Data leaks to help create a climate-smart future

Graphical notes to *The Climate-Smart Agriculture Papers: Investigating the business of a productive, resilient and low emission future*

Todd Rosenstock, Andreea Nowak, Evan Girvetz (eds.)

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This booklet presents a collection of previously unpublished or ongoing research and interventions related to climate-smart agriculture (CSA), with emphasis on experiences in Eastern and Southern Africa. The visual material contained herein offers researchers, development workers and policy-makers teaser insights into new tools, methodologies and data to support CSA scaling efforts. The 35 contributions in this booklet answer to five key questions that currently obstruct the efficient and effective implementation of CSA agendas:

(i) What are the most significant current and near future climate risks undermining smallholder livelihoods?
(ii) How can climate-smart (crop and tree) varieties be delivered quickly and cost-effectively to smallholders?
(iii) What are the most promising CSA technologies and what lessons can be gleaned to help reach scale?
(iv) How can climate risks to value chains be minimized?
(v) What are the most effective scaling-up mechanisms for generating widespread adoption of CSA?

The material for the infographics was compiled as part of the CSA Papers Project. The initiative supported 144 scientists and practitioners in 48 different institutions around the world to finalize and release data, with the intention to encourage the generation and diffusion of new information relevant for projects, plans and policies related to CSA. Twenty-six of the papers have been selected for inclusion in the forthcoming open-source book, The Climate-Smart Agriculture Papers: Investigating the business of a productive, resilient and low emission future (link). The CSA Papers was funded by UK AID through the Vuna Program and implemented by the World Agroforestry Centre (ICRAF) with support of the International Center for Tropical Agriculture (CIAT) under the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)'s Partnerships for Scaling CSA (P4S) Project. CCAFS is carried out with support from the CGIAR Trust Fund and through bilateral agreements. For details please visit http://ccafs.cgiar.org/donors. The views expressed in this document cannot be taken to reflect the official opinions of these organizations.

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Theme 1: Climate Risks and Impacts

Future climate projections in Africa:
Where are we headed?

Evan Girvetz, Julian Ramirez-Villegas, Lieven Claessens, Christine Lamanna, Carlos Navarro-Racines Andreea Nowak, Philip Thornton, Todd Rosenstock

Historical data and climate projections clearly establish the need to act quickly to help African farmers adapt to a changing climate. Too often, however, Climate-Smart Agriculture (CSA) interventions are promoted without a proper understanding of the climate risks for the specific areas involved. Here, we present a wide range of data to help explain what climate change will mean for farmers across eastern and southern Africa (ESA) in the coming decades.

Evidence that Africa's climate has been changing

General Circulation Models (GCMs) provide the most straightforward and scientifically accepted way to project what the future climate might be for specific places. However, climate change simulations performed with GCMs are only possible at coarse resolutions (typically 50–100km grid cells), which are generally too coarse for assessing regional and national impacts. To address this, spatial downscaling techniques can be used to bring these coarse scale maps down to a finer resolution.

Historic climate patterns

Temperature

- annual temperature increase since 1975: 0.03°C
- longer heat waves
- increase in number of extreme temperatures

Precipitation

Decreasing precipitation	Increased rainfall	Increasing frequency of dry spells with an increase in daily rainfall intensity which has implications for run-off	Flooding
West Africa and parts of Southern Africa, particularly Zambia and Zimbabwe	South Africa, and limited parts of east and north Africa	Southern Africa (1961–2000)	Malawi (2015 and 2017)

Future climate predictions

The Coupled Model Intercomparison Project Phase 5 (CMIP5) for our current emissions trajectory - RCP 8.5 (Source: http://climatewizard.ciat.cgiar.org)

Temperature

annual temperature increase: 1.7°C *by 2030s*; 2.7°C *by 2050s*; 4.5°C *by 2080s*

Precipitation

total precipitation change: 4% *by 2030s*; 6% *by 2050s*; 9% *by 2080s*

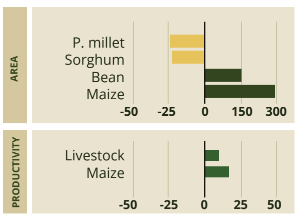
- annual precipitation increase on average in the continent. Increases are expected across much of east and central Africa
- Decreases are expected across parts of southern, western and northern Africa
- Precipitation is also projected to change differently in different months, changing the onset, length and cessation of the growing season
- Increased temperatures are leading to higher rates of evapotranspiration leading to drier soil conditions for agriculture

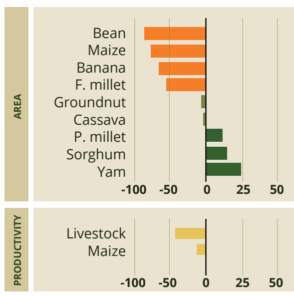
Precipitation is much more difficult to model with certainty into the future, as it may increase or decrease in different places, and also because the processes of precipitation generation are generally not well simulated by the models

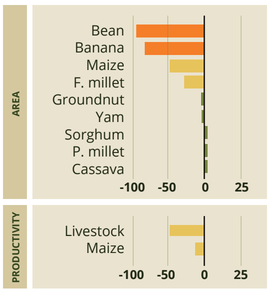
Implications for agricultural production and food security

In the absence of adaptation, climate change is expected to reduce agricultural productivity during the 21st century

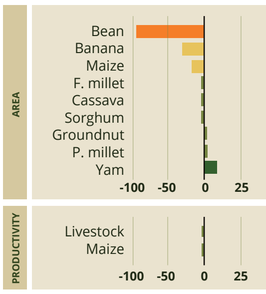
Median change in suitable area of productivity (%)

