services?**

Bundling focuses on the value chain and all the farmers' requirements by offering the various components that farmers require in a single basket. This could be information services, farmers' subscriptions, weather index insurance itself, farmers' discounts and market-related information, all of which can be bundled into one basket which the farmer purchases. There will be cross-subsidisation within that basket, making it easier to scale and target many farmers using one bundle. This is opposed to different entities knocking on the same farmer's door, which is inefficient.

**What is needed to overcome the current lack of awareness and uptake?**

A demand-driven approach to insurance is required where farmers' groups and organisations come together and understand that insurance is for their benefit. They need to push the weather insurance agenda and not have someone else do it. Once they demand it, insurers, re-insurers and other partners will come together and offer products that will benefit the whole agricultural value chain.

*Source: http://spore.cta.int/en/spore-exclusive/godwin-mashiri-climate-proofing-crops-and-livestock-through-smart-insurance.html.*

## 3.11 Discussion

Attributes of successful index insurance

- For WII to be successful, it must be appropriately designed to protect the farmer against the intended risk and should be positively correlated with losses. This requires significant expert input to answer queries on how to quantify losses, for example, "How can we measure losses as defined in the contract?" or "How far from a rain-gauge station does a farm have to be to trigger payment?"
- The very nature of WII makes it impossible to eliminate basis risk entirely. This means that there has to be good communication with clients so that they understand the risks that are covered and are prepared for the possibility of a basis risk event. Attaining this level of mutual understanding calls for considerable effort.
- The WII should have a clearly quantified degree of uncertainty so that a monetary value can be assigned. Smallholders should be able to understand their contracts before buying them.
- There needs to be a demonstrable benefit in buying insurance. This requires the insurance to be packaged with inputs that can demonstrate positive gains.

However, some potential pitfalls of insurance have also been noted. While insurance might decrease short-term vulnerability after an adverse weather event, it is difficult to assess the long-term impact on adapting to climate change. By encouraging people to continue engaging in highly climate-sensitive economic activities or making them more risk-averse with respect to insurance than they would have been otherwise, might prove maladaptive in the long run. Incentives for risk management need to be aligned properly with insurance premiums to avoid maladaptation.

## 3.12 Can Index-based insurance for vulnerable farmers be scaled up?

A common concern with index insurance has been the low demand from poor smallholders and pastoralists that has been observed, even though they are the most vulnerable to weather-related risk. This has been a disadvantage of up-scaling index-based insurance.

Having said that, access to credit and the adoption of better production technologies have been the hallmark of the most successful index programmes. This has resulted in a net positive effect on the uptake of more lucrative production technologies. Evaluations show that livelihood benefits derived from insurance are appreciated and that they currently benefit women farmers more than men.

The case studies discussed in this chapter show that index-based insurance could benefit smallholder farmers in many low-income countries. In spite of the absence of credible quantitative projections, we can safely say that the noticeable increase in smallholders buying index insurance suggests that such programmes have captured a considerable part of the hitherto suppressed demand of smallholders.

## 3.13 Recommendations and lessons learnt

The case studies have also shown that index insurance will not be appropriate in every circumstance and that there are still several challenges to be overcome, including data management, basis risk and logistics. The following points ought to be noted with respect to WII in developing countries:

### a. Insurance offsets farmers' losses

Many case studies have shown that index insurance has helped farmers to offset crop losses, thus maintaining their livelihoods. The increase in food security stemming from index insurance constitutes a value that enables smallholders to pay the premiums. Other tangible benefits include asset protection and access to credit. The use of insurance as a means to act as a buffer against crop losses is the main attraction for smallholders.

### b. Holistic approaches

A notable number of case studies have integrated index insurance into broad development programmes in the quest for climate risk management. The value of index insurance is that it can be perceived as a climate risk management portfolio. It has been designed to target risks such as drought, together with other risk management approaches that are more appropriate for other extremes of weather.

Case studies have shown that it is imperative to collaborate with smallholders, policymakers, scientists and agricultural practitioners. This scenario is ideal for the common appreciation of derived products, trade-offs, disadvantages and limitations on solutions.

### c. Farmer-driven design

Index insurance studies have shown that substantial benefits are realised when smallholders are consulted during the design process. This is important because farmers need to understand the operations of the insurance programme so as to build trust and common understanding, as well as to minimise misunderstandings in the whole process. Case studies have also shown that farmer-driven designs are one way to ensure success in index insurance.

## d. Building trust and capacity

Education and capacity-building have proved to be essential aspects of successful case studies. Basically, insurance is a commitment to pay later for a premium paid now. Farmers' buy-in to the insurance process is vital for ensuring success. Partnering with outfits that have already acquired the trust of clients can expedite the successful scaling up of index insurance in developing countries. Indian insurance projects are good examples of partnering companies that have already earned the trust of clients. A sizable proportion of the budget can be spent on trainers' salaries, communication and radio slots.

## e. Credible science, technology and basis risk

The effective communication of scientific research on index insurance has facilitated the scaling up of many case studies, especially in environments with poor data or reductions of basis risk. Basing index insurance projects on credible scientific findings and close cooperation with research communities has been the key to the success of many case studies by facilitating the use of agro-meteorological findings in quantifying basis risk and its communication to smallholders.

In the case of data-scarce environments, it is now common practice to use remotely sensed data from satellites, whose rainfall estimates can be complemented with the satellite vegetation index, farmer interviews and ground-truthed data.

## References

1. ACRE. 2014. *Grameen Credit ACRE Factsheet*. http://www.grameen-credit-agricole.org/sites/grameen/files/acre_kilimo_salama.pdf

2. Greatrex H., Hansen J., Garvin S., Diro R., Blakeley S., Le Guen M., Rao K., Osgood D. 2015. *Scaling up index insurance for smallholder farmers: recent evidence and insights.* CCAFS Report No. 14. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

3. Hellmuth M.E., Osgood D.E., Hess U., Moorhead A. and Bhojwani H. (eds.) 2009. *Index insurance and climate risk: prospects for development and disaster management.* Climate and Society No. 2. International Research Institute for Climate and Society (IRI), Columbia University, New York, USA.

4. IFAD and WFP. 2010. *Potential for scale and sustainability in weather index insurance for agriculture and rural livelihoods*. Rome, www.ifad.org/ruralfinance/pub/weather.pdf.

5. IFAD. 2011. *Weather Index-based Insurance in Agricultural Development: A Technical Guide.* Reprinted February 2015. International Fund for Agricultural Development (IFAD). http://www.ifad.org/ruralfinance/pub/wii_tech_guide.pdf

6. [IFC] International Finance Corporation. 2013. *Kilimo Salama project description.* Washington DC: International Finance Corporation.

7. *IPCC Fifth Assessment, 2014*. https://cdkn.org/wp-content/uploads/2014/04/AR5_IPCC_Whats_in_it_for_Africa.pdf. Accessed July, 20017,

8. Janzen S and Carter M. 2013. *The impact of micro-insurance on asset accumulation and human capital investments: evidence from a drought in Kenya.* Research Paper 31, Geneva: International Labour Organisation.

# 4. Gender and social inclusion


## Abstract

This chapter addresses the critical links of gender with climate change and agriculture. In Zimbabwe and the rest of the developing world, both women and men are smallholders, yet the role that women play is often unrecognised. Globally, women make up 43% of the agricultural labour force, and in Zimbabwe they provide 70% of agricultural labour. Women face structural barriers that create gender gaps and inequalities. Women farmers in southern Africa, as a result, face barriers in adopting CSA practices, including unequal access to credit, technology and agricultural inputs as well as capacity-building. The changing climate is poised to exacerbate these inequalities unless measures are taken to address them. This chapter demonstrates that climate-smart agriculture practices and policies will need to take these barriers into account and develop solutions to address them. Highlighted CSA case studies not only improve food security and increase incomes, but also benefit women and reduce gender barriers. Finally, the chapter emphasises the importance of developing and implementing gender-responsive climate change and agricultural practices, and of mainstreaming gender into academic curricula.



**Keywords:** climate-smart agriculture, gender, gender-responsive policies, information, technology


## Key messages

i. To create awareness of the links of gender with agriculture and climate change;

ii. To promote the mainstreaming and integration of gender in climate change policies and academic curricula; and

iii., To create awareness of existing climate-smart agricultural practices that promote gender equality.

## 4.1 Introduction: gender, agriculture and climate change in Africa

Both women and men in Africa are smallholders. Women make up just under half (43%) of the global agricultural labour force, while in Zimbabwe, 70% of agricultural labour is provided by women, a sector with the lowest wages in relation to other economic sectors (FAO, 2011; Madzwamuse, 2010). This role is increasing, especially as a result of migration out of rural areas by men and young people in search of employment. Despite this, the contribution of women smallholders often goes unrecognised; work activities such as subsistence agriculture are often underestimated or excluded for reasons such as limitation of data sources and data collection approaches which do not include the unpaid work of women and girls in and around households, as in vegetable gardens and food-processing (Twyman et al., 2014). As a result, as found in a recent review of gender and CSA in southern Africa, women farmers in the region face barriers in their ability to adopt CSA practices, including unequal access to credit, technology and agricultural inputs, as well as capacity-building (Perch and Byrd, 2015).

Therefore, in implementing CSA, it is important to understand the needs, priorities and challenges of different stakeholders. Gender relations, opportunities, socio-cultural norms, access to resources and power dynamics across social lines may lead women and men to have different knowledge, skills and perspectives. They may also have different opportunities and constraints that may help or hinder the adoption of CSA. In fact, if implemented without consideration of gender and social inequalities, CSA practices will fail to take advantage of opportunities to improve livelihoods and may instead increase these inequalities.

### 4.1.1 Developing CSA solutions with women farmers

Women farmers are vulnerable to climate change in a number of ways. Their high dependence on natural resources, added to social and economic inequality results in lower levels of access to and control of key productive assets such as land, information and technology. In Zimbabwe, women make up 24% of the labour force in the non-agricultural sector, and their real incomes are three times lower than those of men. Lower levels of decision-making in households and communities also translate to lesser control over their own and family labour, and over the proceeds of household production. As a result, women farmers are particularly affected by climate change, having lower adaptive capacity in many cases and face greater barriers than men in responding and adapting to climate impacts, and they may be less able to select adaptation options in agriculture, including CSA (FAO, 2011; Madzwamuse, 2010; Huyer, 2016; Perez et al., 2015). In surveys in East Africa, women cited financial and resource limitations as reasons for not implementing adaptive changes in their agricultural practices (Jost et al., 2016).

A study of vulnerable households[4] in Swaziland found that the highest indicators of vulnerability are increases in the number of sick members and of dependents (Nkonde et al., 2014). Since these two issues are closely related to women's workload, as they are family caregivers and child carers, women's empowerment and access to labour support will be an important factor in reducing vulnerability and increasing resilience in the region. These are also important factors that enhance the ability of women farmers and female-headed households to adopt CSA.

Solutions developed to support women farmers will need to take into account access to resources, assets and decision-making at the household level. Because of the different work that men and women do, which is largely dictated by gender norms, men and women perceive climate change differently and are affected by it in different ways. Strategies for implementation need to be developed in consultation and continuous assessment with women smallholders (Jost et al., 2015; Duong et al., 2016). Many conservation agriculture approaches have failed to achieve nutrition goals and in fact have increased women's workloads, for

4 Vulnerability is defined as the inability to withstand the adverse impact of exposure to stresses or shocks associated with environmental and social change, and the absence of the capacity to adapt to the impact (Nkonde et al., 2014).

example, emphasis on manual weeding depends on women's labour in many areas, and as a result, these practices may not be adopted by women (Beuchelt and Badstue, 2013).

Nevertheless, when supported with access to productive assets and capacity development, women can be active agents of change and climate resilience. Engaging women in technology design and management decisions improves community outcomes, as in Honduras, where women have re-designed eco-stoves and developed improved agroforestry management systems (Hottle, 2015). In southern Africa women possess valuable local knowledge for resilience: they are often the managers and producers of seed, and they play a role in seed banks and seed production (Nyasimi et al., 2014). We also know that, when women's awareness of and access to information on climate-smart practices increases, they do adopt them (Twyman et al., 2014, Jost et al., 2015) and that the resilience of households, communities and food systems is increased as a result (World Bank, FAO, IFAD 2015).

This is true also for mitigation. Women and men will often have different responses to mitigation, and valuing women's knowledge can lead to new technologies, management practices, organisational forms and political strategies to encourage low-emission agricultural development. However, mitigation incentives related to the carbon market involve market actors, particularly private investors requiring high returns for investments through emissions reductions, new kinds of monitoring and accountability, and timelines which may marginalise poor women, although carbon payment schemes could theoretically provide new sources of financing for climate-smart agriculture. Additionally, mitigation analysis and policy recommendations are often not accessible or useful to local communities and development practitioners, while the models and related research often take a gender-blind approach that avoids addressing long-standing gender and social inequalities (Edmunds et al., 2013).

Nevertheless, research demonstrates:

- If constraints in access to finances, information and workload are addressed, women can design and adopt innovative tools and techniques in farming.
- New technologies and practices for climate change will be adopted more successfully when they are appropriate to women's interests, resources and demands.
- Increased knowledge and information for women leads to their increased status in the family and community, as well as improved production and sustainable livelihoods.
- Gender-sensitive, socially-inclusive community efforts provide greater opportunities for communities to build resilience from their existing strengths and to experience the ensuing benefits.
- If women are given equal opportunities with men, they can help in making better farm management decisions (Huyer et al., 2015; Huyer, 2016; Jost et al., 2016; Mittal, 2016; Nyasimi et al., 2016).

In short, "greater, differentiated, but equal access to CSA tools and techniques as well as climate services could potentially change how resources are used and improve the balance of gendered roles in agriculture [in southern Africa]" (Perch and Byrd, 2015). It can also increase productivity, improve food security and nutrition levels, as well as educational outcomes for children (World Bank, FAO, IFAD, 2015). To illustrate this, Figure 4.1 shows a female sorghum farmer in western Kenya.

***Figure 4.1 A female sorghum farmer in western Kenya***

*Source: CCAFS*

## 4.2 Can CSA contribute to gender equality and women's empowerment case studies from Africa?

The following case studies from different countries in Africa illustrate these trends and show how CSA can contribute to better gender equality and social development outcomes.

### 4.2.1 Women champion knowledge- and technology-based approaches to climate-smart agriculture in Nyando, Kenya

In Nyando, the late onset of seasonal rainfall leads to the occasional flooding of agricultural fields, destroying crops and eroding productive top soil. Early rainfall can substantially increase the chance of longer dry spells, often leading to pre-season pest outbreaks. Farmers must often replant to ensure a harvest. The Obinju Women's Group comprising of 21 members, uses SMS along with other CSA approaches to help them plan their planting seasons and adapt to climate variability. These practices rely less on rain-fed crop production and more on a mixture of closed polythene tube greenhouses and open spaces fitted with water-harvesting structures and drip supply lines. This protects crops from drought, flooding, insect and pest attacks. Four pilot units are now operational in seven villages, showcasing highly diversified and innovative vegetable and bean seed production under drip irrigation.

The Obinju group has made changes to the technology used to supply water to the drip lines. This is a labour- and energy-saving solar-driven water pump which ensures year-round supply of water with very low maintenance costs. Along with other women leaders, entrepreneurs, and farmers, the group has received special training on how to access and use climate services and agro-advisories. The latest data show that these interventions have helped reduce the number of households that experience at least two months per year with one or no meals per day by 60 percentage points. Together with 50 mixed farmer and youth groups in 106 villages in Nyando region that use CSA approaches, a combined savings and loan portfolio serves 1,675 households, mobilising USD 69,500 in a community innovation fund. Borrowing from the facility has reached 90%. Main uses for the loans include buying food, procuring farm inputs, payment of

school fees and start ups for small trade (Kinyangi et al., 2015). Figure 4.2 shows women receiving special training in CSA in Kenya.

***Figure 4.2 Women farmers learning about CSA technology and practices***


*Source: CCAFS*

### 4.2.2 Gender differences in the adoption of CSA practices in Lushoto, Tanzania

Women and men in Lushoto, Tanzania, were asked to rank a range of CSA practices based on their benefits and potential to support adaptation to climate change. There were significant gender differences in the preference for and use of CSA practices. For example, 80% of the men cited minimal use of tillage as important compared to 20% of the women, while intercropping was cited as important by 72% of the women compared to 28% of men. The three most commonly cited CSA practices for women were intercropping, strip-cropping, using inorganic fertilisers and early planting. For men, the preferred practices were minimal tillage, cutting and carrying feed for livestock, and using improved crop varieties. There were no significant gender differences in preference for use of chemical fertilisers and strip-cropping.

On average, male-headed households integrated 10 CSA practices, compared to five CSA practices for women-headed households. The differences between male- and female-headed households can be attributed to the following factors (Table 4.1):

a. Women have limited access to and use of assets such as land, and hence they are unable to adopt long-term practices such as agroforestry;

b. Women pursue different livelihood portfolios, such as household crops and small livestock management, as opposed to cash crops and large livestock, which are managed by men;

c. Men tend to take more risks; and

d. Men have more access to assets, including credit and extension services, as compared to women (Nyasimi et al., 2016; Perez et al., 2015).

***Table 4.1 Gender-differential CSA practices cited by farmers as the most important for adapting to climate change***

| Most important CSA practices | Percentage of households | | |
|---|---|---|---|
| | Total (n=81) | Male | Female |
| Improved crop varieties | 51.9 | 73.8 | 26.2 |
| Composting | 44.4 | 72.2 | 27.8 |
| Chemical fertilisers | 37.0 | 56.7 | 43.3 |
| Agroforestry | 28.4 | 73.9 | 26.1 |
| Intercropping | 22.2 | 27.8 | 72.2 |
| Cut and carry | 21.0 | 76.5 | 23.5 |
| Strip-cropping | 13.6 | 54.6 | 45.4 |
| Minimal tillage | 12.4 | 80.0 | 20.0 |
| Early planting | 9.9 | 62.5 | 37.5 |

*Adapted from Nyasimi et al., 2016*

### 4.2.3 Gender equality in accessing climate information services

Generally men and women across Africa share common interests in climate and weather information; however, they also use this to make different decisions and to inform different priorities. The extended impacts and importance of these different decisions on their lives and livelihoods should not be underestimated. For example, women farmers in Senegal were more interested in information on forecasts of rainfall cessation at the end of the season than forecasts of rainfall onset, since their planting season began a month later than that of men. For them the risk of early rainfall cessation during millet flowering was greater (Tall et al., 2014).

Women and men also access information through different channels. Farmers in Lushoto, Tanzania, were asked where and how they accessed CSA information. The responses indicated that women tended to use primarily informal institutions such as the market, village groups and other farmers. Religious organisations were used to a somewhat lesser extent. This supports research elsewhere indicating that women tend to use informal networks and organisations for information, rather than organised extensions, NGOs or ICT (Tall et al., 2014; Perez et al., 2015; Perch and Byrd, 2015). Young people especially preferred the newest information and communication technologies, namely mobile phones and television (Nyasimi et al., 2016).

Research in southern Africa shows gender differences in information preferences as well. In one study, women farmers in the region tended to see government and farmers' organisations as important support structures for the adoption of CSA, while men rated government organisations as much less important (Perch and Byrd, 2015). Results from stakeholder workshops in five southern African countries[5] show that a) men and women contribute differently to the value chain; b) women make a larger contribution to agricultural labour on smallholdings; and c) gender differences exist in access to credit and agricultural inputs for CSA (Perch and Byrd, 2015). Figure 4.3 shows the success of equal gender roles in CSA training.

***Figure 4.3 Success of equal gender roles in CSA training***

*Source: CCAFS*

## 4.3 Practice: adoption of CSA by women in Zimbabwe

### 4.3.1 Barriers to the adoption of CSA

Women in Zimbabwe (especially those belonging to female-headed households) are already in a disadvantaged position, and the negative impacts of climate change threaten to further exacerbate this inequality. Women's limited access to productive resources, combined with their disadvantaged position in society, and heavy reliance on natural resources for food and income, increases their vulnerability to climate change-induced stress. These gender differences between men and women imply that their vulnerabilities differ, and hence their needs in terms of CSA will differ as well. For example, in 2010 the village of Chirume in Shurugwi District experienced a prolonged mid-season drought that led to crop failure, increasing the burden for women in feeding their families (Brown et al., 2012). The majority of Zimbabwean women living in rural areas (and dependent on farming as a livelihood) are extremely vulnerable to climate change due to a number of factors. These include cultural restrictions on mobility, in that they have to seek male consent before moving during drought and famine, as well as a gendered division of household labour, lower levels

5 Lesotho, Mozambique, Swaziland, Zambia and Zimbabwe.

of educational attainment, and minimum control over land and other productive assets due to unequal property and land rights. Poverty also exacerbates women's and girls' marginalisation and vulnerability (Takunda, 2015; Brown et al., 2012). It is therefore imperative to incorporate gender considerations into climate change, especially climate-smart agriculture.

Sometimes the impacts of climate stresses have led to changes in roles and responsibilities among women, men and young people. In Chirume village, men and youths became involved in water collection (usually done by women) after heavy rains destroyed a dam, and community members were required to travel over a kilometre to fetch water (Brown et al., 2012).

No agricultural technology or practice is gender-neutral, this being true for CSA as well. As outlined above, gender inequalities in Zimbabwe can hinder adaptation to climate change, including the adoption and scaling up of CSA. For example, TerrAfrica, which works in twelve[6] sub-Saharan countries, found that women farmers have insecure land tenure, limited assets, lack of capital, limited farm inputs, limited mobility and access to climate information, and restricted decision-making power (TerrAfrica, 2011). All this can contribute to low adoption of CSA practices.

In Zimbabwe, women often lack knowledge of feasible options for adapting their production systems because they do not receive extension services (Horell and Krishnan, 2007). The institutions responsible for providing early warning systems and agro-advisories do not provide localised disaster risks, nor do they use appropriate information dissemination strategies that target women in rural areas. As a result, women can experience difficulties in adapting to the increasing frequency and severity of extreme weather events, especially drought (Macherera and Chimbari, 2016). A lack of accurate and timely climate information and technical advisory services, coupled with the unavailability and lack of access to inputs (including suitable crop varieties), constrain their ability to assess the risks and benefits of CSA and to make informed investment decisions. Competing resource use, e.g., labour, cash and biomass, will influence decisions on investing in CSA, so that adoption tends to be low among women. Finally, women lack access to financial resources that can enable them to adopt technologies that mitigate against climate change such as water tanks for rainwater harvesting.

### 4.3.2 Importance of gender for climate-smart agriculture and rural development in Zimbabwe

Social-cultural practices shape how women and men deal with the impacts of climate change. Women farmers are particularly vulnerable to these impacts due to their limited capacity to invest or manage risk. Women contribute to food production and security in a changing climate, and reports show that increasing women's access to agricultural resources to equal those of men can increase yields by 20–30% (FAO, 2011).

Addressing the triple challenge of CSA to increase food security, incomes and low-carbon agricultural practices can also contribute to reducing gender barriers to food production and better livelihoods. Recognising the role of women as drivers of smallholder farming (and in turn CSA) will ensure that the CSA objectives of sustainably increasing agricultural productivity among smallholders and building resilience to climate change are realised (FAO, 2013). Improving access to land resources, climate services, credit and markets has the potential to enhance the adoption and success of CSA and also to reduce gender differences in the management of climate risks.

6 Benin, Burkina Faso, Burundi, Ethiopia, Kenya, Mali, Niger, Senegal, Tanzania, Togo, Zambia and Zimbabwe.

### 4.3.3 Integrating a gender perspective in curricula of higher and tertiary institutions

Engendering agriculture curricula in higher and tertiary institutions in Zimbabwe will ensure that future field practitioners, researchers and extensionists are better prepared to develop gender-responsive CSA research, practice and technologies. This in turn will encourage the integration of gender into agriculture policy and programming (case study 4.1).

**Case Study 4.1: Gender-responsive Pedagogy (GRP) programme, Zimbabwe**

Implemented by the Forum for African Women Educationalists Zimbabwe Chapter (FAWEZI), GRP mainstreams gender equality concepts and practices in primary and secondary teacher-training institutions. This includes developing curricula and conducting training programmes for students, staff, government and NGOs with the goal of facilitating the integration of gender and development in policy formulation and decision-making. GRP is also involved in directly influencing government policy and public awareness to mainstream gender into educational curricula. It is anticipated that raising awareness in this way will influence different sectors of society to ensure a positive impact on women in agriculture.

A meeting hosted by the National University of Science and Technology (NUST) in Zimbabwe in 2015 recommended the establishment of a gender institute to promote gender mainstreaming in the curricula of academic programmes (biophysical and social sciences), as well as in different faculties and areas of specialisation, such as forestry, soils, natural resource management, ICT and policy. Several universities in Zimbabwe currently offer agriculture, natural resources and gender studies as one of their programmes. Notable here is the Women's University of Africa located in Harare, which offers agriculture and social science programmes, as well as gender and development studies. This university is affiliated to UNICEF and seeks to be a leader in promoting gender equality in tertiary education in Africa. The university has the capacity to develop gender and CSA programmes to attract students and experts who are interested in such issues. Another option is the development of short courses (one day to two weeks or more) on gender and CSA. The University of Zimbabwe currently offers short courses on gender, crop and animal sciences. Chibero and Mulezu Colleges of Agriculture are also potential candidate institutions for integrating gender and CSA into the curriculum.

One of the challenges to integrating gender into the curricula of higher and tertiary institutions is the availability of qualified academic staff able to teach gender studies and counter negative attitudes. Not many institutions offer gender courses and those that do tend to be located in social science programmes. Agricultural and related science programmes seldom offer such courses; so that academic staff qualified to teach CSA and gender are rare. It is important to note that academic staff who have attended training workshops on gender mainstreaming have reported that the workshops had a profound positive effect (Onsongo, 2011). Training on gender mainstreaming should be recognised as a social and economic policy concern in higher and tertiary academic institutions.

Acquiring gender knowledge and skills should also be considered a mandatory requirement in higher education. Integrating a gender aspect at all levels, including national programmes (for policymakers), curricula and other forms of teaching, learning and research (for educationalists), will reinforce better use of gender concepts in all sectors.

## 4.4 Gender-responsive policymaking to scale up CSA

Five countries in southern Africa[7] (including Zimbabwe) have developed national agricultural policies. A review of these policies shows that gender, climate change, disaster risk reduction and management are all mentioned. Unfortunately, the gender content only consists of a one-way connection to agriculture or broader environmental or natural resource management factors. Given the current changing climate and its devastating effects on food security, livelihoods and the economy, agricultural policies are needed that are both climate- and gender-responsive. Zimbabwe is committed to ensuring gender equality in its control of productive resources, entrepreneurship and employment. Since 2004, the country has enacted a number of national development policies[8] aimed at improving the lives of women through activities such as livelihood diversification, involvement in non-farm employment, empowerment and access to financial services. However, little positive change has been seen to date (Madzwamuse, 2010).

Women, the young and other vulnerable groups (e.g., the disabled) in Zimbabwe are disproportionately affected by the impacts of climate change (e.g., drought and famine), and they remain largely absent from decision-making processes on agricultural policies and climate change adaptation (Government of Zimbabwe, 2014; Brown et al., 2012). The National Climate Change Response Strategy (NCCRS) of 2014 mainstreams gender, children and the young, people living with HIV and AIDS, and other vulnerable groups into all climate change interventions (Government of Zimbabwe, 2014). Some of the interventions that target women, the young and other vulnerable groups include:

- Strengthening the adaptive capacity of vulnerable groups.
- Enhancing provision of early warning systems on droughts, floods and disease outbreaks, and ensuring a coordinated approach in providing them with emergency services.
- Developing culturally appropriate and gender-sensitive labour-saving green technologies.
- Using integrated adaptation responses that combine indigenous knowledge from the elderly with expert insights, disseminate updated information on climate change, and raise awareness of vulnerable groups on disaster preparedness.

The NCCRS, with an allocation of USD 25 million to gender, ensures that national planning and budgeting will incorporate a gender-sensitive perspective. However, this sector has received the least amount of funding compared to other sectors.

Zimbabwe's national agricultural, environmental, natural resource and other land-related policy and planning needs to recognise the roles and contributions of men, women and young people to ensure that their needs are addressed equitably. Ensuring the allocation of adequate financial resources to support the gender-responsive actions outlined by the policies is a necessary step towards improving gender equality and empowering women. Moving forward, gender research is of fundamental importance in informing the development of CSA practices that will benefit women and men. The use of sex-disaggregated data in CSA will raise the profile of climate change as a policy priority at all levels and inform an integrated approach to climate policy across a variety of other economic sectors in Zimbabwe. At the regional level, there is a commitment from institutions such as the Common Market for Eastern and Southern Africa (COMESA) to ensure that at least 80% of the beneficiaries of agriculture and climate change adaptation and mitigation interventions are female farmers and female-headed households (COMESA, 2015).

Embedding CSA within gender-responsive policies will have the potential to extend CSA beyond food production into agricultural value chains (case study 4.2). In doing so, adoption of CSA will increase, and its relevance among women and smallholder farmers will be strengthened to meet changing and increasingly

7 These are Lesotho, Mozambique, Swaziland, Zambia and Zimbabwe.

8 Among these policies are the Zimbabwe Economic Development Strategy (ZEDS) (2007 – 2010); STERP I and STERP II (2009 – 2010); the Mid-Term Plan (MTP) (2011 – 2015); the Gender-Responsive Economic Policy Management Initiative (GERPMI); and the Broad Based Women's Economic Empowerment Framework (BBWEEF).

variable climate realities. Among the policy actions that the Zimbabwean government can promote to scale up CSA are:

- Working with women, researchers and extension agencies to identify, test and promote suitable gender transformative CSA solutions for different agro-ecological and socio-economic contexts;
- Improving the coordination of policies and strengthening local national and regional institutions to support the implementation of gender-responsive and gender-transformative climate-smart agriculture;
- Promoting innovative and gender-responsive financial instruments;
- Raising the level of national investments that target women and young people in CSA across different economic sectors;
- Including everyone's voices in decision-making and policy processes in agriculture, including women and young people, as well as smallholders in general; and
- Developing pathways for the scaling up and gender-responsive implementation of CSA with the active participation of women, local communities and government officials.

**Case study 4.2: Using the market place to build the resilience of women in Honde Valley, Zimbabwe**

The SNV Netherlands Development Organisation is working with women farmers in Zimbabwe along the value chain, from production to market. Using a transformative gender model called "balancing benefits", women are involved in increasing production and ensuring food security, while at the same time building resilience to climate change. The programmes are involved in changing gender norms and relations within the household and community in order to allow women access to market opportunities. Through the «balancing benefits» model, women are empowered to take an active role in decisions around productive resources and assets, including labour-saving technologies. Of importance is the ability of women to engage in value-added enterprises and thus influence business environments both to support women in agri-business and manage climate risks. The success of this programme is being scaled up through SNV's Rural Agro-dealers Restocking Programme (RARP), a market-led model for revitalising agricultural production by providing the right farm inputs at the right time, as well as low-claim insurance and loans to reduce risk and build capacity.

Another strategy for enhancing the scaling up of CSA is the promotion of gender-responsive ICT-based tools, farmers' fairs and participatory videos of technology adoption. The current Zimbabwe Policy for ICT (2015) aims to mainstream gender in the design and implementation of ICT programmes to ensure that both sexes (women and men) and ages (youth and the old) can access and receive information and opportunities. In Zimbabwe, women's organisations have been instrumental in providing a networking platform to share knowledge and information. Connecting women's organisations with gender-responsive ICT and other participatory methods can also be an effective scaling-up approach for CSA (Ragasa, 2012).

## 4.5 Conclusion and recommendations

In conclusion, we know that women farmers do adopt CSA practices when they have the information, resources and capacity to implement them (Jost et al., 2016). However, serious gender gaps in accessing credit, technology and agricultural inputs, capacity-building and household decision-making hinder their adoption. These key constraints are linked to the assets women possess and their levels of access to income and common property resources. They are also related to the extent to which they interact with and benefit from social support institutions, government and NGOs (Perez et al., 2015). Incorporating a gender

equality perspective into policy-making and implementation is necessary to ensure that the vulnerabilities of women and other disadvantaged groups are identified and addressed. During national planning and budgeting, policymakers should consider sex-disaggregated data in order to highlight inequalities among women, as well as other marginalised groups, including the young. Existing guidelines, e.g., IUCN (2011) gender guidelines for national adaptation plans, can be used as a framework for mainstreaming gender in climate-smart agriculture. Additionally, women's organisations' networking platforms can be used to identify gender-disaggregated priority research and translate the findings from science (including traditional knowledge) into policy actions. Developing a sustainable dialogue forum for both female and male farmers, agricultural and climate change experts, and policymakers to agree on a shared vision and approach to gender-responsive CSA in Zimbabwe will increase the adaptive capacity of all farmers in the country for sustainable and resilient livelihoods.

Specific Recommendations

- Identify and scale up viable gender-sensitive CSA solutions.
- Identify and prioritise CSA support structures such as gender-responsive investment and financial instruments.
- Support and promote women's groups in smallholder agriculture initiatives in a sustainable livelihoods framework.
- Develop, track and monitor policy implementation and service delivery to women in such a way that they do not intensify pre-existing inequalities between men and women.
- Undertake participatory and consultative processes which include women, the young and other less represented social groups in the planning, design and implementation of CSA activities.
- Provide women-targeted training in CSA technologies and practices.
- Nevertheless, participation is not sufficient: increases in control and decision-making by women on the use of resources are still needed to take gender mainstreaming in CSA to the next level.
- Support actions to increase women's income and access to finance through savings and credit, as well as diversified vegetable and market gardening.
- Develop women-targeted climate services (information and insurance) and appropriate channels for these services to support women's access to and use of productive assets.
- Ensure that CSA practices and technologies do not increase women's workload but are geared towards reducing women's burdens.
- Raise awareness among men to help them understand the causes and consequences of socially constructed norms (e.g., issues of masculinity), and also to ensure that they do not feel left out.

## Acknowledgements

This chapter was written by Sophia Huyer and Mary Nyasimi, Gender and Social Inclusion, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). We acknowledge the CGIAR Fund Council, Australia (ACIAR), Irish Aid, European Union, and International Fund for Agricultural Development (IFAD), The Netherlands, New Zealand, Switzerland, UK, USAID and Thailand for providing funding to the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

## References


1. Beuchelt, T. D., & Badstue, L. (2013). *Gender, nutrition- and climate-smart food production: opportunities and trade-offs.* Food Security, *5*(5), 709–721. https://doi.org/10.1007/s12571-013-0290-8

2. Brown, D., Rance Chanakira, R., Chatiza, K., Dhliwayo, M., Dodman, D., Masiiwa, M., Muchadenyika, D., Prisca Mugabe, P. and Zvigadza, S. (2012). *Climate change impacts, vulnerability and adaptation in Zimbabwe.* IIED Climate Change Working Paper No. 3

3. [COMESA] Common Market for Eastern and Southern Africa. (2015*). Regional Strategy for Mainstreaming Gender in Agriculture and Climate Change: Strategic Framework.*

4. Dlamini, C., and Samboko, P. C. (2016). *Towards Gender Mainstreaming in Agriculture, Natural Resources Management and Climate Change Programs in Zambia.* Lusaka, Indaba Agricultural Policy Research Institute (IAPRI). Retrieved from http://www.iapri.org.zm

5. Duong, M. T., Simelton, E., & Le, V. H. (2016). *Participatory identification of climate-smart agriculture priorities*. CGIAR Climate Change, Agriculture and Food Security Program, Copenhagen, Denmark.

6. Edmunds, D., Sasser, J., & Wollenberg, E. (2013). *A Gender Strategy for Pro-Poor Climate Change Mitigation.* CCAFS Working Paper no. 36, (36), 36. Retrieved from http://ccafs.cgiar.org/publications/gender-strategy-pro-poor-climate-change-mitigation

7. FAO. (2011). *The state of food and agriculture 2010–2011: women in agriculture, closing the gender gap for development*. Rome: Author. Retrieved from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3291936&tool=pmcentrez&rendertype=abstract

8. FAO (2013). *Climate Smart Agriculture Source Book.* Rome, Italy. Available at http://www.fao.org/docrep/018/i3325e/i3325e.pdf

9. Government of Zimbabwe, Ministry of Environment, Water and Climate. (2014*). National Climate Change Response Strategy*. Available at http://www4.unfccc.int/sites/nama/_layouts/UN/FCCC/NAMA/Download.aspx?ListName=NAMA&Id=162&FileName=Climate%20Change%20Response%20Strategy.pdf

10. Government of Zimbabwe (2015*). National Policy for Information and Communication Technology (ICT).* Available http://www.ictministry.gov.zw/sites/default/files/downloads/2%20Revised%20Penultimate%20%20Zimbabwe%20National%20ICT%20Policy%202014%20-%20Sept%202014.pdf

11. Horrell S. & Krishnan P. (2007). *Poverty and Productivity in Female-Headed Households in Zimbabwe. Journal of Development Studies* 43(8): 1351-80.

12. Hottle, R. (2015). *Women-led agroforestry and clean cookstoves in Honduras: field evaluation of farmer-led gender-transformative strategies for low emissions agriculture.* (No. 125). Copenhagen, Denmark: CGIAR Climate Change, Agriculture and Food Security Programme.

13. Huyer, S. (2016). *Introduction: Gender, Climate Change and Agriculture. Gender, Technology and Development*, 20(2), 105-116

14. Huyer S, Twyman J, Koningstein M, Ashby J, V. S. (2015). *Supporting women farmers in a changing climate: five policy lessons.* Copenhagen, Denmark. Retrieved from https://cgspace.cgiar.org/rest/bitstreams/60479/retrieve

15. [IUCN] International Union for Conservation of Nature. (2011). *Draft Guidelines to Mainstreaming Gender in the Development of National Adaptation Plans (NAPs).* UNFCCC August 2011.

16. Jost, C., Kyazze, F., Naab, J., Neelormi, S., Kinyangi, J., Zougmore, R., Aggarwal, P., Bhatta, G., Chaudhury, M., Tapio-Bistrom, M., Nelson, S. & Kristjanson, P. (2016) *Understanding gender dimensions of agriculture and climate change in smallholder farming communities.* Climate and Development Vol. 8(2). 2016 Climate and Development, 8 (2), 133–144 .

17. Kinyangi J, Recha J, Kimeli P & Atakos A. (2015). *Climate-smart villages and the hope of food secure households: preliminary results from climate change adaptation and mitigation initiatives in the Nyando climate-smart villages.* CCAFS Info Note. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online at: www.ccafs.cgiar.org.

18. Macherera, M. and Chimbari, M.J. (2016). *A review of studies on community based early warning systems.* Jàmbá: Journal of Disaster Risk Studies 8(1), a206. http://dx.doi.org/10.4102/jamba.v8i1.206

19. Madzwamuse, M. (2010). *Climate Governance in Africa: Adaptation Strategies and Institutions.* Heinrich Böll Stiftung (HBS). Accessed from https://www.boell.de/sites/default/files/assets/boell.de/images/download_de/Climate_Governance_in_Africa.pdf

20. Maunze, S. (2012). *Agro-dealers in Zimbabwe: scaling input provision as key for successful small farmer engagement.* SNV. Paper presented at The Hague, 11-13 April 2012.

21. Mittal, S. (2016). *Role of Mobile Phone-enabled Climate Information Services in Gender-inclusive Agriculture.* Gender, Technology and Development, 20(2).

22. Nkonde, M., Masuku, M.B. and Manyatsi, A. M. (2014). *Factors Affecting Household Vulnerability to Climate Change in the Lowveld of Swaziland.* FANRPAN Policy Brief. Pretoria.

23. Nyasimi, M., Radeny, M., Kimeli, P., Mungai, C., Sayula, G., & Kinyangi, J. (2014). *Uptake and Dissemination Pathways for Climate-Smart Agriculture Technologies and Practices in Lushoto, Tanzania.* Working Paper No. 173. CGIAR Climate Change, Agriculture and Food Security Programme. Copenhagen, Denmark.

24. Onsongo JK. (2011). *Promoting Gender Equity in Selected Public Universities in Kenya.* Addis Ababa, Ethiopia, Organisation for Social Science Research in Eastern and Southern Africa (OSSREA) ISBN: 978-99944-55-62-1

25. Perch, L., & Byrd, R. (2015). *Gender in the CSA Discourse: Making the Case for Gender-Smartness.* Rio+ Centre, Rio de Janeiro, Brazil.

26. Perez, C., Jones, E. M., Kristjanson, P., Cramer, L., Thornton, P. K., Foerch, W., & Barahona, C. (2015*). How resilient are farming households and communities to a changing climate in Africa? A gender-based perspective. Global Environmental Change* 34, 95–107. http://doi.org/10.1016/j.gloenvcha.2015.06.003

27. Ragasa C. (2012). *Gender and Institutional Dimensions of Agricultural Technology Adoption: A Review of Literature and Synthesis of 35 Case Studies.* Conference Paper. IFPRI, Washington DC, USA. Available at http://www.ifpri.org/publication/

28. Takunda J.C. (2015). *Gender Dynamics of Energy Poverty in Urban Zimbabwe: The Case of Hatcliffe Informal Settlement.* American Journal of Social Sciences. Vol. 3(4), 104-114.

29. Tall, A., Kristjanson, P., Chaudhury, M., & Mckune, S. (2014). *Who gets the information? Gender, power and equity considerations in the design of climate services for farmers*. Copenhagen, Denmark: CGIAR Climate Change, Agriculture and Food Security Programme.

30. TerrAfrica (2011). *Sustainable Land Management in Practice: Guidelines and Best Practices for Sub-Saharan Africa*. Field Application. Prepared by WOCAT; coordinated by the Food and Agriculture Organisation of the UN, Rome, Italy. https://www.wocat.net/fileadmin/user_upload/documents/Books/SLM_in_Practice_E_Final_low.pdf

31. Twyman, J., Green, M., Bernier Q, Kristjanson, P., Russo, S., Tall, A., Ampaire, E., Nyasimi, M., Mango, J., McKune, S., Mwongera, C., & Ndourba, Y. (2014). *Gender and Climate Change Perceptions, Adaptation Strategies, and Information Needs Preliminary Results from four sites in Africa.* CCAFS Working Paper no. 83. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online at:www.ccafs.cgiar.org.

32. World Bank FAO, IFAD. (2015). *Gender in Climate-Smart Agriculture*. Washington DC: World Bank.

# Section II. System approaches

# 5. The landscape approach


## Abstract

Diverse ecosystems in Zimbabwe are considered to be under the threat of climate change. In the face of such challenges, Zimbabwe needs to adapt a rigorous landscape approach that will have a positive impact across sectors. This approach places human welfare at the centre of the land-use decision-making process. Normally, the landscape approach is categorised into three components for operationalisation, viz.: landscape goals embracing multiple objectives at different scales, adaptive planning, management, and collaboration, and comprehensive sector involvement. In this chapter, 10 key principles, which can be taken as a checklist for the implementation and operationalisation of landscape management, are discussed. Furthermore, good governance is imperative in landscape approaches, since this determines the levels of transparency through which resources are shared. Among the issues that are critical in the landscape approach are capacity-building, land tenure security, integrated land-use planning and stakeholder participation. Barriers to the landscape approach include policy and institutional hurdles, socio-economic factors, lack of knowledge, and uncoordinated funding for mitigation and adaptation. The chapter also suggests some solutions to these barriers.



**Key words:** conservation, degradation, ecosystems, landscape approach, land use, natural resources, sustainability


## Key messages

i. To meet national food security objectives as well as needs of a variety of stakeholders in a specific landscape, land-use planning and the management of natural resources, need to be coordinated across sectors and through a participatory and consensus-based decision-making process;

ii. Attaining ecologically sound landscape approaches calls for building national and local capacity in developing inclusive governance arrangements. This includes improvements in tenure security and the recognition of individual and groups rights;

iii. Public policies regarding those sectors that have a significant impact on landscape dynamics need to be harmonised, and land-use legislation needs to be enforced through strengthened national and local institutions and governance;

iv. The implementation of REDD+ can play a catalytic role in promoting a landscape approach by reinforcing the forest-agriculture nexus; and

v. A common knowledge base needs to be developed on feasible concepts, techniques and methods to allow stakeholders to develop, implement and monitor landscape approaches.

## 5.1 Introduction

Land is critical for the production of various goods and services that ensure the well-being of the human race. There are competing needs, and viewpoints on land resource by various stakeholders (land/soil, water, agroforestry, watershed, fisheries, forest, urbanisation, industrialisation and agriculture). 'Silo' based approaches are unsustainable hence the need for a holistic approach. Landscape approach is a set of tools, methods and strategies that aim at achieving multiple objectives (social, economic and environmental) of the stakeholders by optimising the interests of all. It aims at achieving ecosystem interests (conservation); economic interests (production) and livelihoods.

Several meetings, such as the Seventeenth Session of the Commission on Sustainable Development (CSD 17), First Global Conference on Agriculture, Food Security and Climate Change and the RIO+20 United Nations Conference on Sustainable Development, all acknowledged the importance of land-based sectors for increasing agricultural productivity. This also involves safeguarding important environmental services, such as water regulation, pollination, biodiversity and climate regulation, as well as reduced emissions and increased sequestration, and improving livelihoods and food security. To achieve these challenging goals, an integrated landscape approach has to be in place to facilitate the diversity of land uses across the landscape, interactions between these different land uses and their associated components.

## 5.2 Unsustainable management of natural resources

Farming, forestry and fishery systems have provided goods and services to a growing global population. However, this has often been achieved at the expense of sustainability with respect to the environment. The consequence of this mode of providing services is the degradation of landscapes, land and water resources, as well as the loss of biodiversity and other ecosystem services. This deplorable situation has been exacerbated by targeted market-driven approaches that tend to optimise the production derived from specific enterprises (e.g., crop or livestock production) that focus on single products that rely on subsidies or support services, such as credit, input supply and marketing.

In addition, some systems are ineffective and unsustainable due to insufficient technical knowledge or a lack of access to resources and investments that could help to minimise the degradation of the natural resource base and the encroachment of agriculture into existing virgin ecosystems (FAO, 2010).

## 5.3 Climate change threat to ecosystems in Zimbabwe

Diverse ecosystems in Zimbabwe are considered to be under the risk of climate change (Zimbabwe National Response Strategy to Climate Change, 2015). Climate change impacts, which are largely negative, will lead to environmental and socio-economic threats to the country's agricultural landscape. Extreme weather events, such as droughts and floods, are predicted to become more frequent, as described in the introductory chapter of this Manual. The devastating 2016 drought in southern Africa is a recent example of such extreme weather events.

