

# We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

6,900

Open access books available

186,000

International authors and editors

200M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index  
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?  
Contact [book.department@intechopen.com](mailto:book.department@intechopen.com)

Numbers displayed above are based on latest data collected.  
For more information visit [www.intechopen.com](http://www.intechopen.com)



---

## Bringing Climate Smart Agriculture to Scale: Experiences from the Water Productivity Project in East and Central Africa

---

Kizito Kwena, Fitih Ademe, Joseph Serge,  
Nezeghty Asmerom, Bernard Musana,  
Razaka Razakamiamanana, Reuben Ruttoh,  
Hezron Mogaka, Assefa Dereje, Kifle Woldearegey,  
Anthony Esilaba and Rosemary Emongor

Additional information is available at the end of the chapter

<http://dx.doi.org/10.5772/intechopen.72365>

---

### Abstract

Since 2010, six research organizations in the region have implemented a regional project that sought to combat food insecurity, poverty and climate change by up-scaling Climate-Smart Agriculture (CSA) technologies across farms and landscapes using the Climate Smart Landscape (CSL) approach. Several CSA technologies were evaluated and promoted across landscapes using this approach with remarkable success. Maize yields in Kenya rose from 0.5 to 3.2 t ha<sup>-1</sup>, resulting in over 90% of the watershed communities being food secure. In Madagascar, rice yields increased from 2 to 4 t ha<sup>-1</sup> whilst onion yields increased from 10 to 25 t ha<sup>-1</sup>, resulting in watershed communities being 60% food-secure. In Eritrea, sorghum yields increased from 0.6 to 2 t ha<sup>-1</sup>. Farmers in Ethiopia earned US\$10,749 from the sale of pasture whilst in Madagascar, watershed communities earned additional income of about US\$2500/ha/year from the sale of onions and potatoes during off-season. Adoption levels of various CSA technologies rose from less than 30% to over 100% across the participating countries, resulting in rehabilitation of huge tracts of degraded land. In a nutshell, the potential for CSL in the region is huge and if exploited could significantly improve our economies, lives and environment.

**Keywords:** climate change, Climate-Smart Landscapes, Climate-Smart Agriculture, innovation platform, food security

---

## 1. Introduction

The East and Central Africa (ECA) subregion is projected to get warmer and wetter by the end of this century. Temperatures are projected to increase by about 2°C and rainfall by about 11% by 2050 [1, 2]. It is therefore possible that the subregion could be food self-sufficient because of climate change. As unfamiliar as this counter-narrative might seem, climate change presents an opportunity for the subregion to think and act differently, to change the way it views growth and interacts with the environment, and to choose a different path toward sustainable development. The Zero Hunger by 2025 target set by African Heads of State is achievable. However, this will only be possible if countries in the subregion invest 10% of their GDP in agriculture and target to grow the sector by 6% as proposed by the African Unions' Comprehensive Africa Agricultural Development Programme (CAADP) in 2003. So how does the subregion get there? By making substantial investments in Climate-Smart Agriculture (CSA). Climate-Smart Agriculture, if adopted, has the potential to usher in a new era of clean and sustainable growth for the subregion.

Climate-Smart Agriculture is an applied set of farming principles and practices that increases productivity in an environmentally and socially sustainable way (adaptation), strengthens farmers' capacities to cope with the effects and impacts of climate change (resilience), conserves the natural resource base through maintaining and recycling organic matter in soils (carbon storage), and as a result reduces greenhouse gas emissions (mitigation) [3]. This approach also aims to strengthen livelihoods and food security, especially of smallholders, by improving the management and use of natural resources and adopting appropriate methods and technologies for the production, processing and marketing of agricultural goods [1, 3–5]. However, for agricultural systems in the subregion to achieve CSA objectives, including improved food security and rural livelihoods as well as climate change adaptation and mitigation, they need to take a landscape approach; they must become 'Climate-Smart Landscapes.' Climate-Smart Landscapes (CSL) operate on the principles of integrated watershed management (IWM) while explicitly incorporating adaptation and mitigation into their management objectives [1, 4].