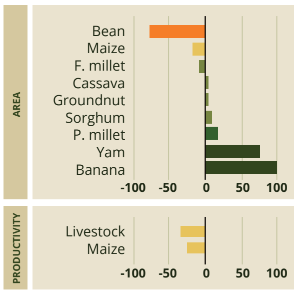


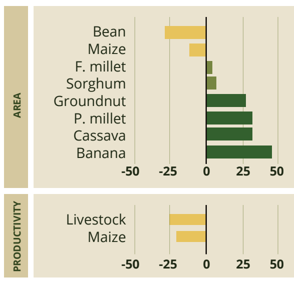




Source: Dinesh et al (2015)







KEY Median change in suitable area or productivity (%): < -50 | -50 to -5 | -5 to 5 | 5 to 50 | > 50

Pests and diseases

Under climate change, pressures from pests, weeds, and diseases are expected to increase, with adverse impacts on crops and livestock

Coffee berry borer | Burrowing nematodes | Black leaf streak disease Striga weed | Whiteflies | Mites | Mealybugs | East coast fever

However, for cassava, climate change could result in an overall decrease in the suitable range of various pests and diseases:

Whitefly | Cassava brown streak virus | Cassava mosaic geminivirus| Cassava mealybug

Planned transformation

3-5 % of sub-Saharan African arable land may need to transform from crop-based systems to either livestock-based systems or to an entirely new land use, due to climate change

Reference:

Dinesh D, Bett B, Boone R et al (2015). *Impact of climate change on African agriculture: focus on pests and diseases.* CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Copenhagen, Denmark

- **African agriculture must adapt in order to ensure food and nutritional security. Management adjustments and crop breeding will be critical in the short- and mid-term, whereas at longer timescales planned transformations will likely be necessary. Various CSA practices and technologies can improve adaptation and productivity, each with varying effectiveness depending on the farming system and site in question.**
- **Climate data and tools are available and accessible to practitioners. More effort, however, should be put into disseminating this information and ensuring that development practitioners understand how it can be used for CSA planning and implementation.**

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The infographic is based on The CSA Papers, funded by a grant from Vuna and developed by ICRAF, CCAFS and CIAT under its Partnerships for Scaling CSA (P4S) Project.

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Climate change and infectious livestock diseases:
The case of Rift Valley fever and tick-borne diseases

Bernard Bett, Johanna Lindahl and Delia Grace

Climate change influences the occurrence and transmission of a wide range of livestock diseases through multiple pathways. Here, we use two well-studied vector-borne diseases — Rift Valley fever (RVF) and tick-borne diseases (TBDs) — as case studies to describe pathways through which climate change influences infectious disease-risk in East and Southern Africa.

The case of Rift Valley fever and tick-borne diseases

Since the 19th century global average surface temperatures have risen steadily impacting:

- rainfall patterns
- intensity of droughts
- viability of ecosystems

Climate change influences the incidence and spatial distribution of livestock diseases either directly or indirectly

Direct impact: Increased risk of disease due to heightened vector-pathogen-host contact

Indirect impact: Changes in disease transmission patterns

Rift Valley fever (RVF)

Rift Valley fever (RVF) is a mosquito-borne viral zoonosis mainly affecting sheep, goats, cattle, buffaloes and camels but also humans.

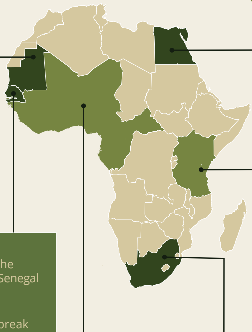
Key drivers of outbreaks of RVF

Following periods of above-normal precipitation (Kenya, South Africa, Tanzania and Uganda)

Relentless and widespread strong seasonal rainfall and high soil saturation (Southern Africa)

Warm phase of the El Niño /Southern Oscillation (ENSO) phenomenon in East Africa (Note: there have been a few incidences [e.g. in mid-1989] when an elevated RVF activity was not ENSO-driven)

Interlude between a dry period, lasting for about a week, and a period of heavy precipitation in Western Africa



MAURITANIA:
2009/2010: Outbreak affected small ruminants, camels and people due to a fourfold increase in rainfall in a desert region in northern Mauritania.

SENEGAL:
1987/1988: During the construction of the Senegal dam on the Senegal-Mauritania border.
2013/2014: RVF outbreak which was intensified by extensive livestock movements.

WEST AFRICA:
1998, 2003, 2010 and 2012: RVF outbreaks occurred after an interlude between a dry period, lasting for about a week, followed by a period of heavy precipitation.

EGYPT:
1977: Outbreaks of RVF associated with the construction Aswan High dam.

EAST AFRICA:
Mid-1989: Outbreaks associated with warm phase of El Nino/Southern Oscillation (ENSO) phenomenon although there have been a few incidences when an elevated RVFV activity was not ENSO-driven.
2006/2007: Outbreak of RVF.

SOUTH AFRICA:
2008 – 2011: RVF outbreaks were associated with relentless and widespread seasonal rainfall and high soil saturation.
Other: Outbreaks of RVF have been reported following flood irrigation in Orange River region and Western Cape Province.

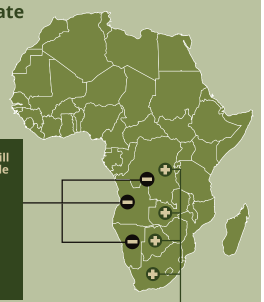
Changes in the distribution and frequency of above-normal precipitation increases the frequency of RVF epidemics.

Ticks and tick-borne diseases (TBDs)

Ticks are important vectors of a wide range of pathogens that cause many diseases in livestock such as:

- theilerioses
- cowdriosis
- anaplasmosis
- babesisosis
- ehrlichiosis
- coxiellosis (Q fever)
- Crimean Congo haemorrhagic fever
- East Coast fever

The effects of climate change on the distribution of ticks based on climate anomalies for 1990s vs 2020s



Increasing temperatures will make the climate unsuitable for ticks

Decrease
Western Angola
Southern DRC
Namibia

Increased rainfall and a rise in minimum temperatures will make the climate more suitable for ticks

Increase
South Africa
Botswana
Zambia
Eastern DRC

An increase in temperature would cause shifts in the spatial distribution of TBDs, with cooler and wetter areas expected to experience heightened risk with climate change.