In the face of such challenges, Zimbabwe needs to adapt a rigorous landscape approach that will have a positive cross-sectoral impact on social, economic and environmental perspectives. The country has a rich biological diversity, which provides ecosystem services such as food, medicine, energy sources, building and craft materials, as well as spiritual, cultural and aesthetic services. This biodiversity also regulates climate, soil fertility and outbreaks of pests and diseases, and maintains functional ecosystems. Vegetation is characterised as mainly savannah woodland interspersed with open grassed drainage lines or *dambo*s (wetlands). However, the recurrent droughts affecting Zimbabwe have also resulted in the loss of a number

of plant and animal species. Furthermore, degraded rangelands will impact negatively on the livelihoods of farmers, particularly small-scale, resource-poor farmers living in marginal areas who are likely to get trapped in poverty. The World Food Programme estimated that 4.1 million people in Zimbabwe were in need of food following the severe drought of 2016 (*http://www1.wfp.org/countries/zimbabwe – accessed on 17/07/2017).*

## 5.4 Perspectives on the landscape approach

The landscape approach (LA) is based on large-scale processes in an integrated and multidisciplinary formulation that takes into account natural resources management which includes environmental and livelihood concerns. The approach ropes in human activities and their institutions as part and parcel of the system. It is anchored in the fact that the main problems are not location-specific and that the appropriate development agenda calls for multi-stakeholder interventions to be brought into play. The LA places human well-being and needs at the centre of the land-use decision-making process, as well as the rights and cultural values of the farmers involved, in as much as it relates to their land-use objectives. This approach also includes a commitment to environmentally friendly solutions and the expected durable success of sustainable development initiatives (on landscape approaches, FAO, 2012b; Farina, 2006).

Farm-level management decisions on such issues of water use, soil management, production system choices and the use of landscape features such as hedgerows affect the surrounding landscape and its associated ecosystem services. Decisions on the use of farm resources and common property resources in the surrounding landscape are a function of the socio-economic situation of the users. It is affected by their tenure and labour security, access to services and markets, as well as their education levels and financial and organisational capacities.

New holistic approaches and technologies for sustainably managing farmlands, rangelands and forests have emerged. For example, integrated watershed and river-basin management are approaches that address a host of land uses in a catchment area, their effects on soil properties and erosion, and the hydrological regime, as well as biomass, energy and biodiversity issues. Upstream and downstream land and water users and their mutual interactions are also included in this approach. A range of sustainable production methodologies designed to enhance productivity as well as contribute to the protection and enhancement of ecosystem services are also enshrined in the landscape approach. Examples of these approaches include sustainable crop production intensification (FAO, 2010 a), organic agriculture (Sanduh et al., 2009), conservation agriculture (Kassam et al., 2009), integrated crop-livestock management (Russelle, 2007) and agroforestry (Jose, 2009). The centrepiece to the success of these methodologies is an integrated landscape approach that takes into account the loaded mosaic of land uses, stakeholder needs, common management practices and their interactions.

The EcoAgriculture Partners (2012) report categorises LA into key actions with three broad, core components for operationalisation. It then lists 10 key principles that can be considered as a checklist for the implementation and operationalisation of integrated landscape management. These three components are: (a) landscape goal(s) encompassing multiple objectives at different scales; (b) adaptive planning and management; and (c) collaborative action and comprehensive stakeholder involvement. These core components are illustrated in Fig 5.1.

Some of the advantages of LA include the following:

- it is not a “one-size-fits-all” approach but rather encompasses several sectors, stakeholders, social, cultural and other conditions across geographical boundaries that broadly make ecological sense;
- it requires that land-use planning and decision-making are considered differently with respect to scale, taking into account spatial components;

- it encourages a combination of bottom-up and top-down principles so as to encourage local community participation; and
- economies of scope and scale: land and water users in a landscape share their skills and assets with a view to achieving economies of scale and cost advantages resulting from integrated production.

***Figure 5.1 Ten principles for a landscape approach to reconciling agriculture, conservation and other competing land uses.***


*Source: Vinod personal communication*

## 5.5 Some governance issues in implementing LA

In order to mount a successful landscape approach, it is imperative to have sound governance structures, since this determines the level of transparency through which resources are distributed. Furthermore, good governance potentially minimises the chances of corruption or abuse of power creeping into the operationalisation of the approach. Good governance also creates the enabling environment for coming up with landscape programmes that are successful and sustainable over time. In this vein, relevant rules and processes should be built into the formulation of resource management policies in a given locality. In addition, these structures should also be flexible such that they are customised to local situations. The following sections touch on some of the most important requirements when implementing the landscape approach.

### 5.5.1 Capacity-building in the landscape approach

To adopt a landscape approach, the participating stakeholders need to be fully informed about the approach, as well as their rights and responsibilities within the landscape, so as to be able to participate meaningfully in discussions pertaining to the land. Capacity-building with respect to landscape management is vital at all levels in order to manage both natural and social systems holistically. Further training may require stakeholders to take part in discussions and negotiations with respect to resource management, learning new tools and methods for landscape management, new approaches for individual or community land management, and technologies and methods for agricultural and forestry activities. Extension services are often used for community capacity-building (FAO, 2012). Box 5.1 illustrates some of the capacity-building requirements.

***Box 5.1 The VI Agroforestry Western Kenya Carbon Project***

Initiated in 2009, the VI Agroforestry Western Kenya Carbon Project works through a well-established extension service covering 45,000 hectares and serving 60,000 farmers. These extension workers collaborate with local community groups, facilitating the training and implementation of sustainable, locally adapted agricultural land management techniques. The project works with local institutions, building the capacities of local extensionists, field officers and farmers.

*Source: Kenya Agricultural Carbon Project, 2011*

### 5.5.2 Security of land tenure

Tenure security and its governance are central to sustainable landscape management. Long-term planning is risky and untenable in an uncertain environment. This state of affairs encourages unsustainable land and resource management, for example, indiscriminate cutting down of trees leading to deforestation. Recognition of the tenure entitlements of all stakeholders in a given landscape enables them to arrive at land-use planning decisions committing themselves to long-term adaptation and mitigation objectives. Tenure-holders and resource-users should be involved in this process of participatory consultations and entitlements.

### 5.5.3 Well integrated land-use planning

Participatory Integrated Land-use Planning (ILUP) has become the main tool for any (spatial) development intervention whose objectives are social, ecological and economic sustainability. As a tool that is dedicated to the interests of different user communities in a defined area, it plays a pivotal role in the landscape approach. Sometimes there are circumstances in which the various interests of small-scale farmers, herdsmen, mining companies, large-scale agricultural investors and the populations of villages and small towns have to be amicably reconciled in a given landscape, while respecting spaces for recreation and protected areas for nature and biodiversity. Land-use planning therefore actively involves the different interest and user communities in finding compromises that permit sustainable development collaboratively.

### 5.5.4 Participation

To arrive at consensus decisions, it is essential to have a legitimate forum where negotiations can take place and conflicts are resolved. All stakeholders should have fair representation in such a forum and be given sufficient capacity to participate effectively. An adequate knowledge base, appropriate to the local setting, is crucial to the landscape approach planning process. This should include an understanding of the problems, needs and objectives of all stakeholders, namely the status and trends of land resources,

appropriate technologies for improved productivity and reduction of environmental impacts, institutional and legal frameworks and economic and market conditions. The latest version of the FAO methodology for agro-ecological zoning (FAO 2012 c) contains a comprehensive account of these various social and environmental considerations.

## 5.6 Climate-smart agriculture and the landscape approach

Climate-smart agriculture is applicable at multiple levels. It covers practices and technologies at the field and farm levels and involves working with communities over a much wider area, such as watersheds and ecosystems (Figure 5.2). Although many examples of successful climate-smart practices exist, there is still much work to be done to improve technologies, policies and institutions to move from single objective production to the implementation of different types of multiple objective systems. The breakthrough towards a broad application of climate-smart natural resource management will require a paradigm shift in our thinking about agricultural production and the related institutional structures that will make this transformation a reality.

***Figure 5.2 Landscape approach incorporating agriculture***

*Photo credit: Shutterstock*

Among the different land uses in the landscape approach, there will be synergies and trade-offs. Some serious efforts are required to manage the synergies and trade-offs between building the resilience of the ecosystems and livelihoods and reducing greenhouse gas emissions. Numerous experiences and best practices that can contribute to reaching the objective of climate-smart agriculture already exist and are discussed in other chapters of this Manual. These practices, which touch on synergies between mitigation and adaptation, as well as supporting the multiple functions of agricultural systems and landscapes, should be scaled up to the landscape level.

By taking a landscape approach and applying climate-smart agriculture, one finds ways of increasing mitigation and adaptation opportunities on community lands as well as the entire ecosystem, while at the same time sustainably increasing and intensifying productivity. Below is a list of activities that can help in this regard:

- The conservation and regeneration of trees and the restoration of degraded forests also increases carbon stocks and may, in addition reduce the pressure on adjacent natural forests and ecosystems, resulting in a decline in emissions. Increasing the diversity of trees allows more overall biodiversity in the landscape, as well as creating favourable moisture conditions. This contributes to the regeneration of soil nutrients, which makes the forest more resilient.
- Trees on farms or agroforestry systems can contribute to mitigating climate change, as they tend to sequester greater carbon quantities than agricultural systems alone. Trees have other important functions, such as providing shade for crops, erosion control and nutrient cycling. They also act as buffers against storms, and hence protect crops. By providing a means to diversify incomes, trees provide a type of insurance in the event of crop failures, since they can provide an alternative income.
- The holistic management of grassland ecosystems and controlled grazing allows for the regeneration of degraded vegetation and soils. This, in turn, creates an opportunity to sequester carbon in the soil, as well as increasing biomass and biodiversity through perennial grasses, shrubs and trees. Well-managed grasslands provide other important benefits, such as increased water infiltration and retention and improved nutrient cycling.
- At the farm level, there are opportunities to increase productivity and carbon sequestration through conservation agriculture. Conservation agriculture combines minimum tillage with crop rotation and covers crops or mulch. This enhances biomass by integrating trees and shrubs in and around the fields. Conservation agriculture also increases tolerance to changes in soil temperature and rainfall associated with extreme climate events such as droughts or flooding.

## 5.7 Barriers to the landscape approach

Even though there is a strong potential for synergies between adaptation and mitigation benefits, several barriers stand in the way of adoption of climate-smart landscapes:

- Policy and institutional hurdles hinder the integration of adaptation and mitigation within the landscape approach. Policies that support conventional agriculture (fossil fuel-intensive) are generally more favourably considered than those that support sustainable and climate-smart practices (Mattison and Norris, 2005). Furthermore, development policy is usually short-term (usually five to ten years), whereas the results of the landscape approach require longer-term planning.
- Institutional barriers usually hinder the addressing of complexities at the landscape level. Usually, landscapes and the interactions between stakeholders and different land uses is complex. In most cases, there are no simple solutions to complex challenges, and a “one-size-fits-all” approach does not apply. This situation, therefore calls for a careful assessment of location-specific challenges, as well as a learning-by-doing approach. Furthermore, ways need to be found that take into account the sector-specific mandates of different ministries to resolve the challenges of working across sectors.
- Socio-economic factors in developing countries usually limit the implementation of climate-smart agriculture even in cases where funding is available and the policy is appropriate. In such cases, poverty, cultural factors, education, access to markets and credit, institutional capacity and a lack of land tenure are known to affect the adoption of sustainable agricultural practices and farmer decisions regarding land use (McCarthy et al; 2011).
- Lack of knowledge and awareness of integrated landscape management at the levels of national and local governments, the private sector and civil-society actors is a serious obstacle to the adoption of a landscape approach. Landscape level ideas take time to filter down to more national and local

actors. Furthermore, many integrated landscape management programmes lack strong monitoring and evaluation components, especially beyond household and community scales, thus making the assessment of landscape-level benefits difficult

- Separate and uncoordinated funding for mitigation and adaptation also pose a constraint on adoption of the landscape approach. Mitigation activities are usually funded by the private sector and carbon finance, whereas adaptation measures are likely to be supported by public funds, NGOs and donors who are interested in poverty alleviation, food security or disaster relief (Schallatek et al., 2012).

## 5.8 Suggested solutions

While the barriers to the landscape approach are considerable, they could be removed through a combination of targeted scientific research, policy and institutional reforms, and the required changes in finding modalities and sources. One area that needs improvement in the adoption of climate-smart landscapes is exploiting scientific evidence and the necessary technical guidance to achieve the best options for agricultural systems and landscapes (Scherr et al., 2012).

With respect to policy and institutions, it is necessary to have a high level of commitment to support conservation agriculture, agroforestry and other climate-smart practices; to promote multi-stakeholder planning across local, regional, national and business interests; to raise the awareness of policymakers and other decision-makers about agriculture and landscapes; to promote landscape governance and resource tenure reforms that facilitate and incentivise planning for landscape management; and to promote local institutions and extension services and clarify agriculture's role in the context of REDD+.

With regard to funding, development is needed of more diverse funding opportunities such as payments for ecosystem services, as well as philanthropic investments, government and private funding to support climate-smart agriculture and integrated landscapes. There is a need to ensure that carbon finance initiatives promote the adoption of best practices that integrate mitigation and adaptation goals. There is also a need to promote strategies that include adaptation as a precondition for obtaining carbon finance for mitigation projects (for instance the UN’s REDD+ and the private sector) and vice versa for adaptation projects.

In the area of socio-economics, there is a need to promote national-level policy and institutional changes to ensure that farmers have the resources and technical capacity to adopt climate-smart agricultural practices. Finally donors should also be encouraged to support local efforts aimed at integrating adaptation and mitigation activities.

## 5.9 Conclusions

By promoting the sustainable management of the natural resource base, preserving and increasing ecosystem services, and building resilience to shocks and disturbances, the landscape approach can greatly support the needs of diverse stakeholder groups. However, the successful implementation of this approach requires strong governance and participatory mechanisms involving all stakeholders. It also demands a multidisciplinary understanding of the environmental, social and economic dynamics within the landscape. In particular, considerable work needs to be done to understand the drivers and agents of agricultural expansion and deforestation so that appropriate policy and finance interventions can be included. This is particularly important in tropical countries where deforestation, driven by a number of factors, is causing widespread land degradation, contributing to greenhouse gas emissions and accelerating the loss of biodiversity. Country- and location-specific cross-sectoral policies targeted financing mechanisms (including REDD+) and governance and regulatory infrastructures need to be devised to reduce the drivers of deforestation, to safeguard forests from agricultural encroachment and to reconcile the diverse sustainable land-use objectives in landscapes in better ways.

The need for a transition to climate-resilient, low-greenhouse gas emitting production systems involves all the land management systems in a given landscape. Climate-smart agricultural measures and policies have to be seen as key components of local, national, and regional climate change strategies. It is important to recognise the multiple dimensions and purposes of natural resource use and management, and the interactions between human land-use, management practices and natural resources. This requires greater consistency across all land-use sectors where the implementation of climate-smart agriculture should play a critical role.

## References


1. EcoAgriculture Partners. 2012. *Landscape-scale Management Approaches to Achieving Agricultural Production, Ecosystem Services Conservation and Livelihood Security in Sub-Saharan Africa:* Literature Review and Synthesis for Policymakers and Practitioners. URL: http://ecoagriculture.org/documents/files/doc_624.pdf

2. FAO. 2010a. *An ecosystem approach to sustainable crop intensification: a conceptual framework.* Accessed June 8th 2012 at *http://www.fao.org/fileadmin/templates/agphome/scpi/SCPI_ Compendium/SCPIConceptual_ framework.pdf*

3. FAO (2012b) *Mainstreaming climate-smart agriculture into broader landscape approach: Second Global Conference on Agriculture, Food Security and Climate Change.* Hanoi, Vietnam. 2012.

4. FAO. 2012c. *GAEZ Global Agro-Ecological Zones User's Guide.* May 2012, http://www.fao.org/nr/gaez/en/

5. Farina D.A. 2006. *Principles and Methods in Landscape Ecology: Towards a Science of the Landscape.* Berlin: Springer Verlag.

6. José, S. 2009. *Agroforestry for ecosystem services and environmental benefits: an overview.* Agroforestry Systems 2009, 76:1–10.

7. Kassam et al., 2009. Kassam A., Friedrich T., Shaxson F., Pretty J. *The spread of conservation agriculture: justification, sustainability and uptake.* International Journal of Agricultural Sustainability 2009, 7:292–320.

8. Kenya Agricultural Carbon Project, 2011. *Climate Change and Sustainable Agricultural Land Use Management March 9, 2011.* Tokyo, Japan

9. McCarthy, N., Lipper, L. & Branca, G. (2011). Climate-smart agriculture: smallholder adoption and implications for climate change adaptation and mitigation. *Mitigation of Climate Change in Agriculture Series 4, FAO http://www.fao.org/docrep/015/i2575e/i2575e00.pdf (visited March 12, 2013).*

10. Mattison, EHA and Norris, K (2005). *Bridging the gaps between agricultural policy, land-use and biodiversity.*

11. Ministry of Environment, Water and Climate (2015). *Zimbabwe's National Climate Change Response Strategy.*

12. Russelle et al., 2007. Russelle M.P., Entz M.H., Franzluebbers A.J. *Reconsidering Integrated Crop– Livestock Systems in North America.* Agronomy Journal 2007, 99:325.

13. Sandhu et al., 2010. Sandhu H.S., Wratten S.D., Cullen R. *Organic agriculture and ecosystem services.* Environmental Science & Policy 2010, 13:1–7.

14. Sara J. Scherr, Seth Shames and Rachel Friedman (2012*): From climate-smart agriculture to climate-smart landscapes.* Agriculture and Food Security 2012.1:12.

15. Sayer, J., Sunderland, T., Ghazoul, J. et al., (2013). Ten principles for a landscape approach to reconciling agriculture, conservation and other competing land uses. *Proc. Natl. Acad. Sci. U.S.A.,* 110, 8349-8356.

16. Schalatek, L., Stiftung, H.B., Nakhooda, S., Sam, B. &Caravani, A. (2012*) Climate Finance Thematic Briefing: Mitigation Finance.* Climate Finance Fundamentals 4. November 2012. Overseas Development Institute-Heinrich Bo¨ ll Stiftung North America.

17. Scherr, S.J., Shames, S. & Friedman, R. (2012) *From climate-smart agriculture to climate-smart landscapes,* Agriculture and Food Security 1 (12): 1-15.

18. World Bank Group, 2016. *Integrated Landscape Approach for Drylands.* http://www.adaptation-undp.org/community-resilience-through-integrated-landscape-management.

# Section III. Practices

# 6. Soil and water management in climate-smart agriculture in Zimbabwe


## Abstract

This chapter addresses how soil and water management practices can contribute to the three pillars of climate-smart agriculture in Zimbabwe. On water, the chapter will look at strategies, such as more efficient irrigation and drainage, and in-situ moisture conservation and water harvesting practices that are applicable under different climatic and scale conditions. On soil, the chapter addresses the problem of soil degradation by discussing strategies to control soil erosion, nutrient management, reduced tillage, mulching, residue management and carbon sequestration. The chapter draws on previous efforts at sustainable intensification, particularly conservation agriculture. The purpose of this chapter is to provide a basis for the end-users of the Manual to view soil and water management through climate-smart lenses and adopt site-specific solutions.



**Keywords:** climate-smart agriculture, conservation, irrigation, soil, water, water-harvesting


## Key messages

i. CSA is not prescriptive about practices but is rather focused on attaining the three pillars supported by key indicators;

ii. Farmers in Zimbabwe should increase their water-use efficiency through the maintenance and rehabilitation of existing structures and the procurement of more efficient irrigation systems;

iii. Farmers should avoid burning, continuous cropping, repetitive tilling and nutrient mining, and instead increase rotations;

iv. Tools such as Aquacrop and Cropwat are invaluable in analysing soil and water management systems in CSA; and

v. The success of CSA in Zimbabwe hinges on policy decisions and access to incentives.

## 6.1 Introduction

### 6.1.1 Background

Stakeholders in agriculture will be required to revise the way in which land, water and soil nutrients are managed to ensure that these resources are used more efficiently to achieve the three pillars of climate-smart agriculture (FAO, 2013). CSA is an extension of previous sustainable intensification efforts summarised in Pretty et al., (2011) which include crop improvements, agroforestry, soil and water conservation, conservation agriculture, integrated pest management, horticulture, livestock and fodder crops and aquaculture, as well as novel policies and partnerships.

A large proportion of communal lands in Zimbabwe are semi-arid, rainfall being a limiting factor in crop production. In addition to the introduction of drought-tolerant crops and modern soil nutrient management, two types of cultural practice have been adopted to stabilise yields, namely in-field and external water-harvesting techniques (Mugabe, 2004). More recent studies have also emphasised the importance of integrating nutrient and water management practices in semi-arid areas where moisture stress is frequent (Nyamangara and Nyagumbo, 2010).

In addition to frequent droughts and high levels of climate variability, Zimbabwe will also be affected by climate change. On average, temperatures and reference evapotranspiration in Zimbabwe were projected to increase, while rainfall was predicted to decrease in the future (Nkomozepi and Chung, 2012). For agricultural production systems to remain productive and have less variability and greater stability in their outputs, they have to be resilient. Resilience is the capacity to adapt to changes and disturbances, and at the same time, maintain core functions. The strategies that have been found to build resilience in agriculture include sustainable soil and water management, biodiversity promotion and the diversification of sources of income (FAO, 2013).

It is widely accepted that climate change is largely anthropogenic and is mostly caused by the emission of greenhouse gases (GHGs), aerosols and chemically active gases (Moss et al., 2010). In addition to fossil fuels, another recognised anthropogenic source of atmospheric increase in GHG concentrations is land-use change and other agricultural activities (Lal, 2001). Agriculture contributes to climate change mainly through releases of methane from rice cultivation and enteric fermentation and of nitrous oxide from fertiliser application. Additionally, agriculture exacerbates climate change through carbon dioxide ($CO_2$) releases associated with deforestation and burning. To reduce the contribution of agriculture to climate change, farmers have to shift to practices such as more appropriate application of fertilisers, less soil disturbance and better irrigation techniques, etc. Additionally, researchers have advised farmers to promote carbon sequestration, i.e., *the natural and deliberate processes by which $CO_2$ is removed from the atmosphere or diverted from emission sources and stored in the ocean, terrestrial environments (vegetation, soils and sediments) and geological formations*.

It is against this background that this chapter will attempt to identify agricultural soil and water management practices suitable for Zimbabwe.

### 6.1.2 What is new in climate-smart agriculture?

CSA is a relatively new approach in Zimbabwe. The most fundamental difference from previously introduced approaches is that CSA is not particularly prescriptive about practices or technologies; rather, its focus is on attaining the three CSA pillars mentioned earlier. In other words, CSA requires spatio-temporal-specific agricultural production technologies and practices that are beneficial in light of the three pillars. On the other hand, CSA largely draws on previous sustainable intensification efforts in agriculture. CSA practitioners will benefit from existing practices, policies and institutions in Zimbabwe. In this chapter, CSA will be treated as

the adoption of existing agricultural practices ("good management practices") that have been documented to improve agriculture through various indicators, e.g., increased water use efficiency, increased drought resilience, improved soil structure and fertility, reductions in nutrient losses, etc.

### 6.1.3 Climate-smart agriculture indicators

In Zimbabwe, research on indicators to be used to assess practices and technologies in CSA is still in its infancy. A recent international report has published the indicators summarised in Table 6.1. In the report, the first, second and third pillars of CSA are classified into the themes of productivity, resilience and mitigation respectively.

***Table 6.1 CSA technical indicators (The World Bank Group, 2016)***

| Theme/pillar | Sub-theme | Indicator |
|---|---|---|
| Productivity | Crop system | Increase in yields, reduction in risk of water/wind erosion, enhances in-soil fertility |
| | Water use | Increase in irrigated land area, reduction in total water withdrawal, increase in water productivity |
| | Energy | Reduction in agricultural energy use, increase in use of renewable energy |
| Resilience | Robustness | Increases stability of production, promotes income diversification, incorporate site-specific knowledge |
| | Cropping system | Increases resilience to drought |
| | Livestock system | Increases resilience to drought |
| Mitigation | Emissions intensity | Reduces GHG emissions |
| | Sequesters carbon | Increases carbon sequestration |

In a study in Kenya and Tanzania, fewer indicators (shown in Table 6.2) are used to analyse, quantify and assess the effectiveness of agricultural practices and technologies. The indicators in the table are the general guidelines used to identify the appropriate soil and water management practises for CSA. In the near future, Zimbabwean researchers should look into developing tools that can be used to identify the most appropriate CSA technologies, as has been done for Tanzania and Uganda (Mwongera et al., 2017).

***Table 6.2 CSA Indicators (Rioux et al., 2016)***

| Pillar | Indicator |
|---|---|
| Productivity | Increases crop yields, increases biomass, increases food-secure periods |
| Adaptation | Increases efficiency of rainfall use, increases yield stability, increases agricultural incomes |
| Mitigation | GHG fluxes, increases soil carbon, increases above-ground biomass |

## 6.2 Water management

### 6.2.1 Irrigation

Access to irrigation provides the means to cultivate an additional crop and is one of the most effective strategies to boost the productivity of small-scale, dry-land farming systems (Maisiri et al., 2005). Especially in the face of climate change, irrigation will be required to counter the predicted increase in evapotranspiration rates and decreases in rainfall in the future (Nkomozepi and Chung, 2012). According to Aquastat (http://www.fao.org/nr/aquastat), of the 4,100,000 ha that were cultivated in 2012/3, only 173,500 ha (ca 4% of the cultivated area) were under irrigation. In addition, the areas under surface, sprinkler and localised irrigation were 46,850 ha, 112,800 ha and 13,880 ha respectively. Surface and sprinkler irrigation methods are utilised in more than 90% of Zimbabwe's irrigated lands, despite the low field-level application efficiency of between 40% and 60%. In CSA, however, farmers are encouraged to use localised irrigation methods (e.g., drip or subsurface irrigation) that have higher field-level application efficiencies of 70% to 90% as surface runoff and deep percolation losses are minimised. Resources permitting, farmers could also use hydro-culture technologies, e.g., hydroponics with very high water-use efficiencies.

A relatively complex technology such as drip irrigation should not be part of short-term relief programmes, but should instead be embedded in long-term developmental programmes to ensure that appropriate technical support is provided in terms of crop management and the development of supply chains for spare parts and additional kits (Belder et al., 2007; Moyo et al., 2006). Renewable energy pumps (e.g., solar-powered pumps) are preferable because they neither use fossil resources nor emit greenhouse gases. Photovoltaic or solar-powered drip-irrigation systems combine the efficiency of drip irrigation with the reliability of a solar-powered water pump. Furthermore, they save labour in rural off-grid areas where hauling of water is traditionally done by hand by women and young girls (Burney et al., 2010).

In an environment of limiting resources, farmers can increase the efficiencies of existing surface and sprinkler irrigation systems by reducing conveyance losses (e.g., maintenance and rehabilitation of canals), appropriate irrigation scheduling and management decisions (e.g., supplementary, full or deficit irrigation). In addition to improving the efficiency of irrigation facilities, strategies such as rain-water harvesting will be beneficial in augmenting already burdened water sources.

### 6.2.2 Water harvesting

Rainwater harvesting is a technology used for collecting and storing rainwater. There are three methods of rainwater harvesting: (i) in situ rainwater harvesting, collecting the rainfall on the surface where it falls and storing it in the soil; (ii) external water harvesting, collecting run-off from rainfall over a surface (e.g., rock surface) and storing it elsewhere; and (iii) domestic rainwater harvesting, where water is collected from roof, street and courtyard runoffs (Helmreich and Horn, 2010). In the case of external water harvesting, permission might be needed from parties with water rights in the catchment area. Domestic rainwater harvesting is beneficial and may reduce water withdrawals for domestic water use at farms.

### 6.2.3 In-situ water-harvesting techniques

In-situ rainwater harvesting refers to the method of diverting, inducing, collecting, storing and conserving local surface runoff for agricultural production (Motsi et al., 2004). A review of the pertinent literature showed that researchers in Zimbabwe have focused on options that (i) prolong periods of soil moisture availability, e.g., tied-ridges, no-till-tied-ridges, off-season weeding, winter tillage, contour planting and mulching; and (ii) promote the infiltration of water into the soil, e.g., potholing, retention of crop residues, ridging/furrowing, terracing, trash lines, vegetative barriers, stone lines and planting basins (Mupangwa et al., 2006; Marongwe et al., 2011; Vogel, 1993). Such technologies increase the time available for infiltration and increase surface storage. Most importantly, farmers are recommended to adopt sustainable techniques that have been evaluated for their soil types and rainfall conditions (Motsi et al., 2004).

The results of recent studies indicate that the use of fertilisers and soil and water conservation (tied ridges and mulching) are indispensable for increasing agricultural productivity, particularly in high-risk, semi-arid areas (Ngugi et al., 2014; TerAverst et al., 2015).

### 6.2.4 External water harvesting

In Zimbabwe, the surface and ground water resources on which most farmers depend are facing the challenges of unpredictability of seasonal rainfall, high losses from evaporation, low conversion of rainfall to runoff and sedimentation in reservoirs (Chitata et al., 2014). For example, the Katoto Reservoir in Mutoko may be completely filled with sediment within less than 120 to 160 years, taking into account population growth and climate change (Patton, 2015). In another study, the Malilangwe reservoir was predicted to lose at least 16% of its storage capacity over the next 100 years at current levels of sedimentation (Dalu et al., 2013). Sedimentation reduces the reservoir's water-holding capacity, hence the yield is reduced both in quantity and reliability, thereby reducing farmers' resilience. Water harvesting is often cited as a feasible option for increasing the resilience of agriculture in Zimbabwe.

External water harvesting can be categorised into micro-catchment and macro-catchment water harvesting, and also includes flood and groundwater harvesting. Micro-catchment water harvesting involves collecting runoff from a small drainage area and storing it, for example, in the root zone of an adjacent infiltration basin planted with trees, bushes or annual crops. Macro-catchment water harvesting takes place on a larger scale and involves capturing rock water or runoff from hill-slope catchments (Prinz and Singh, 2000).

Subsurface water harvesting can be used to take advantage of the water stored in the pores of the large silt deposits in river courses and silted dams in Zimbabwe. Sub-surface water harvesting uses barrages and cut-off walls, and has the advantages of not submerging land to store water and not involving the risk of breaching disasters (Ishida et al., 2003). Barrages are structures capable of blocking the subsurface flow (e.g., across a silted seasonal river channel) and hence retain the water in the local aquifer or divert it to an adjacent aquifer giving larger and easier access to water resources. Barrages are divided into two different types: underground barrages and surface barrages, where both types consist of a main structure that will eventually be located below the ground surface (Forzieri et al., 2008). Barrages can be constructed from stone, concrete or compacted earth. Water can be drawn from subsurface reservoirs through scoop holes, wells or outlet pipes with taps.

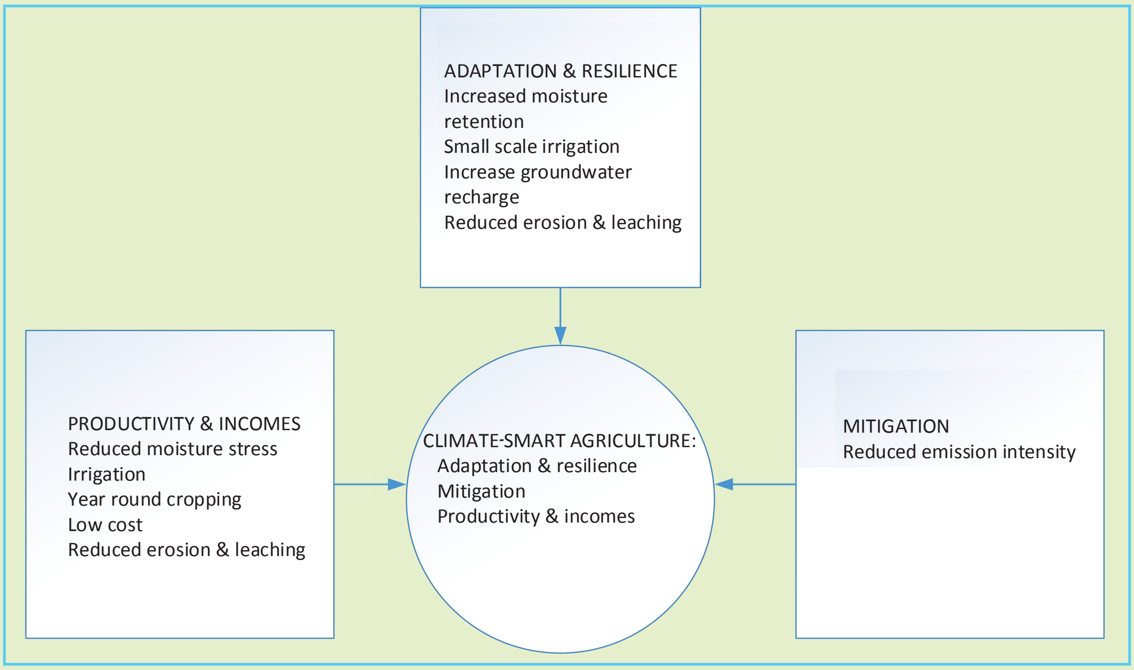
The Dabane Trust advocates the construction of sand dams in Zimbabwe and has played a role in the construction of over 150 sand abstraction water points in Gwanda along the Umzingwane, Thuli and Thepe rivers. Other sand abstraction systems have been built in Nkayi, Tsholotsho, Mangwe, Bulilima, Masvingo, Chivhu, Gokwe and Guruve. The greater success of sub-surface reservoirs is evident in Japan, where the Miyakojima subsurface dams store over 20,000,000 $m^3$ of groundwater, of which 50,000 $m^3$ of water is drawn daily through 147 tube wells (Ishida et al., 2003). The three CSA principles for the water sector are illustrated in Figure 6.1.

**Case study 6.1 on Rain Water Harvesting: The Story of Zephaniah Phiri Maseko**

When Mr Zephaniah Maseko Phiri lost his job at Rhodesia Railways, his concern was how he would care for his family. Coming to settle in the arid Zvishavane District, Mr Phiri built his homestead in an area which was dominated by extensive granite outcrops all around. Soon he discovered that he had built his homestead directly in the path of raging waters (runoff) running down the slopes of the granite outcrops after rain storms. To solve this problem Mr Phiri started working on a plan to divert the rainwater away from his homestead. He experimented with contours, sand traps and stone bands on the slopes to prevent erosion by redirecting rainwater away from his homestead. With time he built underground reservoirs with a system of pipes and contours to collect rainwater from the slopes. The effect of recharge from harvested water was soon apparent on the fruit trees on his homestead. He

then realised that he could apply the same concept to harvest water in his fields, retaining moisture for long periods after rains. Instead of open contours that channel water away from crop fields, Mr Phiri dug infiltration pits within the contours which he called “Phiri pits”. These would collect runoff water in contours and allow it to infiltrate, only channelling it out once the pits were filled. Thereafter a number of researchers have conducted hydrological experiments to authenticate the positive effects of in-situ rainwater harvesting. An intricate network of deepened contours and carefully managed water ways from the outcrops consistently fed Mr Phiri’s fields with moisture throughout the year, while diverting excess water into two large fish ponds, creating a thriving micro-climate surrounded by flourishing fruit trees teeming with birdlife. The concept of “Phiri pits” in contours soon became a world phenomenon for in-situ water harvesting. Mr Phiri won numerous awards and was invited to speak at several conferences and gatherings before he passed away in 2015. An NGO called Zvishavane Water Project was formed in his honour to promote his teachings and his legacy. Many farmers in the district have since adopted Mr Phiri’s teachings and are practising his concepts in their own fields. The results have been phenomenal, enabling farmers to go beyond food security and investing in other family needs such as educating children. Mr Phiri’s legacy lives on, well beyond his own village and humble beginnings. Most importantly, Mr Phiri’s hard work remains his family’s weapon against droughts and mid-season dry spells.

***Figure 6.1 Schematic illustration of CSA in the water sector***




**Can rain water harvesting work across the country?**

The benefits of water harvesting are now beyond debate. Whether in supporting better in-field moisture retention, water for livestock and household use - the practice increases water use efficiency. With declining water resources as one of the most disconcerting impacts of climate change, competences in managing water resources are top on the priority lists of prerequisites for transition to climate-smart agriculture. Many farmers are already investing in different forms of water harvesting techniques. The potential is huge. We are only starting to tap into this precious resource. Imparting the skills that farmers need to analyse their circumstances and invest appropriately into water harvesting techniques needs to be top among the support provided by the government and non-governmental practitioners. Farmer information exchanges, and documentation and sharing of success stories will go a long way in exposing farmers to the depth and breadth of opportunities in their own circumstances.

*Source: Mutamba, M., Ndidzano, K., Matingo, E., Marongwe, S.L., Vambe, L., Murwisi, K., 2017. Cases of Climate-Smart Agriculture in Zimbabwe. VUNA. Pretoria.*

## 6.3 Soil management

### 6.3.1 Introduction

Unsustainable practices, such as continuous cropping with reductions in fallow and rotations; repetitive tillage and soil nutrient mining; overstocking, overgrazing and burning of rangelands; and the overexploitation or clearance of wooded and forest lands cause land degradation (FAO, 2013). In the light of soil and water management, land degradation is caused by soil erosion and nutrient mining. Soil erosion is a multi-stage process involving the detachment, redistribution and deposition of soil in depressions and finally in aquatic ecosystems (Lal, 2001). Nutrient mining refers to a process whereby soil nutrient reserves are depleted because of continued uptake without adequate replenishment. Burning for land clearing, the burning of crop residues and veld fires should be avoided by all means.

### 6.3.2 Management practices

#### 6.3.2.1 Soil conservation/erosion control

In this chapter, "Indigenous Soil Conservation" is advocated, being defined as *a set of soil conservation strategies that evolve from a knowledge base accumulated by local people by observation and experimentation to preserve the soil.* The practices that are promoted include those that decrease the erodibility of runoff and of the soil. Contour ridges and storm-water drains should be established, rehabilitated or maintained, depending on the area. In addition to the in-field conservation strategies introduced above, off-field practices are beneficial in catchments and reduce erosion, siltation and sedimentation. The practices should reduce wind, rain and sleet, as well as gully and fluvial erosion. Some of the methods used in Zimbabwe include gabion blocks, establishing vegetation on bare steep slopes etc.

#### 6.3.2.2 Reduced tillage

Tillage disturbance is the dominant factor that reduces carbon stabilisation in clayey soil, probably by reducing carbon stabilisation within micro-aggregates and thus leading to rapid soil organic matter decomposition (Chivenge et al., (2007). The following four minimum tillage practices that were adopted from Nyagumbo (1999) and are being advocated in addition to zero tillage in this chapter are shown below.

- **(i) No till tied ridging.** This practice consists of semi-permanent ridges with cross-ties along the furrows to trap runoff. Normally once constructed, the ridges should not be destroyed for a period of six seasons depending on the crop rotations practiced. In wet areas, planting is done on top of the ridges, while planting may also be carried out in the furrows in drier areas.
- **(ii) Mulch-ripping.** This practice involves the retention of crop residues on the surface and the use of a ripper to open up planting lines.
- **(iii) Clean ripping.** This system is similar to mulch-ripping, except that no crop residues are retained after harvesting.
- **(iv) Planting basins.** These involve the use of hoes to open up planting holes. The basins should be 15 cm x 15 cm and about 15 cm deep in rows 75–90cm apart with 50–60 cm between the basins in the rows, leaving about 90% of the soil area undisturbed (Zimbabwe Conservation Agriculture Taskforce, 2009).

The justification given by farmers for the continued use of conventional tillage practices like repeated ploughing is to improve infiltration, minimise runoff and prepare seed-beds. Furthermore, the negative effects of a lack of tillage have been recorded in some clay-poor, structurally weak soils of the arid and semi-arid areas that are widespread throughout sub-Saharan Africa. Some studies of the region have found that some soil and water management techniques such as minimum soil disturbance and crop rotation had no significant impact on crop yields (Arslan et al., 2015). The key is to suit the practice to

conditions such as soil, crop, climate conditions etc. For example, a study from the early 1990s established that the no-till tied ridging technique resulted in the highest grain yield in the sub-humid region, while the mulch-ripping technique was superior in the semi-arid region (Vogel, 1993).

The choice of practice adopted depends on the quality of natural resources (soil type, topography etc.), the household resource level (particularly income levels and labour availability) and crop type and intensity, as well as socio-economic and gender issues. Under the CIMMYT project titled "Facilitating the adoption of conservation agriculture in Eastern and Southern Africa", manual and animal traction seeding systems were promoted to reduce the demand for labour. A manual implement, the jab-planter (*matracas*) can go through the mulch and release seed and fertiliser in moist soil. The animal traction systems included planting behind the "Magoye ripper", with ripper tines attached to a plough frame. Finally, there was also an animal traction direct seeder with a coulter that cut through the residues and a ripper tine that opened a furrow, together with seed and fertiliser being placed in the furrow. Currently, low-cost mechanised implements that can be used in communal agriculture are being developed by various manufacturers and researchers, including the Korean Programmes in International Agriculture (KOPIA) Centre, based at the SIRDC research facilities in Harare.

Minimum tillage, when coupled with permanent soil cover with crop residues or growing plants and crop rotation, has the potential to increase water productivity and thereby reduce the risk of crop failure (Thierfelder and Wall, 2009).

#### 6.3.2.3 Mulching and residue management

Mulching and residue management can be defined as a technology whereby, at the time of crop emergence, at least 30% of the soil surface is covered by organic residues from the previous crop (Erenstein, 2002). Crop residues are utilised for soil and water conservation, as well as for soil organic inputs and livestock feed, and are critical in smallholders building and maintaining soil nutrient stocks. Of the soils surveyed in a sample area in Zimbabwe, 77% were deficient in nitrogen, 85% in phosphorus and 55% in potassium. The potential nitrogen and phosphorus losses through the removal of maize stover from fields were found to be 44% and 42% of the total uptakes respectively (Mapfumo and Mtambanengwe, 1999). Mulching therefore offers opportunities to address soil fertility and weed management constraints (Ereinstein, 2003). Mulching improves infiltration, and the soil cover provides effective protection against rain splash erosion and surface runoff.

An analysis of maize yields and conservation agriculture practices indicated that yields were equal or improved in comparison to conventional production systems in "normal" or dry years, but tended to be depressed during seasons with above-average rainfall. The improved water use under conservation agriculture in "normal" or dry years is largely due to the presence of a mulch of crop residues, whereas the absence of tillage in itself can result in the opposite effect of higher runoff and lower levels of infiltration, leading to lower yields (Giller et al., 2009). Furthermore, mulching only tends to be viable when property rights to residual crop biomass are observed and tenure is secure (Erenstein, 2003). In Mozambique, however, a study observed that the mulch is often removed in a matter of weeks by termites, thus reducing the benefits of mulching (Giller et al., 2009). In a separate study, the role of termites is discussed with reference to soil processes, vegetation cover, atmospheric gas exchanges and agricultural intensification (Black and Okwakol, 1997). The potential of mulching depends on the opportunity costs of retaining the mulch and of subsequent changes, e.g., the need for mulch-adapted seeders or extra labour, and alternative weed, pest and disease management practices.

***Example of a trade-off between crop residue retention and utilisation as feed***

The results of a farm-scale study in Mbiri District determined that the optimum fraction of crop residue to be retained in the fields for maximum farm crop production varied for farmers with two or less head of cattle

(80% retention), with two to three head (60–80%) and with four or more heads (40–60%). Farmers with no livestock attained maximum crop production when 100% of their sorghum residues remained in the field, as they do not have access to cattle manure. At the scale of the entire territory, total cotton and sorghum production increased with the density of cattle, at the expense of soil mulching with crop residues.

The study highlights the important role of animal traction and manure in smallholder agriculture and shows that, as farm sizes increase, a larger percentage of residues may be removed (Baudron et al., 2015). Another study showed that there are no significant yield benefits derived from increasing mulch cover beyond 4 t $ha^{-1}$ or around 40% (Mupangwa et al., 2012).

#### 6.3.2.4 Nutrient management

The excessive nutrient mining of the soil in Zimbabwe needs to be addressed by soil fertility/nutrient management systems that take the strong crop-livestock interactions into consideration (Mapfumo and Mtambanengwe, 1999; FAO, 2013). In their review, Mafongoya et al., (2006) presented five options for nutrient management, namely inorganic fertilisers, grain legumes, animal manures, integrated nutrient management and agroforestry options appropriate to smallholders. Inorganic fertilisers, particularly those containing nitrogen, should be applied with effective nitrogen management. A study by Delgado et al., (2011) recommends the use of slow-release fertiliser, nitrification inhibitors, higher use efficiency, multiple applications and application at lower rates in order to reduce losses of reactive nitrogen due to leaching and runoff, as well as losses from volatilisation and mineralisation.

On legumes, self-nodulating promiscuous types of indeterminate soybean (*Glycine max*), pigeon pea (*Cajanus cajan*), groundnut (*Arachis hypogaea*), dolichos bean (*Dolichos lablab*), velvet bean (*Mucuna spp.*), and cowpea (*Vigna unguiculata (Walp)* L.) were found to be among the most promising species for combined nutrient strategies in Malawi and Zimbabwe (Snapp et al., 1998). Similarly, a multi-country study conducted among households in the region showed that fertiliser tree systems also have positive impacts on crop yields and carbon sequestration (Ajayi et al., 2011). Fertiliser Tree Systems (FTS) involve the planting or regeneration of fast-growing nitrogen-fixing trees or woody shrubs that produce high-quality leaf biomass and are adapted to the local climatic and soil conditions. Over the years, different types of FTS have been developed, including sequential fallows, semi-permanent tree- and crop-intercropping, annual relay cropping and biomass transfer (Ajayi et al., 2011).

In addition to compost and animal manure, which is studied extensively in Zimbabwe, studies from abroad present vermiculture—a technology of sustainable development through the use of earthworms in vermi-composting, vermi-filtration, vermi-remediation and vermi-agroproduction (Sinha et al., 2010; Sinha et al., 2014). Worms increase nitrogen levels in the soil by adding their metabolic and excretory products (vermicast), mucus, body fluids, enzymes (auxins, gibberlins and cytokinins) and the decaying tissues of dead worms. Overall, predicting nutrient contributions is critical in developing organic matter technologies because high-quality organic inputs are low in lignin and polyphenol and high in nitrogen, while low-quality materials are having the opposite characteristics (Snapp et al., 1998). Many crop residues and animal manures are of low quality, as they fall below the critical nitrogen content of 1.8 to 2.0% and immobilise nitrogen temporarily, thereby exacerbating the nutrient deficiency. A strategy used worldwide in intensified cropping systems is to combine inputs of organic matter (mulch, compost, crop residues, green manure) with fertilisers to address or prevent macro- and micro-nutrient deficiencies (FAO, 2013).

#### 6.3.2.5 Carbon sequestration

In agriculture, crops and their relation to the carbon cycle are used to sequester carbon permanently in its elemental or stable state within the soil. In addition to the retention of crop residues, the addition of manure and minimum tillage that sequester carbon, various methods that have been suggested include:

i. Cover and catch crops, e.g., grasses and weeds as temporary cover between planting seasons;

ii. Concentrate livestock in small paddocks for days at a time so they graze lightly but evenly to encourage roots to grow more deeply into the soil; and

iii. Restore degraded land, which slows carbon release, while returning the land to agriculture or other use.