For 3 years, the Kenya Agricultural and Livestock Research Organization (KALRO), Rwanda Agricultural Board (RAB), Eritrea's National Agricultural Research Institute (NARI), Ethiopian Institute of Agricultural Research (EIAR), Artelia Madagascar (AMG) and Madagascar's Centre National de Recherche Appliquée au Développement Rural (FOFIFA) implemented a regional project on improving agricultural water productivity using this approach. The project sought to combat food insecurity, poverty and climate change by increasing the availability and productivity of water in smallholder rain-fed and irrigated agriculture at both farm and landscape levels.

The project was implemented from 2010 to 2013 in five countries namely Kenya, Rwanda, Eritrea, Madagascar and Ethiopia with financial support from the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA) and her partners. Due to positive results from this project, a second phase was launched in 2014 and implemented up to 2015 in three more countries (Uganda, Sudan and Burundi) with the aim

of up-scaling 'best bet' CSA technologies from the first phase and establishing more CSL. This chapter seeks to highlight some of the benefits of CSL and its potential in the region with a view to encouraging governments to invest in this noble approach to agricultural development in order to combat food insecurity, poverty and climate change.

## 2. Methodology

To establish and successfully promote and sustain climate-smart agricultural landscapes that could generate important synergies for agricultural production, climate adaptation and mitigation, as well as other livelihood and environmental objectives at farm and landscape scales, the following activities were undertaken.

### 2.1. Selecting the watersheds/landscapes

Two watersheds measuring about 100 km<sup>2</sup> were identified in each country by all stakeholders during the national stakeholders' consultative workshops conducted prior to project inception. The two watersheds were selected based on the extent of their degradation, potential to benefit from improved water management, their vulnerability to climate variability and change, and their food security and poverty levels. Mwanja and Kalii watersheds in Machakos and Makueni counties, respectively, were selected for Kenya; Karama and Muse-Bivumu in Nyamagabe and Bugesera districts, respectively, in Rwanda; Adulala and Ketchema in Ethiopia; Amadir and Molqi in Eritrea; and Ankazomiriotra and Avaratrambolo in Mandoto and Manjakandriana districts, respectively, in Madagascar (**Figure 1**).

These watersheds were all densely populated, highly degraded, food insecure and very prone to high climatic stresses. They therefore presented huge opportunity for CSL to improve agricultural production, resilience and income of their communities through the use of appropriate and available CSA technologies. The sites also had many agricultural development initiatives which complemented CSL efforts. They also had a lot of secondary data on climate, land and water resources, crop production and demographic trends which facilitated long-term planning and accurate simulation of climate change impacts. Finally, they had good land tenure systems which allowed farmers to invest in long-term and capital-intensive CSA practices such as drip irrigation, agroforestry, CA, terracing and water pans across the landscapes.

### 2.2. Conducting the baseline survey

A comprehensive baseline study was conducted at the start of the project to capture the socioeconomic situation, resource availability, average production and income, adaptation, mitigation, biodiversity conservation and risk management approaches of village households before the project. This was done to generate indicators for monitoring the impact of CSA interventions up-scaled across the landscapes by the project and to encourage investment in CSL.



**Figure 1.** Location of climate-smart landscapes in Kenya, Eritrea, Ethiopia, Rwanda and Madagascar.

### 2.3. Forming multi-stakeholder platforms

The project established Innovation platforms in each watershed in which all stakeholders with interest in the watershed were brought together and made part of the project implementation team. They were briefed on the objectives of CSL to secure their buy-in. This was done to consolidate resources, share knowledge, build coalitions and pool investments. The stakeholders were drawn from the watershed communities, local administration, non-governmental organizations (NGOs), government departments, religious groups, donor agencies, agrodealers and financial institutions. They were all involved in landscape planning, project implementation and progress monitoring for CSL objectives, as well as others. Landscape management plans with clearly defined roles and responsibilities were developed to guide this process.