Mitigations and adapatations

It is expected that the incidence and impacts of climate-sensitive diseases will increase. These diseases have established and alternative control measures in place.

Established control measures

- quarantine
- import bans
- identification and removal of suspicious animals
- premises surveillance and reporting
- vaccination
- disinfection
- compensation

However, deployment strategies are inadequate as the animal health delivery systems in most of these countries have deteriorated.

Challenges with vector control

Insecticides

any small reduction achieved is neutralised by re-emergence of large populations of naïve mosquitoes

Acaricides

tick resistance to acaricides is threatening to limit its effectiveness

Alternative control measures

- **use of tick vaccines (specifically for *Boophilus spp.*)**
- **immunization of animals through infection-and-treatment methods (ITM)**
- **breeding of TBD-resistant animals**
- **strategic use of acaricides**

RVF can be reliably controlled using livestock vaccination but delays in response do not provide beneficial outcomes. Studies are underway for alternative vaccination strategies for RVF that might involve periodic vaccination in the high-risk areas in place of reactive or emergency vaccinations.

Surveillance systems control measures

Efficient surveillance systems

- **promptly detect and report disease occurrence patterns for action**
- **guide the prioritization of interventions to geographical regions or periods where/when interventions would yield the best outcomes**

New surveillance systems

- **based on citizen science methods and cloud computing**
- **can help identify the distribution of infectious diseases**
- **provide input data for real-time disease forecasting**
- **are able to analyse surveillance data with climate and land use/land cover data as predictors to generate dynamic risk maps**

Climate change is expected to increase the risk of many vector-borne diseases, including RVF and TBDs as well as reduce the effectiveness of control measures such as vector control efforts. Further research needed in assessing the distribution of these diseases and investigating ways of managing them.

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The infographic is based on The CSA Papers, funded by a grant from Vuna and developed by ICRAF, CCAFS and CIAT under its Partnerships for Scaling CSA (P4S) Project. This work has been produced in collaboration with the International Livestock Research Institute (ILRI).

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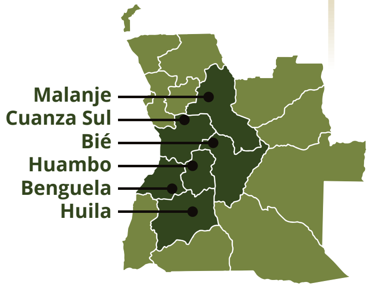
Large scale crop suitability assessment under future climate change: *Insights from Angola's planalto region*

Roland Hunter and Olivier Crespo

There is a risk that climate change will undermine the contributions of the agriculture sector towards national objectives for sustainable development and food security. Here we examine the predicted spatial changes in suitability of Angola's planalto region for production of multiple staple and cash crops, in response to future changes in temperature and precipitation.

Planalto region in Angola



Agriculture in Angola

- Agriculture contributes ~11% to Angola's GDP which is **US$ 129 BILLION**
- **~42%** of the population is employed by agriculture
- The arable land under cultivation is 8% of the available land which is **~58 MILLION HECTARES**
- One subsistence farming family cultivates on average **~1.4 HECTARES**

The crops we assessed

Maize

Annual production **~1,690 kilotonnes**

Maize contributes to the total production of 3 provinces **40%**

Cassava

Annual production

- 2012: **~$1.1 billion**
- 2014: **~7.6** million tonnes
- 2015: **10.1** tonnes per hectare per year

Annual consumption per capita **~288kg**

We used 29 General Circulation Models (GCMs) and the resultant changes to crop suitability index score were calculated by the EcoCrop analytical tool.

What we found

Analysis of GCM models suggests that the Planalto region will undergo complex spatial and temporal shifts in temperature, precipitation and onset of growing seasons

Monthly Precipitation
Prediction by 2050

Sep - Nov	↓ Decrease in entire region for Sep-Oct	↑ Increase in northern Cuanza Sul & Malanje provinces for Nov
Dec - Feb	↑ Increase in entire region, except Huíla	
Mar - Apr	↓ Decrease in southern & eastern regions	↑ Increase in central, western & northern regions
May - Aug	No major changes	

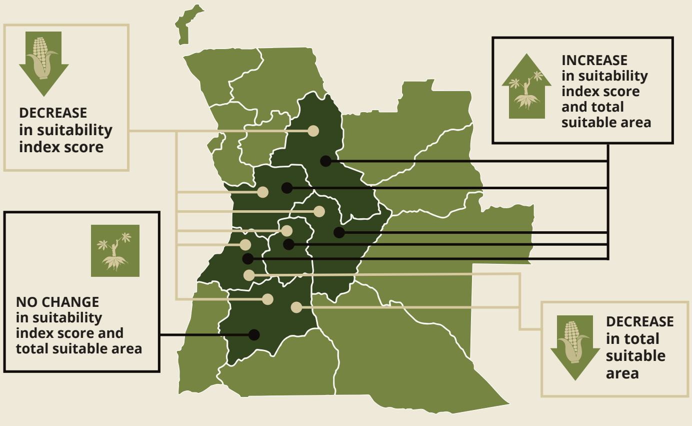
Monthly Minimum Temperature (Tmin)
Prediction by 2050

Sep - Nov	↑ Large increase in entire region
Dec - Feb	↑ Moderate increase in entire region
Mar - May	↑ Large increase in entire region, particularly in south, central & eastern regions
Jun - Aug	↑ Largest increase ~+-1 – 1.5˚C, relative to baseline