The high granite-derived sand content of the majority of soils in much of Zimbabwe and the limited protection for carbon from oxidation have caused most soils to be low in organic carbon, whether cultivated or uncultivated (Snapp et al., 1998). Furthermore, the redistribution of carbon transported with eroded sediments affects several processes that accentuate emissions of greenhouse gases from the landscape to the atmosphere (Lal, 2001). Therefore, soil conservation and erosion-control methods also promote carbon sequestration. In this chapter, only sequestration strategies with direct benefits to yields, and soil and water conservation are advocated. The establishment of deep-rooting and perennial plants will facilitate carbon sequestration, and trees can be used for live fencing, windbreaks, fodder and as riparian forest buffers, etc. Intercropping maize with deep-rooting species such as *Faidherbia Albida* can also be beneficial in aiding carbon sequestration and improving productivity.

The adoption and success of the practices just mentioned will depend on technical, social, economic, technological, farm-level and institutional considerations. The amalgamation of these issues will certainly determine the feasibility of the various practices and the productivity/income and environmental (climate change adaptation and mitigation) returns, and ultimately farmer acceptance.

## 6.4 Tools

### 6.4.1 Introduction

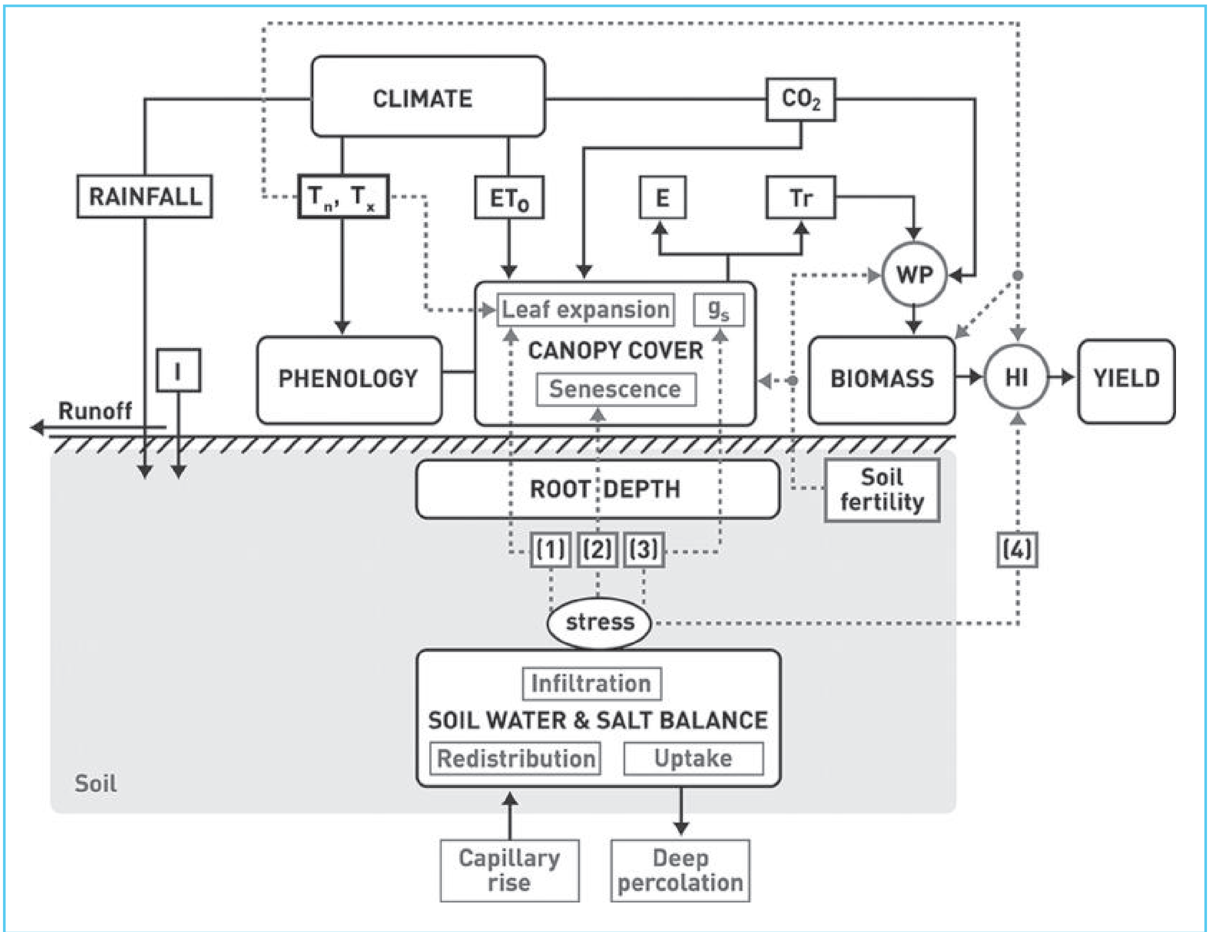
At this point, it is clear that stakeholders need an increasing amount of information to improve their understanding of the possible outcomes of their choice of practices to help achieve the three CSA pillars. In line with recent progress in the use of ICT in agriculture, ICT can also be used to reduce the time and human resources required to analyse complex alternative options in soil and water management.

The use of modelling in agriculture can reduce the uncertainties generated by climate change, improve early warning systems for drought, flood, pests and disease incidence, and thus increase the capacity of farmers and agricultural planners to allocate resources effectively. There are a large number of models that can be used to make decisions on the various issues that have been raised in this chapter, once they have been calibrated and validated. The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) Mitigation Options Tool, for example, is easy to use and provide mitigation options, taking into consideration the agricultural production system, climate, and soil information (Feliciano et al., 2016). The Aquacrop and CROPWAT models, both developed by the FAO, are indispensable in analysing soil and water management issues in CSA.

#### 6.4.2 Aquacrop

The AquaCrop model has a structure that takes the various components of crop production into account, including the soil and moisture balance; the plant, its development, growth and yield processes; and the atmosphere, ambient temperatures, rainfall, irrigation, evaporative demand and carbon dioxide concentration. Additionally, in some management aspects the soil-water balance, crop development and crop yield are explicitly considered. The functional relationships between the different model components are illustrated in Figure 6.2 and detailed descriptions can be found in Raes et al., (2011).

***Figure 6.2 The main components of AquaCrop (Raes et al., 2011)***




Input parameters for the AquaCrop model include crop, soil, irrigation and cultural management. Soil properties such as texture and rootable soil depth will have to be established through research.

### 6.4.3 CROPWAT

CROPWAT was designed for the calculation of crop water and irrigation requirements from soil, climate and crop data, and has been appropriately used as a tool for testing the efficiency of different soil and water management practices under climate change. The crop water requirements are calculated by multiplying the reference evapotranspiration and appropriate crop coefficients ($K_c$). $K_c$ is determined by the aerodynamic roughness of the crop, general resistance within the crop canopy and soil to the flow of heat and water vapour, and reflectance of the crop and soil surface to shortwave radiation. Irrigation requirements are estimated from the difference between crop water requirements and effective rainfall (Allen et al., 1998).

## 6.5 Discussion and conclusion

### 6.5.1 Policy implications and incentive systems

The key requirements for an enabling policy environment to promote CSA transition is greater coherence, coordination and integration between climate change, agricultural development and food-security policy processes (FAO, 2010). As pointed out earlier in the chapter, the transition from conventional or other approaches to climate-smart agriculture comes with challenges, e.g., the temporary immobilisation of nitrogen, increases in the demand for labour in clearing land and weeding, procuring new tillage and

planting equipment, etc. Financial incentives are needed to make it possible for small-scale farmers to adopt CSA and assistance to them is required to find ways to overcome other barriers to adopting climate-smart practices, such as risk, lack of technical information or access to resources. Additionally, the cost-benefit profile of CSA typically involves clear net benefits, but in the form of significant initial costs coupled with gradually rising but stable benefit streams.

Some of the incentives include the Green Climate Fund, which may be accessed through the African Development Bank (ADB) and falls within the framework of the United Nations Framework Convention on Climate Change (UNFCCC), which was founded as a mechanism to assist developing countries to adapt to and mitigate the adverse effects of climate change. The ADB also administers the Africa Climate Change Fund. Local companies such as Carbon Green Africa facilitate the generation of carbon credits and are running successful forest conservation projects (carbon sequestration) in Mashonaland West. In addition, smallholders adopt sustainable practices, e.g., soil and water conservation, when they have secure land tenure.

a. Farmers need policies that remove hindrances in transitioning to climate-smart agriculture and that create synergies with alternative technologies and practices. The following issues were raised in this chapter and can be addressed by means of appropriate policies. According to the Water Act, Chapter 20:24, the efficiency of the irrigation method is given priority in the application of permits. Policymakers should further consider reducing the cost of more efficient irrigation systems through the removal of import taxes and duties and granting loans and tax incentives to local manufacturers;
b. The need to consider how macro-water harvesting or rock-water harvesting can be incorporated into legislation and not disadvantage the associated holders of water permits;
c. The need for policymakers to consider the underground reservoirs in areas of water shortage where the Water Act prohibits the abstraction of water from boreholes and wells;
d. The need for policymakers to consider policies that promote the importation and manufacture of minimum tillage equipment and slow-release fertilisers;
e. For farmers who wish to retain their stover/crop residues, policymakers may need to consider fines for the owners of livestock that feed on their crop residues;
f. There is a need for funding in research and simulation modelling to establish the potential of numerous practices for the different environments in Zimbabwe; and
g. Policymakers will also need to consider policies for the capacity-building of stakeholders in agricultural education, extension, research and technical services.

### 6.5.2 Concluding remarks

There are numerous soil and water management options available that are applicable to various site-specific conditions in CSA. Stakeholders in agriculture will be required to revise the ways in which land, water and soil nutrients are managed to ensure that these resources are used more efficiently in line with the three pillars of CSA. The adoption and success of the practices mentioned in this chapter will depend on various technical, social, economic, technological, farm-level and institutional considerations.

## References


1. Ajayi, O.C., Place F., Akinnifesi F. K., Sileshi G. W., 2011. *Agricultural success from Africa: the case of fertilizer tree systems in southern Africa (Malawi, Tanzania, Mozambique, Zambia and Zimbabwe).* International Journal of Agricultural Sustainability, 9:1, 129-136.
2. Allen R.G., Pereira L.S., Raes D., Smith M., 1998. *Crop evapotranspiration: guidelines for computing crop water requirements.* United Nations Food and Agriculture Organisation, Irrigation and Drainage Paper No. 56, Rome, Italy.
3. Arslan A., McCarthy N., Lipper L., Asfaw S., Cattaneo A., Kokwe M., 2015. *Climate Smart Agriculture? Assessing the Adaptation Implications in Zambia.* Journal of Agricultural Economics, doi: 10.1111/1477-9552.12107.
4. Baudron F., Delmotte S., Corbeels M.,. Herrera J. M., Tittonell P., 2015. Multi-scale trade-off analysis of cereal residue use for livestock feeding vs. soil mulching in the Mid-Zambezi Valley, Zimbabwe. Agricultural Systems 134:97–106.
5. Belder P, Rohrbach D, Twomlow S and Senzanje A. 2007. *Can drip irrigation improve the livelihoods of smallholders? Lessons learned from Zimbabwe.* Global Theme on Agroecosystems Report no. 33. PO Box 776, Bulawayo, Zimbabwe: International Crops Research Institute for the Semi-Arid Tropics. 32 pp.
6. Black H.I.J., Okwakol M.J.N., 1997. *Agricultural intensification, soil biodiversity and agro-ecosystem function in the tropics: the role of termites.* Soil Biodiversity, Agricultural Intensification and Agroecosystem Function., 6(1):37 – 53.
7. Burney, J., Woltering L., Burke M., Naylor R., Pasternak D., 2010. *Solar-powered drip irrigation enhances food security in the Sudano–Sahel.* Proceedings of the National Academy of Sciences of the United States of America, 107 (5):1848 – 1853.
8. Chitata, T., Mugabe F.T., Kashaigili, J.J., 2014. *Estimation of Small Reservoir Sedimentation in Semi-Arid Southern Zimbabwe.* Journal of Water Resource and Protection, 6:1017-1028.
9. Chivenge P.P., Murwira H.K., Giller K.E., Mapfumo P., Six J., 2007. *Long-term impact of reduced tillage and residue management on soil carbon stabilization: Implications for conservation agriculture on contrasting soils.* Soil & Tillage Research 94:328–337.
10. Dalu T., Tambara E. M., Clegg B., Chari L. D., Nhiwatiwa T., 2013. *Modeling sedimentation rates of Malilangwe reservoir in the south-eastern lowveld of Zimbabwe.* Applied Water Science 3:133–144.
11. Delgado J.A., Groffman P.M., Nearing M.A., Goddard T., Reicosky T.D., Lal R., Kitchen N.R., Rice C.W., Towery D., Salon P., 2011. *Conservation practices to mitigate and adapt to climate change.* Journal of Soil and Water Conservation 66(4):118A-129A.
12. Erenstein, O., 2002. *Crop residue mulching in tropical and semitropical countries: An evaluation of residue availability and other technological implications.* Soil and Tillage Research, 67 (2):115–133
13. Erenstein, O., 2003. *Smallholder conservation farming in the tropics and subtropics: a guide to the development and dissemination of mulching with crop residues and cover crops.* Agriculture, Ecosystems & Environment, 100 (1): 17–37.
14. FAO, 2010. *"Climate-Smart" Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation.* Food and Agriculture Organisation of the United Nations (FAO), Rome.
15. FAO, 2013. *Climate Smart Agriculture Sourcebook.* Rome, Italy: Food and Agriculture Organisation of the United Nations.
16. Feliciano D., Nayak D., Vetter S., Hillier J., 2016. *CCAFS Mitigation Options Tool.* www.ccafs.cgiar.org.
17. Giller K.E., Witter E., Corbeels M., Tittonell P., 2009. *Conservation agriculture and smallholder farming in Africa: the heretics' view.* Field Crops Research 114:23–34.
18. Helmreich B., Horn H., 2010. *Opportunities in rainwater harvesting.* Desalination, 251:118–124.

19. Ishida S., Kotoku M., Abe E., 2003. *Construction of subsurface dams and their impact on the environment.* Materials and Geoenvironment, 50(1):149-152.

20. Lal, R., 2001*. Soil degradation by erosion: land degradation and development* 12:519-539.

21. Mafongoya, P. L., Bationo, A., Kihara, J., Waswa, B. S., 2006. *Appropriate technologies to replenish soil fertility in southern Africa.* Nutrient Cycling In Agroecosystems, 76 (2-3): 137-151.

22. Maisiri N., Senzanje A., Rockstrom J., Twomlow S.J., 2005. *On farm evaluation of the effect of low cost drip irrigation on water and crop productivity compared to conventional surface irrigation system.* Physics and Chemistry of the Earth, 30:783–791.

23. Mapfumo, P., Mtambanengwe, F., 1999. *Nutrient mining in maize based systems of rural Zimbabwe. Maize Production Technology for the Future: Challenges and Opportunities.* Proceedings of the Eastern and Southern Africa Regional Maize Conference, 6; Addis Ababa (Ethiopia); 21 - 25 Sep 1998.

24. Marongwe, L. S., Kwazira K., Jenrich M., Thierfelder C., Kassam A., Friedrich T., 2011. *An African success: the case of conservation agriculture in Zimbabwe.* International Journal of Agricultural Sustainability, 9:1,153-161.

25. Moss et al., 2010. *The next generation of scenarios for climate change research and assessment.* Nature, 463:747-756.

26. Motsi, K. E., Chuma E., Mukamuri B. B., 2004. *Rainwater harvesting for sustainable agriculture in communal lands of Zimbabwe.* Physics and Chemistry of the Earth 29:1069–1073.

27. Moyo R., Love D., Mul M., Mupangwa W., Twomlow S., 2006. *Impact and sustainability of low-head drip irrigation kits, in the semi-arid Gwanda and Beitbridge Districts, Mzingwane Catchment, Limpopo Basin, Zimbabwe*. Physics and Chemistry of the Earth 31:885–892.

28. Mugabe, F.T., 2004. *Evaluation of the benefits of infiltration pits on soil moisture in semi-arid Zimbabwe.* Journal of Agronomy 3 (3):188-190.

29. Mupangwa W., Love D., Twomlow S., 2006. *Soil-Water Conservation and Other Rainwater Harvesting Strategies In The Semi-Arid Mzingwane Catchment, Limpopo Basin, Zimbabwe.* 6th WaterNet/WARFSA/GWP Annual Symposium: Sub-Theme 6: Innovations in understanding the water cycle and the link with food production.

30. Mupangwa W., Twomlow S., Walker S., 2012. *Reduced tillage, mulching and rotational effects on maize (Zea mays L.), cowpea (Vigna unguiculata (Walp) L.) and sorghum (Sorghum bicolor L. (Moench)) yields under semi-arid conditions.* Field Crops Research 132:139–148.

31. Mwongera C., Shikuku K.M., Twyman J., Läderach P., Ampaire E., Van Asten P., Twomlow S., Winowiecki L. A., 2017. *Climate smart agriculture rapid appraisal (CSA-RA): a tool for prioritizing context-specific climate smart agriculture technologies.* Agricultural Systems, 151: 192-203.

32. Ngugi L.W., Rao K. P. C., Oyoo A., Kwena K., 2014. *Opportunities for Coping with Climate Change and Variability Through Adoption of Soil and Water Conservation Technologies in Semi-arid Eastern Kenya:* Adapting African Agriculture to Climate Change. Climate Change Management, 149-157.

33. Nkomozepi T., Chung, S.O., 2012. *Assessing the trends and uncertainty of maize net irrigation water requirement estimated from climate change projections for Zimbabwe.* Agricultural Water Management, 111:60-67.

34. Nyagumbo, I., 1999. *Conservation tillage for sustainable crop production systems: Experiences from on-station and on-farm research in Zimbabwe (1988-1997).*

35. Chapter in: Kaumbutho P.G. and Simalenga T.E. (eds.), 1999. *Conservation tillage with animal traction: a resource book of the Animal Traction Network for Eastern and Southern Africa (ATNESA).* Harare. Zimbabwe. 173p.

36. Nyamangara J., Nyagumbo I., 2010*. Interactive Effects of Selected Nutrient Resources and Tied-Ridging on Plant Growth Performance in a Semi-arid Smallholder Farming Environment in Central Zimbabwe.* Nutrient Cycling in Agroecosystems 88(1):103-109

37. Patton B., 2015. *The Impacts of Sediment Yield Estimates on a Small Reservoir in Mutoko, Zimbabwe.* Honours Theses. Paper 375.

38. Pretty, J., Toulmin C., Williams S., 2011. *Sustainable intensification in African agriculture, International.* Journal of Agricultural Sustainability, 9:1, 5-24.

39. Prinz D., Singh A., 2000. *Technological Potential for Improvements of Water Harvesting: Assessment of Irrigation Options.* World Commission on Dams, South Africa.

40. Raes, D., Steduto P., Hsiao T. C., Fereres E., 2011. *AquaCrop 3.1plus Reference manual.* FAO, Rome.

41. Rioux J. et al., 2016. *Planning, implementing and evaluating Climate-Smart Agriculture in Smallholder Farming Systems: the experience of the MICCA pilot projects in Kenya and the United Republic of Tanzania.* 11 Mitigation of Climate Change in Agriculture Series. Food and Agriculture Organisation of the United Nations (FAO), Rome.

42. Sinha, R. K., Patel U., Soni B.K., Li Z., 2014. *Earthworms for safe and useful management of solid wastes and wastewaters, remediation of contaminated soils and restoration of soil fertility, promotion of organic farming and mitigation of global warming: a review.* Journal of Environment and Waste Management, 1(1):011-025.

43. Sinha, R.K., Agarwal S., Chauhan K., Chandran V., Soni K. B., 2010. *Vermiculture Technology: Reviving the Dreams of Sir Charles Darwin for Scientific Use of Earthworms in Sustainable Development Programs.* Technology and Investment, 1(3):2490. DOI:10.4236/ti.2010.13019

44. Snapp, S.S., Mafongoya P.L., Waddington S., 1998. *Organic matter technologies for integrated nutrient management in smallholder cropping systems of southern Africa.* Agriculture, Ecosystems and Environment 71:185-200.

45. TerAverst D., Carpenter-Boggs L., Thierfelder C., Reganold J.P., 2015. *Crop production and soil water management in conservation agriculture, no-till, and conventional tillage systems in Malawi.* Agriculture, Ecosystems and Environment, 212:285–296.

46. The World Bank Group, 2016. *Climate-Smart Agriculture Indicators: Agriculture Global Practice.* World Bank Group Report Number 105162-GLB, Washington.

47. Thierfelder C., Wall P.C., 2009. *Effects of conservation agriculture techniques on infiltration and soil water content in Zambia and Zimbabwe.* Soil & Tillage Research 105:217–227.

48. Vogel H., 1993. *Tillage effects on maize yield, rooting depth and soil water content on sandy soils in Zimbabwe.* Field Crops Research, 33(4):367-384.

49. Zimbabwe Conservation Agriculture Taskforce, 2009. *Farming for the future*. Blue Apple Design. Harare.

# 7. Crop production


## Abstract

This chapter introduces the challenges of crop production in Zimbabwe under the impact of the recent droughts that are associated with climate change and variability, especially in natural regions IV and V. The chapter then introduces climate-smart agriculture as a remedy for the climate change impacts in the affected natural regions in Zimbabwe. The guiding principles and the essence of the three pillars of CSA are described as sustainable agriculture production, climate resilience and mitigation. The chapter then gives case studies of the natural regions exemplifying the three pillars. The case studies presented reflect on the most relevant areas where CSA technologies are recommended in the different natural regions. The roles of tertiary education and extension operations in popularising CSA concepts are also described, together with existing Zimbabwean policies that are relevant to CSA. The conclusion discusses the strategies that AGRITEX, as well colleges and tertiary institutions, could adopt in popularising CSA practices, which would improve understanding of the short-to-long-term results of a CSA intervention.



**Keywords:** adaptation, climate change, climate-smart agriculture, mitigation, productivity, resilience, sustainable


## Key messages

i. Enabling stronger linkages between research and extension, and appreciating the value of local innovations will remain key to the establishment and sustainability of a practical national CSA programme;

ii. Drought-tolerant and high-yielding crop varieties, together with crop diversification will play a pivotal role in reducing the food-security risks associated with climate change;

iii. The identification and development of agricultural clusters and incentive schemes for climate-resilient products will help accelerate the adoption of CSA innovations in Zimbabwe; and

iv. Incorporation of CSA into the curricula of institutions of higher learning will greatly improve farmers' access to climate-resilient technologies and practices, knowledge and information.

## 7.1 Introduction

General environmental impacts associated with projected climate change have been described in the scene-setting introductory chapter. In this chapter on crop production, we restrict the discussion to climate change impacts on the arable agriculture sector. Zimbabwe's agriculture is under threat because it depends on levels of rainfall that are projected to decrease (IPCC, 2014) under climate change. By 2050, climate change impacts in Zimbabwe are likely to show a reduction in rainfall, changes in the onset and cessation of the seasons, frequent mid-season droughts and uneven spatial distribution of rain in the country. Droughts and floods in successive years, as well as temperature increases of between 1°C and 3°C, are likely to dominate the seasons. This might also result in the expansion of Agro-ecological Zone (AEZ) V surface area, as well as the shrinking of AEZ I (Mugabe et al., 2013).

At present, Zimbabwe's AEZs have shifted drastically due to the devastating effects of climate change with more lands becoming marginalised and less productive. Of the five AEZs (natural regions I-V), I, II and III form the greater proportion of the agricultural base for the country as they have comparatively favourable climatic conditions and sufficient rainfall for crop production. Regions IV and V are characterised by low annual rainfall and have largely been reserved for livestock production. In a study conducted by Mugandani et al., 2012, major shifts have occurred in the drought-prone Regions IV and V, which have become drier and more marginalised than previously thought. Zimbabwe's economy is driven by agriculture and the majority of the rural population depends on climate-affected natural resources for their livelihoods. Moreover, about 80% of the rural population lives in Natural Regions III, IV and V. The success rate of rain-fed agriculture in Natural Regions IV and V has been calculated to be in the order of one good harvest in every four to five years (FAO, 2008). These data clearly indicate that Zimbabwe's climatic conditions are drifting towards relatively more arid conditions that are not favourable for arable agriculture. Despite these changes, it is estimated that about 122,000 hectares (6%) of land devoted to agricultural use is irrigable, leaving the rest to depend on rainfall. Table 7.1 shows the farming systems that predominate in AEZs I–V.

The impacts of these climate projections will affect crop yields. Specifically, wheat, maize and horticultural growing areas will shift, coupled with declining yields. Maize, a staple food crop in Zimbabwe, will not be spared these decreasing yields. The IPCC predicts yield losses of between 18% and 30% for maize in southern Africa by 2050 (AR5, 2015). The Report also mentions that sorghum yields could similarly decline. Areas that are suitable for maize cultivation are predicted to decrease by 2080. One study predicts that the south and west of the country will become less suitable for sorghum and maize cultivation, while the north, central and eastern areas will favour maize, sorghum and cotton (Muriwa et al., Brown et al., 2012). Crops such as groundnuts, roundnuts and cassava may benefit from increased $CO_2$ levels (IPCC, 2014). In addition, areas suitable for growing sorghum and cotton are likely to increase by 2080.

Despite the climate change related decline in food-crop yields mentioned above, there is great potential to counter this by adopting climate-smart agriculture. This section will focus on how relevant interventions can contribute considerably to CSA. These interventions are expected to increase productivity while mitigating climate change risks through proven practical CSA techniques such as mulching, intercropping, conservation agriculture, agro-forestry and integrated crop-livestock management. CSA also involves innovative practices such as weather forecasting, early-warning systems and weather index-based insurance. Furthermore, CSA aims at developing new technologies such as drought-tolerant or flood-tolerant crops to meet the exigencies of the changing climate. In the Zimbabwe context, extension officers train the farmers to use these techniques.

***Table 7.1 Natural Regions, rainfall and farming systems in Zimbabwe (adapted from Nyamadzawo et al., 2013)***

| Natural region | Annual rainfall (mm) | Farming system |
|---|---|---|
| I | >1 000 | Suitable for dairy farming, forestry, tea, coffee, fruit, beef and maize production |
| II | 750 – 1 000 | Suitable for intensive farming, based on maize, tobacco, cotton and livestock |
| III | 650 – 800 | Semi-intensive farming region. Suitable for livestock production, fodder crops and cash crops |
| IV | 450 – 650 | Suitable for farm systems based on livestock and resistant fodder crops. Forestry, wildlife/tourism |
| V | <450 | Extensive farming region. Suitable for extensive cattle ranching, forestry, wildlife/tourism |

These practices will only come as part of a deliberate and appropriately tailored extension strategy to improve the following:

- Farmers' access to climate-resilient technologies and practices, and knowledge as well as information for increasing productivity;
- Farmers' capacities to develop and manage climate-smart cropping systems;
- Farmers' access to market information and assistance with income diversification; and
- Farmers' ability to organise themselves better for collective action.

## 7.2 Guiding concepts under CSA

The three pillars of climate-smart agriculture as defined in the introductory chapter will enhance sustainable agriculture production and livelihood resilience, as well as sequestering greenhouse gas emissions from the atmosphere. This also implies promoting the achievement of sustainable food security in Zimbabwe. CSA practices are aimed at achieving food security and broader development goals in the face of the climate risks discussed in section 7.1. However, it ought to be borne in mind that the third pillar (mitigation) is only desirable when it is a co-benefit of the first two pillars, namely increasing production and building resilience to climate change. Furthermore, when applying CSA technologies and practices, careful planning is needed so as to manage the trade-offs and synergies that arise from the three pillars (FAO, 2010). This approach may have a universal CSA application for sustainable crop production in general or different crops across the entire country and farming levels, or it may be differentiated in accordance with the crop and/or agro-ecological region.

Main concepts in this approach:

- CSA technologies for sustained resilience under constrained natural environments;
- Germplasm technology, i.e., promoting the adoption and delivery of drought-tolerant crops, improved high-yielding varieties;
- Crop diversification, i.e., incentives for intercropping, mixed cropping and growing orphan crops; and
- Knowledge-sharing and value-chain analysis.

### 7.2.1 CSA concepts and tools for sustained productivity under constrained natural environments

Increasing areas of Zimbabwe are becoming agriculturally marginalised due to climate change. This results in declining optimal crop growth, leading to low yields or total crop failure. In this regard, the need to execute extension practices and to customise the FAO-funded Farm Management Handbook, endorsed by the government of Zimbabwe in 2011 (FAOSTAT, 2012), could not be emphasised more strongly. Since droughts are frequent in Regions IV and V, farmers are not keen to use expensive chemical fertiliser, even though the soils are inherently poor. Instead, for economic reasons, they would rather use organic fertilisers for crop production. Crop rotation and general agronomy concepts still apply, but the adoption of CSA will produce different perspectives—regarding changes in management practices, decision-making and choice of enterprise combinations on the farm. Extension services will also assist in enhancing awareness and the deployment of relevant concepts by farmers.

The following CSA practices are to be encouraged, especially in severe drought-prone areas of Regions IV and V:

- Conservation agriculture, i.e., mulching, dry planting, no-tillage and minimum tillage, crop rotations, green-manure cover crops and broad-bed furrows that preserve moisture and aid in nutrient recycling;
- Early dry planting of short-season varieties of maize, as well as increasing planting depth to maximise the use of every drop of water received;
- Beneficial crop combinations and succession planting in areas like Chiredzi and Muzarabani, making it possible to establish an irrigated winter crop, given that temperatures are conducive for crop production during the dry winter months;
- Promotion of small-grain, short-season and drought-tolerant crops such as sorghum and millets which are micro-nutrient rich and do not deplete the soil of many of its nutrients;
- Promotion of short-season varieties that can escape drought and make efficient use of the available soil moisture;
- Rainwater harvesting techniques, both infield and off field, groundwater recharge and seasonal water-body retention; and
- Higher efficiency irrigation systems, e.g., drip irrigation that ensures that water application is targeted to meet the requirements at different growth stages.

### 7.2.2 Germplasm technology

The introduction and adoption of new germplasm to produce a significant yield in areas usually associated with total crop failure is now being encouraged, having become an integral part of adaptation to climate change. Conventional plant breeding for drought tolerance, pest and disease resistance has seen an increase in the availability of better hybrids to farmers. This has become important since the risk of drought is projected to increase in many regions, and the prevalence and severity of outbreaks of pest and disease will also change with the changing climate (FAO, 2008). CIMMYT and International Institute of Tropical Agriculture (IITA)'s Drought Tolerant Maize for Africa (DTMA) initiative is a good example of crop interventions that can substantially reduce the risk of yield reductions or crop failure through breeding for greater drought tolerance, while early-maturity varieties can be used for "terminal" drought escape. Through the DTMA project, more than 160 maize varieties were released between 2007 and 2013 (CIMMYT, 2013). The Zimbabwe Agricultural National Research Programme has helped in the dissemination of these hybrids to smallholders.

## 7.3 Crop diversification

Crop diversification can improve resilience in a variety of ways, such as engendering the ability to suppress pest outbreaks, dampening pathogen transmission, buffering crop production from the effects of greater climate variability and extreme events, and increasing household incomes.

In Zimbabwe there has not been much diversification away from maize as the dominant source of food security. The government has recognised this gap and is promoting other crops with better drought tolerance as well as cash crops like cotton. Due to recurrent droughts during recent decades it has become relatively difficult for farmers to rely on maize as the major source of food security. Consequently there is a need to diversify the country's food-security base by encouraging farmers to grow small-grain crops such as sorghum and millet which can tolerate drought conditions (Fig. 7.1). Leguminous cover crops and grasses like Rhodes grass (Katambora grass) can significantly improve the soil structure and consequently farm incomes through savings in inputs.

***Figure 7.1 Seeds for drought tolerant small grain crops at a climate-smart village in Gokwe***


A good example is sorghum production in Zimbabwe. The crop has excellent drought tolerance and multiple end-uses, including food and use in beer brewing, though production is still limited in the rural areas. The government has set purchase prices for millets and sorghum equal to maize in a bid to promote the production of these crops. The other example is cotton, a major source of income for rural communities in AEZ 1V and AEZ V areas. At its peak, cotton accounts for close to a fifth of Zimbabwe's agricultural exports.

### 7.3.1 Knowledge-sharing

A good understanding of the whole value chain from production to market will definitely move agriculture beyond being just a means for improving food security to becoming a tool of economic empowerment. Incorporation of the Food and Agriculture theme for the Zimbabwe National Climate Change Response Strategy into the curricula of colleges should help in the construction of a robust agro-advisory system. AGRITEX monitors drought through crop water requirements and temperature, soil quality, evapotranspiration and rainfall, which are recorded by the Meteorological Services Department (MSD). Extension workers can also promote early maturing varieties by demonstrating their importance on farmers' fields in mother-baby demonstration plots. The Manual can also be written in Shona and Ndebele for the use of smallholders in rural areas. Including the private and public sectors and the donor community in inputs, supply, production, and business support services is necessary to leverage innovations.

## 7.4 Crop production and the three pillars of CSA

### 7.4.1 Essence of the three CSA pillars

As mentioned in the introduction to this chapter, CSA entails enhancing farm production systems to:

- sustainably increase agricultural productivity and incomes;
- strengthen resilience in agriculture (climate change adaptation); and
- reduce agriculture's contribution to climate change (climate change 'mitigation', i.e., minimising greenhouse gas emissions from agriculture and/or acting as a sink of greenhouses gases in the atmosphere).

As opposed to classical farming systems, CSA planning and sustainable agricultural systems come into play, thereby integrating multiple goals and associated trade-offs into actual practice. In most cases, it is not possible to achieve all three pillars in the CSA definition, therefore synergies and trade-offs need to be identified and then the costs and benefits of different options balanced out depending on stakeholder interests (Vermeulen et al., 2012). For example, commercial systems should focus on energy efficiency, thereby reducing their greenhouse gas emissions, including other possible negative environmental impacts.

However, transforming smallholder farming systems to achieve sustainable food security is paramount. Crop productivity can be increased through the adoption of higher yielding crop varieties, the appropriate application of fertilisers and choosing crop species that have higher yield potentials under the given environmental conditions: for example, choosing sorghum over maize in the drier AEZs IV and V.

### 7.4.2 Adaptation through climate risk management

Installing weather stations, rain gauges and equipment to collect data on rainfall, air and soil temperatures, and monitoring runoff rates and soil loss at a central point like a school, and then training farmers to monitor and use the data can provide early warnings about weather threats to newly resettled farmers faced with making cropping decisions. Significant improvements have been achieved through conventional plant breeding and the application of DNA molecular tools to improve yields under drought stress conditions through the development of short-season varieties and water use-efficient varieties. Similarly, breeding for resistance to pests and diseases that are triggered by weather events provides another important source of climate risk reduction.

### 7.4.3 Adaptation through change

CSA can augment already existing sustainable agricultural practices to boost production. Changing planting times and planting depth to suit seasonal weather patterns can reduce the risks of total crop failure and greatly boost production. ICRISAT has developed approaches that focus on equipping farmers to use climate-smart scientific interventions and innovations, climate information for cropping decisions, diversification of livelihoods, links to markets and engaging in profitable agriculture (ICRISAT, 2016). The result has been renewed support for promoting dry land cereals such as sorghum and millet and greater support for groundnut value chains. With the support of the Government of Zimbabwe, ICRISAT also imported 20 tonnes of groundnut seed from Malawi, which was distributed to farmers for seed multiplication and testing.

### 7.4.4 Mitigation

The mitigation potential of crop production largely stems from soil and water management or the agroforestry system under which crops are grown. Alternative sources of energy must also be understood by the farmers, in which case they would be encouraged through appropriate means to adopt such technologies as biogas and heat derived from crop stover. For example, farmers in America derive energy from pelletised maize and wheat residue (see http://extension.psu.edu/natural-resources/energy/field-crops/resources/shelled-corn). The adoption of such methods reduces the number of trees cut down, thus locking up more carbon and enabling the sequestration of more carbon dioxide from the atmosphere.

## 7.5 Farming examples associated with CSA practices

The farming examples below show some components of CSA applications in the agro-ecological zones which are particularly impacted by climate change. Details of these farming practices can be accessed from the links provided.

### 7.5.1 The Green Innovation Hub (Muzarabani): mitigation (AEZ IV)

The Green Innovation Hub (GiHUB) focuses on one of the CSA pillars, i.e., mitigation. It is an incubation platform that seeks to ignite social change and unlock the potential of young people in contributing to sustainable development through novel ideas around smart energy and the sustainable use of natural resources. This is integral to the mitigation of the negative effects of climate change. For example, innovations include cheap, simple and effective direct solar heat pumping systems and access to clean and sustainable energy for low-income households by means of a biogas production plant. http://www.sustainzim.org/winners-201516-green-innovations-hub/ (Accessed on 05/08/2017).

### 7.5.2 Climate-smart villages (Nkayi): adaptation (AEZ IV)

This case study addresses the climate resilience pillar of CSA. Using a multi-model framework for climate, crop, livestock and socio-economic simulation, customised climate change adaptation packages were developed for farmers in Nkayi, Zimbabwe. They re-designed smallholder crop and livestock systems in semi-arid parts of southern Africa to address poverty and enhance resilience to climate change—an example of stakeholder-driven integrated multi-modelling research. The computer-simulated scenarios are helping policymakers to make crucial decisions to support farmers. http://www.icrisat.org/wp-content/uploads/2016/11/Building-Climate-Smart-Villages.pdf (Accessed on 06/06/2017)

### 7.5.3 OneAcre Management (Gokwe North): all three CSA pillars (AEZ IV)

This is an innovative extension tool that is challenging all stakeholders in the agricultural sector through the application of the Climate-smart Village concept to transform agriculture in Zimbabwe in the face of climate change challenges. The aim is to tap into existing institutions and stimulate the adoption of existing and generated knowledge, technologies and agricultural support services that will best meet the emerging challenges arising from climate change and variability. This concept brings together, industry, academia, extension officers and farmers, i.e., appropriate research is taken to the farmer's field on a platform that allows for a new approach to holistic intervention, thus covering all three pillars at the same time. http://www.oneacre.co.zw/ (Accessed on 04/04/2017)

We need technology transfer mechanisms and interventions for the adoption of CSA across the agricultural sector. The OneAcre Mother-Baby clusters in Gokwe North District are good examples of CSA practices. Table 7.2 refers to the three CSA pillars.

### 7.5.4 Foundations for Farming (Mashonaland Central Province): climate resilience (AEZ IV)

The River of Life Church is promoting small-scale conservation farming in post land reform Zimbabwe. This donor-funded project has its origins at Hinton Estates in Mashonaland Central Province, where it was widely used on commercial production lands. The initial aim was to take successful cases of commercial and conservative agricultural practices to the country's smallholders. http://www.fffzimbabwe.org/?page_id=6710 (Accessed on 23/03/2017)

### 7.5.5 Delta Beverages: sorghum production (Chiredzi and Mwenezi): resilience (sustainable food security [AEZ IV])

Delta Beverages provides a ready market for red and white sorghum for some of Zimbabwe's small grain farmers. Small grains are climate-smart in respect of their water-use efficiency and labour requirements and may also be used to promote food security by improving the staple diet. Extension and farmer training programmes accompany these out-grower schemes of Delta Beverages, further boosting the adoption of CSA by industry, extension and farmers. Through this contract farming programme, many families in Chiredzi and Mwenezi are managing to sustain their livelihoods. http://www.delta.co.zw/media-center/news/61-delta-beverages-reduces-red-sorghum (Accessed on 04/08/2017)

*Table 7.2 Some CSA practices as reflected in the three pillars*

| CSA practice | Description | Relevance | Adaptation | Mitigation | Production | AEZ |
|---|---|---|---|---|---|---|
| Conservation agriculture | Reduced tillage; crop residue management and intercropping; crop rotation with cereals and legumes | Carbon sequestration; reducing existing emissions | Increased water retention; reducing crop losses | Promoting carbon storage in soil; water retention increased, thus reducing energy for irrigation | Increased productivity due to higher nutrients in soil, healthier soil, reduce soil erosion | III, IV and V |
| Integrated fertility management | Compost and manure management | Reduce $N_2O$ and $CH_4$ emissions, improving soil structure | Food security | Reducing pollution | Creating carbon sink; improved soil fertility | All AEZ |
| Small-scale irrigation | Whole-year cropping | Improved production; sustainable food security | Reducing total crop failures | | Sustainable food production; creating carbon sink | All AEZ |
| Crop diversification | New crop varieties | Pest resistance, high yields, drought tolerance | Enhances resilience in agriculture | | Sustainable food production; healthier diets | All AEZ |
| Drought-tolerant varieties | Moisture retention | Water and energy smart | Reducing total crop failure and | Short life-cycle reduces environmental impact | Increased incomes and higher yields, climate resilience | III, IV and V |
| Other practices | Early warning system; in situ conservation /harvesting; crop insurance | Reduction of risk sustainable food security | Sustainable production | | Drought resilience agriculture; reduced climate risk; reduced emissions and increased incomes | III, IV and V |

### Case study 7.1 Climate-smart Village: Hezekiah Village, Nembudziya, Gokwe North District

**How did this idea come about?**

The vision of a climate-smart village started way back with the village elders expressing their dream to "transform the village into a green belt" that would maximise the use of available water resources for diversified cropping beyond key crops like cotton and maize, enhancement of fodder production for livestock and mechanisation of operations to improve productivity and reduce drudgery. The idea evolved in recent years to encompass four key elements (i) crop variety testing to match varieties with local conditions; (ii) development of water sources for irrigation and domestic use; (iii) improvement of pastures through local multiplication of seeds for grasses and multi-purpose tree legumes; and (iv) Conservation Agriculture (CA) and introduction of small grains. While many of these initiatives are still in the formative stages, the idea of a climate-smart village has firmly set root among many of the villagers.

**The one-acre concept**

"Our ambition is for every household to have at least one acre of a high quality crop every season, both for dry land crops and for irrigated high value horticulture crops which have been a cash cow for many families in this village. Many of us went to school, funded by income from cabbages and tomatoes. These power lines were all paid for by a very good cabbage crop we had some years back. We know this works and that's what drives us. We are extending the one-acre concept to production of fodder for supplementary feeding of livestock during the dry season. We are also doing the same with trees for multiple uses, including intercropping with field crops. Some are for livestock fodder but some are for fruit trees like mango, a very good income earner for households here. These ladies are on their way to plant mango seedlings as you can see and these should do very well given the good moisture. We still have a long way to go, but the mind-set and the basic ingredients of a climate-smart village are starting to take shape".

*Mr Dangaiso, Village Headman, Hezekiah village*

**Under this concept the villagers developed the following:**

- Improvement of pastures and fodder production;
- Conservation agriculture and adoption of small grains; and
- Development of local water sources.

**Can a climate-smart village approach, result in climate resilience?**

The climate-smart village concept at Hezekiah village is in its infancy, but is certainly bringing people together with a common purpose, driving a broad-based mind-set shift that goes beyond any one practice. Building resilience to climate risk will require such a multi-pronged response covering many facets of rural life as demonstrated in this case. Greater external support than what is available to the farmers in Hezekiah village will be required if we are to go beyond a few isolated examples of climate-smart villages. A combination of knowledge-driven and market-linked approaches that are anchored on improving food security and increasing incomes are key to success. The internal drive, vision, ambition and cohesion, however, will set apart communities that stand, or fall apart in the face of a changing climate.

*Source: Mutamba, M., Ndidzano, K., Matingo, E., Marongwe, S.L., Vambe, L., Murwisi, K., 2017. Cases of Climate-Smart Agriculture in Zimbabwe. VUNA. Pretoria.*

## 7.6 Application of CSA to crop production in Zimbabwe

Table 7.3 shows the CSA technologies that can be applied in the respective AEZs in line with CSA practices. The differences in relation to traditional agriculture (Table 7.1 and CSA, Table 7.3) are found in three features: being climate change centred, balancing trade-offs in search of sustainable production, and the adaptation and mitigation outcomes in the wider scheme of things and the possibility of new funding opportunities, for example, Adaptation Fund, Least Developed Countries Fund and the Voluntary Carbon Market.

***Table 7.3 Benefits of CSA technologies in Zimbabwe's AEZs.***

| AEZ | CSA practice | Benefits |
|---|---|---|
| I and II | Integrated fertility management | Increased productivity, and extra income and profitability of farm enterprise |
| | Small-scale irrigation | Improved water management, year-round crop production, extra income |
| | Crop diversification | Food security and healthy diets |
| III | Conservation agriculture | Water retention and prevention of soil erosion, improved air quality |
| | Use of organic manure and green-manure cover crops | Improved soil fertility, reduce production costs |
| IV and V | Drought-tolerant varieties | Reduce risks associated with crop failure, improved food security |
| | Small-grain and short-season varieties | Drought resistance, reduces risk, increases food security, improves nutrition |
| | Early planting and mulching | Moisture conservation reduces risk of total crop failure |

### 7.6.1 Crops: Climate-smart Agriculture case studies

#### Case Study 7.2 CA for field crops

The Ngwerumes have been practicing CA since 2005. They work closely with Agritex and other development agencies. They now use CA exclusively after realising its benefits. Reported yield gains show a four-fold increase while other benefits like higher tolerance of moisture stress are highly appreciated due to the risks associated with mid-season droughts.

"The yield has improved particularly due to the use of compost in CA systems. Fertility and management determines yields. We encourage thermal composting using dry matter. It is ready to use in eight weeks. Some farmers have up to three composts at a time. By September/October, a CA farmer is ready, waiting for the rain. We also teach soil testing to ensure that fertiliser applications are precisely matched with requirements. Farmers are encouraged to put lime three months before rain."

*Mrs Mukotami, Agritex Officer, Ward 24, Goromonzi District*

### Case Study 7.3 Integration through CA

"We dig basins in September, and in October we put compost in the basins. We put lime in September. We put a small amount of compound D with cup size number 8. Our soils are poor so we maintain the recommended fertiliser application with size number 8 cup. The crops are getting better and better as compared to before we started using the compost, better than when we used to rely on fertiliser. There is a huge difference with others, the maize crop with manure is much better and it doesn't suffer from moisture stress even when we have dry spells. Before CA I used to get 1 tonne. Now I plant half a hectare and I get 3 to 4 tonnes. Now the aim is to keep improving yield through use of manure, rotation, and improved seed varieties. I'm experimenting with green mulching. I can then use it as supplement for livestock. Green mulching covers ground, preserving moisture and suppressing weeds. I also intercrop maize with things like pumpkin, water melons and cucumbers. We get training through workshops and seminars. I'm Chairman of the Zimbabwe Farmers Union (ZFU) for this ward and vice chairman for Goromonzi district so I use these platforms to share experiences and lessons with other farmers."