### 2.4. Prioritizing and up-scaling CSA interventions

As indicated before, the project adopted the CSL approach to resolve the problem of land degradation, food insecurity and poverty in the six watersheds. Climate-Smart Landscapes, like the IWM approach, link production, conservation and livelihood objectives of people with a stake in a given landscape/watershed. It provides a framework for integrating technical,

economic and social knowledge in identifying constraints and in supporting planning and decision-making to achieve sustainable solutions. Through this approach, numerous CSA technologies were evaluated and promoted across landscapes using field demonstrations, field days, farmer exchange visits and trainings. The technologies were selected by farmers based on their ease of adoption, investment required and ability to make best use of increased water availability. These included conservation agriculture (CA), agroforestry, manure management, water harvesting, terracing, mulching, drought-tolerant crops, proper agronomy, high-productivity crop varieties and use of weather-based agro-advisories.

## **2.5. Building capacity of stakeholders**

Capacity of communities was strengthened to enhance adoption and utilization of CSA technologies. The project held numerous meetings to sensitize stakeholders on the benefits of CSA and CSL. Field experiments were also conducted to demonstrate the complete portfolio of CSA interventions and to generate more scientific evidence to support CSA. The project, private sector and local governments also organized regular training sessions for farmers on good agricultural practices.

## **2.6. Monitoring and evaluation**

To attract more interest and investment in CSL, the project developed a comprehensive monitoring framework which captured the multiple benefits of CSL which included yield improvements, food and energy security, adaptation, mitigation, human health, biodiversity conservation and other ecosystems services. Farmers also maintained a daily diary of their farm activities and worked with the project staff to monitor and evaluate the progress of their chosen interventions. These results were digitized and analyzed by researchers and discussed by all stakeholders at the end of every crop season.

## **2.7. Dissemination of outcomes**

Participatory videos on success stories and testimonials from the pilot landscapes were screened in nearby watersheds to spread the message of CSL. Success stories were also widely publicized through local, national and international media. The project also organized regular farmer field days and exchange visits to motivate farmers, address their questions and improve on existing strategies.

# **3. Results**

## **3.1. Food security**

Food security is a major challenge for the East and Central Africa (ECA) subregion. ECA is among the few regions in the world where yields have been stagnant over the past 50 years, leading to a decline in per capita food production and malnutrition. From the baseline surveys conducted at project inception, many households in all the five countries experienced serious food insecurity for many months in a year. In Kenya, for instance, over 50%

of the household in both watersheds lacked sufficient food to feed their families and relied on food aid. The situation was the same in Ethiopia, Madagascar and Eritrea where over 44, 45 and 55%, respectively, of the households were food insecure. However, through project intervention, productivity in all the watersheds/landscapes increased significantly and most watershed communities are now food secure. In Kenya, for instance, by embracing forecast-based farming, tied ridging, seed priming, improved agronomic practices, improved crop varieties, and micro-dosing among other technologies, farmers posted good yields throughout the project period despite most seasons being bad. Maize yields ranged from 1.2 to 3.2 t ha<sup>-1</sup> compared to baseline yield of less than 0.5 t ha<sup>-1</sup> (Figure 2). Hence, most households (hh) in the two watersheds, 3600 hh or over 90%, are food secure.

In Madagascar, adoption of improved rice varieties increased rice yields from 2 to 4 t ha<sup>-1</sup> while onion yields increased from 10 to 25 t ha<sup>-1</sup> due to prudent management of water and other inputs. As a result, communities in Ankazomiriotra and Avaratrambolo watersheds are now 60% food secure. In Eritrea, sorghum yields increased from 0.6 t ha<sup>-1</sup> at project inception to 1.5–2 t ha<sup>-1</sup> due to soil and water conservation (SWC) initiatives.