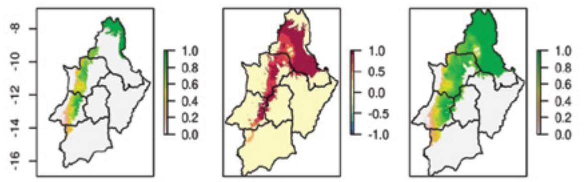
Monthly Average Temperature (Tmean)
Prediction by 2050

Sep - Nov	Large areas of Bié, Huambo, Huíla and Malanje provinces will experience large anomalies (+-1.5 – 2ºC). The majority of the remaining study area, including Cuanza Sul and Benguela provinces are predicted to experience moderate (~1ºC) anomalies in Tmean.
Dec - Feb	↑ Increase in entire region
Mar - May	↑ Increase in entire region
Jun - Aug	↑ Increase in entire region, largest relative to baseline ~+-1.5˚C

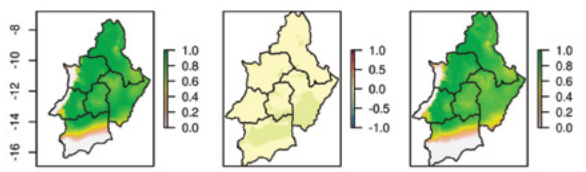
Effects of climate change on distribution of crop suitability



Changes to spatial distribution of areas suitable for production of cassava as a result of climate change



Changes to spatial distribution of areas suitable for production of maize as a result of climate change



These analyses provide a demonstration of the applications of crop suitability models for the identification of potential climate vulnerabilities related to food security, as well as identification of potential climate-resilient subsistence crops to be promoted as a strategy to adapt to changing climate conditions.

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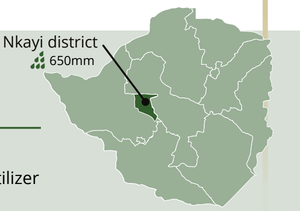
Impacts of climate change: *A sensitivity analysis to understand the role of soils and management on crops in the face of climate uncertainty in Zimbabwe*

Patricia Masikati, Katrien Descheemaeker and Olivier Crespo

Soil fertility and climate are important issues in smallholder farming systems. Here, we study the sensitivity of maize and groundnuts to individual climate factors under three soil types and simulate impacts of the future climate on the two crops across the three soil types in Nkayi district, Zimbabwe.

We used two process-based crop models— Decision Support System For Agrotechnology Transfer (DSSAT) and the Agricultural Production Systems Simulator (APSIM) —to assess the effects of single and combined climate factors on maize and groundnut grain and stover yields across three soil types.



The single climate factors

Fertilizer, Carbon dioxide, Temperature, Rainfall

The soil types

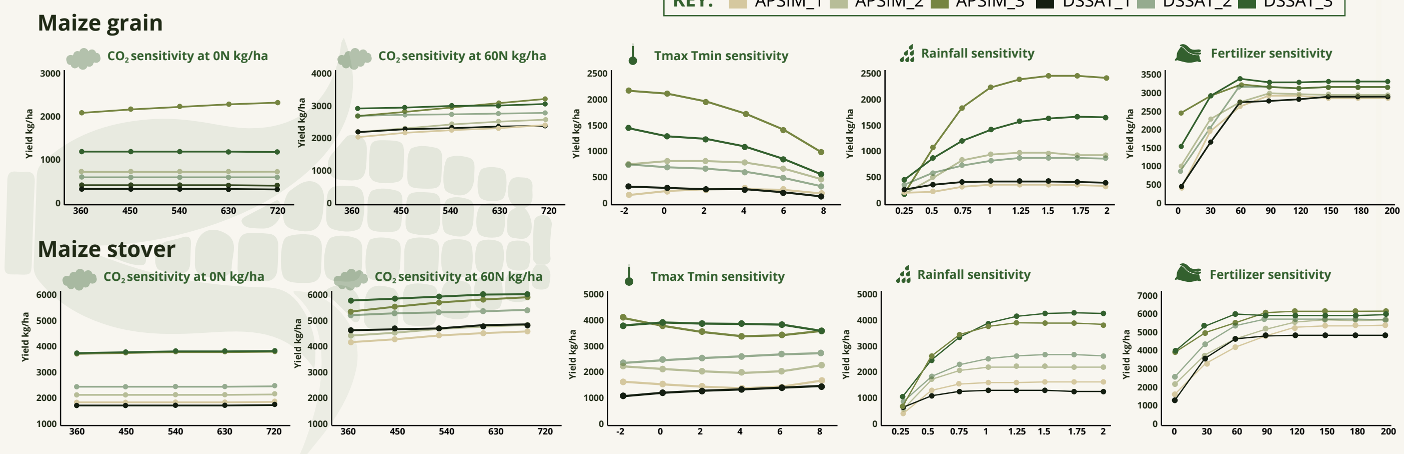
29% Poor
59% Average
12% Better

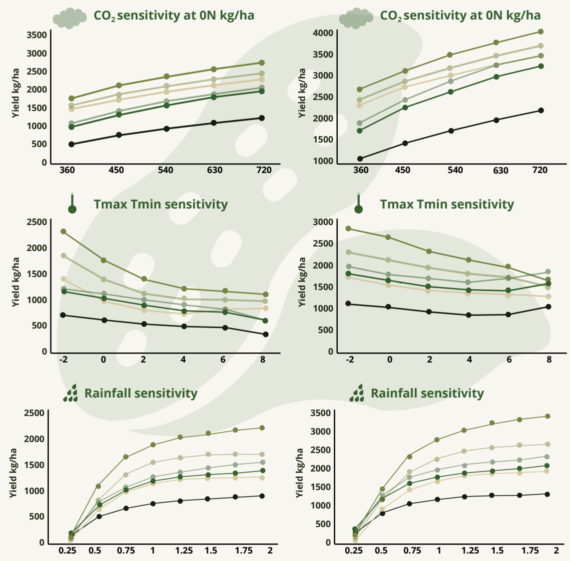
Current farmer management practice

Maize production under farmer practice (low-input system), average fertilizer application: 3 kg/ha* and average manure application: 300 kg/ha*