*Mr Ngwerume, Farmer, Goromonzi District*

### Case Study 7.4 Fodder production and preservation

Poor grazing in Mawanga district during the dry season is key among the challenges facing livestock farmers. Poor nutrition leads to loss of productivity as cows take long to conceive while those earmarked for the market fetch poor prices due to low weights. The Ngwerumes grow legume fodder crops such as Velvet beans (mucuna) to supplement their livestock during the dry season. In addition to growing fodder they also turn ordinary maize stover into palatable and nutritious feed through urea treatment.

"We plant Mucuna beans to use as fodder for livestock. I feed everything, so nothing gets lost. We harvest everything and bale manually in a pit that I prepared for that. We can store the bales for as long as we need. We feed the bales to animals. The seed we sometimes crush and mix with feeds. We put a bit of manure to improve productivity. Mucuna requires rainfall for at least two months to do well. Mucuna fertilises the soil as it fixes nitrogen like all legumes. You can cut it and it will revegetate the next season and give you another crop. We can even plant mucuna amongst the trees as it encourages vertical growth. Here, mucuna is planted among mazhanje trees."

I have a pit for urea treatment of crop residue to make very palatable and nutritious feed for my livestock. From the pit I produce about 500 kg of feed after about six weeks. Cattle love this stuff. As such my animals are always in good condition. Some of the maize stover I use as bedding for cattle during the rainy season. The idea is to get a lot of manure for own use and for selling to the community."

*Mr Ngwerume, Farmer, Goromonzi District*

### Case Study 7.5 Are integrated CSA approaches applicable at scale in smallholder systems?

The case of the Ngwerumes is a typical example of a well-integrated farming system that should be the norm rather than an exception in smallholder settings. While current smallholder systems in Zimbabwe have some elements of complementarities highlighted in this example, there is lots of room to strengthen these. Achieving higher levels of integration that maximise potential complementarities will need investment in a number of areas such as information and extension support, market linkages and innovative financing for smallholder settings. The financial bottlenecks for some of the interventions are quite pervasive and extend to many other investment ambitions within smallholder agricultural development programmes. Although most smallholders can afford structured payments for such investments, the lack of a trusting relationship with the financial sector has undermined access to such support. If large scale adoptions of integrated approaches to CSA are to happen, many facets of how smallholders are financed will need reform.

*Source: Mutamba, M., Ndidzano, K., Matingo, E., Marongwe, S.L., Vambe, L., Murwisi, K., 2017. Cases of Climate Smart Agriculture in Zimbabwe. VUNA. Pretoria.*

## 7.7 The relevance of CSA to agricultural (extension) professionals

Agricultural extension in the country has largely been centred on AGRITEX, the government's extension department, as a public-sector body and conduit for transferring skills, technologies and knowledge to improve productivity. However, for the successful adoption of CSA in crop production, at least two of the three pillars have to be successfully attended to simultaneously, meaning that the country's extension services strategy must be transformed and become consolidated between various government departments and the private sector so as to be able to impart the substantial transformation required in the farming sector.

CSA is a practice that goes well beyond any individual farm enterprise—specifically cropping—and extension must similarly be more than just a conduit for boosting production. Rather, it must become the focus for coordinating and absorbing various farm enterprises and actors (the general public, NGOs, farmer organisations, the private sector and academia) into a holistic agriculture-supporting community. Specifically, transforming extension can contribute to achieving CSA crop-production objectives through the following priority milestones:

- Technology development and information dissemination – developing technologies and encouraging innovation (being able to determine the types of adaptive changes farmers need and when to make them; greater involvement in looking for localised solutions; ensuring that relevant technologies and modes of dissemination keep up with the need for ever-changing climate change adjustments; and a focus beyond the household). Figure 7.2 illustrates one of the technologies;
- Strengthening farmers' capacity-building resilience by strengthening farmers' human and social capital (shifting the presentation of technology packages beyond blanket recommendations; new skills needed at the organisational and individual levels, such as marketing, gender, power and conflict dynamics);
- Facilitation and brokering – the bridging function of extension (extension needs skills in new areas such as building networks, process facilitation, brokerage and process monitoring); and

***Figure 7.2 Existing sustainable agricultural practices (mulching) in Zimbabwe***

- Advocacy and policy support – monitoring advocacy and policy support (extension must be actively involved in monitoring the effects of climate change on agriculture and the progress of CSA efforts, play an important role at the local level in decentralised governance structures to ensure climate change remains on the policy agenda and that funds are allocated for CSA programmes, and be able to explain climate change policies to rural communities).

## 7.8 The role of higher and tertiary institutions in climate-smart practices

Higher and tertiary institutions form the backbone of all efforts to change agricultural practices in Zimbabwe. Agricultural studies, together with primary and secondary research, have now become concentrated at the various institutions of higher learning. Extension services, research institutions, the private sector, educational institutions and agriculture are all local destinations for graduates from local institutions, demonstrating the role of infusion of CSA into the various curricula of institutions of higher and tertiary education.

Thus, these institutions have the potential to promote CSA adoption in Zimbabwe in a number of ways:

- Academic, policy and industry-related research geared towards the improvement of crop production in general;
- Producing graduates to become climate-smart crop farmers;
- Producing specialised agricultural scientists for the private sector whose roles will include various innovations towards CSA through the development of improved and high-yielding crop varieties, chemicals to handle new weeds and pests, the design and manufacture of appropriate machinery and tools to make crop production more efficient, and better weather prediction and management tools;
- Producing future industrialists who are climate-smart and will not only advocate CSA, but be willing and able to invest in it for productivity and research reasons; and
- Continuous learning programmes and opportunities for industry, academia and policymakers at all levels of governance.

***Figure 7.3 Enhancement of women agricultural CSA practices in dry agro-ecological zones***

## 7.9 Policies in place with respect to CSA

Zimbabwe has ratified the UNFCCC, but has not yet adopted a stand-alone climate change policy or legislation. The country has also ratified multilateral environmental agreements such as the Convention on the Conservation of Biological Diversity and the United Nations Convention to Combat Desertification (UNCCD). Some of the most important policies (Table 7.4) with respect to intensifying food-crop production have not fully incorporated climate change aspects into their blueprint.

***Table 7.4 Some important existing CSA-related policies in Zimbabwe***

| ZimAsset (Zimbabwe Agenda for Sustainable Economic Transformation, October 2013 to December 2018) | Command Agriculture: targeted Command Agriculture |
|---|---|
| One of the five clusters is food security and nutrition, through which ZimAsset aims to increase cereal and orphan crop sustainably through: | A scheme aimed at improving food security that was introduced in 2016 to address the interlinked challenges of climate change and food security through the government providing: |
| Increased functional irrigation area from 150 000 to 220 000 ha | Loans to farmers for 400 000 ha of maize crop to produce at least two million tons of grain |
| Provision of loans and contract farming facilities to farmers for the timely delivery of affordable inputs to them | Loans in the form of inputs, including irrigation material; increasing the area under irrigation |
| Open credit lines for all farmers, including A1 farmers | Extension services for knowledge sharing of best farming practices |
| Promoting the production of drought- and heat-tolerant high-yielding crop varieties | Plans to extend to cotton and other crops are underway to build the resilience of farming communities |
| Increased access to local and regional markets by local farmers | Targeting farmers with the capacity to produce at least 5t/ha; if they produce more than 10t/ha, they keep the surplus |

## 7.10 Conclusion and recommendations

### 7.10.1 Conclusions

This chapter has outlined the negative impacts of climate change on national food security in Zimbabwe. Climate-smart agricultural practices (the three pillars) have been put forward as the panacea for sustainable food-security in the country. The guiding principles of achieving sustainable food security are the CSA approaches to germplasm technology, crop diversification and knowledge sharing. The approach taken in this chapter has been to outline the agricultural practices (conservation agriculture, integrated fertility management, small-scale irrigation, crop diversification, introduction of drought-tolerant varieties, etc.) associated with the components of CSA as practised in agro-ecological zones IV and V, where climate change impacts are most evident in terms of recurrent droughts.

Enabling stronger linkages between academic research and extension, as well as appreciating the value of local innovations will remain key to the establishment and sustainability of a practical national CSA programme. As extension workers are pivotal in the implementation and deployment of new technologies to farmers, it is therefore important that they receive adequate training from colleges and universities. Government-led initiatives like ZimAsset and Targeted Command Agriculture which are directed towards sustainable agricultural intensification can explicitly address adaptation and mitigation challenges in order to reduce constraints on smallholders.

### 7.10.2 Recommendations

By explicitly focusing on climate change, CSA opens up new opportunities for agricultural research and development while also augmenting sustainable agricultural practices. Strengthening the links between health, food security and agriculture in the light of climate change impacts should focus not only on technologies and practices, but also on the outcome of these interventions beyond the farm gate. The identification and development of agricultural clusters and incentive schemes for climate-resilient products to encourage CSA adoption and foster economic transformation will also create a conducive environment for implementing CSA nationally. For instance, a cotton production cluster in Gokwe (AEZ IV), and a tea production cluster in Chipinge (AEZ I) can be widely adopted commercially while positively affecting the social and ecological systems in place.

In addition, existing frameworks such as the National Climate Change Response Strategy (NCCRS) and the INDC are pivotal in introducing CSA as they enhance the adaptation of small-scale farmers, providing incentives for low-carbon agricultural activities (conservation agriculture, agro forestry) and promoting integrated land and water management (mixed farming, crop rotation, contour farming). Furthermore, replicating CSA practices and innovations requires institutional coordination between private and public agriculture and climate-related institutions at the international, regional, and national levels, including development partners.

## Acknowledgements

The author wishes to thank Dr Cosmos Magorokosho and Mr. Stanley Gokoma of CIMMYT for sharing their experiences with drought-tolerant maize across southern Africa. Special thanks also go to Dr Xavier Mhike and Mr. Nigel Muchiwanga of Dupont Pioneer for their insights into the state of the seed industry, and agriculture in Zimbabwe. I offer my sincere gratitude to Dr Todd Ngara for providing weather and climate information that was relevant to the theme of crop production.

## References


1. Brown, D, Chanakira, R, Chatiza K., Dhilwayo, M., Dodman, D., Masiiwa, M., Muchadenyika, D., Mugabe, P., and Zvigadza, S., 2012. *Climate Change Impacts, Vulnerabiltiy and Adaptation in Zimbabwe.* IIED Climate Change Working Paper 3,
2. CIMMYT, (2013). *The Drought Tolerant Maize for Africa Project.* DTMA Brief, September. International Maize and Wheat Improvement Centre.
3. Delta Beverages, (2016). *Delta Reduces Red Sorghum Hectarage by 70%.* [online] Available at: http://www.delta.co.zw/media-center/news/61-delta-beverages-reduces-red-sorghum [Accessed on 13 Dec. 2016]
4. FAO, (2008). *Socio-economic Impact of Smallholder Irrigation Development in Zimbabwe.* [online]. FAO Corporate Document Repository. Available at: http://www.fao.org/docrep/x5594e/X5594e03.htm [Accessed on 20 Dec. 2016]
5. FAO, (2013). *Climate Smart Agriculture Source Book.*
6. FAOSTAT, (2012). Statistical Database Food and Agricultural Organisation of the UN. [online] FAOSTAT. Available at: http://faostat.fao.org. [Accessed on 4 Dec. 2016]
7. Foundations for Farming Zimbabwe, (2016). *Foundation for Farming Zimbabwe Official* Website. [online] Available at: http://www.fffzimbabwe.org/?page_id=6710 [Accessed on 10 Dec. 2016]
8. ICRISAT, (2016). *Building climate-smart villages: five approaches for helping farmers adapt to climate change.* International Crops Research Institute for the Semi-Arid Tropics. Available at: http://www.icrisat.org/wp-content/uploads/2016/11/Building-Climate-Smart-Villages.pdf [Accessed on 4 Dec. 2016]
9. IPCC Fifth Assessment Report (AR5), 2015. *What's in it for Africa?*
10. Mugabe, F.T., Thomas, T.S., Hachigonta, S. and Sibanda, L. eds. (2013). *"Zimbabwe" In Southern Africa Agriculture and Climate Change: A Comprehensive Analysis.* Research Monograph, International Food Policy Research Institute, Washington, D.C.
11. Mugandani, R., Wuta, M., Makarau, A. & Chipindu, B. (2012). *Re-classification of Agro-ecological Regions of Zimbabwe in conformity with climate variability and change. African Crop Science Journal,* 20(2), 361 – 369
12. Nyamadzawo, G., Wuta, M., Nyamangara, J., & Gumbo, D. (2013). Opportunities for optimization of in-field water harvesting to cope with changing climate in semi-arid farming areas of Zimbabwe. *Springer Plus*, 20, 100.
13. OneAcre, (2016). OneAcre Official website. [online] Available at: www.oneacre.co.zw [Accessed on 15 Dec. 2016]
14. SustainZim, (2016). Winners of the 2015/16 Green Innovations Hub. [online] SustainZim. Available at: http://www.sustainzim.org/winners-201516-green-innovations-hub/ [Accessed on 16 Nov. 2016]
15. Vermeulen, S.J., Aggarwal, P.K., Ainslie, A., Angelone, C., Campbell, B.M. Challinor, A.J., Hansen, J.W., Ingram, J.S.I., Jarvis, A., Kristjanson, P., Lau, C., Nelson, G.C., Thornton, P.K. and Wollenberg, E. 2012. Options for support to agriculture and food security under climate change. Environmental Science and Policy 15: 136-144.
16. ZimStat, (2015). Climate Change Increases Agric Losses. [online] ZimStat. Available at: http://www.zimstat.co.zw/climate-change-increases-agric-losses [Accessed on 05 Aug. 2017]

# 8. Climate-smart agriculture in livestock and rangeland management in Zimbabwe


## Abstract

This chapter describes a range of climate-smart agriculture, livestock and rangeland management interventions. The interventions are hinged on the three pillars of CSA, namely sustainable productivity, adaptation and mitigation to climate change. The application of CSA to livestock and rangeland management is presented in the context of Zimbabwe's climate change related policies and strategies. The relevance of CSA interventions in the Zimbabwean livestock industry is also explored through the roles of institutions of higher learning and extension professionals. Practical activities have been included to help readers to conceptualise the importance of CSA in livestock and rangeland management in the local (on-farm) context or from field-based experience. The chapter concludes by discussing policy implications at the national level and recommendations for the place of CSA in livestock and rangeland management in Zimbabwe.


**Keywords:** crop-livestock systems, diversification, drought tolerant, rain-fed agriculture, rangeland management

## Key messages

i. In Zimbabwe, the vulnerability of mixed crop-livestock systems to climate change will be reduced by the addition or substitution of crop and livestock species and breeds that are more heat- and drought-tolerant;

ii. A range of mitigation opportunities available are associated with rangeland and feed management interventions that subsequently increase overall herd productivity and the resilience of rangelands to climate change;

iii. ICT should be used to improve access to information and prevailing gaps in knowledge about CSA for rangeland-based livestock systems;

iv. The successful adoption of approaches drawn from CSA in Zimbabwe's livestock sector will require the mainstreaming of CSA into curricula at institutions of higher learning; and

v. Institutional and financial support is imperative to enable smallholder farmers to shift to livestock and rangeland systems that are CSA-based.

## 8.1 Introduction

Livestock require suitable nutrition, veterinary protection, a well-managed habitat, general good breeding and management in order to maximise their productivity. Many of these factors are affected by climate change stressors such as (i) high ambient temperatures; (ii) low or unreliable precipitation; and (iii) unexpected disease pandemics. The probability of drought-induced crop-livestock system failures ranges from 40% to 100% in most agro-ecological regions of Zimbabwe (Figure 8.1). Much reduction in net primary production and carrying capacity is expected in the southern region of Zimbabwe which is suited to extensive cattle ranching. The level of vulnerability among livestock smallholders is also increased by soil salinity, outbreaks of foot and mouth diseases, knowledge gaps, and poor access to resources and markets. On the other hand, livestock, especially ruminants (sheep, goats and cattle), contribute to climate change through (i) enteric fermentation that produces the greenhouse gases methane and carbon dioxide; (ii) poor manure management producing the greenhouse gas (GHG) nitrous oxide; and (iii) changes in land-use patterns along the livestock feed supply chain. CSA is a robust approach aimed at reducing the vulnerability of livestock and rangelands to climate change whilst also limiting their impacts on the climate system.

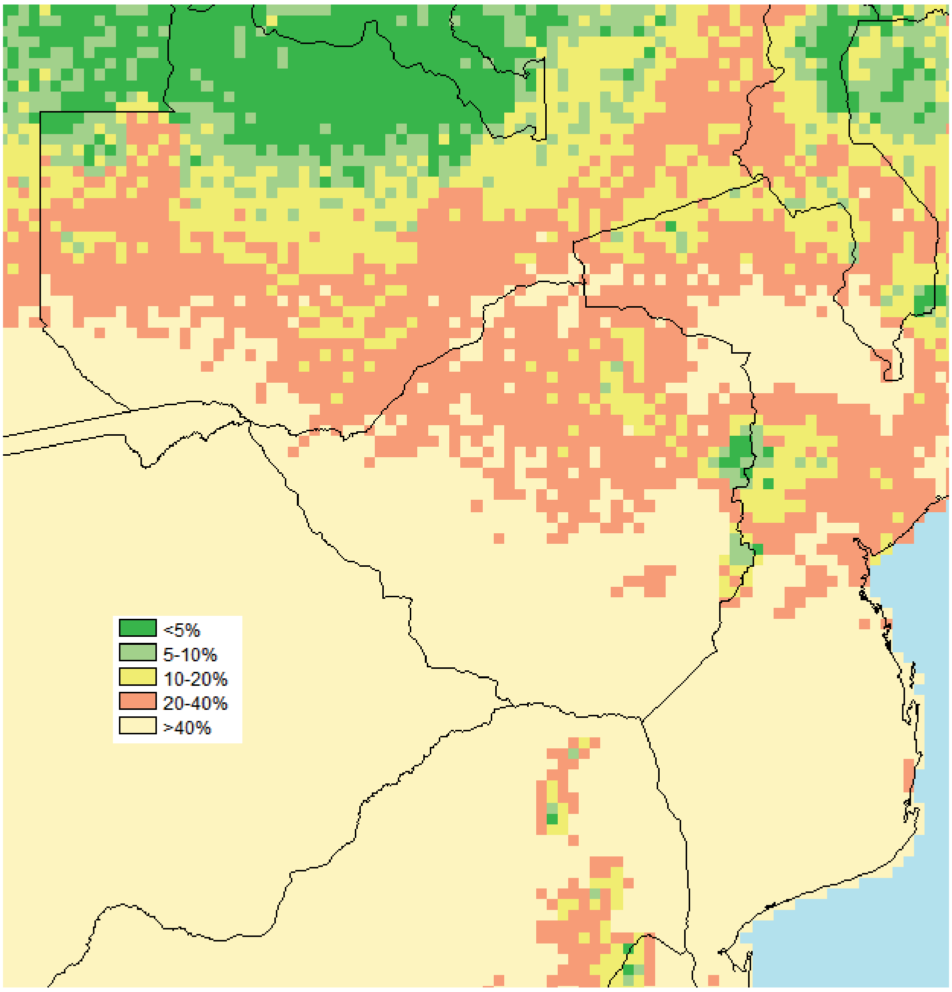
### 8.1.1 Objectives

By the end of this chapter the reader should be able to:

i. explain what CSA is in terms of livestock and rangeland management;
ii. outline the pillars of CSA with respect to livestock and rangeland management;
iii. identify appropriate livestock-based policies, strategies and activities that contribute to the pillars of climate-smart livestock systems; and
iv. recommend CSA policies and practices that are suitable in one's own area in managing livestock and rangelands productively and sustainably.

The frequent and severe droughts that have become common over almost the past decade have reduced dry-season natural grass and browse resources in the main beef-producing areas of Matabeleland, Masvingo, Midlands and northern parts of Mashonaland. Dairy cows, pigs and poultry depend heavily on cereal crops for feed. Small ruminants (sheep and goats) are currently under-utilised resources in Zimbabwe because they are poorly linked to the formal domestic and export meat markets.

***Figure 8.1 Percentage of failed seasons in the 2050s: projections from an ensemble mean of 17 climate models and a high emissions scenarios (RCP 8.5) using methods described in Thornton et al. (2006) and Jones and Thornton (2013, 2015)***




**Activity 1.** *Look up the United Nations definition and accompanying elaboration of the word "sustainability" and relate the definition to livestock and rangeland management. Discuss this concept with your peers to consolidate your understanding. What is climate-smart agriculture in terms of livestock and rangeland management?*

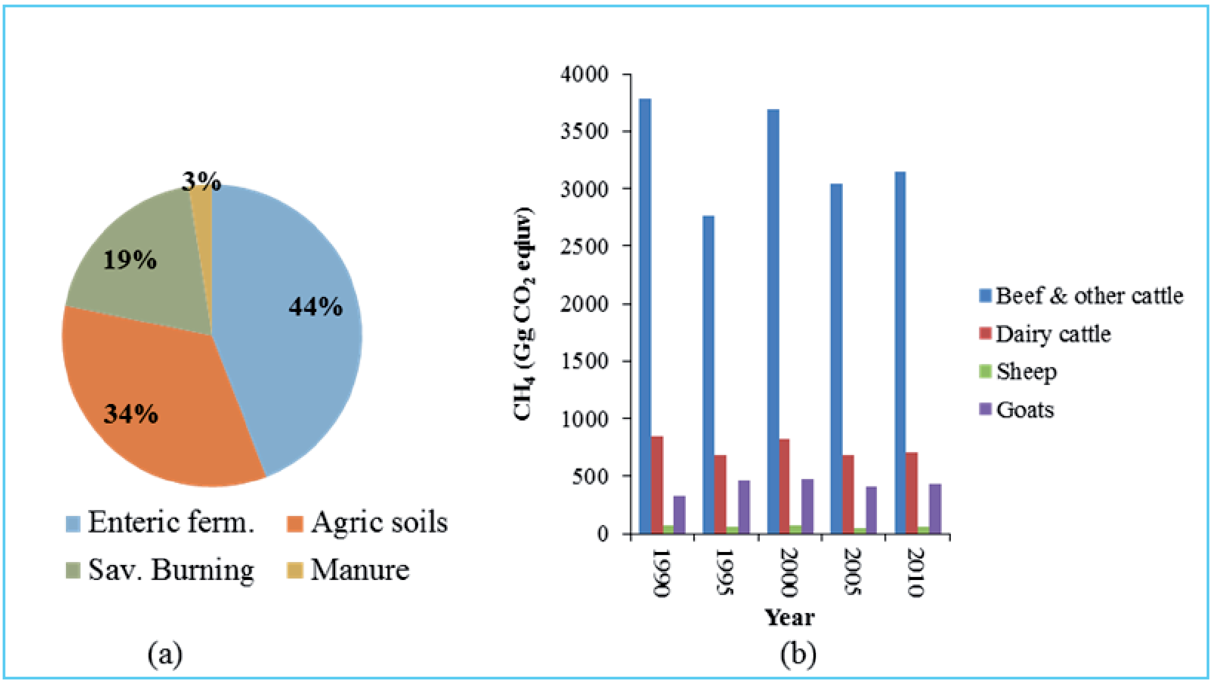
## 8.2 Situational analysis of Zimbabwe's livestock sector

Most of the livestock in Zimbabwe (cattle, sheep, goats and indigenous pigs) are kept on rangelands that occupy 76.8% of the total land area. Overall, the cattle of communal and resettled smallholders make up 90% of the five million national herds and routinely exploit the "patchy" nature of local vegetation, which changes with variations in soil condition. Forage production is unstable due to low (400 mm or less per year) and unpredictable rainfall, and livestock population dynamics are driven by the direct effect of rainfall on annual herbage production. The livestock sector currently contributes 18% of total agricultural domestic product and has the potential to increase this to 36%. Livelihoods in southern Zimbabwe are predominantly based on livestock and are limited in food- and cash-cropping, as they are normally affected by widespread droughts.

The high degree of vulnerability of this livestock-producing region is compounded by economic marginalisation due to low rainfall. Inherent droughts often result in reduced water supply, quantity and quality of feed and food resources, increased spread of vector-borne livestock diseases and disease vectors, and heat stress. These factors affect feed intake and animal productivity, claiming large numbers of livestock per year, perpetuating food insecurity as well as reducing the supply of primary products down the value chains. Mean Annual Precipitation (MAP) is predicted to decline by 10%, 15%, 16% and 14% in the Gwayi, Mzingwane, Runde and Save catchments respectively under business-as-usual conditions by 2050 (Davis and Hirji, 2014). Net Primary Production (NPP) will decline from over eight to five tonnes per hectare per year by 2080. This translates into a decrease in the rangeland carrying capacity for livestock, with the southwest and northwest regions experiencing greater reductions in NPP than other parts of the country. Variable climate events present a unique stocking management problem for farmers.

To make matters worse, livestock, especially ruminants (sheep, goats and cattle), also contribute to climate change mainly through GHG emissions (methane) and poor manure management (nitrous oxide). Of the 14% of global GHG contributed by agriculture, about 65% is contributed by cattle. The overall direct GHG emissions from livestock and feed production constitute some 80% of total global agricultural emissions. Activity data used for Zimbabwe's livestock GHG inventory includes spatially diverse information such as livestock numbers and areas of grassland burnt, that are obtained from a combination of sources such as censuses, surveys, farmer interviews, filed observations, remote sensing and expert knowledge. Figure 8.2 shows the national inventory of GHG emissions from Zimbabwe's agricultural sector. The estimates of livestock GHG emissions are based on the IPCC Guidelines (2006) Tier I method of multiplying activity data, e.g., number of animals in each livestock species by default regional emission factors.

***Figure 8.2 Inventory of GHG emissions from Zimbabwe's agricultural sector: (a) key sub-sector analysis of GHGs; and (b) domesticated ruminant methane emissions between 1990 and 2010 (Mapanda and Svinurai, 2015). Also see Appendix I in this chapter.***




Although climate change contributes to rangeland degradation, rangelands can be used to reduce climate change pressures through carbon sequestration. Fortunately many options exist to conserve or reverse rangeland degradation in specific livestock habitats, inclusive of wildlife management. This is particularly

important for sustainability. The key constraints on livestock and rangeland management in Zimbabwe are technical as well as policy-related and can be summarised as:

i. Increased frequency of droughts or long dry spells that cause severe on-farm shortages of forage and falls in the livestock sector's share of agricultural GDP;
ii. Inadequate grazing infrastructure (fence, water points, dip tanks);
iii. Alarming spread of notifiable diseases, particularly foot and mouth disease; and
iv. A lack of a rangeland or pasture development and management strategies. This includes grazing management, rangeland rehabilitation and a lack of climate-smart fodder crops.

**Activity 2.** *Discuss with a colleague or two how we can sustainably manage the crop-livestock nexus in a way that contributes to intensification and diversification of environmentally sustainable livestock production, and to reduce the risks and levels of vulnerability.*

**Activity 3.** *There is little information on how these interactions may be affected by changes in climate and climate variability. How do you think this serious gap in knowledge might be closed so that crop-livestock interactions may offer some buffering capacity to help smallholders sustain productivity, adapt, and offer mitigation options in response to climate change?*

Reducing the environmental footprint of livestock is imperative. Innovative responses are needed from livestock researchers and extension practitioners by embracing cross-cutting issues. According to ZimVac (2015), livestock has the potential to be an important source of both household food and farm income, yet its contribution in smallholder farming areas of Zimbabwe is low due to the fact that per-capita ownership of livestock has worsened. This can easily be traced to over-reliance on rain-fed agriculture and low-end technology. At full capacity of resource utilisation, opportunities exist in the entire livestock production chain, since the sector already employs 70% of smallholder crop-and-livestock farmers, supplies raw materials to the food-manufacturing industry and enhances food security.

## 8.3 Guiding concepts of CSA with respect to livestock and rangeland management

The main guiding concept under the theme of livestock and rangeland management is that CSA must be adopted along the livestock value chains using the "farm-to-fork" concept. This may be defined as food production at the farm level going down to consumers through intermediary processes supported by value chain actors and support corridors like farmers' networks, processors, transporters, abattoirs, wholesalers and retailers (Camagni and Kherallah, 2014). The pre-farm part of the value chain, i.e., the manufacture and distribution of inputs (seed, fertiliser, feed, water, energy, and veterinary drugs) is critical in inserting raw materials into the value chain.

### 8.3.1 Relationship of livestock and rangeland management with the three pillars of CSA

Livestock and rangeland management options should add value to the diversity of desirable interventions that are likely to be effective and efficient in the Zimbabwe context in order to ensure positive outcomes that are directly related to all three pillars of CSA, namely:

**Productivity.** Where rangelands are managed to enhance both biological and economic field-level efficiencies, they can offer the cheapest feed resources. They can be utilised sustainably by maintaining a good balance between and among different livestock value chains. In Zimbabwe, this may be achieved through: (i) maintaining a rangeland free of pests and predators; (ii) increasing the population of beneficial plants and animals; (iii) increasing or stabilising pollination services by insects to increase crop production;

and (iv) managing the timing and flow of rainwater within the rangeland ecosystem. Crop-livestock systems are based on complementarity and mutual benefits (Scherr et al., 2012; Harvey et al., 2013).

**Adaptation.** In the face of climate change, livestock and rangeland management should opt for resilience through a diversity of land uses and promote biodiversity across the rangelands. The main message is that the negative impacts of climate change are mostly beyond the reach or control of livestock farmers and the only way to sustain livelihoods is not to fight with nature but to embrace it innovatively. This should be done to reduce losses from pests, parasites, diseases and climate change stressors such as recurrent droughts and flash floods. The proof of the adaptation concept lies in the realisation that a more diversified portfolio of livestock and rangeland management for better food and nutrition security and income streams can act as a buffer against the shocks of climate change.

**Mitigation.** A more diversified landscape management system that promotes reforestation, natural and irrigated pasture development and over-sowing rangelands with useful grass and legume species results in increased plant populations and hence the utilisation of carbon dioxide via natural photosynthesis (carbon sinking) (FAO, 2012). Also see table in Appendix I of this chapter.

## 8.4 Case studies

### Case study 8.1: Livestock practices

In Zimbabwe, sustainable livestock farming has been achieved on smallholdings and ranches in the past through a number of production systems which range from smallholder mixed crop-livestock systems to intensive livestock rearing. The key feature that makes these systems climate-smart is that crops can produce resources (crop residues or cash) that can be used to manage livestock. In the face of a changing climate, livestock can provide manure to crops, as well as cash to cushion farmers against climate risks in times of crop failure. The integration results in greater farm efficiency, productivity and sustainability. Conservation agriculture practices have been implemented through the sustainable intensification of production, thus ensuring food security while contributing towards efforts to mitigate climate change, whilst crop residues have been used to feed livestock.

### Case study 8.2: National drought mitigation strategy

Zimbabwe's national drought mitigation strategy is a seasonal emergency plan that the Ministry of Agriculture, Mechanisation and Irrigation Development (MoAMID) manages based on statistics from a joint partnership between the Famine Early Warning Systems Network (FEWS NET), the World Food Programme (WFP) and the FAO's Global Information and Early Warning System (GIEWS). GIEWS provides crop and food production forecasts which pre-warn livestock producers in drought-prone areas. The national drought mitigation strategy provides a situation analysis of the agricultural sector and recommends strategies for implementation to reduce the effects of drought, based on the crops and livestock assessment reports of the preceding season. In the 2015 to 2016 season, livestock drought-mitigation interventions aimed to (i) promote early destocking; (ii) support the provision of subsidised stock feeds; (iii) promote pen fattening programmes; (iv) encourage hay banking; (v) undertake FMD vaccination; (vi) repair and drill more boreholes; (vii) prevent and control veld fires; and (viii) explore the feasibility of fodder crop production under irrigation. However, early warning systems and programmes have deteriorated due to inadequate funding, the deterioration of weather-monitoring infrastructure and capacity, limited technology, and capacity for modelling climate projections. The design and implementation of early action responses has therefore become difficult locally.

### Case study 8.3: Rangeland and livestock research interventions

The Department of Research and Specialists Services (DRSS), through its livestock research stations, has conducted a lot of trials demonstrating that technology-based feed and feeding interventions are useful for improving feed utilisation potential as well as increasing livestock productivity. These include improved grazing management and animal response trials at the Grassland, Makoholi and Matopos Research Stations. The use of improved pasture and agroforestry species has been demonstrated at Grassland Research Station, including the use of nutritious diet supplements that reduce methane production in ruminants. The retail outlet-based distribution of multi-nutrient blocks has shown that the digestibility of fibrous feeds can be improved drastically. Since livestock production in smallholder areas subsists on fibrous crop residues and veld pastures that lack adequate proteins, energy, minerals and vitamins, better utilisation is achieved if supplementation is carried out using the high-density nutrient block. The most popular method of supplementation is the use of urea, molasses and mineral blocks. These nutrient blocks increase the productivity of meat and milk and promote higher reproductive efficiency in livestock species, hence reducing greenhouse gas emissions from the rumen and manure.

### Case study 8.4: Livestock health management interventions

Livestock health management interventions aimed at preventing animal diseases such as foot and mouth disease, as well as Newcastle and African swine fever vaccination programmes, have been carried out by the Department of Veterinary Services and Livestock Production and Development. Other key measures for disease-free livestock production encouraged by the Zimbabwe Herd Book include the management of herd sizes and age structures. In grazing livestock systems, interventions aimed at increasing heat tolerance through the use of heat-tolerant indigenous breeds like the Mashona, Tuli and Nkone have been promoted. Appropriate manure-management practices, especially in rural areas, have been promoted by the Department of Agricultural, Technical and Extension Services since political independence in 1980. It has been shown that, if livestock waste (excreta) is processed properly, nitrous oxide emissions will be reduced drastically. On the other hand, the manure produced will help improve crop or pasture productivity. Successfully tried options include the anaerobic digestion of manure stored in liquid form or slurry that lowers methane emissions while producing useful energy. Another option is to compost solid manures to reduce nitrous oxide emissions while producing organic fertiliser.

## 8.5 Application of CSA practices in livestock value chains in Zimbabwe

CSA can be effective if interventions are identified and applied at each level of the value chain, e.g., input processes, grazing management, feed supplementation, manure management, animal breeding, veterinary protection, marketing and the processing of animal products. The roles of each player in the value chain also need to be elucidated and synchronised. Elsewhere, cases of holistic rangeland management and ultra-high density grazing implemented by Allan Savory and others have been accepted as applications of CSA practices in livestock and rangeland management. However, whilst holistic rangeland management is climate-smart, the Allan Savory approach has not been accepted in the field of rangeland science. Climate-smart agricultural practices applicable to livestock and rangeland management in Zimbabwe include but are not limited to:

i. Application of science and advanced technology in feeding and nutrition through appropriate feed formulation and precision feeding;

ii. Over-sowing legumes in grazing paddocks, especially in the high veld (high rainfall region);

iii. Bio-fortification of livestock forage;

iv. Application of science and advanced technology in genetics and reproduction;

v. Improved animal herd or flock health control programming; and

vi. General improvements in animal husbandry.

The extension of these approaches in Zimbabwe are beneficial because of large productivity gaps in the smallholder sector as well as the fact that CSA practices listed above can help with mitigation and building resilience to climate change. Practices alone will not be effective as there is a need for policy support that promotes early warning through the forecasting of risks and continuous scoping of the impacts of climate change so that prompt responses build resilience among livestock farmers. Livestock utilises the largest proportion of land resources in Zimbabwe, with grazing land occupying up to 65% of land. Over the years, increases in stocking densities have resulted in overgrazing and rangeland degradation. Over-utilisation of rangelands has also caused deforestation in some areas. Because of the long dry season, livestock in Zimbabwe subsists on poor-quality feed, thus worsening methane and nitrous oxide emissions from ruminant digestion and manure management respectively.

## 8.5.1 CSA entry points in livestock and rangeland management

There are numerous entry points for initiating CSA programmes in livestock value chains to enhance productivity, adaptation and mitigation actions. For CSA practices in livestock and rangeland management to be effective, value-chain approaches should be embraced widely because this brings relevant stakeholders together to make decisions in a coordinated way (Vermeulen et al., 2008). This also creates a pathway for the inclusion of smallholders in modern livestock value chains so that they can embrace practices such as the use of well-formulated feeds that reduce methane production, better manure management that reduces emissions of nitric oxide, and planting pastures that assimilate carbon dioxide (Gerber, 2015). Drought-tolerant crops like small grains and fodder like Brazilian gold grass, bana grass, cowpeas, lablab, lucerne, thornless acacia, and pigeon pea may be championed in the drier provinces. The rearing of improved indigenous livestock species through selection can increase the population of drought-, disease- and heat-tolerant livestock breeds.

**Activity 4.** *Do you think the value chain and rangeland landscape system approaches mentioned earlier are relevant, effective, efficient and have the desired impact on mainstreaming CSA within livestock value chains? What obstacles and opportunities do you expect to counter?*

## 8.5.2 CSA at the input processes level

### 8.5.2.1 Resolving poor soil fertility to improve the quality of crop residues and pastures

Good-quality feed is well known for reducing the enteric fermentation that produces methane in ruminants. To obtain abundant high-quality crop residues, dryland and irrigated pastures, soil nutrient depletion should be reversed by these practices:

i. Using legume forages as green manure. This is achieved by intercropping suitable legumes like groundnuts rotated with staple crops, mainly cereal grains. The legume tops can be fed to livestock as protein-providing crop residues;

ii. Using legume forages as green manure in agroforestry systems;

iii. Using legume forages as green manure in forage legume/grass mixtures. This will result in 13-34% of fixed nitrogen transferred from legume to grasses;

iv. Mass production of forage legumes such as velvet bean (*Mucuna pruriens*), lablab (*Lablab purpureus*), cowpea (*Vigna unguiculata*), pigeon pea (Cajanus cajan), lucerne (*Medicago sativa*), leucaena (*Leucaena leucocephala)*, thornless acacia (*Acacia angustissima*), and sesbania (*Sesbania sesban*) as protein sources to improve feed-conversion efficiency, thus decreasing enteric methane emissions by about 25-33%; and

v. Sequestering carbon into the soil through ancient practices like mixing carbon with ash. Potash improves soil fertility, while soil fauna utilise the carbon.

## Case study 8.5 Fodder production and preservation for livestock feeding: Guyu Communal Area, Gwanda District

**What is the nature of climate risk in Guyu?**

"Guyu falls under the dry Natural Region V. We receive between 280 to 300 mm of rainfall annually. Temperatures can go up to 45$^{o}$C. Cattle and goats are the main form of livelihood for farmers here. Cropping is nearly impossible because of the harsh climate but farmers still plant maize, cowpeas, and small grains such as sorghum and millet. The soils are poor and sandy, highly fragile and prone to erosion. As you can see this also leads to massive siltation of rivers, including the Thuli river which is the biggest river here. Even our 32 hectare irrigation scheme which draws water from the Thuli river uses sand abstraction as the river is heavily silted resulting in base flow being more reliable than surface flow. Food security is a major issue here. Farmers rely on selling livestock to buy food. We have monthly livestock auctions for cattle and goats. Buyers are usually abattoirs and individual traders. The biggest threat to livestock production is the shortage of fodder during the dry season. The last drought wiped out large numbers of cattle due to shortage of feed."

*Mr. Dlomo, Agritex Officer Guyu, Gwanda*

**Locally driven research on fodder**

In Guyu, the concept of growing fodder for supplementing livestock during the dry season was introduced by the Matopos based International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). The intervention focuses on encouraging livestock farmers to grow hardy but highly nutritious fodder legumes such as velvet beans (Mucuna), Sunhemp, Dolichos Lablab, and cowpeas. These legumes are highly tolerant to moisture stress and can be very productive even in the harsh climate typical of Natural Region V. Farmers with reliable water sources were also encouraged to plant other types of fodder such as Lucerne, Bana grass and Katambora Rhodes grass as these usually require supplementary irrigation. A number of farmers are now tasked with the responsibility of locally multiplying the seed that was brought in through the ICRISAT initiative in collaboration with Matopo Research, with a view to making it locally available for farmers. In addition to growing fodder crops farmers have also been trained in low cost techniques for preserving and enhancing the nutritional value of crop residue such as maize stover. Techniques such as urea treatment are now being used by farmers to transform unpalatable, low nutritional value crop residues into high quality feeds that are appropriate for livestock earmarked for sale. Bales of properly preserved fodder can be kept for years without losing nutritional value, serving as a valuable emergency feed in the event of droughts or veld fires. Farmers producing more than they need are now selling excess fodder to their neighbours, thereby diversifying their income base. With some farmers having as many as 200 herd of cattle, the stakes are high. The threat of losing animals due to lack of grazing is real as demonstrated by the recent drought (2016/2017 rainy season).

**Preservation of fodder**

Techniques for fodder preservation are highly priced by farmers like Mr Makwala. They have learnt to bale fodder and store it for use during the dry season, starting in June until November when the rains come. Urea treatment of maize stover also produces high quality but low cost stock feed. After harvesting maize the dry stover is chopped into small pieces that are loaded into the treatment pit, sprinkled with feed quality urea and some water. The mixture is covered in black plastic for 6 weeks after which it is removed from the pit for storage or feeding.

**Can fodder Production and preservation drive climate resilience in dry regions of Zimbabwe?**

Fodder production and preservation is clearly one of the most relevant climate-smart interventions in drier regions where grazing shortages during the dry season and droughts is a major cause of poor

livestock productivity and deaths. The success of this approach in places like Guyu which is in one of Zimbabwe's driest regions implies that the practice can be used virtually everywhere in the country. Even in higher potential areas, production of high quality fodder can be used to improve productivity of livestock through supplementary feeding in winter as well as getting livestock ready for the market. The low-cost nature of this approach and the unlimited potential to multiply seed locally makes it accessible even to poorer households who otherwise cannot afford to buy commercial feeds. Large tracks of fallow land in most communal areas around the country, some of it abandoned due to declining soil fertility or lack of inputs, could be brought into production of fodder, boosting performance of livestock. Most of the fodder species are legumes that require minimal additional fertilisation as they fix their own nitrogen. Field crops planted after these legumes also benefit from the nitrogen fixed in the previous year, making these lands viable for cropping again. With their broad leaves most of the legumes also suppress weeds, reducing labour requirement and even diminishing weed pressure for other food crops in subsequent yields. Dual purpose varieties of fodder crops such as sorghum and cowpeas are particularly easy to integrate with typical smallholder cropping systems as they also contribute to food security. Innovative treatment of maize stover with urea is virtually applicable in almost all communal area contexts as maize is a major part of the cropping system. This will not only add nutritional value to the crop residue but will also make preservation and storage easier, avoiding losses due to fires and natural elements. Most of the work happens during the off-season when farmers are not busy in the fields, making such practices compatible with the labour budgets of typical smallholder farmers.

*Source: Mutamba, M., Ndidzano, K., Matingo, E., Marongwe, S.L., Vambe, L., Murwisi, K., 2017. Cases of Climate Smart Agriculture in Zimbabwe. VUNA, Pretoria.*

#### 8.5.2.2 CSA in grazing management

##### *8.5.2.2.1 Promoting carbon sequestration and reversing deforestation and rangeland degradation*

Carbon sequestration in plants simply means using up the carbon dioxide so that emissions into the atmosphere are mitigated. Plants assimilate carbon dioxide, a greenhouse gas, into starch through photosynthesis. Planting a lot of grasses, legumes and trees, either on a dry-land basis or under irrigation, increases plant population density and hence the surface area for photosynthesis (leaf area index) and the production of biomass. Preventing the wanton cutting of trees and promoting tree-planting policies and strategies have the potential to increase carbon assimilation in woody plants. Preventing more degradation and re-establishing degraded grasslands can be done through rotational grazing management and veld reinforcement as mitigation strategies.

##### *8.5.2.2.2 Reducing post-harvest losses of hay*

Interventions focused on establishing storage banks of fodder and hay can help reduce post-harvest losses due to spontaneous fires, moulds, pests and rodents and hence deliver multiple benefits through productivity and adaptation. Drilling more boreholes for livestock is a plausible intervention in the southern region of Zimbabwe, where rainwater is seasonally low. In semi-arid Namibia, for instance, projects implemented by NGOs like NOLIDERP and the Millennium Challenge Account – Namibia, and Meatco Foundation have proved that sinking boreholes and establishing watering points within the rangelands have a profound effect on mechanisms adapting livestock to heat stress (http://www.fanrpan.org/documents/d01760/, 2014).

#### 8.5.2.3 CSA in feed supplementation

The techniques presented below are already being implemented by some large-scale commercial farmers. Feed supplementation is traditionally meant to correct nutrient deficiencies, but of late it has been discovered that the practice can be used to reduce net greenhouse emissions from livestock (Clark, 2009).

The effectiveness of the following six strategic techniques to decrease methane emissions from ruminants have been proved through applied research:

i. Improved forage quality: feeding ruminants with good-quality roughage increases the activity of rumen cellulolytic bacteria at the expense of the methanogens that produces methane gas;

ii. A larger proportion of concentrates in the diet that are well-balanced to meet animal requirements promotes rumen fermentation that suppresses methane production. Feeding at least 55% forage and up to 45% concentrates in high-producing dairy cows decreases methane production significantly. Up to 8.5% of the dietary energy intake can be lost as methane (Clark, 2009);

iii. More rumen-resistant starch in the ruminant diet results in lower methane production in the rumen;

iv. Adding fats and oils when it is economic and at levels that do not affect digestion has been shown to lower dietary energy losses in the form of methane by up to 37% (Clark, 2009);

v. Secondary plant metabolites improve feed conversion efficiency and in the process reduce methane production; and

vi. Feed additives boost feed utilisation efficiency and reduce pollutants in manure. Novel mitigation opportunities consist of adding feed additives like prebiotics, probiotics, acetogens, ionophores, bacteriocins, organic acids and plant extracts like condensed tannins. Many enzymes like phytases are already in use by commercial feed companies.

#### 8.5.2.4 CSA in manure management

Intensive livestock production creates challenges in managing the large volumes of manure produced. Manure contributes to greenhouse gases, but conscious efforts can be made to capture the manure in solid, liquid or slurry form. It can then be stored, treated and utilised to enrich soils in an environmentally sustainable manner through biogas production.

#### 8.5.2.5 CSA in animal breeding

CSA interventions in animal breeding can be effected by using strategic crosses to combine complimentary traits that adapt the resultant crossbred animals to climate change. Breeding productive animals that are well-adapted to heat stress and are drought-tolerant is achieved through crossbreeding. Accelerating the spread of the desirable traits is achievable through assisted animal reproduction. This involves artificial insemination with service being natural or assisted through heat synchronisation. Though requiring a lot of expensive resources, innovative arrangements can be made at the community level, where farmers benefit from social capital.