### 3.2. Increased income

A dominant feature of the ECA is widespread poverty and malnutrition. Majority of the people in the subregion, including all the watersheds, live in abject poverty. In Machakos and Makueni counties in Kenya, for instance, about 52 and 64% of the population, respectively, live below the poverty line (on less than US\$ 1 per person per day). However, through CLS approach, the situation in all the watersheds improved markedly. In Ethiopia, for instance, farmers in Adulala were able to harvest 102 kg of honey worth about US\$ 568 in one season from 10 out of 28 beehives set up by the project. About 22 households benefitted from these proceeds, and the income is bound to increase with time as more hives get colonized. Farmers in Adulala also managed to harvest and sell pasture/grass worth US\$ 10,749 from the hillside rehabilitation activity. A total of 720 farmers benefitted from these proceeds.

In Madagascar, watershed communities are now able to earn additional income of about US\$ 2500 ha<sup>-1</sup> yr<sup>-1</sup> from the sale of onions and potatoes during off-season due to prudent

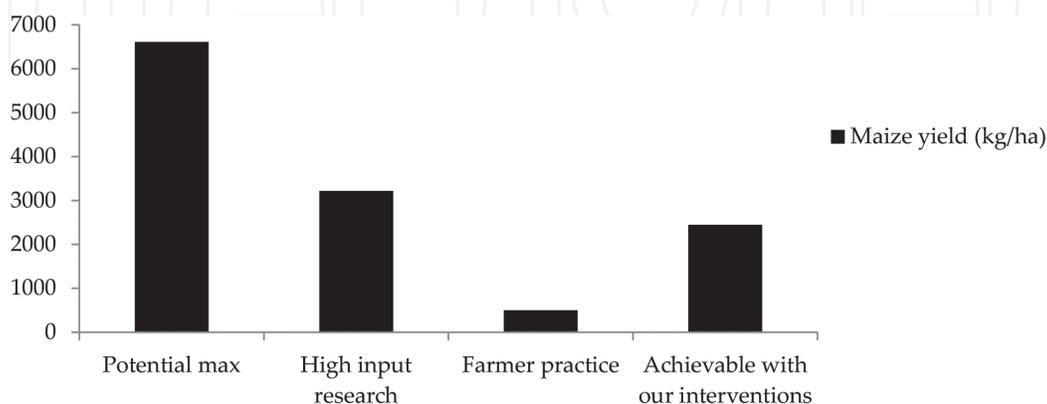


Figure 2. Effect of CSA interventions on maize yields in Kenya.

management of water and other inputs. Similarly, in Eritrea, each of the 66 out of 480 households who adopted agroforestry was able to earn about US\$ 450 in just 6 months from the sale of *Rhamnus* leaves and vegetables. Most of them used this money to buy sheep and poultry to diversify and increase income.

### 3.3. Ecosystem improvement

Low adoption of productivity-enhancing technologies has widely been blamed for low agricultural productivity in sub-Saharan African. From the baseline surveys conducted in the five countries, most farmers were knowledgeable about CSA practices but did not adopt and use them. In Mwanja watershed in Kenya, for instance, 77 and 87% of farmers were knowledgeable about irrigation and tied ridges but only 18 and 16% practiced the technologies, respectively. However, awareness and use of terraces were the highest in both sites with 98.9 and 87.1% in Mwanja and Makindu, respectively (Table 1).