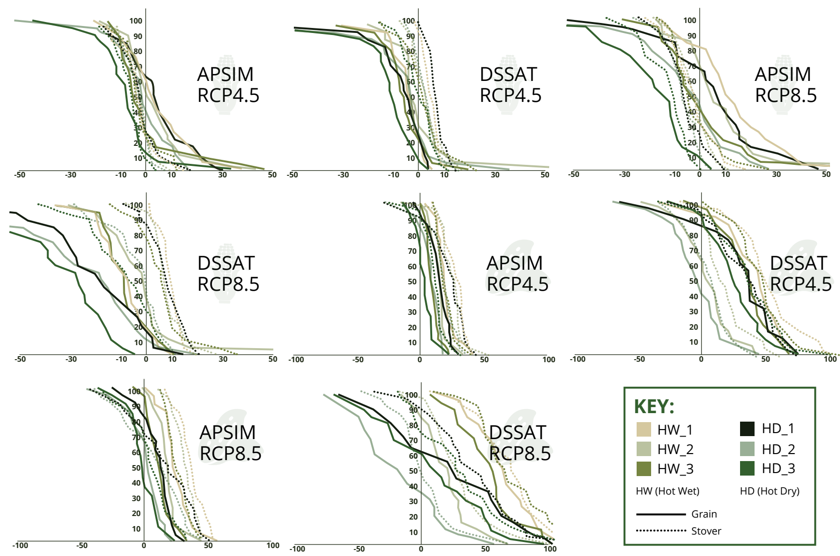
Groundnut production under farmer practice, use of low yielding recycled seed with no fertilizer

Maize & groundnut response to climate factors





Combined effects of climate factors



Soils play an important role in determining outputs of crop-climate interactions and can buffer or aggravate climate impacts. More empirical and quantitative information is needed regarding soils. Local biophysical and socio-economic conditions need to be considered for establishing recommendations and these should not be static as soil status is dynamic depending on a several factors. Crop model tools can be used to better understand the disaggregated effects of climate elements on crop production in light of climate change. For future farming systems, soils with higher organic carbon and water holding capacity will be more important.

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Gender and climate change in East Africa: *Impacts on farming households and gendered response strategies*

Emmanuel Bizimungu and Mensah Kodwo Emmanuel

Sub-Saharan African countries will bear the brunt of a rapidly changing climate and the impacts will be felt mostly by farming households. Here, we contribute to the literature on climate impacts and adaptation by exploring how individual adult male and female agricultural decision-makers with differing gender and agricultural characteristics experience climate shocks in Uganda and Tanzania.

The analysis is based on a comprehensive intra-household and farm production decision making survey data set which was collected from 600 households in Uganda (2014) and 550 households in Tanzania. In Uganda, Nwoya district was the site for the data collection, whereas in Tanzania two main districts, Mbarali and Kilolo, were selected for data collection. (Winowiecki et al., 2017).

Country profiles

Future climate trends in Tanzania and Uganda

Average temperature increase of 1.5°C **in the** next two decades

Variations in rainfall patterns: increased intensity, increased frequency and magnitude of floods and droughts

Average temperature increase of 1.3°C **by** 2050

Variations in rainfall patterns: increase in wet seasons

Gender trends

Variations in gender norms and access to production resources between men and women lead to gender gaps in agriculture production within and across the two country contexts.

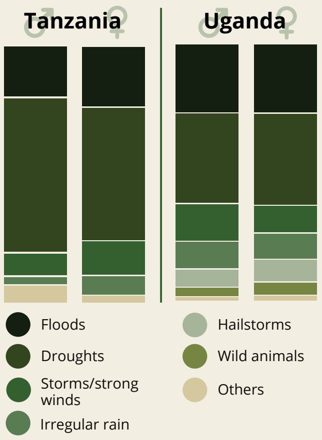
What climate shocks were experienced and what was the response?

Variables positively influencing farmers' use of coping/adaptation strategies:

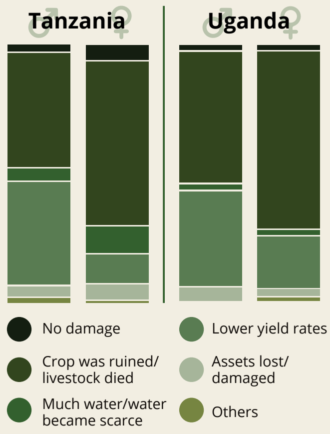
- **Gender** — Influence based on gender needs and roles
- **Education** — Higher education
- **Farm size** — Larger farm size
- **Climate information** — Higher access
- **Social capital** — Greater involvement
- **Age** — More farming experience
- **Access to credit** — Higher level of credit
- **Extension** — More information received
- **Radio** — Greater awareness
- **Livestock** — As insurance or as an asset
- **Household size** — Labour and larger size

The climatic shocks and damages experienced by farmers and their use of coping/adaptation strategies:

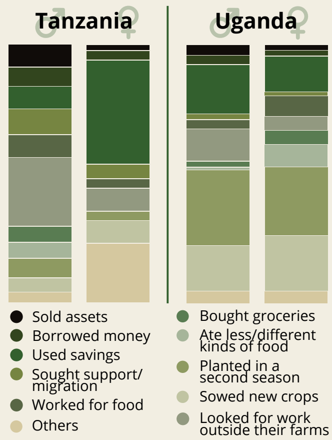
Climate shocks



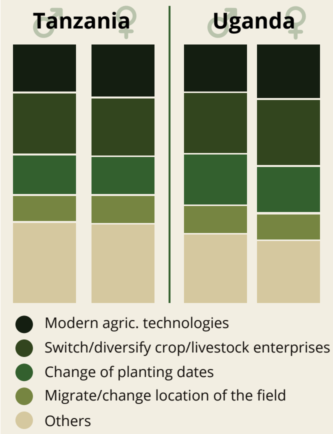
Damages



Coping strategies



Adaptation strategies



Surveyed households who did not take any action following damages by climatic shocks	Tanzania		Uganda	
	65% **Male**	76% **Female**	30% **Male**	16% **Female**

The adaptation strategies are mutually interdependent and are used as substitutes by farmers

Strategy	Tanzania ♂	Tanzania ♀	Uganda ♂	Uganda ♀
Modern agricultural technologies	19%	21%	19%	22%
Switch/ diversify crop/ livestock enterprises	24%	23%	24%	26%
Change of planting dates	15%	15%	20%	18%
Migrate/ change location of the field	10%	11%	10%	10%

The link between climate, gender and agriculture requires a better understanding of a household's experience and specifically how the male and female decision makers are impacted by and responding to climate shocks and climate change. Immediate actions (coping strategies) are gender sensitive in both countries, however, for longer term adapatation strategies, decision making is jointly done. Across eastern Africa, there is a need for the design and implementation of gender-responsive and context-specific climate adaptation and CSA programmes to meet the specific needs and farming objectives of both male and female decision makers.

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The infographic is based on The CSA Papers, funded by a grant from Vuna and developed by ICRAF, CCAFS and CIAT under its Partnerships for Scaling CSA (P4S) Project. This work has been produced from data collected in Uganda and Tanzania by International Institute for Tropical Agriculture (IITA) and International Center for Tropical Agriculture (CIAT), together with IFPRI. Data source: Winowiecki, L., Mwongera, C., Twyman, J., Shikuku, K., Ampaire, E., Miyinzi, C., Läderach, P. (2017). Intra-household and farm production decision making survey in rural Tanzania and Uganda. DBASE, Harvard Dataverse. https://doi.org/doi/10.7910/DVN/0ZEXKC

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Theme 2: Adaptive Germplasm Delivery Systems

Role and challenges of the private seed sector in developing and disseminating climate-smart crop varieties in East and Southern Africa

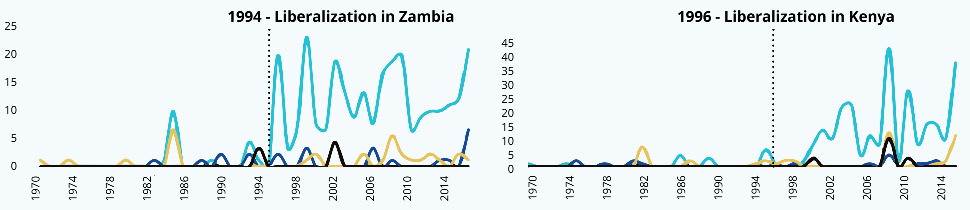
Biswanath Das, Francois Van Deventer, Andries Wessels, Given Mudenda, John Key and Dusan Ristanovic

Climate change in East and Southern Africa (ESA) will require rapid development and dissemination of climate-smart (CS) crop varieties in order to ensure food security. Here we discuss how the emerging private seed sector in ESA can play a major role in the deployment of CS crop varieties, particularly maize.

Liberalization: Increased private sector investment in the ESA seed industry

In most of ESA, plant breeding and the seed industry was dominated by public institutions and parastatals until the mid-1990s when the seed sector was liberalized.

Official variety releases since 1970 for 4 key crops in Zambia and Kenya



The local seed companies in ESA

Most of new local seed companies have relied on licensing varieties from public institutions such as national agricultural research systems (NARS), universities and international agricultural research centers (IARCs).

80 seed companies operating in ESA (estimated) *of which* Less than **25%** have invested in proprietary crop improvement and R&D

Over **90%** of agricultural R&D expenditure in SSA is made by the public sector *and* Over **80%** of varieties have been released by the public sector

Public Private Partnerships (PPPs)

Increasing the rate of genetic gain for CS traits and shortening the breeding cycle for variety development relies on:

- access to elite germplasm;
- reliable phenotyping platforms for the traits of interest such as drought;
- adoption of modern breeding methods that reduce breeding cycle time such as doubled haploids and genomic selection.

Drivers of genetic gain for CS traits in maize in ESA breeding program		Strength rating of public pipeline breeding program	Strength rating of international private pipeline breeding program
Access to elite germplasm	Locally adapted, elite germplasm	●●●	●●
	Donor germplasm from temperate/global resources	●●	●●●
Phenotyping platforms for CS traits (eg drought, heat)	Establishment of phenotyping platforms in ESA for CS traits	●●●	●
	Phenotyping protocols and technology (remote sensing, electronic data capture, data storage)	●●	●●●
Adoption of modern breeding technology	Double Haploids	●●	●●●
	Genomics	●●	●●●
	Integrated data management systems	●	●●●
Mechanization of breeding programs	Seed inventory management, movement, tracking and packing	●●	●●●
	Planting, harvesting, seed drying, seed storage	●	●●●

KEY: ●●● High; ●● Medium; ● Low

Enhancing delivery of CS seeds

Improved variety life spans remain long and incentives to replace varieties are absent within ESA, creating a deterrent to private sector investment.