**Activity 5.** *It is important to note that CSA is context-specific. From your own practical experience of working with livestock farmers, (i) list additional practices; and (ii) provide possible interventions that you deem applicable to smallholder livestock farmers in your area. Specify the livestock species in each case. As an extension officer, outline a step-by-step approach that you will use to help livestock value chain actors identify where improvements along the chain can be made using CSA.*

## 8.6 The role of extension professionals in CSA

In Zimbabwe, technical and market information is disseminated to farmers through extension services and agriculture marketing authorities respectively. Extension practitioners are expected to be abreast of the latest livestock production processes, including trouble-shooting techniques. Climate change awareness is now noticeable among farmers, and they need to be guided accordingly by extension professionals. This means that the latter should always provide adequate information to farmers so that they retain the trust and respect farmers have for them. There is a need to ensure that extension workers are knowledgeable

and have access to information on climate and CSA practices through ICT and in-service training. Because most of the farmers that extension professionals will be dealing with are woman in rural areas, extension staff need to be well-versed in issues of gender balance and gender empowerment so that they can effectively assign roles, responsibilities and capabilities to both men and women in implementing CSA. Extension plays an intermediate role in technology transfer.

**Activity 6.** *Do you agree that global attention to agriculture as one of the most climate-vulnerable sectors provides an opportunity to accelerate a much needed reform of extension and advisory services? Support your position to a colleague in a one-to-one discussion.*

## 8.7 The role of institutions of higher learning

Institutions of higher education are in a better position to produce and disseminate information about all value chain segments from "farm to fork", including conditions involving the development of regulations and standards to deal with climate change. Zimbabwe has over 10 universities that offer animal science degrees and many agricultural colleges train research and extension professionals at various levels. The University of Zimbabwe and Mazowe Veterinary College also produce a lot of veterinary practitioners. Therefore, in order to produce functional graduates, it is necessary to anchor CSA in the various modules taught at these national institutions through curricula reviews. Graduates from these institutions are future national actors in implementing changes at the field level. Thus, institutions of higher learning should be prepared to:

i. Facilitate the implementation of novel CSA policies for livestock and rangelands and their execution;
ii. Support the integration of CSA for livestock and rangelands-related knowledge into national curricula;
iii. Implement new CSA for livestock and rangeland practices in respective departments at these institutions; and
iv. Inspire internal changes that prepare college and university lecturers to embrace and employ new CSA competencies in their everyday responsibilities.

Institutions of higher learning in Zimbabwe need to heighten their concern for gender-sensitive approaches to achieving CSA in livestock and rangeland management. They should also champion research to understand better how men and women can adapt to climate change, mitigate emissions and at the same time maintain food and nutritional security. Institutions of higher education need to research and offer more solutions for how ICTs such as radio, television, video, the internet, and media and mobile services can play a pivotal role in facilitating CSA in livestock and rangeland management.

## 8.8 Policy implications of CSA for livestock and rangeland management

It is vital for Zimbabwe to have institutional and policy adjustments specifically geared towards supporting the transition to climate-smart agriculture. The main requirements for creation of an enabling policy environment that will promote climate-smart agriculture to enhance food security and mitigate GHG emissions are greater coherence, coordination and integration between climate change, livestock development and food-security policy. It is commendable that Zimbabwe is currently developing a National Livestock Policy recognising that climate change is real and that it contains some approaches that are CSA-compliant. More needs to be done for the livestock sub-sector plans to have stronger CSA components, especially at field-level planning, implementing and monitoring of CSA-inclined livestock and rangeland projects and programmes.

Actions to reduce GHG emissions in Zimbabwe's livestock sector have been pronounced at policy level (Svinurai and Mharapara, 2015). The government uses the Environmental Management Act to take legal actions against farmers who burn rangelands uncontrollably. The non-prescribed burning of savanna rangelands reduces their capacity to regrow (carbon assimilation) and to compensate for carbon losses in grazed and burned biomass. The negative impacts of veld fires include GHG emissions, reduction in

rainwater infiltration, increased soil erosion, reduced soil carbon, biodiversity loss and loss of human and animal life. Some practices to control fires include early burning (cool season fire) to reduce the destructive levels of uncontrolled veldt fires, and the establishment of fireguards by either controlled back burning or the slashing of grasses along potential fire starting areas such as roads and railway lines. Policies that are not financially supported will not produce the desired results, especially for cattle, whose turnover period is at least three years, while rangeland responses can take up to a decade. An example is the fact that the Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) initiated in the 1980s contributed significantly to socio-economic and ecological resilience and sustainable development in some communal rangelands. However, continued implementation of the programme has been hampered by a lack of adequate financial and technical support.

## 8.9 Conclusion and recommendations

This chapter concludes that CSA is imperative for livestock and rangeland management because livestock value chains are intertwined directly and indirectly with declining precipitation levels and global warming. It can also be concluded that local innovation with respect to adaptation and mitigation of climate change in livestock value chains requires an extension system that is unquestionably knowledgeable in CSA approaches. We can conclude that investments through innovative inclusive financing should be arranged to increase sources of rural income and make rural households more resilient and predictable in order to ensure the sustained migration of rural households out of poverty, using climate-compatible livestock and range-management pathways.

It is therefore recommended that:

i. CSA should be embraced using a multifaceted approach that encompasses rangeland landscapes, livestock value chains, and environmental and socio-economic policies;

ii. The use of climate science data for livestock and rangeland management planning can reduce the uncertainties generated by climate change, develop early warning systems for drought, flash floods and incidences of pest and disease, and thus increase the capacity of farmers to deal with their vulnerabilities and reduce risks; and

iii. Extension professionals and institutions of higher learning have a central role to play in livestock farmers' ability to access CSA information.

## Acknowledgements

We would like to acknowledge the Chinhoyi University of Technology and the University of Zimbabwe Marondera College of Agricultural Sciences and Technology for in-kind support with office and internet services. We greatly appreciate all the livestock and environment practitioners, researchers and scientists for their contributions through focus groups and one-to-one discussions. We also appreciate the financial and logistical support provided by the UNEP DTU Partnership and its partners.

## References


1. Camagni M, Kherallah M. 2014. *Commodity value chain development projects. Rome, Italy:* International Fund for Agricultural Development.

2. Clark R.A., 2009 *Feeding strategies for reducing methane;* http://www.wattagnet.com/articles/3354-feeding-strategies-for-reducing-methane, Retrieved on 8 February 2017.

3. Davis R and Hirji R. 2014. *Climate Change and Water Resources Planning, Development and Management in Zimbabwe*. An Issue Paper. World Bank and Government of Zimbabwe. Harare.

4. FAO 2012. *Mainstreaming climate-smart agriculture into a broader landscape approach.* Rome, Italy: Food and Agriculture Organisation of the United Nations.

5. Gerber, P., 2015. Efficiency gains for enteric methane mitigation and productivity: contribution to CSA and investment opportunities Main messages. *In Climate smart agriculture (CSA) 2015: Global Science Conference, Climate-smart livestock session, 16-18 March 2015, Le Corum, Montpellier, France.*

6. Harvey A, et al., 2013. *Climate-Smart Landscapes: Opportunities and Challenges for Integrating Adaptation and Mitigation in Tropical Agriculture.* Conservation Letters 7.

7. Henry, B. et al., 2012. *Livestock production in a changing climate: adaptation and mitigation research in Australia.* Crop and Pasture Science, 63, pp.191–202.

8. IPCC. 2006. H. Eggleston, Buendia L., Miwa K., Ngara, T. and Tanabe K. IPCC *Guidelines for National Greenhouse Gas Inventories.*

9. Jones PG, Thornton PK (2013). *Generating downscaled weather data from a suite of climate models for agricultural modelling applications*. Agricultural Systems 114, 1-5.

10. Jones PG, Thornton PK (2015). *Representative soil profiles for the Harmonized World Soil Database at different spatial resolutions for agricultural modelling applications.* Agricultural Systems 139, 93-99.

11. Mapanda F. & Svinurai W. 2015. *National Inventory Report of Green House Gas Emissions from Zimbabwe's Agriculture Sector:* Final Report. Ministry of Environment, Water and Climate and United Nations Environment Programme. June 2015.

12. Scherr SJ, Shames S, Friedman R. 2012. *From climate-smart agriculture to climate-smart landscapes.* Agriculture & Food Security 1: 12.

13. Svinurai W. & Mharapara I. 2015. *Zimbabwe's Intended Nationally Determined Contributions for Agriculture to the UNFCCC:* Final Report. Ministry of Environment, Water and Climate and United Nations Environment Programme. August 2015.

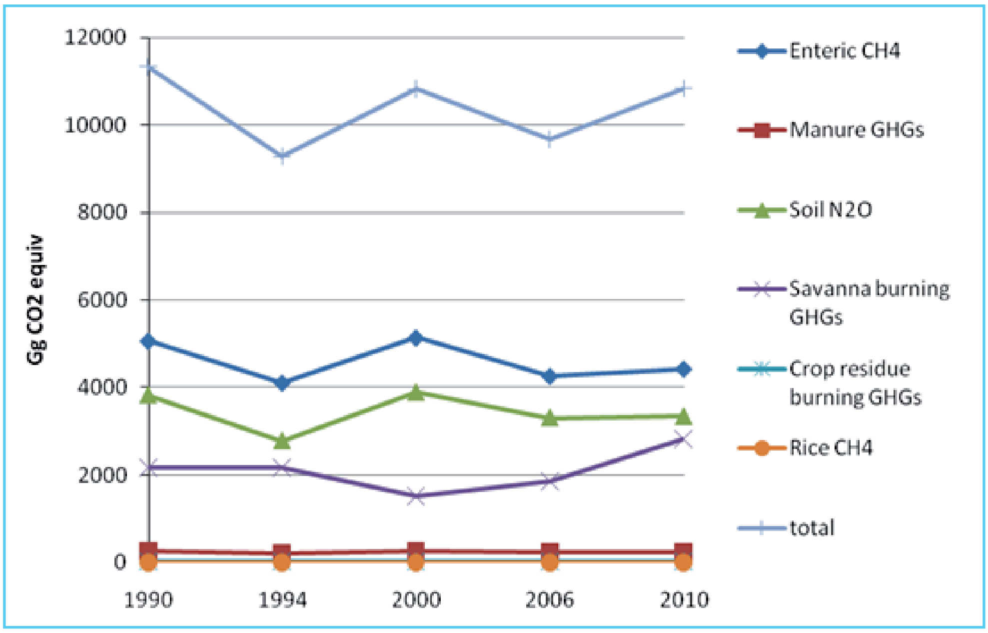
14. Thornton PK, Jones P G, Owiyo T, Kruska R L, Herrero M, Kristjanson P, Notenbaert A, Bekele N and Omolo A, with contributions from Orindi V, Ochieng A, Otiende B, Bhadwal S, Anantram K, Nair S, Kumar V and Kelkar U. 2006. *Mapping climate vulnerability and poverty in Africa.* Report to the Department for International Development, ILRI, Nairobi, Kenya, May 2006, 200 pp.

15. Vermeulen S, Woodhill J, Proctor F, Delnoye R. 2008. *Chain-wide learning for inclusive agrifood market development: a guide to multi-stakeholder processes for linking small-scale producers to 11.*

16. ZimVAC, 2015. *Zimbabwe Vulnerability Assessment Committee Report.*

# Appendixes I

***Greenhouse gas emissions from Zimbabwe's agriculture sector (Mapanda and Svinurai, 2015)***




***Potential strategies for reducing GHG emissions from Zimbabwe's livestock sector***

| Farm management component | Mitigation strategy |
|---|---|
| Grazing management | Correct grazing pressure/optimum stocking density<br>Introduce pastures (grasses and legumes in rangelands)<br>Opportunistic management (controlled pastoralism) |
| Feed management | Use well-formulated diets with supplements<br>Use anti-methanogenic feed additives, e.g., Browse Plus®, Yeasac® and Fibrozyme®<br>Free-choice provision of vitamins and minerals |
| Herd management | Enhance productivity using indigenous breeds<br>Reduce age at first calving<br>Extend lactation persistence<br>Maximise annual weaner turnover<br>Improve productivity through pen fattening<br>Decrease days to slaughter<br>Feedlot fattening – 90 days or 150 days |
| Breeding management | Use assisted reproduction technologies like AI with synchronisation of estrus (heat)<br>Use faster growing genotypes<br>Use more fecund genotypes |

*(Adapted from Henry et al., 2012)*

# 9. Sustainable forest management and agroforestry

## Abstract

In light of the climate change risks mentioned in the introductory chapter, this chapter focuses on how forests, Sustainable Forest Management (SFM) and agroforestry can contribute to combating climate change. It also explores how land degradation is linked to climate change and shows how sustainable forest management addresses forest degradation and deforestation while increasing the direct benefits to people, and efforts to combat climate change. One section is devoted to how agroforestry can be practised by deliberately integrating woody perennials (e.g., trees, shrubs, palms or bamboos) and agricultural crops or animals on the same piece of land in some form of spatial and temporal arrangement. In this context, the importance of trees for human well-being and how they provide humans with good and services (forest ecosystem goods and services for household consumption, including food, fuelwood and medicines) is discussed. The discussion also goes into how the planting of trees in croplands increases the absorptive capacity of the soil and reduces evapotranspiration, raindrop impact, soil erosion and the soil temperature of the crops planted beneath. Towards the end of the chapter it is shown how forestry and agroforestry contribute to the three pillars of climate-smart agriculture.

**Key Words:** agroforestry, climate change, forestry, land degradation, sustainable forest management

## Key messages

At the end of this chapter, readers are expected to be able to:

i. Understand forests, deforestation, sustained forests management and agroforestry in the context of climate change;

ii. Analyse the drivers of deforestation and how they can be minimised;

iii. Explain terms related to SFM and agroforestry;

iv. Explain how forests help in climate change mitigation and adaptation; and

v. Finally, identify CSA components relevant to forests, land degradation and agroforestry.

## 9.1 Introduction

Forest ecosystems are important for life and supplying important goods and services, yet they are also threatened by several anthropogenic factors, including clearing for agriculture, use of wood fuel, accidental fires, and climate change. This chapter is divided into five sections as follows: Section 9.1, on the importance of forests and their classification; Section 9.2, on the linkages of land degradation to climate change and forests; Section 9.3, on sustainable forest management and climate change; Section 9.4, on agroforestry and CSA, and finally Section 9.5, on some forestry-related aspects in Zimbabwe.

In line with the theme of the Manual, i.e., CSA linkages to forest and agroforestry, climate change will be discussed with respect to their role in CSA. It is evident that climate change is a threat to the well-being of humanity. However, forests can still provide a partial solution to this threat, since they are closely connected to climate change—that is, forest loss and the consequent land degradation both contribute to climate change. Agriculture, land use, land-use change and forestry jointly contribute about a quarter of all global GHG emissions.[9]

It is therefore logical that, by conserving forests we are also reducing carbon emissions, since they sequester carbon from the atmosphere. Since the destruction of forests has a considerable impact on climate change, this may also impinge on the multiple benefits for biodiversity and humanity. These include reducing GHG emissions by acting as a carbon sink and the preservation of functioning virgin forests, giving us a fighting chance to combat climate change. Forests and trees on farms, i.e., agroforestry, can also be a significant carbon sink—one that can be can be enhanced through afforestation and conservation efforts, including carbon sequestration in biomass and soils.

### 9.1.1 Importance of forests

**Sustainable Development Goal 15**

Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss.

*Source: UN, 2015*

Forests are areas of land with trees higher than five metres and a minimum canopy cover of 10 percent, excluding land that is mainly used for agriculture or urban use. Trees may be temporarily absent in managed forests and still be classified as forest land (FAO, 2015a). The potential impacts of climate change on forests include changes in species composition, shifts in forest ecosystem boundaries and species ranges, changes in growth rates, increased flora and fauna migration, loss of biodiversity, increased frequency and intensity of forest fires, and increased reliance on trees and forests for survival, leading to over-exploitation. The majority of local communities sustain their livelihoods by direct use of the goods and services. The forest ecosystem provides for household consumption (food, fuelwood and medicines) and the generation of incomes from trade in both timber and Non-timber Forest Products (NTFPs). To continue utilising these goods and services, forests should be managed sustainably to support one of the Sustainable Development Goals (Goal 15). Furthermore, the delivery of goods and services is threatened by climate change, consequently impacting rural livelihoods and the forest industry.

In smallholder farming systems, forests and farms often form part of complex rural landscapes, which collectively fulfil the livelihood needs of rural inhabitants. Increasing the resilience of forest systems to maintain and enhance the flow of the ecosystem's goods and services, mitigating emissions from the sector by reducing deforestation and increasing forest cover and agroforestry are some of the interventions that contribute to CSA, but these need to be considered in the context of the wider landscape (Mbow et al., 2014; Locatelli et al., 2015).

9 https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data

### 9.1.2 Classification of forest resources in Zimbabwe

There are several classification systems for Zimbabwean forest ecosystems. One of them is the Ecosystem Land Classification Approach adopted by the Convention on Biological Diversity (CBD) (2010a), which divides Zimbabwe into five eco-regions, which are based not only on floral compositions but also on landscape characteristics (Table 9.1).

***Table 9.1 Classification of Zimbabwean ecosystems using the Ecosystem Land Classification Approach (CBD, 2010a)***

| Ecoregion | Area ($km^2$) | % of land area |
|---|---|---|
| Kalahari sands | 46 891 | 12 |
| Central watershed | 195 379 | 50 |
| Zambezi escarpment | 62 521 | 16 |
| Save-Limpopo Lowveld | 78 151 | 20 |
| Eastern highlands | 7 815 | 2 |

The other classification of the natural forest ecosystem is the Flora Zambesiaca and Afromontane phyto-region based on floral composition (White, 1983). The Afromontane phyto-region covers 781 500 ha. The Flora Zambesiaca comprises five woodlands types: dry Miombo (17 690 074 ha), Mopane (12 277 515 ha), *Combretum-Terminalia* (2 374 729 ha), *Acacia* (1 581 070 ha) and Zambezi teak (1 404 544 ha).

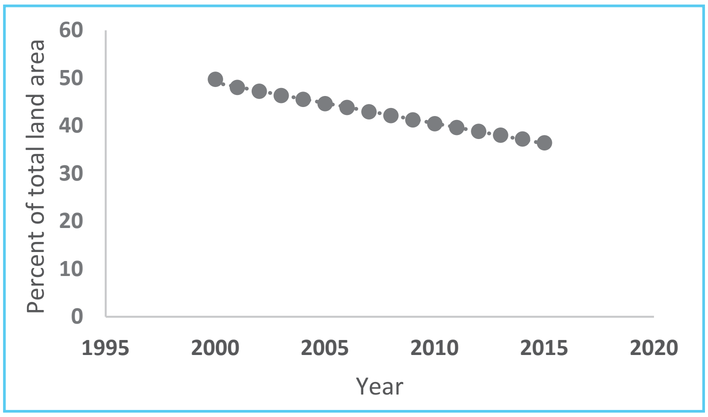
Indigenous woodland conservation has become a priority in Zimbabwe. This has been made all the more necessary by the increase in the number of smallholder tobacco farmers, who mainly depend on firewood to cure tobacco (Manyanhaire and Kurangwa, 2014). Agriculture, and in particular tobacco production, has become the major driver of deforestation, being up to 10 times more aggressive than the sum of all other factors in Zimbabwe (Sacchetto, 2012). Clearing land for tobacco planting, barn construction and the curing processes themselves requires large quantities of wood (up to 37 $m^3$ wood/1 kg of tobacco) resulting in deforestation and forest degradation (Sacchetto, 2012).

Plantation forests account for 0.4% of the land area covering 155 000 ha and consist of exotic species of pines, eucalyptus and the black wattle (*Acacia mearnsii*) (Patterson et al., 2007). These plantations are concentrated in the eastern part of the country, where rainfall is high enough to sustain tree growth and productivity, and they are a source of timber, poles, pulp and paper, tannin and furniture. There are also smaller plantations of eucalyptus in the central part of the country (Mvuma, Headlands, Norton and Marondera) and in rural communities under the rural afforestation programme.

## 9.2 Deforestation and land degradation

Drivers of deforestation in Zimbabwe have been increasing since 2000, when significant environmental and land-use changes began to take root due to land conversions for crop production, grazing land, energy uses, fire and frequent droughts. On the other hand, population increase and migration have pushed people to areas in the vicinity of protected forests, resulting in encroachments on forest land, both planted and natural (GIZ, 2012). The conversion of forest land for agricultural purposes, its clearing for firewood and over-grazing by livestock, mainly goats, has impacted negatively on forest and woodland regeneration in Zimbabwe.

***Figure 9.1 Zimbabwean forest cover changes between 2000 and 2015***




*Source: www.indexmundi.com*

Figure 9.1 shows the change in the forested areas of Zimbabwe over a 15-year period. Degradation is not only a human-induced environmental change, but also nature-induced, especially in regions vulnerable to climate change and climate variability (GIZ, 2012). However, agricultural productivity and food security can be increased while halting or even reversing deforestation by using sustainable and climate-smart technologies such as agroforestry (Garitty et al., 2010) and conservation agriculture.

Land-use change is a driver of environmental and climate change in Zimbabwe, especially through the expansion of agriculture, as well as economic and technological development. Increasing population pressure in the communal areas has led to the fragmentation and degradation of forests as a result of their clearance for agriculture and harvesting for firewood, poles and other forest products. An estimated 300,000 hectares are converted annually to arable land and other uses (NCCR, 2015). Forests and climate change are inextricably linked, i.e., there is a relation of interdependence between forests and climate change. The potential impacts of climate on forests include changes in the following: forest ecosystem boundaries, growth rates, fauna and flora migration, and species growth rates, among others. Reducing Emissions from Deforestation and Forest Degradation (REDD+) through sustainable forest management, forest conservation and the enhancement of carbon stocks is seen as a major strategy for mitigating climate change. This is discussed in Section 9.3.2.

With respect to adaptation, appropriate strategies include the adoption of land-use plans that identify forests for bona fide land use, the injection of upfront investments for supporting adaptation endeavours and capacity-building for pertinent forest management plans in a changing climate, as well as intensifying climate data acquisition for Monitoring and Evaluation Reporting (MVR).

## 9.3 Forests and the environment

Forests provide many services, including provisioning services, regulatory services, cultural services and support services (Table 9.2). In order to maintain these multiple roles, it is important that forests are managed sustainably after considering key environmental factors such as soils, water and biodiversity. The conservation and improvement of soil resources is essential to sustainable forest management, and this can only be done practically by having a working knowledge of the composition and functions of soils and how they are affected by forest management operations.

***Table 9.2 Basic roles of trees and forests***

| | |
|---|---|
| **Provisioning services**<br>▪ Timber, food, fibre and fuel<br>▪ Genetic resources<br>▪ Biochemicals<br>▪ Fresh water | **Cultural services**<br>▪ Spiritual and religious values<br>▪ Knowledge system<br>▪ Education and inspiration<br>▪ Recreation and aesthetic value |
| **Regulatory services**<br>▪ Invasion resistance<br>▪ Herbivory<br>▪ Pollination and seed dispersal<br>▪ Climate regulation<br>▪ Pest and disease regulation<br>▪ Natural hazard protection<br>▪ Erosion regulation and water purification | **Support services**<br>▪ Primary production<br>▪ Provision of habitat<br>▪ Nutrient cycling<br>▪ Soil formation and retention<br>▪ Production of atmospheric oxygen<br>▪ Water cycling |

*Source: Millennium Ecosystem Assessment (MEA), 2005*

### 9.3.1 Sustainable forest management

Sustainable Forest Management (SFM) is a responsive measure for climate change mitigation and adaptation, and also contributes to sustainable food security in a number of ways. Climate-smart forestry requires widespread application of SFM principles and practices. Mainstreaming climate change into forest policy and practice will entail the identifying of synergies and managing trade-offs with other forest management goals. SFM can provide solutions to three Sustainable Development Goals (SDGs): Goal 2 to end hunger, achieve food security and improved nutrition and promote sustainable agriculture; Goal 13 to take urgent action to combat climate change and its impacts; and Goal 15 (see Box 9.1).

***Box 9.1 Two targets under Goal 15 of SDGs support SFM***

"By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally" and "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".

SFM can play an important role in integrating forests into strategies for development, food security, poverty reduction, sustainable land use and climate change mitigation and adaptation. To enhance SFM as a responsive measure, capacity-building in remedial practices is essential if Zimbabwe is to combat climate change effectively. This capacity-building should include integrated fire management, integrated pest and disease management, harvest planning (including road-building), silvicultural practices and nutrient and water regulation.

Environmentally, SFM also contributes to carbon sequestration. There is an important relationship between carbon storage and sequestration by forests and changing temperatures: the more carbon that is stored in forests, the lower are $CO_2$ emissions into the atmosphere. This relationship is gaining traction in the climate change negotiations, as tropical countries are preparing themselves to reduce emissions through increasing forest carbon stock so as to benefit from REDD+ issues, as described in 9.3.2.

Socially, SFM also contributes to the provision of a wide range of goods, such as food, wood and fibre, and ecosystem services, such as climate regulation, water catchment protection, poverty reduction, spiritual fulfilment, aesthetic enjoyment, income generation, and employment.

### 9.3.2 Deforestation and forest degradation

The UN in 2008, set in place the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD) which is supported by FAO, UNEP and UNDP, and provides an economic incentive for conserving and enhancing forest carbon sinks and changing the way forest resources are used (FAO/UNDP/UNEP, 2008). This is a new way of curbing $CO_2$ emissions, by paying for actions that prevent forest loss or degradation. The reduced $CO_2$ emissions can be traded as carbon credits, while people can be paid to manage forests. UNFCCC calls for action to reduce human pressure on forests through the development and implementation of national strategies or action plans for "reducing emissions from deforestation and forest degradation plus conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries" (REDD+; UNFCCC, 2002: 2016).

In Zimbabwe, the biggest REDD+ project is the Kariba project, managed by Carbon Green Africa, which covers four rural district councils (Nyaminyami, Hurungwe, Mbire and Binga) extending over 1.4 million hectares in two provinces. To support forest conservation, communities are taught skills to increase the productivity of land sustainably, including marketing to increase the distribution and income from crops which in turn prevents the future clearing of forests. The potential of international strategies such as REDD+ in woodlands and savannahs can be achieved by the recovery of woodlands after clearing, since most of the woodland species have extensive rooting systems that facilitate recovery after cutting (Shirima et al., 2015) and are able to sequester carbon.

## 9.4 Agroforestry

### 9.4.1 Agroforestry and climate change

Agroforestry has the potential to contribute to both climate change mitigation and adaptation by sequestering carbon and enhancing resilience. To provide the services needed to combat weather extremes and other climate change associated impacts, agroforestry, like other management options in the climate change toolbox, ought to be practised proactively. For example, in the case of trees, this means planting several years prior to the benefits. In this regard, these practices should be able to offset lost opportunity costs by providing non-climate change mitigation and adaptation services that are valued by farmers, in the meanwhile. This partially constitutes agroforestry's appeal as a climate change mitigation and adaptation tool.

> ***Box 9.2***
>
> **Agroforestry** can also be defined as a dynamic, ecologically based natural resource management system that, through the integration of trees on farms and in agricultural landscapes or through the production of agricultural products in forests, diversifies and sustains production for increased economic, social and environmental benefits for land users (FAO, 2016).

The accruing agroforestry benefits (favourable microclimates, enhanced biodiversity, providing windbreaks, improved soil fertility, diversification of production, and reduced nutrient runoff and erosion) are the elements that can be tagged without losing sight of the ultimate goal of combating climate change through mitigation and adaptation. Box 9.2 gives the socio-economic and environmental benefits.

### 9.4.2 Concepts and principles of agroforestry

Agroforestry is distinguished from traditional forestry by having the additional aspect of a closely associated agricultural or forage crop. Agroforestry systems and practices vary with the needs of different farmers, and outcomes may also differ considerably, depending on the conditions under which agroforestry is practised.

To be called agroforestry, a land-use practice must satisfy four key criteria—the 4 I's (Gold, et al., 2013):

- **Intentional.** Combinations of trees, crops and/or animals are intentionally designed and managed as a whole unit rather than as individual elements in order to yield multiple products and benefits;
- **Intensive.** Agroforestry practices are intensively managed to maintain their productive and protective functions. These practices often involve annual operations such as weeding, cultivation, pruning, pollarding and fertilisation;
- **Interactive.** The biological and physical interactions between the tree, crop and animal components are actively manipulated to yield multiple products and benefits; and
- **Integrated.** The tree, crop and/or animal components are structurally and functionally combined into a single integrated management unit. Integration may be horizontal or vertical, and above or below ground, either sequentially or simultaneously.

**The economic benefits** include the reduction of agricultural inputs, especially when using leguminous species which fix nitrogen to improve soil fertility. At the same time, this maintains or increases production and may diversify production in farming systems, for example, food, fodder, lumber, building materials and wood fuel.

**The social benefits** include improvements to the health and nutrition of the rural poor. The on-farm production of several products, often collected from off-farm sources, can reduce the time and effort needed to obtain them, often lessening the burden on women or generating money if the products can be sold.

**The environmental benefits** may include a range of environmental services such as improving soil fertility, minimising soil erosion, giving crops and livestock protection from the wind, restoring degraded lands, and water conservation. If properly designed and managed, agroforestry systems can also contribute to biodiversity conservation and climate change adaptation and mitigation. However, if not done properly, agroforestry can cause decreases in production because of competition among trees and crops.

### 9.4.3 Agroforestry systems and practices

Agroforestry has been practiced for a very long time in many parts of the world and varies from landscape to landscape, country to country and region to region, depending on human needs and capabilities and the prevailing environmental, cultural and socio-economic conditions. Agroforestry systems can be classified on the basis of their dominant components into agrisilviculture, silvopasture, agrosilvopasture, silvoagriculture, silvoagropasture, pastoral silviculture, multipurpose and other systems, such as apiculture with trees, aqua-forestry, and mixed woodlots. The arrangement of the components can vary in space and time (Nair, 1985; Beetz, 2011; Gold et al., 2013).

Agroforestry practices used worldwide include improved fallows (3–4 year fallow with nitrogen fixing trees/shrubs), alley cropping (trees planted in alleys, with crops between the alleys), taungya (plantation forestry allowing farmers to plant crops in young stands), home gardens (multi-storey structures like gardens), growing multipurpose trees and shrubs in farmlands, boundary planting, farm woodlots, orchards and tree gardens, tree plantations, shelterbelts, windbreaks, conservation hedges, fodder banks, live fences, silvopastoral systems, and apiculture with trees. Examples are shown in Figs 9.2 and 9.3.

***Figure 9.2***

*a.Windbreaks* *b. Alley cropping* *c. Live fence* *d. Silivopasture*

*Photo credit: Shutterstock*

***Figure 9.3 Potential of agroforestry in affecting production and ecosystem services that will be impacted by climate change***

| General landscape setting for an agroforestry practice | Mixed feedstock for biofuels | Soil erosion protection | Water quality protection | Chemical drift barrier | Bank Stabilisation | Habitat for native pollinators | Habitat for natural pest control | C sequestration | Microclimate mod. for crops | Wildlife corridor | Snow drift control | Urban storm water treatment | Flood attenuation | Recreation | Aesthetics |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| In-field operation | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | ✓ |
| Upland/edge-of-field location | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ |
| Riparian location | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ |
| Rural/urban interface location | | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

Potential services influenced by agroforestry

*Source: adapted from Bentrup, 2008.*

## 9.4.4 Agroforestry and forestry contributions to CSA

**Mitigation.** Trees planted in fields as live fences, windbreaks, alley cropping, fodder banks, woodlots or improved fallows can sequester carbon in biomass and soil and supply fuelwood, poles and other forest-based products, thus preventing the destruction of natural forests (Mbow et al., 2014). This includes actions that increase tree cover (afforestation, reforestation and agroforestry), thus reducing deforestation and degradation (i.e., slowing down the rate of land degradation) and thereby increasing carbon sequestration in biomass and soil.

***Box 9.3***

**Mitigation** aims to reduce GHGs or enhance carbon sinks, while Adaptation aims to reduce the vulnerability of people and ecosystems to climate variability and change, i.e., the degree to which they are susceptible to, and unable to cope with, adverse impacts of climate.

**Adaptation.** Tree canopies have the direct benefits of reducing soil temperature for crops planted underneath and reducing runoff velocities caused by heavy rainfall. Healthy and diverse ecosystems are more resilient to most natural hazards. Trees on farms can be used as shelterbelts or windbreaks and play an important role in protecting against landslides and floods. They also stabilise riverbanks and mitigates soil erosion (Van Noordwijk et al., 2011; Mbow et al., 2014). Agroforestry also helps restore and protect ecosystem services related to soils and watersheds due to improved management systems and better management of biomass, including crop residues (FAO, 2010).

Forest ecosystems provide human societies with a wide range of services that reduce vulnerability to climate change impacts, particularly changes in temperature and rainfall, and the frequency, duration and intensity of floods and droughts. Forests regulate water and climate by sequestering $CO_2$ (i.e., mitigation) and also prevent soil erosion. In order for communities to continue benefitting from forest ecosystem services, adaptation strategies must also reduce the impacts of climate change on forest growth, species diversity and ecosystem function. Box 9.3 shows these two components of CSA.

**Production.** Most agroforestry systems aim to increase or maintain the productivity of farming systems. For example, by adopting agroforestry practices on farms, farmers are able to harvest tree products, supplement their diets, and also develop additional income streams. The Garitty et al., (2010) report showed increased maize yields in lands with *Faidherbia albida* in Malawi and Zambia over low rainfall seasons.

Forests facilitate primary production, nutrient cycling, soil formation and the provision of ecosystem goods, such as non-timber forest products, food and fuel. Therefore, for forest activities to support CSA, adaptation actions targeted particularly at the most vulnerable communities and sectors of the population (e.g., women, children, the elderly, indigenous populations) and forested ecosystems (e.g., woodlands, mountains, wetlands) are required to focus on the most efficient and cost-effective adaptation options, in addition to capitalising on adaptation-mitigation synergies. These options should focus on sustainable forest management and/or agroforestry.

## 9.5 Forestry and related activities in Zimbabwe

### 9.5.1 Forestry, agroforestry and climate change in Zimbabwe

The Zimbabwe Agenda for Sustainable Socio-Economic Transformation (ZimASSET), clearly in line with SDG Goal 15, shows the importance of conserving natural resources. Zimbabwe's Intended Nationally Determined Contributions (INDC) (2015) has a target of a 33% reduction in GHG emissions by 2030, to be achieved partly through CSA. Sustainable forest management should be considered a viable solution to the challenges within the agriculture sector, especially in respect to the use of land and other natural resources. Forests play a key role in maintaining the quality and quantity of water supplied by watersheds such as the Mafungabutsi forests and the gazetted forests in Matabeleland. Therefore, forested watersheds have the potential to affect water resources. Learning from other countries such as Ethiopia, Sudan, Uganda and Kenya, farmer-managed regeneration projects have potential for REDD+ activities (Mbow et al., 2012) and for restoration of the degraded Miombo woodlands. Drivers of deforestation must be addressed to achieve the goals of sustainability and REDD+ (Kissinger, 2011).

Several forest-related climate change adaptation measures have been introduced in Zimbabwe (Table 9.3).

***Table 9.3 Forest-related adaptation strategies for selected climate change impacts in Zimbabwe***

| Climate change impact | Adaptation strategy |
|---|---|
| Increased risk of fire due to higher frequency of heat waves and expansion of areas affected by drought. | Forest fire protection: fire guards, fire awareness etc.;<br>Reduce deforestation and degradation which open up the forest, decreasing shade and humidity, exacerbating local climate variation, and increasing drought, land degradation and susceptibility to fires. |
| Erratic rainfall. | Protection of land from flooding and erosion;<br>Rainwater harvesting techniques;<br>Use of hydrogel during tree planting in dry season. |
| Extreme weather events, e.g., droughts and floods. | Tree planting/agroforestry, watershed management, risk management plans. |
| Regulation of water flow and water quality. | Protection of stream banks and catchment areas to improve water quality and quantity. Forest ecosystems store water, regulate base flows, mitigate floods and reduce runoff, erosion and sedimentation. |
| Reduced agricultural yields. | Sustainable forest management, as the rural poor increase their collection of wild foods and other products from the forest. Agroforestry. |
| Outbreaks of pests and diseases. | Selection of resistant tree and crop species. |

Agriculture is the mainstay of the Zimbabwean economy and forest land is being reduced to meet the rapidly growing demand for both agricultural and non-agricultural products. That being the case, agroforestry becomes a viable option for CSA as it provides several benefits including carbon sequestration. As a land-use practice, agroforestry takes care of the best land use, soil fertility and farmer needs for food, fuel, timber and fodder and simultaneously helps sustain rural economies and the environment. However, agroforestry systems also have limitations, and a careful analysis should be carried out before they are introduced.

### 9.5.2 Role of higher and tertiary institutions in climate-smart agriculture

Higher and tertiary institutions have a role to play, especially in researching suitable agroforestry species so that recommendations can be made to farmers and extension agents. They can also facilitate capacity-building within local institutions and strengthen the governance process for SFM and REDD+. Furthermore, higher and tertiary institutions can facilitate understanding and training in the REDD+ process, including issues of Monitoring, Reporting and Verification (MRV), as communities participate in REDD+ projects (UNEP, 2014). In addition, the university curriculum should cover the issues of climate change and SFM, including international agreements.

There is also a need for more research on physiological adaptations of species that are able to survive in dry conditions as well as the biodiversity of dryland forests and woodlands to use as tools to underpin sound forest management practices. The relative neglect in respect of domesticating trees reflects the difficulties involved in manipulating them as trees are large organisms that take up a lot of space, making their study expensive.

### 9.5.3 Policy implications, challenges and opportunities

Forest- and tree-based resources are supported not only by local legislation, but also by regional and international treaties and arrangements. The development and up-scaling of traditional and improved agroforestry systems also requires an enabling environment, such as clear land and tree tenure, a robust legal framework, support for agroforestry product value chains and coordination of the various sectors involved.

In light of the growth of the tobacco industry, the regulations of the tobacco wood energy programme should be strictly adhered to in order to save forests from destruction. The laws regarding fire should be enforced at all levels. Among policy recommendations are the following:

- Forested land and catchment areas should not be tampered with as these are the key to water supplies and electricity generation in Zimbabwe;
- Given the increase in tobacco farming and the clearing of indigenous woodland and forests, farmers should be encouraged to continue planting trees for energy or seek alternative sources of energy;
- Ensuring adequate new investment in the energy sector, including renewable energy;
- Improving land management practices to promote agroforestry and limit the risk of environmentally damaging veld fires;
- Community involvement is critical in sustainable forest management, as it also enhances community livelihoods, involves traditional leaders and undertakes inter-sectoral collaboration to strengthen horizontal engagements;
- Strategic partnerships with regional and global players can provide effective environmental management and sustainability;
- SFM is consistent with both adaptation and mitigation, hence there is a need to consider climate change in management plans to reduce vulnerability and to facilitate adaptation to climate change;
- Agroforestry promotes the growing of multipurpose trees that are also palatable to livestock as trees and shrubs are threatened by the free-range policy for livestock during off-season periods; and
- In areas where goats are kept, the regeneration of natural forests and any attempts at agroforestry may not succeed unless laws are modified to protect agroforestry in rural areas.

Despite the benefits that climate-smart practices can provide, the barriers that could make farmers reluctant to adopt these practices include a lack of:

- technical knowledge or capacity;
- financing, and discouragement resulting from possible short-term crop yield reductions;
- risk management options (e.g., insurance), tenure insecurity, local customs and traditions; and
- access to new information and technologies.

There is a need for coordinated policies that utilise the frameworks of the landscape approach in order to fulfil both climate and development objectives (Matthews et al., 2014). The specific policy tools and actions that the government should strengthen or introduce, to deal with climate change include supporting more forestry projects under the implementation of INDCs and Nationally Appropriate Mitigation Actions (NAMAs), among other priority sectors. The issue of illegal settlers needs total political commitment with implementation of land reform following strict environmental protection mechanisms.

## 9.6 Conclusion and recommendations

In light of the impending climate change risks associated with global warming, this chapter has focused on how forests, sustainable forestry management, and agroforestry in Zimbabwe can contribute to combating climate change. It has been clearly shown that the phenomena of virgin forests, sustainable forest management, agroforestry, and land degradation are inextricably linked to climate change mitigation and adaptation. The chapter has also demonstrated how sustainable forest management addresses forest degradation and deforestation while increasing the direct benefits to people, and efforts to combat climate change. The current emphasis on increasing resilience to climate change and reducing agricultural greenhouse gas emissions, strengthens the support for sustainable forest management and climate-smart agriculture.

Zimbabwe is endowed with natural capital—especially forest resources, land, and a climate which can sustain the livelihoods and economy of the people in both urban and rural areas. Degradation of the forest resource base results from a combination of factors that have their roots in the economy, social organisation, policy/politics and ecology. However, mounting pressures on forest resources have caused large-scale forest and land degradation—thus calling for immediate action in seeking newer approaches to the farming system in order to meet the basic needs of present and future generations. There is a need for the development and implementation of sustainable forest management and agroforestry projects for purposes of mitigating and adapting to climate change.

The destruction of forests adversely affects the livelihoods of rural communities and if it continues, massive crowds of environmental refugees and a tremendous decline in the biological productivity of these ecosystems will become more evident. Therefore, to improve livelihoods, the economy, and environmental sustainability, use of improved agroforestry systems using a combination of crops, multipurpose trees and pastures will become inevitable. Agroforestry has the potential to stabilise the production of food, forage, firewood and timber, as well as to protect the environment. The failure to develop appropriate sustainable natural resource management, policy and increased investment in the forest sector will increase poverty, environmental degradation, resource-based conflict and other illegal activities. The reduction of losses in soil fertility, the reclamation of degraded lands and the promotion of synergistic interaction between crop production and forests are generally suggested as good climate change policies.

## References


1. Beetz, A. (2011). *Agroforestry: An Overview. National Sustainable Agriculture Information Service,* National Center for Appropriate Technology (ATTRA) IP155. Available at: www.attra.ncat.org. Accessed November 2016.

2. Bentrup, G. 2008. *Conservation Buffers: Design Guidelines for Buffers, Corridors, and Greenways.* General Technical Report SRS-109. Asheville, NC: USDA Forest Service, Southern Research Station

3. CBD. (2010a). *Zimbabwe's Fourth National Report to the Convention on Biological Diversity.* Ministry of Environment and Natural Resources Management. Republic of Zimbabwe. Harare.

4. FAO. (2010). *Climate-smart agriculture: policies, practices and financing for food security, adaptation and mitigation*. Rome.

5. GIZ. (2012) *Desertification Fact Sheet, 2001*. Available at: https://www.giz.de/expertise/downloads/Fachexpertise/giz2012-en-basic-fact-sheet-africa.pdf. Accessed December 2016.

6. FAO. 2016. *State of the World's Forests 2016. Forests and agriculture: land-use challenges and opportunities*. Rome.

7. FAO. (2015a*). FAO assessment of forests and carbon stocks, 1990–2015: reduced overall emissions, but increased degradation.* Available at: http://www.fao.org/3/a-i4470e.pdf. Accessed February 2017.

8. FAO/UNDP/UNEP. (2008). *UN Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD).*

9. Garrity, D.P., Akinnifesi, F.K., Ajayi, O.C., Weldesemayat, S.G., Mowo, J.G., Kalinganire, A., Larwanou, M. & Bayala, J. (2010*). Evergreen agriculture: a robust approach to sustainable food security in Africa.* Food Security, 2,197–214.

10. Gold, M., Cernusca, M. & Hall, M., (eds.). (2013). *Training Manual for Applied Agroforestry Practices*. Available at: www.centerforagroforestry.org. Accessed December 2016.

11. IndexMundi. (2016) *Zimbabwe Land Area* . Available at: http://www.indexmundi.com/facts/zimbabwe/indicator/AG.LND.FRST.ZS

12. IPCC. (2014). *Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Available at: https://www.ipcc.ch/reports/ar5/wg3. Accessed December 2016.

13. Kissinger, G. (2011). *Linking forests and food production in the REDD+ context. CCAFS Working Paper no. 1.* CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available at: www.ccafs. cgiar.org. Accessed November 2016.

14. Locatelli, B., Catterall, C. P., Imbach, P., Kumar, C., Lasco, R., Marín-Spiotta, E., Mercer, B., Powers, J. S., Schwartz, N. & Uriarte, M. (2015). *Tropical reforestation and climate change: beyond carbon.* Restoration Ecology*,* 23, 337–343. doi:10.1111/rec.12209.

15. Manyanhaire, I. O. & Kurangwa, W. (2014). *Estimation of the Impact of Tobacco Curing on Wood Resources in Zimbabwe.* International Journal of Development and Sustainability, 3(7), 1455-1467.

16. Matthews, R.B., van Noordwijk, M., Lambin, E., Meyfroidt, P., Gupta, J., Verchot, L., Hergoualc'h, K. & Veldkamp, E. (2014). *Implementing REDD+ (Reducing Emissions from Deforestation and Degradation): evidence on governance, evaluation and impacts from the REDD-ALERT project.* Mitigation and Adaptation Strategies for Global Change, 19(6), 907–925.

17. Mbow, C., Skole, D., Dieng, M., Justice, C., Kwesha, D., Mane, L., El Gamri, M., Von Vordzgbe, V. & Vrji, H. (2012). *Challenges and Prospects for REDD+ in Africa: Desk Review of REDD+ Implementation in Africa.* Copenhagen: GLP-IPO.

18. Mbow, C., Smith P., Skole, D., Duguma, L. & Bustamante, M. (2014*). Achieving mitigation and adaptation to climate change through sustainable agroforestry practices in Africa.* Current Opinion in Environmental Sustainability, 6, 8–14.

19. Millennium Ecosystem Assessment. (2005*). Ecosystems and Human Well-being: Synthesis.* Island Press, Washington, DC.

20. *National Climate Response Strategy for Zimbabwe* (NCCR), 2015

21. Nair, P.K.R. (1985). *Classification of agroforestry systems*. Agroforestry Systems, 3, 97-128. doi:10.1007/BF00122638.

22. Patterson, W., Camilien, J. W. & Russell, D. (2007). FAA 118-119. *Analysis Conservation of Tropical Forests and Biological Diversity*. USAID-Zimbabwe.

23. Prabhakar, V.K. (1998). *Social and Community Forestry*. Satish Garg, New Delhi, pp. 90-106.

24. Sacchetto, C. (2012*). Impact of Tobacco Growing on Deforestation*. Document prepared for UNITAB and FERTRATAB. Available at: http://www.cittadeltabacco.it/wp-content/uploads/2012/09/2-The-impact-of-tobacco-growing-on-deforestation-January-2012.pdf. Accessed: December 2016.

25. Schoeneberger, M. & Bentrup, G. (2012). *Branching out: agroforestry as a climate change mitigation and adaptation tool for agriculture*. Journal of Soil and Water Conservation, 67 (5), 128A- 136A.

26. Shirima, D.D., Totland, Ø., Munishi, P.K & Moe, S.R. (2015). *Does the abundance of dominant trees affect diversity of a widespread tropical woodland ecosystem in Tanzania?* Journal of Tropical Ecology, 31, 345-359.

27. United Nations. (1992). *Non-legally binding authoritative statement of principles for a global consensus on the management, conservation and sustainable development of all types of forests. Annex III.* Report of the United Nations Conference on Environment and Development, Rio de Janeiro, 3–14 June 1992. A/CONF.151/26, volume III. United Nations, New York, New York, USA. Available at: http://www.un.org/documents/ga/conf151/aconf15126-3annex3.htm. Accessed December 2016.