The low level of adoption of terraces in Makindu was due to the relatively flat landscape compared to Mwanja. Landscape at Mwanja is hilly, and slopes often exceed 25%, making it essential to use structures such as terraces. Similarly, high level of adoption of irrigation and tied ridges in Makindu compared to Mwanja was due to availability of water and ease with which it could be applied. Tied ridging is labor intensive, and this could be the reason behind low usage of this technology in both Mwanja and Makindu locations. Various models have been used to deliver these technologies to farmers with very minimal success. However, through the CSL approach adopted by this study, several CSA technologies were up-scaled with very positive results. In Kenya, for instance, out of 198 farmers trained on terracing to conserve soil and water and improve productivity, over 700 constructed them on their farms and realized very good maize yields. Similarly, of the 146 farmers trained on pitting to harvest runoff and grow fodder, over 600 managed to dig over 50,000 pits on their farms and plant Napier grass for their livestock. The extra adopters learnt from their neighbors who attended the trainings. As a result, huge tracts of degraded land have been rehabilitated and over 100 tonnes of pasture produced compared to zero at inception. Farmers have been able to sell them and earn extra income.

Technology	Knowledge (%)**	Usage (%)**	Mwanja		Makindu	
			Knowledge (%)	Usage (%)	Knowledge (%)	Usage (%)
Conservation farming	72.4	44.8	68.9	31.2	75.1	58.3
Irrigation	81.9	30.6	76.8	18	86	43.2
Mulching	66.1	32.2	75.2	27.3	58.9	37
Terraces	98.9	87.1	98.8	98.1	99	76.1
Tied ridges	74.1	41.1	87	16	74.1	66.2
Water harvesting	85.3	53.8	91.6	62.4	80.1	45.1

\*\*Significance at  $p \leq 0.01$ .

**Table 1.** Technology knowhow and use.

Benefits	Mwania	Makindu	Mean
Decreased runoff and erosion (%)	78	83	81
Increased water infiltration (%)	26	86	56
Improved soil moisture conditions (%)	43	53	48
Improved soil physical properties (%)	—	75	38

**Table 2.** Benefits of investments in SWC technologies.

Majority of the technologies adopted were mainly for soil and water conservation (SWC) and were preferred because of their perceived benefits. The benefits included decreased runoff and erosion (81%), increased water infiltration (56%), improved soil moisture conditions (48%) and improved soil physical properties (38%) as shown in **Table 2**. A study conducted in the two landscapes/watersheds to compare the rate of adoption of these and other CSA technologies between male- and female-managed farms established that there was no difference in the adoption rate between male- and female-managed farms in the two watersheds; however, male-managed farms preferred capital-intensive technologies such as irrigation while female-managed farms adopted labor and capital-reductive technologies such as conservation agriculture [6].

Finally, farmers in Rwanda and Kenya established nurseries and planted over 1.5 million tree seedlings on their farms to improve the environment and generate income.

#### 4. Conclusions

The high level of adoption of CSA practices in landscapes/watersheds across the countries clearly indicates that available CSA technologies are acceptable to farmers if the same are tailored to meet the needs and requirements of the farmers with due consideration to their biophysical and socioeconomic conditions compared to generalized recommendations targeting a given agroecology or administrative unit. Another important finding of this work is that mobilizing communities and enhancing their capacity to better understand the tangible and intangible benefits from CSL and CSA interventions has much bigger impact than dealing with individual farmers. The landscape/watershed committees and innovation platforms established under this project played a vital role in increased adoption of CSL in all target countries.

In a nutshell, the potential for CSL approach and its benefits in the region are huge. However, to successfully transit from CSA to CSL: (1) all stakeholders in a given watershed/landscape must be involved in the planning, implementation and monitoring of this transition; (2) a comprehensive monitoring framework that clearly indicates the socioeconomic and environmental benefits of CSL must be developed, and the results communicated to stakeholders regularly to attract more investment in CSL; (3) the sites must have many

ongoing agricultural development initiatives to complement and reduce the cost of establishing CSL; a lot of secondary data on climate, land and water resources, crop production and demographic trends to facilitate long-term planning and accurate simulation of climate change impacts; and good land tenure systems to enable farmers invest in long-term and capital-intensive CSA practices; (4) massive civic education and capacity building are required to educate stakeholders on the benefits of CSL; (5) ready market must be available to absorb increased agricultural yields from CSL; and (6) landscape communities must embrace weather-based agro-advisories to minimize risks posed by climate variability and promote investment in CSL.