Number of active seed companies and sales of certified seed in ESA countries 2015/16

Number of active seed companies	Country	Sales of certified seed in metric tonnes (MT)
18	Ethiopia	27,756 MT
19	Kenya	38,835 MT
21	Malawi	14,350 MT
15	Mozambique	4,375 MT
29	Tanzania	8,308 MT
13	Uganda	9,554 MT
10	Zambia	33,018 MT
13	Zimbabwe	44,150 MT

Few countries in ESA have a seed market of sufficient size to warrant significant R&D investment given the number of competing seed companies. The region as a whole, however, forms an attractive market and many countries in ESA share common maize agro-ecologies: harmonization of seed laws across the region can significantly encourage investment whilst ensuring the most competitive varieties are available on regional scale.

Release criteria	Zambia	Zimbabwe	Tanzania	Kenya	Malawi	South Africa
Number of seasons of official NPT	2	None	1	2	3	0 *(company assumes risk of commercialization)*
duration preceded by DUS		1 year	1 year			
duration preceded by company trialing		2 years	2 years			
Number of locations for NPT	6	Minimum 5 sites	3 in each agro-zone	6 – 12 *(depends on kit)*	6 – 12	N/A
Is farmer evaluation necessary for release?	✗	✗	✓	✗	✗	✗
Release criteria	Must be DUS and have value for cultivation and use (VCU)	Must be DUS and competitive. Low yielding varieties with special traits (eg disease tolerance) will be considered	Must be DUS and competitive. Low yielding varieties with special traits (eg disease tolerance) will be considered	Superior to commercial checks in terms of yield (5-10%) or other special attribute(s). DUS with valid descriptor for seed certification	Superior performance to commercial checks with proven VCU	DUS and entry onto national Variety List
Are CS traits (drought, heat tolerance, etc.) considered or tested during release?	Considered, but not tested	Considered, but not tested	✗	✓	✗	Yes for Biotech traits
DUS data required on lines, hybrids or both?	Hybrid	Hybrid	Both	Hybrids	Hybrids	Hybrids
Number of seasons of DUS	1	1	1	2	1	1
DUS concurrently with NPT?	✓	✓	✗	✓	✓	N/A
Minimum number of years from submission to release	2	2	2	2	2	N/A
Member of UPOV?	✗	✗	✓	✓	✗	✓
Following PVP guidlines?	✓	✓	✓	✓	Yes, some	✓
Can releases from a neighbouring country be sold?	✗	✗	✗	✗	✗	Yes *(if variety list is open for crop)*
Does certified seed have to be produced in country or can seed be imported?	✗	Variable policy applies	✗	✗	Yes *(to qualify for Govt input program)*	✗
Average age of hybrids in cultivation	10 years	13 years	14 years	14 years	11 years	4 years
Rate of hybrid seed adoption	65%	95%	20%	80%	15%	98%

NPT: National Performance Testing
DUS: Distinct, Uniform, Stable
UPOV: International Union for the Protection of New Varieties of Plants
PVP: Plant Variety Protection

The liberalisation of the seed industry in ESA in the 1990s and subsequent growth of the private sector presents a significant opportunity to develop and disseminate CS varieties through formal, certified seed systems at scale. Developing PPPs to increase the rate of genetic gains for CS traits, harmonization of regional seed laws and extension support to drive the replacement of aging varieties with CS options will contribute significantly to dissemination of a new generation of improved maize varieties with CS traits.

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The infographic is based on The CSA Papers, funded by a grant from Vuna and developed by ICRAF, CCAFS and CIAT under its Partnerships for Scaling CSA (P4S) Project.

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Fast-tracking the development and dissemination of a drought tolerant maize variety in Ethiopia in response to the risks of climate change

Berhanu T. Ertiro, Girum Azmach, Tolera Keno, Temesgen Chibsa, Beyene Abebe, Girma Demissie, Dagne Wegary, Legesse Wolde, Adefris Teklewold and Mosisa Worku

Climate change projections suggest increased frequency of drought in many parts of Sub-Saharan Africa (SSA). Replacement of old varieties with new drought tolerant (DT) varieties will be crucial in responding to the future risk of drought. Here, we look at the successful development and commercialization of BH661, a drought tolerant maize variety in Ethiopia.

The journey to successful adoption of BH661

Maize is the second most widely cultivated cereal in Ethiopia after teff. Because of its wide cultivation and popularity, the replacement of BH660 with a DT variety was considered crucial to address the increased frequency of drought as a result of climate change in Ethiopia.

Grain yield advantage of BH661 over

BH660	BH670
10.2%	12.9%

Head to head comparison

	BH661	BH660	BH670
Days to maturity	160	159	159
Plant height (cm)	272	280	277
Ear height (cm)	170	183	179
Lodging (%)	20	32	30

1952

1952
The Ethiopian maize breeding program was initiated by first collecting germplasm from various national and international sources. It later focused on use of germplasm of east African origin due to agro-ecological similarity.

1980

Early 1980's
The national hybrid maize breeding program was launched for major maize growing agro-ecologies of Ethiopia.

1984
Historic drought hits Ethiopia.

1988
The first top cross maize hybrid variety, BH140,was released for the mid-altitude sub-humid agro-ecology.

1990

1993
A late maturing three-way cross hybrid, BH660, adapted to the mid-altitude moist and transitional highland maize agro-ecologies released.

1993
The launch of the National Extension Intervention Program (NEIP) by the Ethiopian government in partnership with Sasakawa Global 2000 (SG2000) played a key role in popularization and dissemination of these hybrids.

1995
An intermediate-maturing single cross hybrid, BH540, adapted to the mid-altitude moist maize agro-ecology was released.

2000

2002 - 2010
3 hybrids accounted for over 90% of the total maize seed sales (35,000 tons) by Ethiopian Seed Enterprise (ESE), the primary public seed supplier in Ethiopia. BH660 constituted over 55% of total hybrid seed sales.

3 Hybrids *account for* 90% *of total maize seed sales*

2006-2009
Field trials conducted where 9 to 12 hybrid combinations were tested in more than 30 optimum and random drought environments.