28. United Nations. (2015). *Transforming our world: the 2030 agenda for sustainable development. Resolutions adopted by the general assembly on 25 September 2015. United Nations A/RES/70/1. Sustainable development goals. Goal 15: Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss.* Available at: http://www.un.org/sustainabledevelopment/biodiversity/. Accessed December 2016.

29. UNFCCC. (2002) *Marrakesh Accords decision 17/CP.7.* Bonn: UNFCCC. Available at: http://unfccc.int/resource/docs/cop7/13a01.pdf. Accessed December 2016.

30. UNEP_2014*_Annual_Report-2015UNEP_Annual_Report20_14*

31. UNFCCC. (2008). *Report of the Conference of the Parties on its thirteenth session, held in Bali from 3 to 15 December 2007*. FCCC/CP/2007/6/Add.1. Bonn: UNFCCC.

32. UNFCCC. (2016). *Key decisions relevant for reducing emissions from deforestation and forest degradation in developing countries (REDD+).* Decision booklet REDD+ (Includes the Warsaw Framework for REDD+). Available at: http://unfccc.int/files/land_use_and_climate_change/redd/application/pdf/compilation_redd_decision_booklet_v1.2.pdf. Accessed December 2016.

33. Van Noordwijk, M., Hoang, M.H., Neufeldt, H., Öborn, I. & Yatich, T. eds. (2011). *How trees and people can co-adapt to climate change: reducing vulnerability through multifunctional agroforestry landscapes.* Nairobi: World Agroforestry Centre (ICRAF). Nairobi.

34. White, F. (1983). The Vegetation of Africa: *A Descriptive Memoir to Accompany the UNESCO/AETFAT/UNSO Vegetation Map.* Natural Resources Research 20. UNESCO, Paris.

35. *Zimbabwe's Intended Nationally Determined Contribution (INDC).* 2015. Submitted to the United Nations Framework Convention on Climate Change (UNFCCC).

# 10. Fisheries and aquaculture in Zimbabwe


## Abstract

In the last two decades, the fisheries and aquaculture sectors have been playing a critical role in developing food resources, combating hunger, and ensuring food security in most developing countries. In addition, fish-farming and the nurturing and harvesting of aquaculture produce have become viable farming alternatives for food-insecure communities. Growing demand due to increased human populations requires corresponding increase in food and agricultural production, including aquaculture, which will need to expand by 60% to meet increased demand. Zimbabwe is already experiencing the debilitating effects of climate change which also threaten fisheries and aquaculture production, among other factors. It is therefore imperative that climate-smart agriculture practices highlighted in this chapter be developed and used to cope with the impacts of the changing environment in the fisheries and aquaculture sectors of the country. Zimbabwe has enormous potential to develop and grow its fisheries and aquaculture, given the good climate, vast land reserves and its huge reservoir capacity (60% of southern African waters). However, the success of CSA in fisheries and aquaculture will require substantial technical and financial investments in order to achieve food security and nutrition, particularly in the agro-based economy of Zimbabwe.



**Key words:** aquaculture, climate-smart agriculture, fisheries, fish-farming


## Key messages

i. Fisheries production from natural fish stocks has been declining globally, regionally and nationally (Zimbabwe) due to climate change impacts and overfishing, among other factors;

ii. Over the last two decades, the demand for fish has increased worldwide, including Africa;

iii. The fisheries and aquaculture sectors in Africa, including Zimbabwe, have increased in dimension and can make a significant contribution towards filling the demand gap of over 260% by 2020;

iv. Relevant CSA fisheries and aquaculture systems for Zimbabwe would include research and innovation in technologies for affordable fish feed, breeding (hatchery) equipment and techniques, good-quality fish fingerlings, more effective feeding mechanisms, efficient post-harvest techniques and value addition;

v. A robust fisheries and aquaculture sector in Zimbabwe would address nine of the 17 sustainable development goals, namely: no poverty, zero hunger, good health and well-being (1-3), clean water and sanitation (6), industry, innovation and infrastructure (9), responsible consumption and production (12), climate action (13), life below water (14) and life on land (15); and

vi. An enabling environment for CSA in fisheries and aquaculture for Zimbabwe involves financial, technical and policy interventions, and an integrated approach.

## 10.1 Introduction

### 10.1.1 Global and regional overview: fisheries and aquaculture production

The global Blue Revolution (http://www.economist.com/node/1974103) which began in the 1970s as an initiative to boost protein production to combat hunger has led to the growth and development of the aquaculture industry. Africa is no exception to this and has recorded increased fishery development and aquaculture production in both natural waters and specifically-constructed aquaculture production units (Coche, 1994; Kapetsky, 1994; Agular-Manjarrez and Nath, 1998; Moehl et al., 2006). Compared to capture fisheries which are estimated to have reached their peak and are now recording decreasing production generally, aquaculture is currently recognised as the fastest and economically sustainable food producing sector in the world, growing at an annual rate of ten percent in Africa (FAO, 2014 http://www.iafi.net/Resources/Documents/5%20Iddya%20Karybasagar%20for%20Lahsen%20Ababouch%20Keynote%20Oct01.pdf. The development of aquaculture fits well into the CSA narrative, particularly when practiced in smaller and intensive units in the tropics as opposed to its extensive use in the oceans which has been associated with environmental destruction and degradation (https://newint.org/features/1992/08/05/blue).

Africa has a long history of fisheries and traditionally, the fisheries industry has been based on natural fish stocks. In the past two to three decades, and concordant with global trends, these stocks have been declining due to a myriad of factors, including over-harvesting, climate change and variability, and changes in land use and cover, among other factors, thus leading to increased pressure on fisheries (Ndebele-Murisa et al., 2010; Ndebele-Murisa, 2014). Classic examples of declining fisheries in the continent include those from Lakes Kariba, Malawi, Tanganyika and Victoria. In addition, depletion of fish stocks due to illegal and unregulated fishing in the coastal zones and oceans surrounding the continent have also been noted.

While it is still modest, African aquaculture production has entered a steady phase of expansion (Jamu and Aynla, 2003). Historically, the first instance of aquaculture dates back to 2,500 years ago when Egyptians are recorded to have farmed tilapia fish in ponds adjacent to the Nile River (Rural Fisheries Programme, 2010). Although the Nile Tilapia, locally known as ‘bream’ may have been grown thousands of years ago, there is little tradition of fish culture in most African countries (Bardach et al., 1974; Ridler and Hishamunda, 2001).

Though aquaculture exists in varying degrees to many farming regions, when coupled with other factors such as severe political and socio-economic constraints and a changing climate, as well as pressure exerted on fisheries due to population expansion (Ndebele-Murisa et al., 2017), the result is a small fisheries sector that makes only a small contribution to food security and economic development.

In 2008, nearly 10 million people, or 1.5% of Africa’s population were directly or indirectly dependant on fish-farming with the continent realising about USD 3 billion from exports annually (AfDB, 2008). The reported production of 121,905 tonnes in 1997 is more than three times that of the 36,685 tonnes reported by FAO in 1984. By 2014 (three decades later), the global per capita fish supply rate had risen to a record breaking 20 kg per person. In 2014, Africa produced a total yield of 1.7 million tonnes of fish out of a total 73.7 million tonnes of global production, with an estimated value of about USD 160.2 billion (FAO, 2016a, http://www.fao.org/3/a-i5555e.pdf), with fish from aquaculture contributing 44.1%, rising from 31.1% of the total global fish production realised in 2004. As of 2016, aquaculture was providing half of all the fish consumed by humans (FAO, 2016a). Currently, over 26 species of fish are utilised in aquaculture production in Africa, of which Tilapia, Catfish, and the common carp are more predominant. Molluscs as well as oysters are also bred in the coastal zones.

Concerns over the future of fisheries and aquaculture resources arise from the threats posed to natural fish stocks by illegal harvesting done in unsustainable ways, as well as by climate change, among other factors (Ndebele-Murisa et al., 2010; Hecky et al., 2010; Ndebele-Murisa, 2014; IPCC, 2007, 2013, 2014; Oguto-Ohwayo et al., 2016; Efitre et al., 2017). This has driven investment into fish farming practices, as

well as policies being developed especially for poor communities in arid environments as a sustainable livelihood measure and ultimately, poverty eradication. However, this is not without drawbacks. Most rural households operate outside the cash economy, with some rural communities in arid Zimbabwe still relying on barter trade and thus have little disposable income with which to purchase feed and fertiliser that make aquaculture an economically viable trade. This has seen many donor organisations and in particular, the African Development Bank (AfDB) venturing into fisheries and aquaculture in Africa in a bid to minimise the threats posed by the over-exploitation of natural fish stocks, and aid in value addition, poverty eradication through job creation and enhancement of sustainable livelihoods, among others. In Zimbabwe, for example, the AfDB has supported the largest fish-farm, Lake Harvest (AfDB, 2011).

### 10.1.2 Fisheries and aquaculture production in Zimbabwe

In this chapter, aquaculture (which is used interchangeably with ‘fish farming’), is defined as the breeding, rearing and harvesting of aquatic organisms (includes both animals and plants) under controlled or semi-controlled conditions while fisheries are defined as natural, often open aquatic ecosystems (known as ‘capture’ fisheries). Both yield produce for subsistence, and hold commercial, recreational and ornamental value. According to the Japanese Resource Council, Science and Technology Agency, aquaculture is defined as, “… an industrial process of raising aquatic organisms up to final commercial production within properly partitioned aquatic areas, controlling the environmental factors and administering the life history of the organism positively and thus is considered as an independent industry from the fisheries hitherto.” In our context, these definitions are used with a bias towards fish production as this is the most common produce among other aquatic organisms such as crabs, crocodiles, crayfish, freshwater shrimp, and algae in Zimbabwe. Being landlocked, only freshwater aquaculture can be practised in the country, as opposed to marine and brackish water aquaculture.

Zimbabwe relies on animal husbandry as its main protein source. A growing awareness that capture fisheries are reaching a peak (Ndebele-Murisa et al. 2011) has seen a rise in aquaculture production (www.herald.co.zw/fish-farming-coprehensive-aquaculture-policy-in-zim/). Health consciousness, with a preference for white over red meat has also increased demand for fish, which is also a cheaper source of protein thus driving aquaculture production. Despite being landlocked, Zimbabwe, like many African countries, has the desired climatic conditions for fresh water fish farming and the potential to develop aquaculture in sustaining livelihoods (especially of the rural majority), food security and economic development through value addition and export of fish and fish products (Jamu and Ayinla, 2003). According to the Zimbabwe National Parks and Wildlife Authority, if all of Zimbabwe’s 41 major reservoirs were fully utilised there is potential to increase fish production output up to 1.5 million tonnes, supporting 1.2 million people at the primary production level. The country has one of the largest fish farming operations in Africa that produces over 9,000 tonnes of Nile Tilapia per year. Zimbabwe holds an estimated 60 percent of all dammed water in the Southern Africa Development Community region, i.e., close to 10,000 dams and produced over 18,000 tonnes of fish in 2014 (Table 10.1), which has since risen to over 21,000 tonnes against an estimated demand of 60,000 tonnes per year (UNDESA, 2013, FAO, 2017).

The fishery sector in Zimbabwe comprises capture fisheries, aquaculture, recreational fisheries and a very limited ornamental fish selection (www.fao.org/fishery/facp/ZWE/en). About 114 indigenous fish species and an additional 30 exotic species are exploited, but only a few species (about six) have been used for aquaculture production (FAO, 2016b). Despite this wide variety of fish being produced in Zimbabwe, two species, Nile Tilapia ‘bream’ (Oreochromis niloticus) and the freshwater Tanganyika sardine, commonly known as ‘Kapenta’, are the most commercially preferred fish and they contribute significantly to fish production in Zimbabwe (FAO, 2003, 2007, 2016b). Rainbow trout (Onchorynchus mykiss) is also produced in the Eastern Highlands, generally for the urban up-markets and for recreational fishing. Fisheries from Lake Kariba are the mainstay of the fishery sector, with large aquaculture farms such as Lake Harvest and Kariba Bream contributing significantly to fish production. Commercial fishing across the country occurs

mainly in the large reservoirs such as Lakes Kariba, Chivero, Mutirikwi, Manyame and Mazvikadei. Smaller dams, rivers and ponds provide fish for subsistence purposes (FAO, 2017).

***Table 10.1 Value of fisheries and aquaculture in southern Africa. Table extracted (with permission) from Mutimukuru-Maravanyika et al., (2015)***

| Country | Total employed (fisheries) | Total employed (aquaculture) | Fisheries GDP (%) | Fisheries in Agric. GDP (%) | Total fish production in 2014 (tonnes) | Aquaculture production in 2014 (tonnes) |
|---|---|---|---|---|---|---|
| Angola | 452,603 | 823 | 1.7 | 4.25 | 275, 450 | 450 |
| Botswana | 581 | 0 | 0.002 | 0.16 | 234 | - |
| DRC | 376,275 | 2,035 | 5.53 | 6.31 | 238, 970 | 2, 869 |
| Lesotho | 112 | 602 | 0.018 | 0.14 | 345 | 900 |
| Madagascar | 166,013 | 12,210 | 2.76 | 8.47 | 125, 100 | 13, 352 |
| Malawi | 173,328 | 8,334 | 3.83 | 5.87 | 115, 953 | 4, 748 |
| Mauritius | 6,838 | 346 | 0.19 | 3.76 | 8 353 | 500 |
| Mozambique | 374,027 | 922 | 3.03 | 10.0 | 222, 822 | 1, 200 |
| Namibia | 386,973 | 1,132 | 6.5 | 52.42 | 414, 359 | 740 |
| Seychelles | 160,249 | 0 | 17.73 | 20.68 | 87, 408 | - |
| South Africa | 499,749 | 7,168 | 0.25 | 6.73 | 416, 520 | 4, 314 |
| Swaziland | 174 | 441 | 0.013 | 0.094 | 110 | 100 |
| Tanzania | 510,876 | 44,641 | 4.86 | 9.69 | 371, 977 | 10, 317 |
| Zambia | 142,204 | 6,490 | 3.2 | 3.51 | 79, 894 | 20, 271 |
| Zimbabwe | 26,101 | 4,685 | 0,56 | 2.73 | 18, 102 | 10, 090 |

### 10.1.3 Recreational fishing

Recreational fishing is carried out in most of the reservoirs that qualify as recreational parks under the Zimbabwe Parks and Wildlife Management Authority (ZPWMA). Anglers are not regulated closely except for the issuing of licences for fishing in reservoirs within park estates or for trout fishing in the Eastern Highlands. Subsistence angling is a common activity in all reservoirs near urban centres, mainly Lakes Chivero, Manyame and Kariba (ZPWMA, 2017). Sport fishing for trout is carried out in reservoirs and rivers in Nyanga National Park in the Eastern Highlands and the Manyame, Mutirikwi, Manyuchi, Manjirenji, Matopos, Muzhwi, Ncema, Osborne, Mayfair and Zhowe dams, are other reservoirs supporting fisheries, with gillnet and seine net being the dominant gear in use (FAO, 2017; Katunga, 2016). Sport fishing for

tiger fish (Hydrocynus vittatus) is also permissible in Lake Kariba, and the annual Kariba International Tiger Fishing Tournament brings in substantial revenue for the country (http://www.worldlakes.org/uploads/14_Kariba_Reservoir_27February2006.pdf).

### 10.1.4 Aquaculture production

Aquaculture production in Zimbabwe is conducted for subsistence and commercial purposes. Subsistence aquaculture occurs at household level and is generally limited to a few pond-based enterprises. There are also a few donor-driven projects which aim to boost aquaculture and fish-farming across rural districts and sustain the livelihoods of rural communities in the arid parts of the country. For example, a donor-driven project led by World Vision International-Zimbabwe in partnership with Aquaculture Zimbabwe and the Basilizwi Trust is currently running in Zimbabwe. The project is funded by the European Union (EU) and focuses on enhancing fish-farming by promoting the untapped aquaculture sector in Zimbabwe which has great potential to improve food security as a diversified livelihood strategy under changing climatic conditions (Gumbo, 2015). The three implementing partners have the project running in eight selected districts (Beitbridge, Binga, Hwange, Kariba, Insiza, Masvingo, Mwenezi and Umzingwane) across the country. However, these efforts are not without challenges as climate change, explosive population growth and the consequent overharvesting and degradation of water resources, among other factors are still to be overcome. Commercial aquaculture enterprises in the country vary from small- to large-scale of which the following farms—Lake Harvest Aquaculture Pvt Ltd, Kariba Bream Farm, Mazvikadei Fish Farm, Trout Farm, Inn on the Ruparara Farm, Clairmont Trout Farm, and Radco Timber Farm stand out as large-scale.

### 10.1.5 Types of aquaculture

Determining the type of culture to practice is dependent on a number of factors, for example, intensity of culture, level of water exchange, structures used, type of fish, and climate. Zimbabwe's climate provides a favourable environment for both capture and aquaculture fisheries production. Aquaculture can be broadly categorised into extensive, intensive and semi-intensive. Extensive aquaculture is a low skilled practice that involves the use of large stagnant ponds that only allows a limited number of stock receiving no supplementary feed, and minimal attention. Extensive fisheries and aquaculture programmes have been developed in Zimbabwe within dams and reservoirs such as Chivero, Kariba, Mazvikadei and Mutirikwi - deriving secondary functions of commercial fisheries. On the other hand, semi-intensive aquaculture requires a certain level of managerial skills and a much greater extent of intervention through supplementary feed or water quality and air circulation systems. It also tends to bear higher costs in setting up as well as operations, with higher risks of mortalities because of diseases, poor management, and/or force majeure. (FAO, 2017). Semi-intensive aquaculture systems have intermediator conditions between extensive and intensive aquaculture.

Despite being more technical than extensive and semi-intensive culture systems, intensive aquaculture is advocated for Zimbabwe in order to boost production. Intensive aquaculture relies on electricity to operate and solely depends on supplementary feed to sustain the high stock rates while using a rather small space in an efficient manner. Continuously flowing water is used in intensive aquaculture which is advantageous for fish culture as it supplies abundant dissolved oxygen and flushes away waste products and unconsumed feeds. Examples of intensive and commercial aquaculture ventures in Zimbabwe include Lake Harvest Aquaculture, and Kariba Bream, both located in Kariba. The fish aquaculture types practiced in Zimbabwe include open cage fish farming, open and closed recirculating systems and pond (mostly earthen) and tank-based fish farming. These are described in detail in the context of CSA in ensuing sections.

## 10.2 Need for climate-smart agriculture in fisheries and aquaculture

In a bid to successfully tackle current food security and climate change challenges, the adoption of CSA practices is essential. These practices increase productivity, enhances livelihood resilience and reduce

greenhouse gases (www.fao.org/3/a-an177epdf&ved=0ahU). The rural and less economically viable communities in Zimbabwe that practise fisheries and aquaculture either use equipment such as cages and nets provided by donor organisations or self-sustaining fish ponds that grow tilapia at varying scales. Climate change and variability in the form of erratic rainfall patterns and increases in temperature negatively affect fisheries and aquaculture production, livelihoods and ultimately the economy. Tilapia is a better option for fish farming under unpredictable climatic conditions as they are generally more resilient and can tolerate a wider range of tropical high temperatures (https://ccafs.cgiiar.org/news/swimming-towards-adaptation-climate-smart-aquaculture#.WXxi58vRbqa). Given the historical trends of increasing temperatures and more erratic rainfall patterns across the country - especially in Natural regions III to IV (Mugandani et al., 2012; Ndebele-Murisa and Mubaya, 2015; Brazier, 2015), aquaculture works well as a strategy for coping with and adopting to climate change and variability, and consequent increased aridity as it requires less water for fish production as compared to the production of crops and livestock. Having a robust fisheries and aquaculture sector in Zimbabwe would address nine out of the 17 sustainable development goals, namely: no poverty, zero hunger, good health and well-being (1-3), clean water and sanitation (6), industry, innovation and infrastructure (9), responsible consumption and production (12), climate action (13), life below water (14) and life on land (15).

There exists great potential for the development of aquaculture in Zimbabwe given the large tracts of land as well as good weather that can suit the breeding of various fish and other aquaculture species (Mandima, 1994 and 1995). The recent recurrent droughts in southern Africa, Zimbabwe included (Sithole and Murewi, 2009), have also had a toll on livestock production, which coupled with frequent outbreaks of anthrax and foot and mouth disease, have seen a sharp decline in beef and dairy production, as well as the banning of beef exports to the EU (Chingono, 2014, Mukaro, 2016). Thus, beef prices continue to rise in Zimbabwe, and many consumers have switched to poultry consumption over the past decade. Analysis of meat prices in Zimbabwe (Livestock and Meats Advisory Council) shows that, on average, beef and chicken cost US$5-6 per kg and pork US$4.50 per kg in comparison with fish which costs US$2.50-3.50 per kg. The vast difference in prices between livestock and fish has aided in increasing the demand for the cheaper protein source.

## 10.2.1 Current aquaculture systems in Zimbabwe

### 10.2.1.1 Pond culture

Pond culture is the most common form of aquaculture in Zimbabwe. It can be divided into static and flowing water ponds, of which the latter are more suitable to highlands with flowing and good supplies of water. Ponds vary in form from simple earthen ones to reinforced ones (cement, plastic) and can be raised (watershed) or dug on flat ground (excavated) or drawn from reservoirs with raised sides (levee) (Whitis, 2002; Egna and Boyd, 1997). Ponds may be designed in such a way that they can be rain-fed (sky ponds) and/or may have inlet and outlet systems for controlled water circulation. The water supply may be from a stream or a canal or from underground sources such as wells. The water retentivity of the ponds depends on soil composition of the pond bottom and subsoil water level. The sandier, the soil, the less likely it is to retain water in the pond system. In order to enhance production, pond aquaculture systems may require liming (to balance the water pH), application of manure and/or fertilisers (based on pond soil and water quality), stocking of fingerlings, regular supplementary feeding of fish, and harvesting of fish at the right time. Most of the training and capacity building of aquaculture in Zimbabwe is currently based on pond culture as it is a simple form of production which is cost-effective. This is suitable for a suite of purposes from subsistence to commercial; small to medium and large (intensive) scale with pond design, stocking and feeding mechanisms applied accordingly (http://articles.extension.org/pages/58771/pond-culture). In rare cases, such as in larger aquaculture ventures, fish breeding is being practised while smaller and donor-driven operations rely on external sources for fish fry (see section 10.3.3). This addresses the issue of sustainability of aquaculture for the local farmer, as ensuring good quality seed (fry) is important for

successful fish production and this could be one area of research, development, and training for extension services and smallholder farmers in the country in order to boost aquaculture production.

#### 10.2.1.2 Tanks

Earthen, polythene, galvanised steel, fibre glass, and concrete tanks can be placed along the course of a river or stream or on any land surface to be used for aquaculture. These materials are used in the construction of tanks because they do not easily become contaminated with poison or other toxic materials. Tanks come in various shapes and sizes (http://www.farmB.com/aquaponics/aquaculture-tank) and are easy and relatively cheap to maintain. Tanks are closed aquaculture systems and are therefore similar to ponds in their operation. They can be operated indoors or outdoors (http://www.aquacare.com/products/fish-farming-tanks/). The difference between ponds and tanks is that tanks are constructed above ground but can be made to 'interact' with soil at the bottom. Often used for research and training purposes, conditions in the tanks can be controlled and activities such as fertilisation, supplementary feeding and stocking are essential. The harvesting of fish is easy in these aquaculture systems. Tanks are not popular in Zimbabwe but are used for hatchery purposes with an example of them at Radco Timber Farm in Bindura in the form of small tubs that are used to grow fry. However, tanks are one form of aquaculture which can be widespread in Zimbabwe due to the advantages associated with closed aquaculture systems as they can grow more fish with less feed, less water and less stress as compared to other closed systems. However, unlike raceways (see section) 10.2.1.4, there is need for enhanced aeration and the water to be cleaned regularly to avoid contamination and pollution.

#### 10.2.1.3 Pen and cage culture

Basic procedures involved in the management of pen and cage culture are very much like those in pond and tank cultures. These involve construction and preparation of the culture facilities for stocking, rearing, and harvesting although some variations are to be expected. However, pens and cages, which can be floating or submerged in flowing (rivers, streams, estuaries, seas) or stagnant waters (lakes, reservoirs, large ponds) are open systems and are subject to less control than ponds and tanks, therefore, fertilisation, liming and the application of pesticides is not possible. The advantage of cage culture as compared to pen culture may be due to its greater flexibility in terms of siting the structures. Yields from pen and cage culture are generally high, with or without supplemental feeding depending on the natural productivity of the water body. Disadvantages of pen/cage culture include: the fact that they are difficult to handle when water is rough; high dependence on artificial feeding and need for high quality feed in the form of protein, vitamins and minerals; high levels of feed losses are recorded because of the open cage walls which also mean that there is interference with natural fish populations around the pens/cages; and lastly, there is a high risk of theft. Examples of cage culture in Zimbabwe include grow out cages set up by private enterprises in Kariba, Karoi and Zhohwe Dams. Though few, these have been successful as commercial ventures and with increased capital, cage culture can be increased across the country given the high number of reservoirs that the country possesses.

#### 10.2.1.4 Raceways

Raceways are culture chambers that are generally long and narrow through which water flows and therefore provide good aeration and oxygen conditions. Unlike tanks that are a closed system, water enters at one end and leaves through the other end in most cases. The advantages of tanks and raceways is that they are closed aquaculture systems and therefore there is no water exchange with the environment and the water can be subject to extensive treatment where high densities of organisms can be bred. In this case the farmer has complete control over growing conditions where conditions such as temperature can be regulated, parasites or predators controlled, and harvesting is simple. In addition, feed and drugs can be administered efficiently into the system which enables the fish to grow quickly and uniformly. One disadvantage, like in most closed system is the risk of disease outbreak which can easily spread and affect

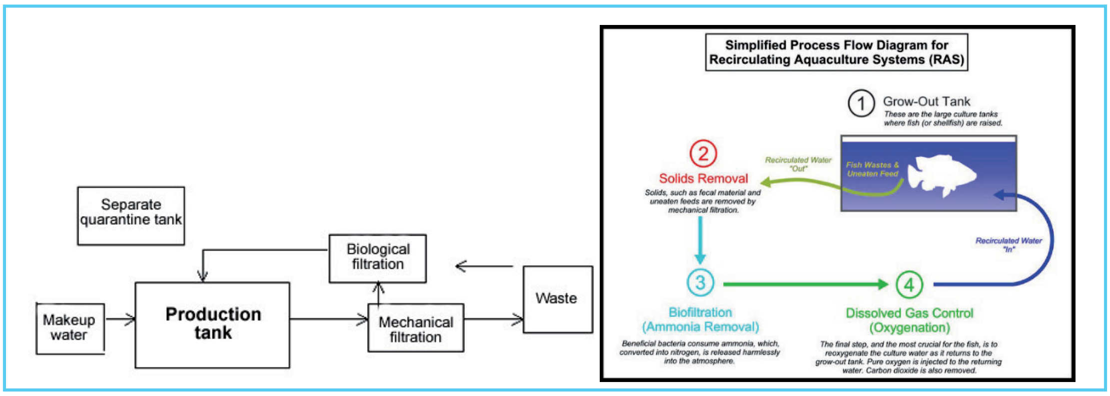
large populations especially under intensive, high density culture. Raceways are not practiced widely in Zimbabwe. Examples of raceways are found at Kariba Bream which breeds the Nile Tilapia. Like cages, raceways can be encouraged as a form of aquaculture in Zimbabwe as they have been successfully used in some places in Europe, to boost aquaculture production.

#### 10.2.1.5 Recirculation aquaculture systems

In Recirculation Aquaculture Systems (RAS), a large amount of high-quality fish can be grown using a small amount of water which is re-used or re-circulated. The water conservation and reuse aspect of RAS is important as a CSA approach.

In addition, a properly functioning recirculation system aerates the water, adding oxygen and conversely removing carbon dioxide, as well as the ammonia that fish excrete as a by-product of the catabolism of protein (Figure 10.1). This helps create good water quality conditions which in turn, boost production. However, because of the high costs involved in setting up a RAS, only a handful of operators in Zimbabwe have managed to acquire this facility. A RAS can be run inside a greenhouse to ensure warm water temperature throughout the growing cycle. Home-made biofilters are effective in purifying the water before it can be recycled. Cheap materials such as wood chips and wheat straw have been shown to be more effective biofilters than the traditional plastic media (Saliling et al., 2007).

***Figure 10.1 An illustration of a Recirculation Aquaculture System***




*Source: Blue Ridge Aquaculture http://www.blueridgeaquaculture.com/recirculatingaquaculture.cfm*

#### 10.2.1.6 Integrated aquaculture system

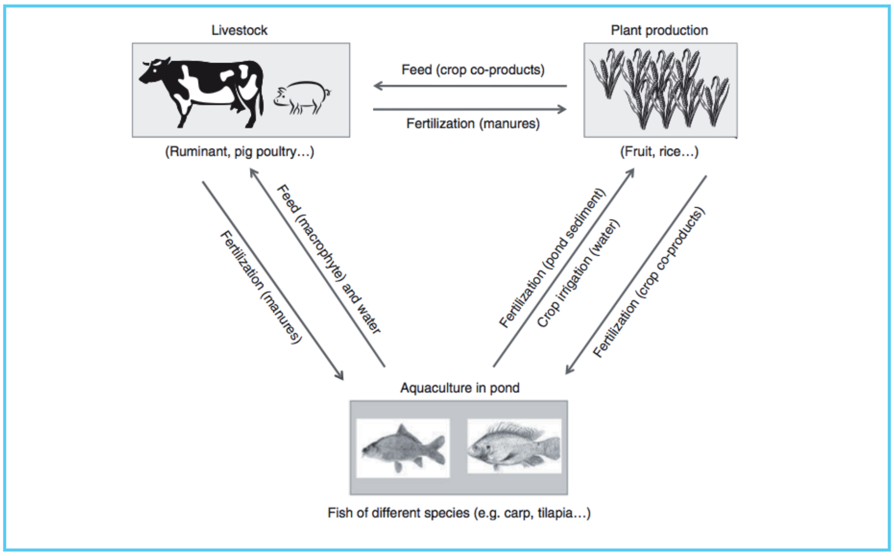
If sustainability is to be achieved, particularly under the projected warmer and increased arid conditions, food production systems should be integrated in ways that allow sequential linkages between different farming activities for efficient use of available scarce resources (Little et al., 2003). The integrated aquaculture system is a sustainable way to address environmental scarcities which manifests in different forms such as land shortages, financial stresses and various socio-economic constraints (http://www.mekarn.org/workshops/environ/PDF/Lindberg). It entails production of fish, crops and other livestock within a coordinated framework in which one production benefits from the other (Land based aquaculture assessment framework, 2017). This system has been in practice for over 1,500 years in countries such as India and China.

Given the scarcity of water resources, in part due to climate change and variability, integrated aquaculture becomes the best practice to use resources efficiently. In fact, integrated aquaculture is regarded as an alternative for efficient use of resources, water recycling, and energy saving (www.researchgate.net/publication/226829080_Integrated_Agri-Aquaculture_Systems). The cost effectiveness of using

wastewater is also another advantage of this practice. While aquaculture is an important source of fish stock, employment and profits, it also presents ecological, environmental and socio-economic challenges. On the other hand, integrated aquaculture not only has minimum environmental impacts, but also increases productivity (Angel and Freeman, 2009). However, this practice requires good management to balance between inputs and nutrient flows (www.lbaaf.co.nz/land-based-aquaculture/integrated-aquaculture/). It is important to note public health considerations and concerns (www.fao.org/fileadmin/templates/FCIT/Meetings/World_Water_Day_2011/5) when using wastewater for agricultural production (http://www.who.int/water_sanitation_health/wastewater/Volume3_v2.pdf). In Zimbabwe, such concerns would fall under the jurisdiction of regulatory authorities such as the Environmental Management Authority (EMA), Zimbabwe National Water Authority (ZINWA) and the Standards Association of Zimbabwe (SAZ).

Integrated aquaculture involves the concurrent or sequential linkages of two or more activities, of which at least one is fish-farming. These may occur directly on-site or indirectly through off-site needs and opportunities. The benefits of integration are synergistic rather than additive (Little et al., 2003) and the fish, crops and livestock components may benefit to varying degrees. In an integrated system, fish, livestock and crops are produced within a coordinated framework, the waste products of one component serving as a resource for the other. For example, manure from livestock and/or poultry production can be used to enhance crop production, crop residues and by-products feed fish and animals, supplementing often inadequate feed supplies, thus contributing to improved fish, crop and animal nutrition and productivity (Figure 10.2).

***Figure 10.2 An illustration of an integrated agri-aquaculture system***



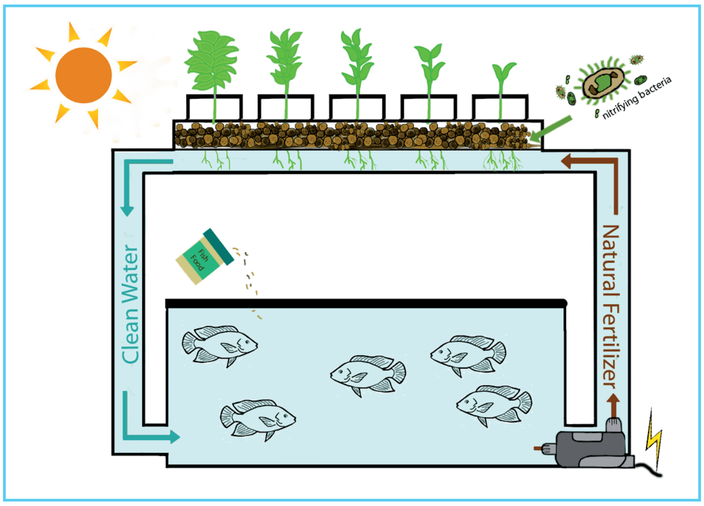

*Source: Dumont et al., 2013 https://www.ncbi.nlm.nih.gov/pubmed/23257276*

The production and processing of livestock and crops generate by-products that can be used for fish-farming. Direct use of livestock production waste is the most widespread and conventionally recognised type of integrated farming. Production wastes include manure, urine and spilled feed, which may be used as fresh inputs or be processed in some way before use. Water from fish ponds is rich in nutrients and is therefore used to irrigate crops, thus completing the cycle. An example of an integrated aquaculture programme which covers Hwange and Binga Districts is the EU-funded programme which was launched in 2013, in partnership with the Basilwizi Trust, World Vision and Aquaculture Zimbabwe. In Hwange the project is working with capture fisheries, and in Binga District both capture fisheries and aquaculture are being implemented (http://www.basilwizi.org/basilwizi/projects/intergrated-aquaculture-agriculture-project).

### 10.2.1.7 Aquaponics

Aquaponics is the combination of aquaculture and hydroponics (the soil-less growing of plants such as crops and vegetables)—that is, growing fish and plants together in one integrated farming system (Figure 10.3). This integrated approach to farming has been used since time immemorial especially by the Chinampas of Mexico and in integrated paddy systems across parts of Asia (see: https://www.milkwood.net/2014/01/20/aquaponics-a-brief-history/). It is currently, highly acclaimed particularly when used with renewable energy sources such as solar. Environmentally friendly organic waste is circulated and used to fertilise each component thus producing minimal waste http://www.dw.com/en/sustainable-farming-project-combines-aquaculture-and-hydroponics/a-16927582. The waste from the fish ponds provides an organic food source for the growing of plants. The plants provide a natural filter for the water the fish live in. Like the integrated aquaculture system, aquaponics is a technology that is ideal for intensive commercial and non-commercial aquaculture setups with the advantages of efficiency in water usage and conservation (Gith, 2013, Bradeley, 2014).

***Figure 10.3 How aquaponics work***




*Source: Ecolife (https://www.ecolifeconservation.org/aquaponics/)*

The hydroponics technology works well for CSA because of the water conservation and farm integration advantages as well as being a potentially more sustainable method of food production that uses 90% less water and soil as compared to traditional agricultural methods of production (Diver, 2006; Rakocy et al., 2006; Love et al., 2014; and (https://attra.ncat.org/attra-pub/viewhtml.php?id=56). Aquaponic systems are beneficial in many ways which include the use of dissolved waste nutrients by plants, reduced waste discharge, minimal water exchange and reduced operational costs particularly in arid environments. In addition, these systems require substantially less water quality monitoring as compared to standalone hydroponics or RAS. Because of its integrated nature, fish production through aquaponics requires less land. Aquaponic systems require moderate capital investment, energy inputs and skilled management. This method of aquaculture production has not been explored to a large extent in Zimbabwe despite its suitability under CSA due to its soil and water conservation characteristics as well as its potential for high productivity. However, the higher maintenance and costs associated with the setup, especially at commercial scale, in comparison to other aquaculture methods may be viewed as disadvantageous.

### 10.2.1.8 Breeding and hatchery technologies

A hatchery is a place for artificial breeding, hatching, and rearing through the early life stages of animals (Crespi and Coche, 2008). Proper site selection determines the success of a hatchery. This entails that

the site should be at close proximity to the market so as to minimise transport costs. The water should be oxygen rich, of good quality, with optimum temperatures which is essential for successful spawning and hatching. The first step in artificial reproduction is selection of females from broodstock and then their transfer to the holding tanks within a hatchery. The most common technique employed to induce final maturation and ovulation is to inject the female with hormones or pituitary gland material (http://www.nefisco.org/downloads/Clarias). Ponds should be protected against predators such as birds by using bird-netting and by low walls to keep out frogs. The ponds should also be inaccessible to wild fish. For southern Africa, the recommended breeding span for broodstock is 3-4 years. Trout are usually ineffective breeders after 2-3 years as they are a short-lived species. For breeding techniques for different types of fish see: http://www.nda.agric.za/doaDev/sideMenu/fisheries/03_areasofwork/Aquaculture/AquaDocumentation/ManualRuralFreshwaterAquaculture.pdf.

Developing hatcheries can be considered as a CSA activity in terms of increasing productivity, ensuring good quality and reliable aquaculture seed, and therefore enhanced production. In a country whose agriculture is currently rain-dependant, any enhancement of production that is not directly controlled by nature (rain-dependant) can help farmers to combat and cope with adverse impacts of climate changes and variability. To breed a species, one needs to know if the fish is a pair, hence determining the sex of the fish is an important step. Once males and females have been distinguished, a suitable pair or spawning group should be chosen. Before placing the parent fish together for spawning, they should be conditioned by feeding the fish a variety of healthy foods to bring them to the best condition for spawning. Many species can be conditioned using well-balanced flake food, although others can be conditioned on live foods such as insect larvae and flying insects. Currently, aquaculture companies in Zimbabwe have been breeding for in-house stocking with just a handful producing seed for sale (FAO, 2017).

Though some species readily spawn in an aquarium, the eggs or fry often do not survive because of predatory parents or other fish. Often the fry die because of unfavourable and/or unclean water conditions. Many species that practice brood care will harm other tank mates in attempting to guard the eggs. Because of these issues, most aquarists who breed fish use separate spawning tanks. The spawning tank should be like a hospital tank with a protected heater so that the fish are not burnt, a slow-moving filter (sponge filter) so that the eggs or fry are not sucked up, and also have good aeration. In Zimbabwe, a number of fish breeding centres and hatcheries have been developed by both government (Ministry of Agriculture, Mechanisation and Irrigation Development; Zimbabwe National Parks; and Wildlife Management Authority) and private actors such as Lake Harvest and Kariba Bream in Kariba as well as Radco Timber Fish Farm in Bindura. The Zimbabwean government fish breeding structures, namely the Henderson Research Centre and Chivero Hatchery are dilapidated as they were largely driven by donor funding which has since dwindled while the private players are mostly producing fingerlings for their own production or to sell to a few non-governmental aquaculture projects. This presents an opportunity to develop breeding technologies and aquaculture hatcheries that can be used to grow the aquaculture sector as well as boost natural fishery stocks.

#### 10.2.1.9 Farm equipment and feed

This represents an important component of fisheries and aquaculture research and development. If these sectors are to be grown and developed successfully in the context of CSA, there is need to develop appropriate equipment and feed. Equipment requirements largely depend on the type of rearing to be done and the level of production envisaged. The following considerations are essential:

i. **Pumping:** In addition, to a reliable water source, there is need to ensure that water is supplied to the aquaculture facility. When it is not possible to have a gravity water supply, pumping needs to be studied.

ii. **Harvesting:** This component of the fishery and aquaculture production is very important. This is because there is need to handle the produce with much care in order to prevent harvesting

and post-harvest losses. There are several methods that can be used for harvesting and in open fisheries these include different types of netting, hook and line, seining with a reed fence or basket trapping. In ponds and tanks, the most efficient method is drainage of water down to 20-30% level and subsequent seine netting. This yields an average 80% at the first attempt after which the water can be further drained in order to harvest the rest of the fish. In the case of controlled environments such as cages and RAS as well as aquaponics, the main advantage is that complete harvest of the fish can be done.

iii. **Aeration:** This is essential in order to allow oxygen to diffuse from the atmosphere and dissolve in the water as this is the form in which it can be assimilated by fish and other aquaculture animals. Aeration can be natural (wind) but if the production of the farm is to be successful, there is need to invest in aeration equipment (see: http://pentairaes.com/media/docs/03-PAES-Master-Catalog-39th-Edition-Aeration.pdf). In this way, air can be infused from the bottom of the water or by surface agitation from a fountain or spray-like device to allow for oxygen exchange at the surface. There are two main aeration systems. One is aeration by pulsed air, in which a blower generates air at relatively low pressure through the pipe to air stones or other diffusers. This system is particularly well adapted to small-scale facilities and for fry and small fish, since it does not cause damage due to water turbulence. The second is aeration by mechanical agitation. This has different aerators (fountain aerator, paddlewheel and Venturi system), and these are more suitable to large-scale aquaculture facilities where stocking densities are high.

iv. **Fish graders:** These are used to grade the fish and separate them according to their individual sizes. This operation is very important because it allows a dramatic improvement in growth performance and improves the overall management of the farm's facilities. If the fish are not graded properly, the smallest ones have difficulty in gaining access to the food (due to physical competition with larger fish) and are stressed, resulting in poor growth performance.

v. **Complementary equipment:** These include general equipment such as water quality measuring meters. A daily check of temperature and oxygen is essential and is an integral part of the fish-farm's management.

vi. **Feeding:** manual or using machinery: Providing fish with a nutritionally balanced diet is essential to grow a healthy stock of fish. In fish-farming, the variety of fish feed must be carefully considered because feed represents 70% of the production cost. Processed feeds are formulated to meet the basic nutritional requirements of fish. Quality fish feeds also need to be supplied to supplement essential nutrients, vitamins and minerals, making processed feed a convenient source of staple food for most farm-raised and aquarium fish. Processed dry feed includes flake, tablet, pellet and crumb forms. These feed types come in many different sizes to incorporate all types of fish. Some dry feeds are designed to float, while others are designed to sink to accomodate bottom feeders. Live fish food is an exceptionally good source of fish food. Feeding live food is necessary for fish with specialised needs, as in the case of many carnivorous fish, wild specimens and fry. Not only does live food mimic the feeding habits of fish in their natural environment, it can also provide many benefits that commercial feeds have not been able to replicate to this day.

## 10.3 Climate-smart agriculture practices in fisheries and aquaculture

Although it has been widely recognised that some fishery and aquaculture practices can have negative impacts on the environment, at the same time they also have some positive spin-offs towards environmental sustainability. Such environmentally sensitive practices should also be done being cognisant of the changing climate and climate variability to ensure sustained livelihoods. Aquaculture and fisheries best practices have minimum impacts to the environment, low GHG emissions and consume low amounts of water. Such practices promote innovation to reduce post-harvest losses. GHGs from fisheries and aquaculture can be reduced by improving fuel efficiency and reducing travel distance by increasing consumption closer to the source. CSA practices for fisheries and aquaculture are quite similar to other sectors such as agriculture and forestry. For instance, water harvesting technologies can also be employed and water then can

become available for aquaculture throughout the year. While the preceding section highlighted the current aquaculture systems in Zimbabwe, the changing environment requires innovations and technologies in CSA that enhance fish production in both capture fisheries and aquaculture. Such practices may include focus on the following research and development:

### 10.3.1 Fish feeds and fingerlings

Stock feeds gobble up 70% of the costs of aquaculture production. Currently, there is only one known commercial supplier of fish stock feed in Zimbabwe, Aquafeeds, which operates as part of the Profeeds Company (although Lake Harvest, the largest aquaculture producer in Zimbabwe supplies its local operations from its own plant in Uganda). As a result, there is no competition or incentives that could help reduce costs, and operating costs for aquaculture operators in Zimbabwe are quite high. Thus, approaches which can reduce costs would be beneficial. Research and development on fish-stock products that can provide essential trace minerals, as well as protein and fat at a reduced cost are vital if aquaculture feed stock costs are to be reduced. Such research could concentrate on developing various options to enhance feed stocks and could also include the use of locally available inputs such as maggots from domestic waste, Kikuyu grass, breeding insects and other invertebrates (which are high in both protein and fat content) for feed. This would ensure that fish stock feeds of various qualities and value are made available to farmers. This is crucial if aquaculture is to expand to become a substantial contributor of fish and protein in the country. Other methods that have been tried elsewhere and can be investigated and used for fish stocks in Zimbabwe include the use of natural products such as manure, crop/plant residues and enhanced algal and plankton production. Research can also be carried out on how to improve the quality of fingerlings coupled with cost-effective fish feeds. Better feeds and feeding practices that are more ecosystem friendly need to be adopted http://www.cfuzim.org/index.php/agriculture/8568-fish-farming-and-aquaculture-policy-in-zim.

### 10.3.2 Providing more effective and less wasteful feeding mechanisms

One of the problems plaguing fish-farmers in Zimbabwe is the wastage of food during the feeding of the fish. In addition, as the fish jostle for the food, they end up hurting each other, causing reductions in the productivity of the fish to some extent. There is therefore a need to devise better feeding mechanisms for a host of different fish farming methods. These can include the use of automated systems for multi-sensing and the analysis of water quality parameters interfaced with automatic controls to detect and regulate conditions to optimise the aquaculture environment, including feeding mechanisms in aquaculture ponds.

### 10.3.3 Pond and hatchery design and stocking

This is related to the feeding problems highlighted in the preceding section. There is a need to investigate the most effective designs of ponds, hatcheries and tanks that can house fish at different stages of development, including fingerlings and juvenile fish. This refers to issues of water environment, quality and quantity, fish-stocking densities, and ensuring optimum conditions for fish growth and development. http://www.fao.org/docrep/t8598e/t8598e05.htm. It is envisaged that varying designs and a suite of ponds and cages for housing fish can include ponds, tubs, tanks and raceways for use in different environments http://www.fao.org/docrep/t8598e/t8598e05.htm.