## Acknowledgements

The authors are grateful to ASARECA and her partners for the financial support. We are also grateful to the landscape/watershed communities and other stakeholders in the five countries for participating in this study.

## Author details

Kizito Kwena<sup>1\*</sup>, Fitihi Ademe<sup>2</sup>, Joseph Serge<sup>3</sup>, Nezeghty Asmerom<sup>4</sup>, Bernard Musana<sup>5</sup>, Razaka Razakamiamanana<sup>6</sup>, Reuben Ruttah<sup>1</sup>, Hezron Mogaka<sup>7</sup>, Assefa Dereje<sup>8</sup>, Kifle Woldearegey<sup>8</sup>, Anthony Esilaba<sup>9</sup> and Rosemary Emongor<sup>10</sup>

\*Address all correspondence to: [kwenakizito@yahoo.com](mailto:kwenakizito@yahoo.com)

- 1 Kenya Agricultural and Livestock Research Organization (KALRO), Katumani Research Centre, Machakos, Kenya
- 2 Ethiopian Institute of Agricultural Research (EIAR), Melkasa Agricultural Research Centre, Nazareth, Ethiopia
- 3 Artelia Madagascar, Antananarivo, Madagascar
- 4 National Agricultural Research Institute (NARI), Asmara, Eritrea
- 5 Rwanda Agricultural Board (RAB), Kigali, Rwanda
- 6 Centre National de Recherche Appliquée au Développement Rural (FOFIFA), Antsirabe, Madagascar
- 7 Environmental Research & Policy Analysis Group, Nairobi, Kenya
- 8 Mekelle University, Mekelle, Ethiopia
- 9 Kenya Agricultural & Livestock Research Organization (KALRO), Nairobi, Kenya
- 10 Kenya Agricultural & Livestock Research Organization (KALRO), National Agricultural Research Laboratories, Nairobi, Kenya

## References

- [1] Food and Agriculture Organization of the United Nations (FAO). *Climate-Smart Agriculture Sourcebook*. 1st ed. Rome, Italy: FAO; 2013. 570 p. ISBN: 978-92-5-107720-7, E-ISBN978-92-5-107721-4
- [2] World Bank, editor. *Climate-Smart Agriculture: A call to Action*. 1st ed. Washington DC, USA: World Bank Group; 2011. 28 p. <http://documents.worldbank.org/curated/en/992021468197391264/Climate-smart-agriculture-a-call-to-action>
- [3] Food and Agriculture Organization of the United Nations (FAO). *Climate-Smart Agriculture: Policies, practices and financing for food security, adaptation and mitigation*. In: FAO, editor. *Conference on Agriculture, Food Security and Climate Change; 31 October 2010-5 November 2010; Hague, Netherlands*. Rome, Italy: FAO; 2010. p. 48. [www.fao.org/docrep/018/i3325e.pdf](http://www.fao.org/docrep/018/i3325e.pdf)
- [4] Scherr SJ, Shames S, Friedman S. From climate-smart agriculture to climate-smart landscapes. *Agriculture and Food Security*. 2012;**1**(12). DOI: 1186/2048-7010-1-12
- [5] Lipper L, Thornton P, Campbell BM, Baedeker T, Braimoh A, Bwalya M, Caron P, Cattaneo A, Garrity D, Henry K, Hottle R, Jackson L, Jarvis A, Kassam F, Mann W, McCarthy N, Meybeck A, Neufeldt H, Remington T, Thi Sen P, Sessa R, Shula R, Tibu A, Torquebiau E. Climate-Smart Agriculture for food security. *Nature Climate Change*. 2014;**14**:1068-1072. DOI: 10.1038/nclimate2437
- [6] Jay K. *Gender Disaggregated Analysis of Adoption of Agricultural Water Management Technologies in Eastern Africa [Thesis]*. London, UK: University College of London; 2012. 76 p