### 10.3.4 Post-harvest techniques and value addition

If fisheries and aquaculture production are to be enhanced in Zimbabwe, there is a need to develop smart post-harvest and value addition techniques. These may include such processes as deboning and packaging, freezing, and training on managing and maintaining equipment and operations. The techniques may also involve the use and application of well-researched preservation techniques in processing fish to retain quality and increase shelf life, as well as adding value to produce a wide variety of products. This also includes improved methods of known techniques such as drying fish by smoking, sun-drying and

salting. Novel technologies such as the use of solar dryers to mimic the natural drying process can be applied, given that sunshine is in plentiful supply in Zimbabwe. Techniques and technologies can revolve around the harvesting, storage, preservation, transporting and general handling of fish, while value addition may include tinning, filleting, mincing and developing other products such as fish paste. In addition, the production of several value-added products such as emulsion-based foods, Fish-protein Isolates (FPI), Fish-protein Hydrolysate (FPH), Homogenised Fish Protein (HFP) and gelatine, can be investigated, developed and continuously improved upon (Affognon et al., 2015).

### 10.3.5 Ecosystem approach

An ecosystem based approach is a holistic approach that encompasses all aspects of socio-economic factors and biophysical environment (FAO, 2010). This approach not only focuses on fisheries but views the sector as a combination of the various natural and manmade environments. It ensures use of practices that are sustainable for future generations. Given this view, aquaculture practices should not have negative impacts to other components of the environment. This practice also ensures the participation of various stakeholders from the public and private sector which also ensures that these stakeholders contribute towards capacity building, financial assistance, and formulation of new technologies for continued socio-economic sustainability. In Zimbabwe, we recommend that issues such as land tenure be investigated as in some cases farmers do not have rights over some resources such as land and water. There are some communities which are dependent on shared scarce water resources which might increase their vulnerabilities in the face of climate change http://www.fao.org/docrep/013/i1750e/i1750e00.htm.

#### Transformational adaptation

***Case study: From crops to fish farming***

Fish farming is being promoted in Mutasa District of Zimbabwe to diversify livelihood sources in the face of a changing climate. This is a relatively new undertaking for many farmers in the area as fish is not among the class of livestock often domesticated. Such “transformational” forms of adaptation where farmers take on entirely new production systems in response to a changing climate are quite distinct from more “incremental” approaches which seek to refine already existing systems. Involving new systems and, transformational changes are often quite daunting for farmers as they represent a steep learning curve. Sustained information, training and learning exchanges are key to this endeavour.

**The “how” of fish farming**

A key element of the interventions promoting fish farming in Mutasa District is the training and farmer exchange programmes that aim to provide exposure to farmers. Although this might look like a daunting undertaking for an outsider, those doing it emphasise that it is not as complicated as most might think. As described by Mr Saphiri, the technology is quite simple.

*Mr Saphiri—Transformational adaptation (from crops to fish)*

**Technical requirements of fish farming**

"Recommended ponds are those measuring 10m x 10m that can carry 500 fish from when they are fingerlings to maturity. The pond has a deeper end (1.5–1.8m) and shallow end (0.5 – 0.8m). The shallow end is where he feeds them from. When it's cold you see the fish going to the deeper end and when it's hot they prefer the shallow end. A pipe on the deep end is needed for cleaning purposes and drainage. During the first week fish are to be fed with Juvenile I, then Juvenile II and III in Week 2 and 3 respectively. It is important to check weight gain at regular intervals. After that, feed them Growers till harvesting time. Planting trees around the pond is generally not encouraged. Trees will interfere with sunlight, fish like warmer temperatures.

The issue of oxygen is critical—running water is the best as fresh water brings naturally dissolved oxygen. Still water systems are also possible if one does not have running water. These just need more regular cleaning to avoid accumulation of dirt from things like fish excreta. How do you detect low oxygen levels? When you see fish staying on top of the water it suggests oxygen levels are low. The pond might be dirty, so you need to clean and add fresh water. Ensure that there are not too many green plants in the water as this may reduce oxygen levels, particularly in the evening when there is competition for oxygen so fish may die. Algae has to be present but the quantities have to be managed to avoid competition."

*Mr Jombe, Agritex, Mutasa District*

**Can fish farming offer a viable CSA alternative at scale?**

The idea of fish farming is getting broader acceptance. In this Ward alone two groups are constructing ponds. Each group has 38 individuals, mostly women. The interest came after the field day that was held by Mr Saphiri. The groups are using more water efficient systems of ponds that uses plastic lining (dam liners) to prevent any seepage of water. Tilapia fish can easily adapt to most climates and fish generally prefer warmer climates. This is compatible with a trend of rising temperatures that is expected to continue with climate change in the country. As such fish farming (especially with breeds like Tilapia) has the potential to do well in every part of country as long as one has a source of fresh water. The low cost of infrastructure and low operating costs also mean that this option is accessible to even poorly resourced farmers. The local market is grossly undersupplied with fish, meaning that there is a huge opportunity for marketing of fish across the country. It's clear that this is a viable investment option for diversifying rural livelihoods in the face of a changing climate. Considerable investment is however required for support training of extension staff, learning exchanges for farmers and for bigger projects, deploying necessary financing.

**Lessons Learnt from Mr Saphiri**

Detailed technical understanding of fish farming displayed by the local AGRITEX official, Mr Jombe, and the Fish Farmer himself, Mr Saphiri, is very encouraging. Even though this is a relatively new enterprise, the training programmes seem to be very effective and the required information and experience is now available locally. With more exposure for farmers through field days and additional investment in extension services, the prospects for fish farming in Mutasa district seem good.

## 10.4 Fisheries

Inland capture fisheries have been the major source of fish in Zimbabwe where more yields were realised when compared to yields from aquaculture. FAO statistics show that before 2014, more fish yields were realised from capture fisheries rather than aquaculture (FAO, 2016b, http://www.fao.org/fishery/facp/ZWE/en). Capture fisheries involve fish extraction from surface waters (Welcomme et al., 2010). This type of fishery remains important to Zimbabwe's fisheries sector as most of the country's private and public dams are home to the practice of capture and recreational fisheries. Large scale commercial capture fisheries are present at Lake Kariba followed by Lakes Manyame and Mutirikwi as well as Chivero and Mazvikadei Dam (FAO, 2003, http://www.fao.org/fi/oldsite/FCP/en/ZWE/body.htm). Inland capture fisheries are often characterised by small-scale or household fishing which raises participation at various levels for local consumption (Welcomme et al., 2010). More often, increased participation reportedly accounts for overfishing, leading to reduced wild fish stocks and possible extinction of species in rivers and dams.

### 10.4.1 Drivers of capture fisheries

**Demand** is the major driver which most often leads to an increase of capture fisheries.

**Economic conditions** drive and shape consumer choices especially when it comes to food. When economic conditions deteriorate, people resort to cheaper sources of food and nutrients such as fish which are a good yet cheap source of protein.

**Policies and management/regulations** of a country also drive demand to some extent as it creates an enabling environment. Effective regulation of fisheries from guiding policies to enforcement stabilise capture fisheries whilst lack of regulation and enforcement will lead to increased capture fisheries. Zimbabwe has relatively progressive fisheries development policies whose objectives are inclusive of the following:

i. Knowledge-based management approach;
ii. Economic growth that is pro-poor; and
iii. Food security

The principal objective of the management of Lake Kariba and other water bodies is the maintenance of optimum sustainable yields of fish populations by promulgating and enforcing conservation principles. The development, control and management of fisheries in Zimbabwe are sufficiently covered by enabling laws.

**Fishery enhancement** is as a result of fish introductions to lakes for enhanced fish production. This tends to promote increased capture fisheries as fish stocks are increased. An example of this driver is the Command Fisheries Programme introduced by the Government of Zimbabwe in 2017 which has seen the introduction of fish into major dams with 700,000 fingerlings distributed across 20 districts in the country through the Ministry of Environment, Water and Climate's Zimbabwe Parks and Wildlife Management Authority. The Programme was launched in the newly commissioned Tokwe-Mukosi Dam where over 20,000 fingerlings were stocked with an additional 1.5 million fingerlings expected to be stocked in the same reservoir by the end of the year (New ZIANA, 2017; http://www.bh24.co.zw/government-embarks-on-command-fish-farming/). ZPWMA) has also recently stocked Insukamini Dam with 100,000 fingerlings in Midlands Province, while over 110,000 fingerlings have been stocked in other dams that excludes Insukamini. Figure 10.4 shows fish introduced into Biri Dam (Mashonaland West Province) as part of the Programme. Unfortunately, these fish did not survive the introduction.

***Figure 10.4 Fish introductions in Biri Dam, Mashonaland West, Zimbabwe as part of the National Command Aquaculture Programme. Picture was taken during the annual waterfowl count at Biri Dam (July 2017), courtesy of Chinhoyi University of Technology's Department of Wildlife, Ecology and Conservation***

## 10.4.2 Current methods of capture farming (based on fishing gear) and their impacts

**Use of gill nets** – gill nets are the most common gear used for fishing at commercial scale. The governing body for capture fisheries, the Zimbabwe Parks and ZPWMA sets the specific mesh sizes of gillnets to be used for fisheries and they also enforce the use of the standard mesh-sizes by fishing cooperatives. The Authority is also responsible for regulating the material used in the manufacture of gill nets to minimise the long-term effects of ghost-fishing when gillnets are torn and lost in lakes, dams or rivers. Ghost fishing occurs when gillnets used for fishing are torn away from where they are set and are carried to other parts of water bodies where they continue to "catch" fish or other organisms especially when they are not biodegradable. Oftentimes, gill nets do not just catch fish, they can potentially catch anything that happens to try and swim through them.

**Seine-netting** – This form of fishing is also used in the country besides gill-netting. An impact of this fishing method is that it results in large amounts of by-catch. In Lake Kariba where the bulk of fishing is mainly based on Kapenta (Limnothrissa miodon), use of seine nets results in by-catches of tigerfish (Hydrocynus vittatus).

**Electro-fishing** – This type of fishing is mostly done as part of research when different sized fish from juveniles to adults are sought. Special research permits from ZPWMA are required before this can be practiced.

**Rods** – Small scale fishing by local people usually involves the use of fishing rods which make use of bait to capture fish. The number of hooks per fishing rod is restricted by the ZPWMA and a bag system which restricts the number of fish to be caught per day is used. Overall, this method minimises the risk of overfishing.

**Other informal fishing methods** – As capture fisheries are characterised by numerous small-scale fishers for household consumption, some methods of fishing are often improvised at local level without adhering to standard methods of fishing. Fishermen prefer to use traditional and illegal methods, which also kill fingerlings. This can include drown nets, mosquito nets or old tin cans with food inside as fish bait which is often detrimental to the growth of the fishing industry.

### 10.4.3 Conservation and sustainability of fisheries

The drivers of capture fisheries described in this chapter can lead to increased and unregulated fishing by both commercial and small-scale fishers. This can threaten the sustainability of natural fish stock in dams and more so, under a changing climate. Thus, conservation measures, including direct controls on catches and/or fishing, are designed to reduce death rates due to fishing and pollution, especially on small juvenile fish. These control measures include restricting fishing gear size, closing up areas which are restricted from fishing such as river mouths, and permitting only licensed users to fish (FAO, 2016b). Similarly, there will always be an incentive to reduce mesh size further or to fish in previously closed areas to catch more abundant stocks of fish that are being protected by conservation measures.

Demand for fish and advances in technology have led to fishing practices that are depleting fishery resources. Sustainable fishing guarantees that there will be populations of freshwater wildlife for the future (Box 10.1). It is important to follow practices such as those in the Philippines, where the Tagbanua people have traditionally employed fishing practices that simultaneously harvest and maintain fish populations (National Geographic Society, 2017, https://www.nationalgeographic.org/encyclopedia/sustainable-fishing/). They fish for specific species only during certain times of the year and set aside certain areas, such as protected spots, in which fishing is prohibited. They use hook-and-line methods, catching only what they need to feed themselves and their communities. Conservation approaches are important in the wake of climate change and variability which have been shown to bear a compounded negative effect on fish production among other factors and have been attributed to the declining fish stocks in the major fishery of Kariba (Ndebele-Murisa et al., 2011; Marshall, 2012).

***BOX 10.1 Fishing nets in Africa***

The Shangani people of South-eastern Zimbabwe use reed nets and fish traps (maduwo) that have holes big enough to allow juvenile fish to pass through but small enough to trap the adult fish. This ensures sustainability by allowing the younger fish to survive and provide a brood stock for the next season. Present-day fish poachers use similar traps but these will be covered with mosquito nets which trap every size of fish and preserve nothing for the future. Even most gillnets used by commercial and artisanal fishermen today grossly infringe the mesh sizes prescribed by the Parks and Wildlife Act. The Shangani Chiefs would prohibit fishing in nursery zones and during spawning periods, a method also adopted in modern fishing regulations, but today we see a lot of protected areas being fished out. Hopefully, the National Fisheries Policy being developed for Zimbabwe will address these issues by reviewing traditional fishing methods and learning from them. Because of the need to feed more people today and export our products, aquaculture should be encouraged so that we can balance the conservation of wild fish populations versus demand with increased fish production.

## 10.5 Climate-smart agriculture: system approaches

System approaches denote that whole systems that lead to best practices for climate-smart agriculture must be considered rather than looking at single elements or practices in CSA. System approaches in CSA would therefore entail detailed analysis of ecosystems, value chains and landscapes (AG Team, 2016, https://agrilinks.org/blog/watch-systems-approach-climate-smart-agriculture).

### 10.5.1 Ecosystems

#### 10.5.1.1 Climate change

Evidence shows that many of the effects of a changing climate are already occurring, including an increase in the surface water temperature of lakes and rivers (IPCC, 2014; NASA, 2017, https://climate.nasa.gov/effects/). It is likely that these trends will continue and that there will be changes in the flow regime of streams and rivers associated with projected changes in the amount, seasonality, intensity and distribution of precipitation. This will cause an increase in the transport of sediments and nutrients downstream to lakes, as well as changes in precipitation, evaporation and flooding dynamics that will cause changes in water levels, habitat structure and water residence times in wetlands. Climate change will also result in shifts in ecological conditions by supporting the spread of pathogens, parasites and diseases, with potentially serious effects on human health, agriculture and fisheries.

#### 10.5.1.2 Invasive species and diseases

Climate change-induced alterations of ecosystem conditions can enable the spread of invasive species (Thomas et al, 2008) through both range expansion and the creation of habitats and conditions that are suitable for newly introduced invasive species. Invasive species are generally viewed as having a broader range of tolerances (i.e., a bigger bioclimatic envelope) than natives, thereby providing invaders with a

wider array of suitable habitats (Walther et al., 2009). A shift in temperature, for example, might then have significant impacts on a native species, but little impact on introduced species, thereby altering the competitive dynamics between them. The broad categories of climate change impacts on species composition and ecosystems are gradually becoming better defined, though the full implications of these types of changes, particularly at the site level are still unknown and could be unique in each case.

#### 10.5.1.3 Socioeconomic issues: livelihoods and resilience

Climate change has already had significant impacts on the livelihoods of communities and households, especially in the drought-prone regions of Zimbabwe. In these areas, adequate water resources are available (e.g., Binga with access to Lake Kariba), thus a shift towards greater dependence on aquaculture and fishery resources is inevitable. The introduction of CSA methods is therefore vital for the sustainability of such practices and for ensuring food security for these communities. It is also important to guard against the imposition of certain technologies that may not be acceptable to these communities.

## 10.6 Value chains

### 10.6.1 Transportation of products from source to markets

Zimbabwe has a fairly good road network, but for fish products there is still need for specialised transport vessels. The cost of fuels and the poor road conditions and networks compromises the market price of the product, although fish remain relatively cheap compared to other livestock products.

### 10.6.2 Live translocation of aquatic animals

During the period that is required to bring the fry up to market size, the fish will be physically transferred several times (from pond to pond, pond to cage etc.), it is therefore important to foresee the acquisition of all the equipment necessary for these movements.

### 10.6.3 Post-harvest technologies

The supply chain includes all links from the point of production (point of catch or farm site in the case of aquaculture) to the end-user or final consumer. The supply chain for fish and fishery products can involve a large number of people between the fisher or fish-farmer and the final consumer. The supply side of fish and fishery products is affected by factors such as market demand, prices, seasonality, climatic conditions, population dynamics, economic situation, fuel prices, and the policy and legal environment. The perishable nature of fish requires special attention to handling, grading and packing, and the market price is usually dependent upon its quality, although this is not always the case when demand does not match supply.

The application of modern fishery technology starts from culture and ends in exporting the product. As noted earlier, post-harvest fishery technology involves processing, preservation, handling, harvesting and marketing. In developing countries, such as Zimbabwe where tropical weather and under-developed infrastructure contribute to the problem, losses sometimes reach staggering proportions. Losses occur in all operations, from harvesting to handling, storage, processing and marketing. Many developing-country producers are marginalised from global supply chains due to their poor maintenance of quality standards. In general, low-tech developing country suppliers earn less for their resources, whereas industrial nations earn extra premiums by means of marketing information systems, supply chain management, quality assurance regimes, transport, handling, post-harvest and production technologies. A number of the donor-driven aquaculture initiatives as mentioned earlier in this chapter endeavour to teach fish farmers some post-harvest techniques but this knowledge and practice has not been fully utilised to prolong the shelf life of fish post-harvest. However, notable examples of best practices when it comes to meeting high standards for harvesting fish such as Lake Harvest and Kariba Bream can be emulated and encouraged across the nation.

### 10.6.4 Public health issues

As with any agricultural commodity, both actual and potential public health hazards exist. Some of these can be prevented, but others are still unknown because of the lack of science-based assessment of human risk and inadequate diagnostic and detection procedures. The proper cleaning, processing, storage, handling and marketing of these highly perishable products, the restriction of consumption to properly cooked products and attention to sanitary operating procedures will minimise potential safety hazards. Health problems may arise when abuse of regulations and carelessness occur. Other public-health risks in some locations are linked to the transmission of diseases by insect or snail vectors, such as schistosomiasis and malaria.

## 10.7 Enabling environment for CSA

Enabling CSA environments are the framework conditions that facilitate and support the adoption of climate-smart technologies and practices. They include policies, institutional arrangements, stakeholder involvement, gender considerations, infrastructure and insurance schemes, as well as access to weather information and advisory services. They help build institutional capacity at all levels and reduce the risks that deter farmers from investing in new technologies and practices (https://www.csa.guide/csa/enabling-environments).

Policies should be put in place that strengthen institutions in support of CSA for fisheries and aquaculture development in Zimbabwe. All stakeholders from private and public sectors will need to be involved in the development of context-specific options to ensure the fisheries and aquaculture sector is climate-smart. There should also be capacity building at grassroots level as some CSA practices require expertise in order for them to be successful. There is need as a country to think around how we can acquire the necessary competencies and integrate the various stakeholders so as to provide resilience through an interdisciplinary approach.

### 10.7.1 Policy review and analysis

The creation and implementation of appropriate policies and an enabling environment are essential for achieving the widespread adoption of CSA in Zimbabwe. In general, the objective in CSA policy engagement is to guide policies and remove components that act as disincentives for adopting CSA such as public subsidies, while reallocating resources to programmes that provide incentives for the adoption of CSA. Policy tools and instruments, such as rural credit programmes, input- and output-pricing policies, subsidies, support for investments with public-good benefits, property rights, research and extension services and safety net programmes can all be used to increase the incentives for the actors involved, including farmers, to modify production systems and build capacities for CSA (FAO, 2013). Zimbabwe's bilateral/international obligations include the Protocol on Economic and Technical Cooperation concerning the Management and Development of Fisheries on Lake Kariba and the Transboundary Waters of the Zambezi River, the SADC Protocol on Fisheries, the Convention on Biological Diversity, CITES and the Ramsar Convention. Zimbabwe is also a member of the Aquaculture Network for Africa (ANAF), all of which are more technically binding and aimed at conservation rather than sustainable use.

### 10.7.2 Legislation

The Parks and Wildlife Act (Chapter 20:14) lays down the regulations for aquaculture management in Zimbabwe, while the Zimbabwe Parks and Wildlife Management Authority grants authority for the development of aquaculture on state dams and in waters designated as recreational parks. However, recent developments within the Ministries of Water, Environment and Climate, and that of Agriculture, Mechanisation and Irrigation Development are overseeing the development of a fisheries and aquaculture policy framework that will revolutionise the implementation of aquaculture programmes in the country and its development is set to be finalised soon.

### 10.7.3 Role of Public-Private Partnerships

Public-private Partnerships (PPP) will strengthen the implementation of sustainable aquaculture and fisheries programmes. For example, the recent formation of the Zimbabwe Fish Producers Association in 2016, which is all inclusive and focuses on increasing aquaculture production in the country is a case in point.

### 10.7.4 Research and development, training and extension

Research institutions and academia continue to play a leading role in CSA initiatives in the aquaculture sector and a key area in this regard is the improvement of fingerling and feed production and supply as mentioned earlier, as well as extension services. In terms of training, the development of robust capacity building and curricula in fisheries and aquaculture that meet the industry's needs as well as tailored internships and mentorship at fish farms and aquaculture-related industries as reflected by the resolutions made by the SADC-WorldFish-FAO Aquaculture Expert Working Group (2016) are essential for Zimbabwe. A few positive steps have been made in that direction with the University of Zimbabwe's, University Lake Kariba Research Station (ULKRS), for instance, having been awarded EU funding via World Vision for the construction of an experimental aquaculture facility that will spearhead research in the country. The Department of Freshwater and Fishery Science at Chinhoyi University is working with WorldFish and Lake Harvest towards the development of aquaculture research and training services such as short courses and attachment for practical experience. The Zimbabwean Government, through the Research Council of Zimbabwe, should prioritise the funding of CSA research in line with the national economic blueprint—the Zimbabwe Agenda for Sustainable Socio-Economic Transformation (ZimAsset).

### 10.7.5 Gender issues

Gender mainstreaming in the fisheries and aquaculture industries is of paramount value in CSA, as most vulnerable populations include women and children. The empowerment of women in fish production sectors has already set a pace in aquaculture production and poverty alleviation. Most case studies and running projects in fish farming in Zimbabwe have women in leading roles. Drawing more attention and education of women in this sector will be one of the key drivers of success in the implementation of CSA.

## 10.8 Conclusions

This chapter has described the history, development, status and potential of the fisheries and aquaculture sectors of Zimbabwe. Scenarios of the development and implementation of climate-smart approaches in these sectors were discussed. Zimbabwe is set for increased production and development in fisheries and aquaculture despite a changing climate. CSA approaches and practices present opportunities to grow the fisheries and aquaculture industry in order to meet growing demand and to enable water and soil conservation within a sustainable framework.

## References


1. African Development Bank (AfDB) 2011. *AfDB supports largest tilapia fish farm in Zimbabwe. African Development Bank Group*. https://www.afdb.org/en/news-and-events/afdb-supports-largest-tilapia-fish-farm-in-zimbabwe-8508/.
2. African Development Bank (AfDB) 2008. *Review of the performance of the current fisheries portfolio of the African Development Bank: Brief to the Board*. Agriculture and Agro-Industry Department – OSAN.
3. Affognon, H., Mutungi, C., Sanginga, P. and Borgemeister, C., 2015. *Unpacking postharvest losses in sub-Saharan Africa: a meta-analysis*. World Development, 66, pp.49-68.
4. AG Team 2016. WATCH: *A systems approach to Climate-Smart Agriculture.* Agrilinks. https://agrilinks.org/blog/watch-systems-approach-climate-smart-agriculture.
5. Agular-Manjarrez, J. and Nath, S.S. 1998. *A strategic reassessment of the fish farming potential in Africa.* FAO, Committee for Inland Fisheries of Africa. Rome, Italy
6. Angel, D. and Freeman, S., 2009. *Integrated aquaculture (INTAQ) as a tool for an ecosystem approach to the marine farming sector in the Mediterranean Sea*. Integrated mariculture: a global review: 133-183.
7. Bardach, J.E., Ryther, J.H. and McLarney, W.O. 1974. *Aquaculture. The farming and husbandry of freshwater and marine organisms.* Cambridge, UK: John Wiley & Sons, Inc. http://eu.wiley.com/WileyCDA/WileyTitle/productCd-0471048267.html.
8. Bradeley, K. 2014. *Aquaponics, a brief history.* https://www.milkwood.net/2014/01/20/aquaponics-a-brief-history/
9. Brown, D., Chanakira, R.R., Chatiza, K., Dhliwayo, M., Dodman, D., Masiiwa, M., Muchadenyika, D., Mugabe, P. and Zvigadza, S. 2012. *Climate change impacts, vulnerability and adaptation in Zimbabwe*. International Institute for Environment and Development (IIED) Climate Change Working Paper 3. http://pubs.iied.org/pdfs/10034IIED.pdf.
10. Chingono, N. 2014*. EU maintains Zim beef exports ban.* Daily News, 16 February 2014. https://www.dailynews.co.zw/articles/2014/02/16/eu-maintains-zim-beef-exports-ban
11. Coche, A.G. 1994. *Aquaculture development and research in sub-Saharan Africa*. FAO, Rome, Italy.
12. Commercial Farmers Union of Zimbabwe (CFU) 2017. *Fish farming and aquaculture policy in Zimbabwe.* http://www.cfuzim.org/index.php/agriculture/8568-fish-farming-and-aquaculture-policy-in-zim.
13. Crespi, V. and Coche, A. 2008. *Food and Agriculture Organization of the United Nations (FAO) Glossary of Aquaculture*. Rome, Italy.
14. Diver, S. 2006. *Aquaponics- Integration of Hydroponics with Aquaculture*, (https://attra.ncat.org/attra-pub/viewhtml.php?id=56
15. Dumont, B., Fortun-Lamothe, L., Jouven, M., Thomas, M. and Tichit, M. 2013. *Prospects for agroecology and industrial ecology for animal production in the 21st century.* Animal 7: 1028-1043.
16. Egna, H.S. and Boyd, C.E. 1997*. Pond aquaculture. CRC Press,* Washington DC, USA.
17. Food and Agriculture Organisation of the United Nations (FAO) 2003. *Information on fisheries in the Republic of Zimbabwe.* Food and Agricultural Organisation. www.fao.org/fi/oldsite/FCP/en/ZWE/body.htm.
18. Food and Agriculture Organisation of the United Nations (FAO) 2010. *Aquaculture Development.* http://www.fao.org/docrep/013/i1750e/i1750e00.htm.
19. Food and Agriculture Organisation of the United Nations (FAO) 2013. *Climate-Smart Agriculture: Sourcebook-Rome*, Italy: Food and Agriculture Organization of the United Nations.
20. Food and Agriculture Organisation of the United Nations (FAO) 2014. *The state of world fisheries and aquaculture 2014: Opportunities and challenges*. http://www.fao.org/3/a-i3720e.pdf

21. Food and Agriculture Organisation of the United Nations (FAO) 2016a. *The state of world fisheries and aquaculture 2016: contributing to food security and nutrition for all.* Rome: Food and Agriculture Organization of the United Nations, 200 pp. http://www.fao.org/3/a-i5555e.pdf.

22. Food and Agriculture Organisation of the United Nations (FAO) 2016b. *Fishery and Aquaculture Country Profiles: The Republic of Zimbabwe.* Food and Agricultural Organisation. *Accessed 28 July 2017*, http://www.fao.org/fishery/facp/ZWE/en.

23. Food and Agriculture Organisation of the United Nations (FAO), 2017. *Fishery and Aquaculture Country Profiles: The Republic of Zimbabwe.* http://www.fao.org/fishery/facp/ZWE/en.

24. Gith, T. 2013. *Sustainable farming project combines aquaculture hydroponics,* http://www.dw.com/en/sustainable-farming-project-combines-aquaculture-and-hydroponics/a-16927582.

25. Gumbo, D. 2010. *Regional review of sustainable forest management and policy approaches to promote it – Sub-Saharan Africa.* Background Paper for the UNEP Green Economy Report.

26. Hecky, R.E., Mugidde, R., Ramlal, P.S., Talbot, M.R. and Kling, G.W. 2010. *Multiple stressors cause rapid ecosystem change in Lake Victoria*. Freshwater Biology 55(1): 19-42.

27. Jamu, D.M. and Ayinla, O.A. 2003. *Potential for the development of aquaculture in Africa.* WorldFish Center Quarterly 26(3): 9-13.

28. Intergovernmental Panel on Climate Change (IPCC) 2007. *Freshwater resources and their management,* in Parry M.L., Canziani O.F., Palutikof J.P., Van der Linden P.J. and Hanson C.E. (eds.). Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK. 976 pp.

29. Intergovernmental Panel on Climate Change (IPCC) 2013. *Summary for Policymakers, in Alexander, L. et al. (drafting authors.).* Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.

30. Intergovernmental Panel on Climate Change (IPCC) 2014. In, Niang I. et al*. Africa- Chapter 22. Contribution of Working Group 2 to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, UK. http://ar5-syr.ipcc.ch/resources/htmlpdf/WGIIAR5-Chap22_FINAL/.

31. Kapetsky, J.M. 1994*. A strategic assessment of warm-water fish farming potential in Africa. CIFA Technical Paper No. 27*. FAo, Rome, Italy. Katunga, R. 2016. Bass fishing at Mayfair Dam. The Sunday News, March 13, 2016. Accessed 18 March 2017, www.sundaynews.co.zw/bass-fishing-at-mayfair-dam.

32. Land based aquaculture assessment framework 2017. *Integrated Aquaculture – IMTA* www.lbaaf.co.nz/land-based-aquaculture/integrated-aquaculture/.

33. Little, D., Edwards, P., Nations, F. A. O. O. T. U. and Service, I. W. R. 2003. *Integrated livestock-fish farming systems,* FAO, Rome, Italy.

34. Love, D.C. Fry, J.P., Genello, L., Hill, E.S., Frederick, J.A., Li, X. and Semmens, K. 2014. *An international survey of aquaponics practitioners PLoS* One 9 (7) p. e102662.

35. Mandima, J. 1994. *Aquaculture development and research in Zimbabwe.* In: Coche, A.G. Aquaculture development and research in sub-Saharan Africa. FAO, Rome, Italy.

36. Mandima, J. 1995. *Socioeconomic factors that influence the adoption of small-scale rural fish farming at household level in Zimbabwe.* Naga, the ICLARM Quarterly, 18(2), pp. 25-29.

37. Marshall, B.E. 2012. *Does climate change really explain changes in the fisheries productivity of Lake Kariba (Zambia-Zimbabwe)?* Transactions of the Royal Society of South Africa, 67(1), 45-51.

38. Moehl, J., Brummett, R., Boniface, M.K. and Coche, A., 2006. *Guiding principles for promoting aquaculture in Africa: benchmarks for sustainable development.*

39. Mugandani R., Wuta M., Makarau A. and Chipundu B. 2012. *Re-classification of agro-ecological regions of Zimbabwe in conformity with climate variability and change.* African Crop Science Journal 20: 361-369.

40. Mutimukuru-Maravanyika, T, Nsonga, A., Mudenda, H.G., Mwiya, S., Beveridge M and Chimatiro, S. 2015. *Zambia fisheries sector overview: State, challenges and key recommendations.* WorldFish, Lusaka, Zambia

41. Mukaro, A. 2016. *Zim beef exports face EU ban*. Zimbabwe Independent. www.the.independent.co.zw/2006/03/31/zim-beef-exports-face-eu-ban/.

42. NASA 2017. *The consequences of climate change*. https://climate.nasa.gov/effects/.

43. National Geographic Society 2017. Sustainable fishing. https://www.nationalgeographic.org/encyclopedia/sustainable-fishing/.

44. Ndebele-Murisa, M.R., Mashonjowa, E. and Hill, T. 2011. *The decline of Kapenta fish stocks in Lake Kariba–a case of climate changing?* Transactions of the Royal Society of South Africa, 66(3), 220-223.

45. Ndebele-Murisa, M., Musil, C. F. and Raitt, L. 2010. *A review of phytoplankton dynamics in tropical African lakes*. South African Journal of Science 106: 1-6.

46. Ndebele-Murisa, M.R. and Mubaya, C.P. 2015. *Climate change: impact on agriculture, livelihoods options and adaptation strategies for smallholder farmers in Zimbabwe.* In: Murisa, T. and Chikweche, T. (eds.). Beyond the crises: Zimbabwe's transformation and prospects for development. Harare, Zimbabwe: TrustAfrica and Weaver Press, pp. 155-198.

47. Ndebele-Murisa M.R. 2014. *Associations between climate, water environment and phytoplankton production in African lakes.* In, Sebastiá M.T. (Ed.) Phytoplankton: Biology, Classification and Environmental Impacts. Nova Science Publishers Inc, New York, ISBN: 978-1-62948-652-9 Pp 37-62.

48. Ndebele-Murisa M.R., Kimirei I.A., Mubaya C.P. and Bere T. (Eds.) 2017 (*In Press*). *Ecological changes in the Zambezi River Basin*. CODESRIA Book Series, Dakar. ISBN 978-2-86978-713-1.

49. New ZIANA 2017. *Government embarks on command fish farming*. Business Around the clock, BH24, 8 June 2017. http://www.bh24.co.zw/government-embarks-on-command-fish-farming/.

50. Rakocy, J.E., Masser, M.P. and Losordo, T.M., 2006. *Recirculating aquaculture tank production systems: aquaponics—integrating fish and plant culture.* SRAC publication, 454, pp.1-16.

51. Ridler, N. and Hishamunda, N. 2001. *Promotion of sustainable commercial aquaculture in sub-Saharan Africa.* Volume 1. Policy framework. FAO Fisheries Technical Paper. No. 408/1. Rome, FAO, 67p.

52. Rural Fisheries Programme 2010. *A manual for rural freshwater aquaculture. Rural Fisheries Programme.* Department of Ichthyology and Fisheries Science, Rhodes University

53. Saliling, W.J.B., Westerman, P.W. and Losordo, T.M., 2007. *Wood chips and wheat straw as alternative biofilter media for denitrification reactors treating aquaculture and other wastewaters with high nitrate concentrations.* Aquacultural Engineering 37(3): 222-233.

54. Sithole, A. and Murewi, C.T.F. 2009. *Climate variability and change over southern Africa: impacts and challenges.* African Journal of Ecology 47: 17-20.

55. Thomas, R., Kane, A. and Bierwagen, B.G. 2008. *Effects of climate change on aquatic invasive species and implications for management and research.* http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1045&context=usepapapers.

56. UNDESA 2013. *World Population Prospects: the 2012 revision.* New York, Population division, United Nations (UN). http://esa.un.org/wpp/.

57. Walther, G.R., Roques, A., Hulme, P.E., Sykes, M.T., Pyšek, P., Kühn, I., Zobel, M., Bacher, S., Botta-Dukát, Z., Bugmann, H. and Czucz, B., 2009. *Alien species in a warmer world: risks and opportunities*. Trends in Ecology and Evolution 24(12): 686-693.

58. Watershed 2010. *A Manual for Rural Freshwater Aquaculture Fisheries.* http://www.nda.agric.za/doaDev/sideMenu/fisheries/03_areasofwork/Aquaculture/AquaDocumentation/ManualRuralFreshwaterAquaculture.pdf.

59. Welcomme, R. L., Cowx, I. G., Coates, D., Béné, C., Funge-Smith, S., Halls, A., and Lorenzen, K. 2010. *Inland capture fisheries.* Philosophical Transactions of the Royal Society B: Biological Sciences 365(1554): 2881-2896. http://doi.org/10.1098/rstb.2010.0168.

60. Whitis, G.N. 2002. *Watershed Fish Production Ponds: Guide to Site Selection and Construction.* Southern Regional Aquaculture Center Publication No. 102.

61. World Bank 2016. *Climate driven water scarcity could hit economic growth by up to 6 per cent in some regions..* The World Bank. www.worldbank.org/en/news/press-release/2016/05/03/climate-driven-water-scarcity-could-hit-economic-growth-by-up-to-6-percent-in-some-regions-says-world-bank

62. World Health Organisation (WHO) 2008. *Key issues on the safe use of wastewater and excreta in aquaculture* http://www.who.int/water_sanitation_health/wastewater/Volume3_v2.pdf.

63. Zimbabwe National Parks and Wildlife Act. *Parks and Wildlife* Act 20:14. http://www.parlzim.gov.zw/acts-list/parks-and-wild-life-act-20-14. Government Printers, Harare, Zimbabwe.

64. Zimbabwe Parks and Wildlife Management Authority (ZPWMA) 2017. *The Zimbabwe Parks and Wildlife Management Authority: Parks Overview.* www.zimparks.org/index.php/hm.

# 11. Energy management in agriculture

## Abstract

Energy is essential for agriculture in Zimbabwe. On the other hand, energy generated from fossil fuels results in emissions of greenhouse gases which are linked to climate change. Therefore this chapter endeavours to advocate renewable forms of energy which have a benign effect on climate change. These renewable sources of energy are the sun (solar energy), wind, water and geothermal energy. The intensive use of energy in modern agriculture calls for judicious management of traditional forms of energy, coupled with the accelerated diffusion of technologies that are related to renewable forms of energy. This is imperative for sustainable food production. The chapter assesses the extent to which renewable energies and energy management opportunities can support the triple-win strategy being promoted through the CSA concept. The combination of renewable energy and improvements in efficiency contribute to all three pillars of CSA, i.e., improving productivity, climate resilience and reducing emissions from fossil fuel utilisation. Zimbabwe has a high potential for the exploitation of renewable energy. A number of solar PV projects have been implemented demonstrating the suitability, sustainability and economic convenience of off-grid solar power installations. Other projects that have shown good results are biomass use from wood waste, bagasse, and biogas generation from bio-digesters. Although the average wind speed in Zimbabwe (3m/s) is relatively low, developments in wind technology make power generation and water pumping feasible. Finally, the chapter shows that there is need for the capacity-building and strengthening of tertiary institutions that teach and conduct research on energy efficiency and renewables.

**Key Words:** adaptation, energy conservation, energy efficiency, energy management, GHG emissions mitigation, renewable energy

## Key messages

By the end of the chapter, students and agricultural practitioners should be able to:

i. define the terms energy management, energy conservation, energy efficiency and renewable energy;
ii. understand the role of Energy Management (EM) and Renewable Energy (RE) in agriculture;
iii. understand the link between energy use, food production and GHG emissions;
iv. know how to identify Significant Energy Users (SEU) as a prerequisite for EM interventions;
v. identify EM opportunities;
vi. have an appreciation of the potential application of RE in agriculture;
vii. understand typical barriers to implementing Energy Efficiency (EE) measures and RE technology deployment and uptake, and suggest ways to overcome them; and
viii. know the regulatory and institutional set up of EM and RE in Zimbabwe.

## 11.1 Introduction

### 11.1.1 Definitions of energy management and renewable energy

**Energy management (EM),** in the context of this chapter, refers to managing all forms of energy used at the farm and beyond the farm gate, as well as optimising operations and processes of value chain addition to reduce energy usage and costs by implementing an Energy Management System (EMS). This requires the judicious and effective use of energy to maximise profits (minimise costs) and enhance competitive positions. EM requires use of action plans that focus on two major components: Energy Conservation (EC) and Energy Efficiency (EE). Simply put, EM uses less energy for the same output without compromising on quality.

**Energy conservation** involves activities which reduce the wasteful use of energy usage through appropriate behavioural aspects (i.e., if you do not need, switch it off). The term energy efficiency is widely used, but not always well understood. According to UNIDO (2011), EE may be defined as the ratio of useful outputs to energy inputs for a system where the latter may be an individual energy conversion device (e.g., a boiler), a building, an industrial process, a firm, a sector or an entire economy.[10]

**Renewable Energy (RE)** is any energy source that is naturally replenished, that is, from a source that is not depleted when used, such as solar, wind, geothermal, biomass or hydroelectric generation.

### 11.1.2 Energy, climate change and agriculture

Worldwide agricultural energy activities are largely fossil-dependent. To enhance food security while at the same time reducing reliance on fossil fuels in agro-processing activities, there is need to engage in sound management of energy systems (to decouple energy use from increased agricultural productivity), as well as to shift to the use of renewables to mitigate climate change. Climate change threatens the stability and productivity of agricultural systems in Zimbabwe. Agriculture is itself the second major GHG-emitting sector after the energy sector. Therefore, there is a need to address issues of sustainable food production, climate resilience and mitigation.

### 11.1.3 Energy and gender in agriculture

In Zimbabwe, women and girls are often primarily responsible for gathering biomass for the household's energy needs, a reflection of traditional socio-cultural roles. Rural electricity access is only about 21%, reflecting the challenge of energy scarcity and thus increasing biomass usage. According to the SADC Renewable Energy and Energy Efficiency Status Report (REN 21, 2015), Household Air Pollution (HAP) arising from the use of biomass for cooking is affecting about 9.6 million people in Zimbabwe, and approximately 9,200 deaths a year are attributed to it. Sociological and behavioural changes, as well as economic and financial incentives to broaden technical options should be explored to lessen the domestic energy burden on these women and girls. These include, improved cooking stoves and fuel efficiency, a switch to local renewable energy resources for electricity generation, Liquefied Petroleum Gas (LPG) use and raising awareness.

## 11.2 Energy management and renewable energy in Zimbabwe

Sustainable agriculture uses farming techniques that ensure good environmental health, economic profitability, and social and economic equality without compromising the ability of future generations to meet their own needs (Brundtland Commission, 1987). However, as a result of the industrialisation and consolidation of agriculture, food production has become increasingly dependent on energy derived from

10 UNIDO (2011). Barriers to industrial energy efficiency: a literature review.

fossil fuels (FAO, 2014), a condition that is largely unsustainable. There is a need for the reduced use of non-renewable energy sources and their replacement with renewable sources and/or physical labour to the extent that this is economically feasible.

### 11.2.1 Energy sources: supply and demand in Zimbabwe

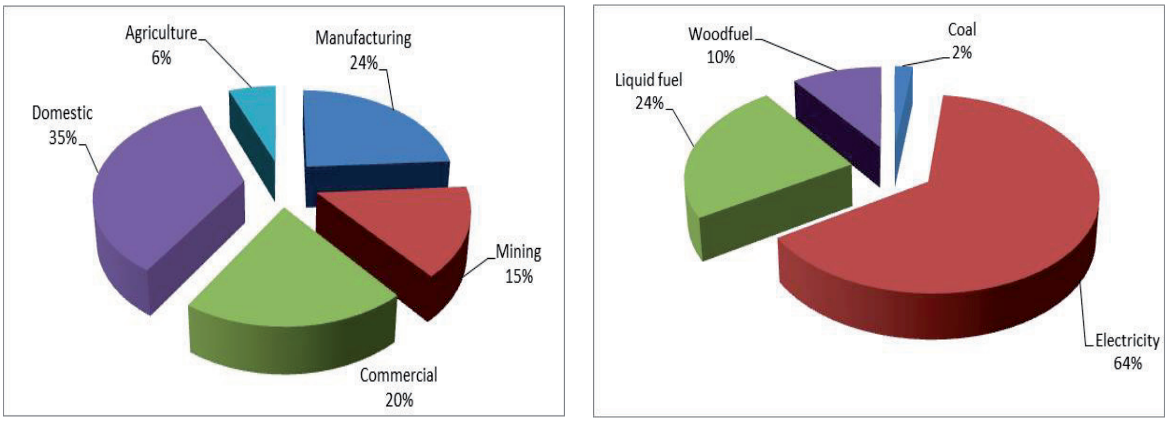
The main sources of energy in Zimbabwe are coal, wood fuel, electricity and petroleum fuels. According to the 2009 national energy balance, wood fuel provides the bulk (61%) of the total energy supply, followed by liquid fuels (18%), electricity (13%) and coal (8%) (NEP, 2012). Regarding electricity, coal is still the main pillar of installed capacity (58%), followed by large hydroelectric (37%), whereas clean energy sources (small hydroelectric plants, biomass and waste) cover only 5% of national needs (MoEPD, 2016a). The majority (67%) of the Zimbabwean population live in rural areas and derive their livelihoods directly from agriculture-related activities.

The national electrification percentage is about 40%, there being little penetration of other forms of energy such as LPG, and charcoal, or renewables such as solar, biogas, wind power and small hydro-power. Zimbabwe's national electricity peak demand at current suppressed industrial capacity utilisation is 1,400 MW against an average supply of 1,000 MW, leaving a supply deficit of 400 MW (MoEPD, 2016b), which is met through imports of energy from neighbouring countries. The deficit can be reduced by increased use of energy-efficient measures and renewable energy interventions in all sectors of the economy, including agriculture.

### 11.2.2 Energy consumption in agriculture

According to the 2014 International Energy Agency report, Zimbabwe's energy balance for the agricultural sector was 584 kilo tonnes of oil equivalent (ktoe) or 6,791.92 GWh, as shown in Figure 11.1 (a). The agriculture sector in Zimbabwe directly consumed 6% of the total electricity produced (9,341 GWh) in 2013 (ZERA, 2014), as shown in Figure 11.1(b).

***Figure 11.1 Energy consumption***




(a) Energy balance in agriculture (Electricity consumption by sector, GWh)

(b) Electricity consumption by sector, GWh (Energy balance in agriculture)

*Source: IEA, 2014*

*Source: ZERA, 2014*

The sector has the potential to save 12% (58.75 GWh/year) in electricity consumption through a number of energy-efficient measures (ZERA, 2015). In Zimbabwe, electricity and fossil fuels are used by small- to large-scale commercial farming systems, whereas in most rural areas, animal-drawn and human labour are the most exploitable sources of power for subsistence farming and small family farming units. Table 11.1 shows the main energy sources used in the agricultural production cycle.

***Table 11.1 Energy sources in agricultural production in Zimbabwe***

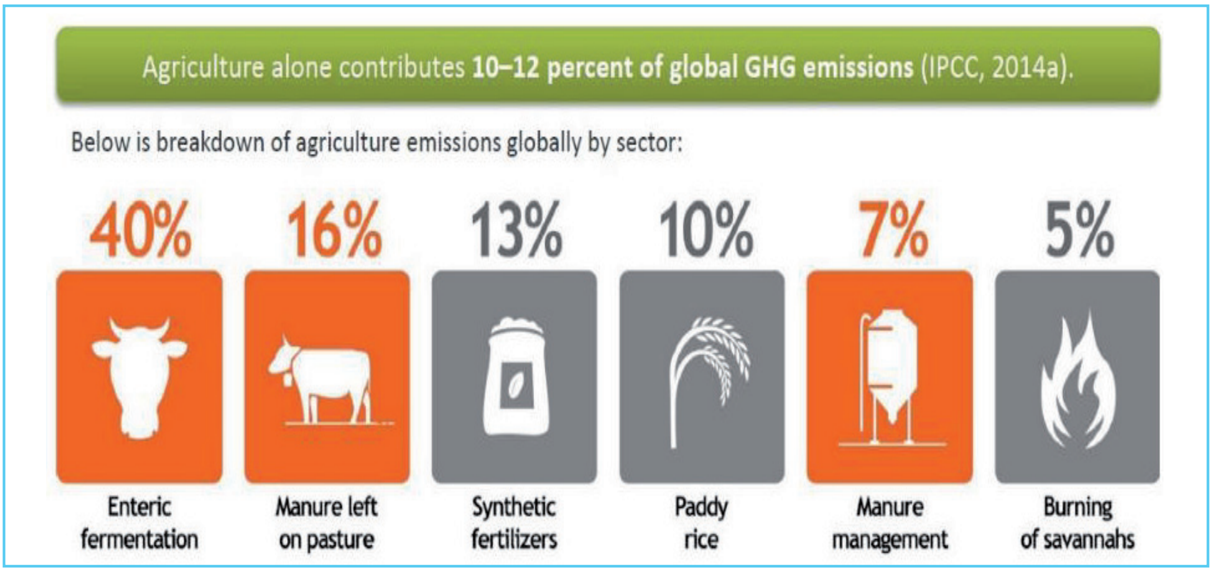
| Direct use of energy | Energy sources |
|---|---|
| Operating heavy farm machinery and large trucks | Diesel |
| Operating small vehicles | Diesel, petrol |
| Operating small equipment | Diesel, petrol, coal, LPG, electricity, wood, solar, human, animal |
| General farm overheads | Electricity, paraffin |
| Marketing | Diesel, petrol, human, animal |
| Value addition processes | Diesel, coal, LPG, electricity, wood |
| **Indirect use of energy** | **Energy sources** |
| Fertilisers, pesticides, insecticides, herbicides, farm equipment. | Electricity, coal |

*Adopted from FAO, 2013*

### 11.2.3 Emissions from agriculture

Globally, agriculture is a significant sector in terms of GHG emissions. The sector contributes 5.0 to 5.8 GtCO2eq/year, corresponding to 10–12% of total anthropogenic GHG emissions (Smith et al., 2014). If pre- and post-process emissions are included, global food systems contribute between 19% and 29% of global GHG emissions (Vermeulen et al., 2012). The majority of agriculture-related emissions are generated in developing countries, with an average contribution of 35% to global emissions (Smith et al., 2014). Figure 11.2 shows the relative contributions of agriculture processes, activities or sectors to global agriculture emissions.

***Figure 11.2 Breakdown of agricultural emissions***




*Source: MICCA, 2015*

Most of the sub-sectors mentioned in Figure 11.2 are energy-related, either because they are heavily energy-demanding in their production processes (synthetic fertilisers, for instance), or just because they might constitute an on-farm costless source of energy (manure).

As mentioned earlier, agriculture is the second major national source of GHG emissions, contributing about 44% of total emissions (22,019.566 Gg CO2eq) in Zimbabwe. This percentage (44%) is higher than the average mentioned for developing countries. Thus, it is clear that there is urgent need to decouple increased agricultural productivity from increased emissions.

There are tools which can be used to estimate GHG emissions and carbon sequestration, such as the EX-ACT (EX-Ante Carbon-balance Tool),[11] which provides ex-ante estimates of the impact of agriculture and forestry development projects, programmes and policies on GHG emissions and carbon sequestration.

### 11.2.4 Energy management standards

Zimbabwe has developed energy standards (ZWISO 50002-4:2014, ZWISO 50015:2014) modelled on the international energy standards ISO 50000 series, which can help the country to manage, track and improve its energy use. The standards help in implementing an energy management system based on the Plan-Do-Check-Act cycle. Good energy management plugs unnecessary energy leaks, improves the cost competitiveness of the product and hence boosts incomes.

## 11.3 Opportunities for energy management and renewable energy

The key steps in implementing EM opportunities involve establishing the baseline energy use (energy auditing) and identification of all Significant Energy Users (SEUs). Once key energy users are identified, steps are taken to identify the key drivers for the energy use. Energy-saving opportunities are then identified and energy targets set before they are implemented. The energy consumption with EM measures in place is then measured, monitored and tracked to evaluate the implemented measure's energy savings. The ISO 50001 management model can be used for continual improvements of energy use. EM opportunities are implemented as mitigation measures to reduce anthropogenic GHG emissions.

The profitability and sustainability of all the components of the agro-value chains may be improved by addressing their energy intensity through energy-efficient measures. Table 11.2 summarises the opportunities for cost savings offered by the introduction of energy-efficient measures in each element of the value chain, expressing them as impacts or benefits.

Only a few measures may end up showing a trade-off with other issues, such as the case of conservation agriculture (low mechanisation and soil disturbance versus high labour demand) or drying field crops (no energy costs versus potential increase of post-harvest losses). Drivers of energy usage need to be identified and addressed.

### 11.3.1 Barriers and strategies for implementation of EM and RE

The following are some of the general barriers to implementing EM and RE in the agricultural sector:

- Lack of enabling policy and regulatory framework for EM and RE;
- Lack of awareness of the benefits of EE;
- Limited or lack of technical expertise in energy systems, e.g., energy auditing;
- Focus is on yield (output) instead of on energy efficiency and energy conservation;
- Component approach instead of systems approach in energy systems;

11 (www.fao.org/tc/exact/ex-act-home/en)

*Table 11.2 Energy management opportunities in agriculture*

| Area | Energy efficiency measure | Impacts/benefits<br>▲= positive/improvement<br>▼= negative impact |
|---|---|---|
| **Crop production** | **Conservation agriculture**, different combination of:<br>- better crop rotations<br>- association and cover crops<br>- grass strips along the contour of waterways<br>- water diversion ditches, terraces of various types<br>- minimum or tillage-reduced tillage systems<br>- surface mulches<br>- contour planting<br>- building up soil organic matter<br>- organic agriculture techniques<br>- combinations of the above | ▲ Reduce mechanical tillage<br>▲ Reduce soil erosion<br>▲ Reduce run-off during intense storms<br>▲ Conserve water<br>▲ Help to retain soil nutrients<br>▲ Reduce energy consumption<br>▲ Increase crop yields<br>▲ Reduce GHG emissions due to transportation and use of inorganic fertilisers<br>▼ Increase workload and time needed |
| | **Optimisation of mechanical systems** (Systems approach):<br>- match mechanical equipment to load requirements<br>- planned maintenance of mechanised systems, etc. | ▲ Reduce energy consumption<br>▲ Reduce costs of production<br>▲ Increase productivity |
| | **Correct timing for fertiliser application**<br>(Increase fertilisation efficiency) | ▲ Improve fertiliser uptake<br>▲ Reduce fertiliser overload and waste<br>▲ Reduce fertilisation costs |
| | **Efficient water use**<br>- water harvesting, water re-use (drainage or wastewater effluent)<br>- mulching<br>- use of drip, micro-spray, low energy, precision application irrigation systems<br>- high value-low water use crops<br>- lining canals, mend pipe leaks | ▲ Minimise water usage and reduce energy consumption for pumping and irrigation system<br>▲ Reduce soil erosion<br>▲ Help to retain vital nutrients |
| | **Use of field drying** | ▲ Reduce energy consumption<br>▼ May result in yield reduction due to destruction of grains by pests |
| | **Alternative drying**<br>- solar drying where applicable<br>- energy-efficient dryers, e.g., rocket ban for tobacco curing | ▲ Improve quality<br>▲ Reduce energy consumption |

| | | |
|---|---|---|
| **Livestock production** | **Use locally available or on-farm feed** | ▲ Reduce cost<br>▲ Reduce emissions from transportation |
| | **Buy concentrates** to reduce transportation costs | Reduce fuel usage and hence emissions |
| | **Manure management** for use as fertiliser and for biogas production | ▲ Reduce fertiliser costs<br>▲ Improve organic matter, soil structure and fertility<br>▲ Reduce emissions from open-air manure decomposition<br>▲ Reduce emissions from fossil fuels-based cooking and lighting<br>▲ Improve household economy, decreasing energy costs<br>▲ Decrease time spent for firewood fetching, and increase time for non-farming activities |
| | **Energy system optimisation**<br>- Building energy efficiency<br>- LED lighting<br>- Refrigeration<br>- Heating, ventilation and air-conditioning system | ▲ Reduce energy consumption<br>▲ Reduce costs<br>▲ Reduce GHG emissions |
| **Fisheries and aquaculture** | **Energy system optimisation**<br>- Circulating water by gravity<br>- Use of greenhouses to improve temperature<br>- Use of biological feeds, e.g., algae | ▲ Reduce energy consumption<br>▲ Reduce GHG emissions<br>▲ Reduce costs<br>▲ Permit food processing and storing |
| **Processing and distribution** | **Energy system optimisation**<br>Throughout the whole processing and distributing system: enveloping, processing, lighting, refrigeration, electro-mechanical systems (motor, pumps etc.), HVAC and equipment maintenance | ▲ Reduce energy consumption<br>▲ Reduce GHG emissions<br>▲ Reduce costs<br>▲ Improve efficiency in the value chain |
| | **Efficient transport system**<br>- Optimise routes on the farm and reduce field trips by combining operations where applicable | ▲ Reduce fuel consumption<br>▲ Reduce GHG emissions<br>▲ Reduce energy consumption<br>▲ Decrease air pollution |
| | **Decentralisation of processing (**where applicable) | ▲ Reduce energy consumption<br>▲ Reduce GHG emissions |
| **Retailing, preparation and cooking** | **Building envelope energy**<br>- Lighting efficiency<br>- HVAC and refrigeration optimisation<br>- Selection of energy-efficient equipment<br>- Follow good equipment maintenance practice | ▲ Reduce energy consumption |

- Lack of incentives for energy efficiency;
- Limited/lack of financial resources; and
- Poor information and record keeping of energy use.

Proposed strategies to overcome these barriers include:

- Government should enact enabling policies and policy instruments that promote EE and EC through relevant institutions;
- Training of experts on EM, RE and energy auditing, including measurement, monitoring and verification;
- Documenting and sharing the achievement of annual energy goals and targets;
- Promote research, uptake and deployment of RE and EE through favourable financing mechanisms; and
- Behavioural change.

### 11.3.2 Adaptation measures to reduce losses and risks in the energy system

Due to the current food insecurity in the country, Zimbabwe prioritises adaptation initiatives to climate change as set out in her INDCs submitted to the UNFCCC in 2015. Table 11.3 summarises the adaptation measures which can be pursued under CSA in Zimbabwe:

***Table 11.3 Adaptation measures in agriculture***

| Adaptation measure | CSA pillar | Possible indicators or proxies | Impacts/benefits |
|---|---|---|---|
| Conservation agriculture (CA) | ☒ Productivity<br>☒ Resilience<br>☒ Mitigation | - Yield per hectare<br>- Land area under CA<br>- Number of people practicing CA | ▲ Improved soil nutrients<br>▲ Reduced water and energy consumption<br>▲ Reduced emissions |
| Improved seed and crop varieties | ☒ Productivity<br>☒ Resilience | - Yield per hectare<br>- Land area under improved seed and crop varieties<br>- Number of people using improved seed and crop varieties | ▲ Varieties that are tolerant to climate-related stresses (require less water, hence less energy for pumping water) |
| Improved livestock breeds | ☒ Productivity<br>☒ Resilience | - Yield per livestock unit<br>- Number of people with improved livestock breeds<br>- Number of livestock under CSA | ▲ Breeds that are tolerant to climate-related stresses (require less fodder, have higher food conversion efficiencies, better disease resistance etc.) |
| Strengthening management of water resources and irrigation | ☒ Productivity<br>☒ Resilience<br>☒ Mitigation | - Land area under efficient irrigation system<br>- Number of people using efficient irrigation system<br>- No. and capacity of new water-harvesting and storage systems | ▲ Climate change affects both rain-fed and irrigation agriculture. Water-harvesting though various storage mechanisms<br>▲ Improved water efficiency<br>▲ Integrated water resource management |
| Private insurance | Resilience | - Number of farmers under insurance cover | ▲ Reduces climate-related risks to farm-level production, infrastructure and income |

*Source: Adopted from Smith and Skinner, 2002; Heumesser, 2015.*

Note: the indicators or proxies are given as examples and are therefore not exhaustive.

### 11.3.3 Mitigation measures to reduce GHG emissions

Zimbabwe is pursuing mitigation measures to reduce GHG emissions in agriculture when these exist as the core benefits of an adaptation measure. For example, the push to mechanised farming and improved irrigation water efficiency is not borne out of the need to reduce emissions from fuel use or electricity, but to improve yields in the face of dwindling water supplies (adaptation).

There are three main GHG mitigation options in agriculture:

- Increasing carbon dioxide storage in soils and biomass;
- Reducing emissions during agricultural production; and
- Indirectly, reducing the required volume of agricultural production.

These mitigation options are due to a number of measures, some of which are shown in Table 11.4.

***Table 11.4 GHG mitigation measures in agriculture***

| Mitigation measure | CSA pillar (other than mitigation) | Possible indicators (or proxies) | Comment |
|---|---|---|---|
| Energy efficiency | ☒ Productivity<br>☒ Resilience | - Energy intensity (kJ or kWh/kg of production)<br>- Energy costs | ▲ Water efficiency improvement, reduced energy consumption |
| Use of renewables | ☒ Productivity<br>☒ Resilience | - Crop/livestock yields<br>- Capacity of RE systems installed<br>- % RE in the energy mix<br>- No. of people using RE technologies | ▲ RE technology diversity<br>▲ Energy security |
| Nutrient management (fertilisers, crop residues and manure) | ☒ Productivity<br>☒ Resilience | - Crop yield per ha<br>- Number of people using bio-fertilisers<br>- Land area under bio-fertiliser<br>- No. of people adopting manure management | ▲ Soil conditioning<br>▲ Soil nutrient improvement/ retention |
| Strengthening afforestation programmes | ☒ Productivity<br>☒ Resilience | - Forest cover increase<br>- Estimated emissions reductions per farmer | ▲ Enhance carbon sinks<br>▲ Kariba REDD+ programme<br>▲ CAMPFIRE programmes and Trans-Frontier Conservation Areas |
| Improved Agronomic practices | ☒ Productivity<br>☒ Resilience | - Yield per hectare<br>- Area under inter-cropping<br>- Number of people doing crop rotation | ▲ For example, inter-cropping, crop rotation, biomass cover, crop associations |
| Improve livestock management | ☒ Productivity<br>☒ Resilience | - Yield per livestock unit<br>- Quantity of improved fodder used | ▲ Feed formulations: use of feeds with low emissions from digestion (ruminants), higher conversion efficiencies |
| Waste reduction | ☒ Productivity | - Energy intensity<br>- Water intensity<br>- Waste generated per unit | ▲ Reduced waste in processing results in better yields |

*Source: Adopted from B. Kundermann, 2014; C. Heumesser 2015.*
Note: the indicators or proxies given are examples and are therefore not exhaustive.

### 11.3.4 Renewable energy resources with potential in agriculture

Zimbabwe is endowed with relevant potentialities for the exploitation of renewable energy. For agricultural purposes, solar, wind, biomass and hydropower are discussed in this section due to their wide applicability in the sector.

#### 11.3.4.1 Solar photovoltaic, solar thermal and wind resources

An assessment by the International Renewable Energy Agency (IRENA) on Solar Photovoltaics (PV), Concentrated Solar Power (CSP) and wind energy zones covering countries in the power pools of eastern and southern Africa, identified the following potential for renewable energy sources in Zimbabwe:

- Solar PV: 109 GW (at 230 W/m2),
- CSP: 39.5 GW (at 270 W/m2)
- Wind power: of 39.3 GW (at 200 W/m2)

With an average solar energy of 16–20MJ/m2 (4.4–5.5 MW/m2) and 3,000 sun-hours annually (NEP, 2012), solar PV, solar thermal, and CSP are feasible and attractive in most parts of the country. Solar intensity and sunshine hours are the two variables that are essential for evaluating the feasibility and profitability of solar system installations. The assessment is based on specific site, farm or production system energy demands. PV and CSP are also suitable for on-farm power generation, while solar thermal can address hot water needs in households and on farms. It is possible to use online web-tools and calculators capable of attributing these variables to a specific place by providing the geographical coordinates such as the Renewable Energy Target (RET) Screen or the Photovoltaic Geographical Information System (PVGIS).

Wind power, with an average wind speed of about 3m/s, (NEP, 2012) constitutes a concrete energy potential, but that potential is highly site-specific. However, average wind speed is suitable for water-pumping for various farm requirements, while at higher altitudes and with advanced technology, the resource can be used for power generation.

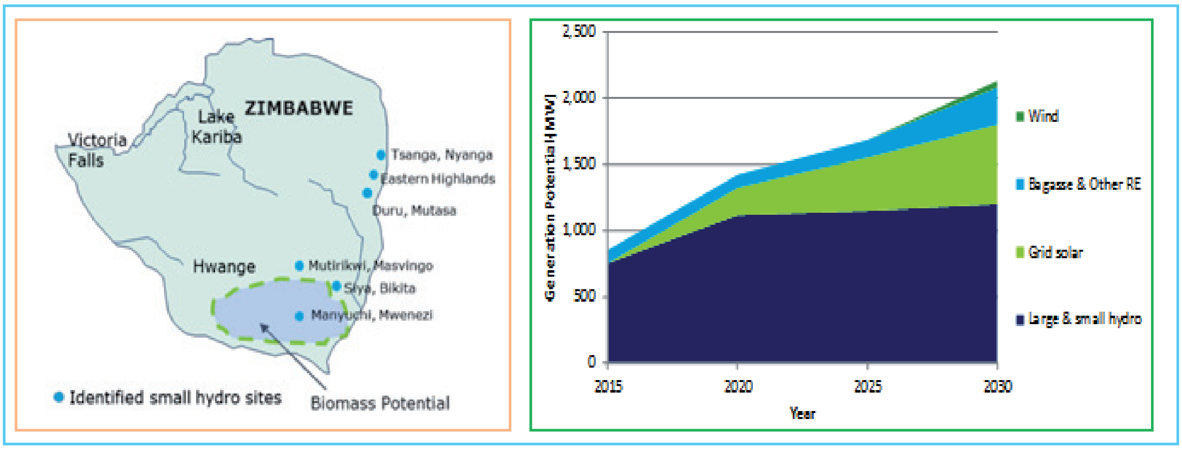
#### 11.3.4.2 Biomass

Zimbabwe has ample biomass resources with a potential of 1,000 MW (Draft Renewable Energy Policy, 2016), ranging from bagasse from sugar-milling to sawdust from timber-processing and forestry waste, as well as agricultural and livestock waste. Agricultural and livestock waste can be used for biogas production for domestic and farm needs, while sawdust can be used to make briquettes for domestic use or for electricity generation. Examples include the 78 MW Tongaat Hulett bagasse-fed plants, the 18 MW Green Fuel (bagasse) plant and the 0.5 MW Border Timbers (timber waste) plant. Household and institutional bio-digesters are being installed by the Rural Electrification Agency and some NGOs. The objective is to broaden the energy mix and lessen the demand for electricity and fossil fuels used for heating and cooking purposes. Figure 11.3 shows the biomass potential in Zimbabwe.

#### 11.3.4.3 Hydropower

Zimbabwe's large hydropower projects produce more than 3,840 MW, mainly concentrated along the Zambezi River, including the 2,400 MW Batoka Gorge plant. Most of Zimbabwe's small and mini-hydro potential is located in the Eastern Highlands, which are mainly run-off river schemes. Currently, the installed mini-hydro capacity is 25 MW (ZERA, 2015). There is potential to generate 120 MW from small and mini-hydro resources (NIB, 2008). The draft renewable-energy policy has provisions for the construction of small-hydro plants at all major irrigation dams, thus using water to produce electricity before it is used for irrigation. Figure 11.3 shows the potential for biomass and hydropower generation in Zimbabwe.

***Figure 11.3 (a) Biomass and hydropower potential in Zimbabwe; (b) Grid-connected renewable energy targets to 2030, MW***




(a) *Source: UNIDO, 2013*

(b) *Source: SE4ALL, Action Agenda Zimbabwe*

# 11.4 Importance of energy management in CSA

## 11.4.1 Role of tertiary and research institutions

In meeting the mitigation pillar for CSA, Zimbabwe should pursue a low-emissions development pathway. Tertiary and research institutions should have support for the research, development, deployment and diffusion of new green technologies in the agricultural sector. These institutions should also:

- Conduct capacity-building for extension workers: pre-train and in-service training of extension workers (on EE and RE in agriculture) under the Ministry of Agriculture, Mechanisation and Irrigation;
- Conduct adaptive capacity and vulnerability assessments; and
- Design curricula on energy management for CSA from the primary education level to the tertiary level.

## 11.4.2 Relevance to agricultural extension officers

Energy is the key to attaining food security. Extension workers who are in direct contact with farmers should be knowledgeable about energy trends, costs, efficient technologies and new technologies and should also be able to disseminate their knowledge effectively by directing appropriate information communication technologies on energy and energy management information to various stakeholders in the agro-value chain.

## 11.4.3 Financing sustainable energy use in agriculture

The financing of CSA activities from public resources in Zimbabwe is rather inadequate. The increasing risk and uncertainty that farmers face due to climate change impacts is having serious implications for agricultural investment. Therefore, a blend of different financing mechanisms should be adopted in order to have a significant impact on energy management in CSA in Zimbabwe.

The financing mechanisms may include the following:

- Public finance;
- Innovative business models like Energy Service Companies (ESCOs);
- Local or regional development banks such as the AfDB;
- Financial instruments, such as feed-in-tariffs;
- Public-private sector partnerships; and
- Private sector

## 11.5 Case studies

Transition to CSA and the achievement of sustainable food production, climate adaptation and mitigation and energy security can only happen if existing examples of energy-smart food systems can be scaled up significantly (FAO, 2013). This section gives examples of sustainable-energy projects that have been implemented successfully in Zimbabwe.

### 11.5.1 Electricity and heat production at Charter Saw Mill in Chimanimani

This combined heat and power plant (Figure 11.4) produces 0.5 MW of electricity and 5 MW of process heat. The project was successfully connected to the national grid in June 2011. The waste wood and sawdust that is produced within the sawmill itself (both renewable resources) forms the heat source for the boilers, which produce steam that is then turned into electricity. Use of saw mill waste has helped to solve the problem of waste disposal.

***Figure 11.4 Biomass Power plant running on sawmill and wood waste and micro-hydro site***

*Source: ZERA, 2015 and BTL*

### 11.5.2 Chipendeke mini-hydro (Practical Action Zimbabwe)

The 25 kW micro-hydro scheme at Chipendeke (Figure 11.4), Mutare South, was commissioned in 2008. The run-off river scheme has a mini-grid for 27 households, six shops, a school and a clinic.

### 11.5.3 Biodigesters: Victory Farm

Waste from pig pens is channelled into the biogas digester (Figure 11.5), which produces power for the farm. Excess methane gas is pressurised and stored in gas tanks. This gas is used to power the generator. The farmer has also developed a small mobile digester made from a 200-litre oil drum. The waste produced from his kitchen is fed into this digester on a daily basis, and it provides enough energy for cooking.

***Figure 11.5 Use of biogas digester at Victory Farm (Beatrice) and solar application in tobacco barns***

*Sources: HIVOS, 2014/ Tobacco Research Board, Kutsaga Station, Harare, 2015*

## 11.5.4 Drying

The Kutsaga barn is designed to promote high-combustion efficiency, minimising the release of greenhouse gas emissions. As a result, it uses up to 62% less fuelwood than rocket or conventional barns. While the conventional barn uses 9 kg of wood to cure a kilogramme of tobacco, and the rocket barn between 4 and 4.5 kg, the Kutsaga barn shown in Figure 11.5 uses just 3 to 3.5 kg.

## 11.5.5 Solar-powered irrigation scheme at a Selous farm, Norton

A 0.96 kWp solar-powered drip-irrigation demonstration unit (Figure 11.6) was set up at a Selous farm, Chegutu District, with a 0.75 hp solar pump unit. The system produces 10,000 litres of water per day, which is fed via a 2,000-litre storage tank. Water flows by gravity to irrigate one acre of vegetables (Figure 11.6).

***Figure 11.6 Solar-powered drip-irrigation demonstration***

*Source: ZERA 2015:*

## 11.5.6 Village Case studies

### 11.5.6.1 Case study on solar powered drip irrigation: Zinkondweni irrigation scheme, Umzingwane District

The use of solar powered pumping systems is a recent innovation that promises to be a game changer for low-cost, sustainable irrigation design.

**Can solar powered drip irrigation play a significant role in upscaling?**

The case of Zinkondweni irrigation scheme shows that the era of solar powered irrigation has arrived. Such off grid systems mean that irrigation is no longer restricted to areas with electricity or to those that can afford the high operating costs of diesel powered pumping systems. Solar powered irrigation systems can be installed anywhere, utilising both surface and underground water sources. Groundwater sources are generally underutilised in Zimbabwe yet trends in climate such as the rising temperatures suggest that these are more secure water sources than surface storage that is prone to high evaporative losses. Developing and managing ground water sources is perhaps one of the most important adaptation investments that justify deployment of public, private and development financing. Although the initial cost may seem high, the infrastructure is designed to last for many years and with high-value crops and all year round production, payback periods are very short. Such investments are potential areas of partnerships with the private sector and financial institutions to leverage financing.

Drip irrigation technology is low-cost, versatile, and highly water-efficient, ensuring that every drop goes to improving productivity. As reduced availability of water is one of the main impacts of climate change in many parts of the country, improving water use efficiency is a top priority.

*Source: Mutamba, M., Matingo, E., Marongwe, S.L., Vambe, L., Murwisi, K., 2017 Case studies of Climate Smart Agriculture in Zimbabwe. VUNA Pretoria*

### 11.5.6.2 Example of integration of clean energy (biogas) into CSA systems, Goromonzi District

The Ngwerume family in Mawanga, Ward 24, Goromonzi District have discovered the benefits of a “green living” approach to every aspect of the household. They now fully appreciate that most aspects of their farming system and the household are connected and often complement each other in ways that drive much better outcomes than when they are treated as stand-alone entities. Their objective is to have an integrated climate-smart farming system that maximises such complementarities. Although the Ngwerumes are farmers they believe a green living approach needs to touch every aspect of their life beyond crops and livestock. In many ways they view their personal lives as intricately connected to the farming elements of the household. As such their climate-smart investments are not only aimed at sustainably increasing productivity and resilience of crop/livestock systems, but should also drive improvement in overall quality of life for the household.

Key elements of the Ngwerume ”green” household include production of biogas from livestock manure for cooking, the use of conservation agriculture (including use of compost from the biogas) for crops, production of legume fodder for livestock. A unit for solar drying is also used for preservation of crops, vegetables and fruits. Around the homestead the family also manages a variety of exotic and indigenous trees for multiple purposes.

#### 11.5.6.3 Biogas fuel for cooking

The concept was introduced by SNV to many farmers in Goromonzi district but only a few have been able to use it as they do not have the required minimum number of cattle and co-financing that was needed to build the bio-digesters. One needs at least six animals to have a functional biogas plant and most farmers don't have such numbers.

**Technical details (in farmer's language)**

"I opted for the nine cubic metre system. For the construction, I needed 35 bags of cement and other additional inputs such as impermo[12] that was used to make the digester water tight. After construction was complete we had a problem because we needed two tonnes of fresh manure for initial feeding into the digester. I had to go to an abattoir in Goromonzi to get fresh manure. We then mixed cow dung and water in the same proportion and fed it through the inlet. It takes about one week for fermentation to occur. After about two weeks the system is producing a lot of gas, enough to cook all day. You need to feed the digester daily. I use four buckets of cow dung per day, mixed with 20 litres of water. The mixture needs stirring to get a consistent liquid that is then poured into the digester through the inlet. The digester is like a big pot—it's in the centre. This is where you have the gas collection pipe that goes to the kitchen. You have valves that can be can be opened and closed to regulate flow of gas. As you add fresh dung every day, an equal volume of slurry is pushed out of the digester through the outlet point into the pits. The sludge is fully digested so it does not have any odours or grass seed. We mix the sludge with other green plant matter in alternating layers for about a month to make very high quality compost. We have researchers that have analysed the nutrient content of the compost and they found it to be of very high quality. Now I am now adding poultry manure to my compost mix and I believe it is even getting better. That's what we use for our crops and the results are better than inorganic fertilisers. I even sell excess compost to other farmers."

"The biogas is very safe unlike other forms of gas. We get enough gas to cook as much as we want all day. We are even cooking beans! The heat is safe for pots. We have been using this for 3 years with no problems. We don't even know about collecting firewood."

*Mr Ngwerume, Farmer, Goromonzi District*

#### 11.5.6.4 Solar water heating

Rural households that have access to electricity are a small minority in Zimbabwe. Unfortunately, even for those that are lucky to be connected to the grid, the high cost of electricity often means that they can only use electrical power for basic functions such as lighting. The Ngwerumes were motivated by these realities to invest in a solar water heating system to reduce their cost of electricity. Not only is this contributing to their intentions to be a green household and better quality of life, it has significantly reduced their electricity costs.

"We installed a solar water heating system to reduce electricity cost. This geyser gives us hot water all the time. Since we started cooking with biogas and using the solar geyser, our electricity bill has come down from USD 50 to only USD 20 despite my large family."

*Mr Ngwerume, Farmer, Goromonzi District*

12 A waterproofing sealant usually mixed mortar

#### 11.5.6.5 Solar drying to preserve output

Like most farmers the Ngwerumes grapple with the challenge of minimising post-harvest losses and spreading supply of key products beyond peak season. A solar dryer for preserving a variety of products such as vegetables, fruits and even meat is now enabling the household to minimise losses due to oversupply during peak harvest seasons and take advantage of higher prices during the off-season periods.

**Extending the season with solar drying**

"We use solar dryer for all things that require drying, such as meat, cassava, sweet potatoes, all types of vegetables and even tomatoes and fruits like bananas. This minimises losses due to oversupply during the peak season when the markets are flooded. We can store for long periods after drying. It's helpful because you have supplies even during the off-season. Even indigenous vegetables that are very nutritious can be made available throughout the year. Fresh is good but the dried stuff is more valuable when you sell it offseason when supplies are at their lowest. If it's very hot two days is enough to dry most things."

*Mrs Ngwerume, Farmer, Goromonzi District*

## 11.6 Recommendations

Zimbabwe's greatest barriers in achieving energy efficiency and energy management are information dissemination, a lack of legal or statutory instruments to enforce energy management and to some extent, the technical capacity to carry out energy audits to account for energy use, identify energy leakages and decide how to plug them. For large-scale agro-commercial enterprises, it is recommended that energy champions for energy efficiency and energy management activities be appointed. Smallholders should be trained to measure, monitor and track their energy use. The capacity-building of extension workers in areas of energy management is vital. Energy information on efficiency measures, as well as alternative sources of energy, should be readily available to both large- and small-scale farmers. The information gap on financing mechanisms, the causes of global warming and climate change impacts, as well as how resilience and mitigation can be achieved should be addressed. This will encourage energy management in the agro-value chain process. Policy and policy instruments addressing energy efficiency and energy management should be strengthened.

## 11.7 Conclusion

The dependence of agriculture and the agro-value chain process on fossil fuels increases Zimbabwe's energy insecurity and presents a threat to its food security while increasing its GHG emissions. To increase food productivity at competitive prices, the country should adopt CSA embracing energy management. The benefits of energy efficiency and the use of renewable energies are environmental, economic and social. These include reduced energy intensities and reduced GHG emissions and therefore the cost competitiveness of products. Use of alternative energy increases adaptive capacity, while energy efficiency is a mitigation measure with core adaptation benefits. Energy management contributes to the three pillars of CSA: sustainable food productivity, resilience and mitigation, while enhancing food and nutritional security.

## References


1. Brundtland Commission 1987*. Our Common Future.* Oxford University Press.

2. B. Kundermann 2014. *Potentials for Greenhouse Gas Mitigation in Agriculture, Review of research findings, options for mitigation and recommendations for development cooperation.* GIZ, Germany.

3. CZI 2016. *Confederation of Zimbabwe Industries, Manufacturing Survey 2016* [available at http://www.czi.co.zw/index.php/downloads].

4. BTL. Border Timbers Limited (BTL) - *Thermal Power, Case Study Zimbabwe, Rift Valley Energy Ltd* [ available at http://www.riftvalleyenergy.com/projects/btl-1-thermal-power-plant-2/].

5. FAO 2006. *Energy and Gender Issues in Rural Sustainable Development.* Rome, Food and Agriculture Organisation of the United Nations.

6. FAO. 2013. *Climate-Smart Agriculture Sourcebook. Module 14: Financing Climate-smart Agriculture.* Rome, Food and Agriculture Organisation of the United Nations [available at www.fao.org/docrep/018/i3325e/i3325e.pdf].

7. FAO. 2014. *Building a Common Vision for Sustainable Food and Agriculture: Principles and Approaches.* Rome, Food and Agriculture Organisation of the United Nations [available at and accessed on 27/10/16 http://www.fao.org/3/a-i3940e.pdf].

8. FAO 2012. Energy Smart Food at FAO: An Overview, Rome, Italy; Food and Agriculture Organisation of the United Nations [available at http://www.fao.org/docrep/015/an913e/an913e.pdf].

9. FAO 2013. Climate-Smart Agriculture Sourcebook. Module 5; Sound Management of Energy for Climate-smart Agriculture. Rome, Italy; Food and Agriculture Organisation of the United Nations [available at www.fao.org/docrep/018/i3325e/i3325e.pdf].

10. FAO-MICCA 2015. *Module 1: Climate change and agriculture of the Learning Tool on Nationally Appropriate Mitigation Actions (NAMAs) in the agriculture, forestry and other land use (AFOLU) sector* [available at: http://www.slideshare.net/FAOoftheUN/tag/namatool]

11. GoZ 2012. *National Energy Policy (NEP), Government of Zimbabwe.* Ministry of Energy and Power Development, Harare.

12. GoZ 2013. *Zimbabwe Agenda for Sustainable Socio-Economic Transformation (Zim Asset).* Government of Zimbabwe (GoZ), Harare.

13. Heumesser, C. 2015. *Climate Smart Agriculture Indicators and Index, World Bank, 15 Jan* [available at https://www.asti.cgiar.org/sites/default/files/pdf/s-t-partnerships/CSA-results-indicators.pdf; accessed 03.11.16].

14. http://practicalaction.org/rural-sustainable-energy-development-zimbabwe [accessed 07.11.2016].

15. http://practicalaction.org/rural-sustainable-energy-development-zimbabwe [accessed 07.11.2016].

16. International Energy Agency (IEA), 2011. *World Energy Outlook 2011.* Paris.

17. IRENA 2015. *Renewable Energy in the Water, Energy & Food Nexus* [available at: http://www.irena.org/DocumentDownloads/Publications/IRENA_Water_Energy_Food_Nexus_2015.pdf].

18. Magombo, G. 2016. *Challenges Faced by Independent Power Producers*. Zimbabwe Energy Regulatory Authority Independent Power Producers Workshop, Harare 31 October.

19. MEWC 2016. *Zimbabwe's Third National Communication (Draft) to the United Nations Framework Convention on Climate Change,* Ministry of Environment, Water and Climate (MEWC). Harare.

20. MoEPD 2016a. Draft Renewable Energy Policy. Ministry of Energy and Power Development, Zimbabwe.

21. MoEPD 2016b. *Zimbabwe's power demand falls 40 percent as industries fall silent*, The Financial Gazette, May 23, 2016 [available at http://www.financialgazette.co.zw/zimbabwes-power-demand-falls-40-percent-as-industries-fall-silent/].

22. NCCRS 2015. *Zimbabwe's National Climate Change Response Strategy.* Ministry of Environment, Water and Climate (MEWC). Harare.

23. NIB 2008.The *Ministerial Conference on Water for Agriculture and Energy in Africa* (2008). National Investment Brief: Zimbabwe. Sirte, Libyan Arab Jamahiriya, 15-17 December.

24. REA 2015. *Renewable Energy Development in Zimbabwe, Harare, Rural Electrification Agency* [available at http://unfccc.int/files/na/application/pdf/module_1_3.renewable_energy_development_in_zimbabwe.pdf].

25. SE4All 2015. *Sustainable Energy for All Country Actions processes in Zimbabwe, 2015, Draft Report,* Ministry of Energy and Power Development, Harare.

26. Smith P., M. Bustamante, H. Ahammad, H. Clark, H. Dong, E.A. Elsiddig, H. Haberl, R. Harper, J. House, M. Jafari, O. Masera, C. Mbow, N.H. Ravindranath, C.W. Rice, C. Robledo Abad, A. Romanovskaya, F. Sperling, and F. Tubiello 2014: *Agriculture, Forestry and Other Land Use (AFOLU). In: Climate Change 2014:* Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change

27. [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA [Available at https://www.ipcc.ch/pdf/assessment- report/ar5/wg3/ipcc_wg3_ar5_full.pdf]

28. Smith, B., and Skinner, M.W. 2002. *Adaptation Options in Agriculture to Climate Change: A Typology, Mitigation and Adaptation Strategies* for Global Change, Vol. 7, pp. 85-114.

29. UN 2015. Report of the Intergovernmental Committee of Experts on Sustainable Development Financing, United Nations. www.un.org/esa/ffd/publications/report-icesdf.html

30. Vermeulen, S.J., Campbell, B.M., Ingram, J.S.I., 2012. *Climate change and food systems.* Annual Review of Environment and Resources, 37, 195e222. [available at http://www.annualreviews.org/doi/pdf/10.1146/annurev-environ-020411-130608].

31. ZERA 2014. *Zimbabwe Energy Regulatory Authority* Annual Report, 2013.

32. ZERA 2015. *National Energy Efficiency Audit Report*, 2015, Zimbabwe Energy Regulatory Authority, Harare.

33. ZERA 2015. *Farmers Indaba Workshop: use of renewable energy as an alternative source of energy in the farming sector, 18 August.*

# 12. Climate-smart Agriculture in Zimbabwe—the way forward

## 12.1 Introduction

This chapter is based on the conclusions of all the preceding chapters of the Climate-smart Agriculture Manual for University Level and Professional Level Agriculture Education in Zimbabwe. It is centred on three broad categories namely: Enabling Environments; Systems Approaches and Practices. The multi-stakeholder approaches, steps and processes show that Zimbabwe as a country needs to stay abreast with the global trends and developments in CSA as well as address the needs of its stakeholder communities including higher and tertiary institutions of agriculture.

This chapter evaluates the CSA Manual's approach vis-à-vis the Climate Technology Centre and Network Response Plan to climate change keeping in mind the agents (individuals and institutions) through whom desirable change can be wrought. This chapter also explains what the targeted readers of the Manual must do regardless of the barriers they may contend with to put CSA knowledge into practice.

The 11 chapters in the Manual will surely facilitate the development of methodologies associated with climate change mitigation and adaptation, food security, and sustainable development. The focus of the Manual is to highlight the importance of assessing the mitigation and adaptation benefits of identified practices which increase productivity. The barriers to their adoption as well as the incentives available are clearly enunciated, as are its positive impacts on food security, income, and livelihoods of rural and commercial farmers, and smallholders in particular. Some of the CSA concepts discussed are: zero tillage, raised bed planting, crop residue management or mulching, crop diversification (horticulture, mushroom cultivation, etc.), agroforestry, nutrient management, water management (drip irrigation), rangeland management, seed bank nurturing, advisories based on improved weather forecasting and ICT, general capacity building and knowledge sharing, energy management and efficiency, and fisheries and aquaculture.

## 12.2 Background of the chapter themes

Agricultural production and productivity are reliant on the conditions of climate, soils, crops, livestock and others, and also on the actions of mankind within a changing climate.

The CSA Manual was developed as the result of a series of national stakeholder workshops which involved participants from various agricultural sectors. These participants included the offices of the President and Cabinet; Ministry of Agriculture, Mechanisation and Irrigation Development; Ministry of Environment, Water and Climate; AGRITEX; UN Agencies; seed companies; civil society organisations; academia; farmers' organisations; research institutions; and the media.

In order to address the three themes of CSA as per definition, the Manual focuses on the three categories alluded to above, enabling environment, systems approach and practices. In attempting to address climate change in the agricultural sector, the CSA Manual also draws on Zimbabwe's agricultural productivity landscape. Weather-based index insurance, gender and social inclusion, climate information services are also looked into comprehensively.

## 12.3 Key challenges in implementing CSA in Zimbabwe

- Lack of skilled human resources. Many smallholder farmers continue to follow environmentally unsustainable conventional tillage, unsustainable water management practices, cutting down of trees, use of slash and burn methods, and flood irrigation (in a water-stressed region) which further increases forest degradation and soil infertility due to low soil moisture content.
- Lack of adequate institutional and technological capacity to maximise germplasm of crop and livestock as well as the absence of climate change mitigation and adaptation education, information, and training in colleges of agriculture, universities and extension services.
- In many parts of Zimbabwe livestock husbandry consists of open grazing, land degradation and the loss of forest cover. This often leads to the releasing of greenhouse gases into the atmosphere, thus buttressing the fact that livestock rearing is a major source of global methane emissions.
- Lack of knowledge and access to credit and climate finance which can increase and sustain adoption of CSA measures.
- Gender inequality. The limited space for women to champion agricultural production and productivity because of lack of land ownership and tenure, access to inputs, resources and credit, education, and extension services in some instances constitutes more challenges.
- There is a yawning gap in the lack of documentation of traditional soil and water conservation methods. A good example of this are the “Zephania Phiri pits” described in Chapter 6 of this Manual. Farming activities around the otherwise arid lands in the area were transformed through Phiri’s innovations. However, his methods are only documented sketchily. The methods could be used for upscaling CSA practices in the country. There is often limited information and documented experience about alternative techniques that can aid the adoption of CSA practices. These need to be studied, documented and shared.
- The costs involved in the adoption of most CSA practices are a major barrier as in most cases the accruing benefits are not realised until some years later. Among these costs are opportunity costs of land and labour, upfront cash outlays that in most cases are out of reach of smallholder farmers. When all is said and done the promotion of CSA technologies tend to cost more than what is proffered in climate change literature. The ideal situation would be the adoption of CSA technologies that can be leveraged with earmarked funds for the promotion of these practices at the national level. There is therefore a need for greater access to finance at different phases of the growing period.

## 12.4 Conclusions

- Zimbabwe has moved in the right direction by incorporating climate change issues in national policies and strategies, however, there are still notable gaps which need to be addressed. The policies should be intertwined into agriculture extension guidelines and manuals in a way that resonates with the vast majority of the rural farming population so that they embrace them in their farming practices.
- In Zimbabwe there are projects and programmes that conduct and promote climate-smart agricultural practices and technologies. However, these programmes and projects are being implemented in a fragmented project-based manner which does not augur well for the adoption of CSA practices at national level. Good examples of such projects and programmes are the Green Innovation Hub (Muzarabani), Climate-smart Villages (Nkayi), and OneAcre Management (Gokwe North).
- There are a number of institutions/organisations and government departments involved in sustainable agriculture in Zimbabwe but they need to coordinate their endeavours in ways that mutually benefit each other. As the situation stands, they seem to be duplicating many functions or worse still, working at odds with each other in their operations.

## 12.5 Recommendations

a. According to the Climate Technology Centre and Network (CTCN) Technical Assistance Response Plan, the CSA Manual is expected to bring in consistency between sustainable agriculture, food security and climate change policies in Zimbabwe. It will also assist in other issues, viz.:

   i. Capacitate students from colleges of agriculture and higher and tertiary institutions to provide CSA extension services;

   ii. Increase CSA adoption in smallholder farming communities, rural villages, and agricultural enterprises through training, monitoring and evaluation;

   iii. Reduce GHG emissions in on-farm activities through CSA training, and water and energy management; and

   iv. Improve transfer of knowledge by current extension workers and increase agriculture productivity in smallholder farming communities, rural villages and agriculture enterprises.

   With respect to post-assistance plans and actions, NGOs like Green Impact Trust and other interested organisations could utilise the CSA Manual as follows:

   i. In consultation with the Zimbabwe Government develop a CSA Policy and Strategy or Framework;

   ii. Promote Green Impact Trust student exchange programmes within Africa and in South-South cooperation so as to share experiences and integrate solutions to develop agriculture;

   iii. Increase stakeholder awareness of CSA across the value chain, especially in rural communities;

   iv. Develop CSA demonstration centres in all government-run colleges of agriculture across the country;

   v. Develop CSA demonstration centres in traditional chief's homesteads; and

   vi. Develop a climate-smart village as model for rural development.

b. CSA needs to be integrated into main government strategies, guidelines, manuals and development plans. In this regard, it is commendable that the MoAMD recognised this need and asked for the development of this CSA Manual for agriculture institutions and extension cadres. Priority needs to be given to CSA practices that enhance productivity, resilience as well as GHG emissions.

c. Some measures are required to bring the livestock sector in line with climate-change responses. These include improving production and feeding systems, breeding of low methane-emitting animals as well as introducing manure management methods that enhance reduction of emissions. Efforts should also be made towards introducing restricted grazing so as to avoid overgrazing which results in land degradation, and crop residue removal associated with open grazing.

d. It is important to have a proactive platform for governmental institutions, NGOs, donors, private sector and civil society organisations in Zimbabwe to fill gaps and enhance collective action on CSA. Such a platform would enable the existing sustainable agriculture implementing institutions to share information, knowledge and experience which is crucial.

e. In order to overcome these challenges, we continue to urge the Zimbabwe Government to introduce targeted programmes for the much needed CSA practices for small/marginal farmers. This will require significant Government innovative interventions and investments across policy, regulatory and infrastructural aspects of the agricultural and allied sectors.

## *Climate-Smart Agriculture contributing to low carbon and climate resilient development*

CTCN
CLIMATE TECHNOLOGY CENTRE & NETWORK

The Climate Technology Centre and Network (CTCN) fosters technology transfer and deployment at the request of developing countries through three core services: **technical assistance**, **capacity building** and **scaling up international collaboration**. The Centre is the operational arm of the UNFCCC Technology Mechanism, it is hosted and managed by the United Nations Environment and the United Nations Industrial Development Organization (UNIDO), and supported by more than 300 network partners around the world.

**CTCN Supported by:**

European Commission

UDENRIGSMINISTERIET DANIDA

UN environment
United Nations Environment Programme

UNIDO

United Nations Framework Convention on Climate Change

Norwegian Ministry of Foreign Affairs

Canada

MINISTERO DELL'AMBIENTE E DELLA TUTELA DEL TERRITORIO E DEL MARE

環境省
Ministry of the Environment

FORMIN.FINLAND.FI
MINISTRY FOR FOREIGN AFFAIRS OF FINLAND

Ministry of Science, ICT and Future Planning

Spanish Cooperation

Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Swiss Confederation
Federal Department of Economic Affairs, Education and Research EAER
State Secretariat for Economic Affairs SECO

METI
Ministry of Economy, Trade and Industry

Comhshaol, Pobal agus Rialtas Áitiúil
Environment, Community and Local Government

**Ministry of Agriculture, Mechanisation and Irrigation Development**
Department of Agriculture Education and Farmer Training
Ngungunyana Building
No. 1 Borrowdale Road
Harare, Zimbabwe
Tel: +263 (0) 4 797390
+263 (0) 4 797400
info@moa.gov.zw
moa@moa.gov.zw
www.moa.gov.zw

cover design by:
**Bizani** Media Productions