2009
Exceptionally severe drought year.

2010-2012
BH660 is the most popular maize hybrid in Ethiopia but is over 20 years old and was not developed for drought tolerance. Between 2010 and 2012, annual certified seed production of this variety peaked at 6,000 tons.

Annual certified seed production of BH660 peaks 6,000 tons

2010

2011
The National Variety Release Standing Committee officially approved the release of BH661 for commercial cultivation.

At the end of 2011, the Bako National Maize Research Center supplied 400 kg of breeder seed of each of the parental lines, and 450 kg of the single cross parent to five certified seed producers; produced and distributed 1.7 tons of certified seed to interested parties and established demonstration plots, organized farmers' field days and intensively used public television stations for promotion of this hybrid in the two most widely spoken Ethiopian languages, Amharic and Afan Oromo.

By 2012
Many institutions were actively promoting BH661 while four of them had already begun production of basic seed, ESE produced 6.0 tons of certified seed.

2012
Maize growing areas including western and southern Ethiopia experienced drought during the main growing season.

By 2014
Five companies produced nearly 2,900 tons of certified seed.

2,900 tons *of certified seed produced by 5 companies*

Today

2016
Drought caused by El Niño severely affects maize production.

By 2016
Five companies produced nearly 9,000 tons of certified seed.

9,000 tons *of certified seed produced by 5 companies*

The successful development and commercialization of BH661 can serve as a valuable case study for breeders, seed companies, extension agents, regulatory and policy makers in how to aggressively replace aging crop varieties with new climate smart varieties. Success was due to higher grain yield and the involvement of various stakeholders in popularization of the variety. Nonetheless, overreliance on a single variety presents risks and therefore the development and release of new climate smart varieties should be a continuous process.

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The infographic is based on The CSA Papers, funded by a grant from Vuna and developed by ICRAF, CCAFS and CIAT under its Partnerships for Scaling CSA (P4S) Project. Financial support from the government of Ethiopia and various CIMMYT managed projects (e.g. DTMA, SIMLESA) are highly appreciated. All maize collaborating centers in Ethiopia are highly acknowledged for data collection.

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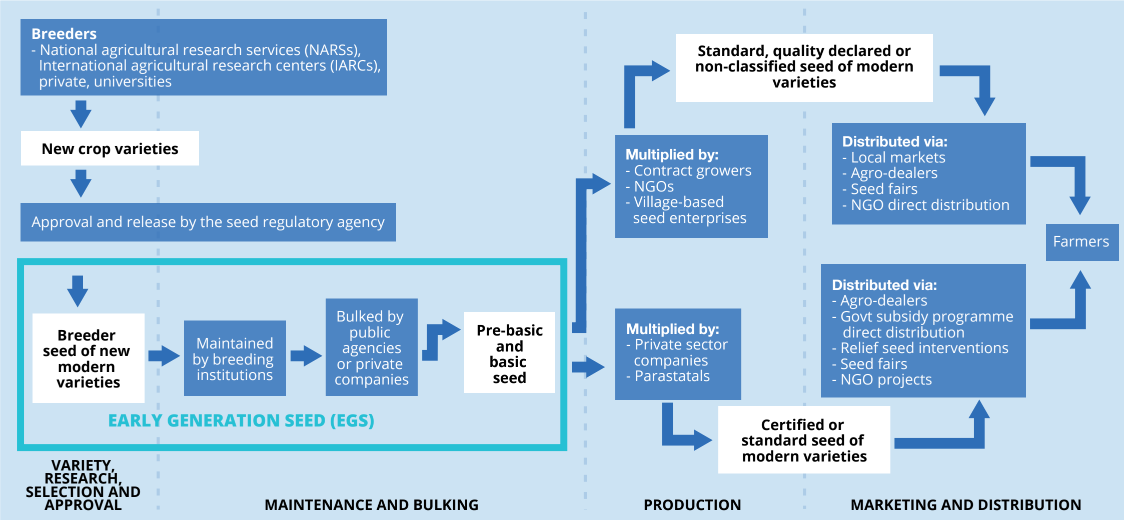
Access to early generation seed:
Obstacles for delivery of climate-smart varieties

Laura Cramer

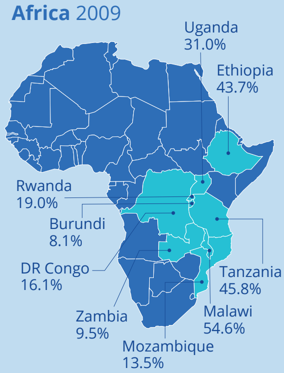
Changing climates in eastern and southern Africa will require farmers to adjust which crop varieties they grow. Enabling access to more suitable crop varieties requires well-functioning seed systems in which actors work in harmony across the supply chain. This infographic highlights the importance of early-generation seeds (EGS) to delivering improved bean seed to farmers.

How does a seed system work?



Source: AgriExperience (2016)

Adoption of modern bean varieties in sub-Saharan Africa 2009



Source: Muthoni and Andrade (2015)

How do farmers access seeds in Kenya? (%)

Local market	40.1
Own stock	36.2
Agro-dealer	11.6
Friends/family	5.7
Government	5.1
NGO/UN	0.9
Other	0.3
Contract growers	0.1

Source: McGuire and Sperling (2016)

Case studies (Kenya)

Case study 1: Successful partnerships for highland bean varieties

In 2011, a disease known as Maize Lethal Necrosis (MLN) was first reported in Kenya. Beans were recommended as a substitute crop for maize so farmers could avoid the disease. New varieties suitable to the highlands were needed urgently.

Early Generation Seed

Through previous breeding work, Egerton University had used genetic materials provided by the International Center for Tropical Agriculture (CIAT) and developed three bean varieties with disease resistance which were suitable for planting in the highlands. EGS for these varieties was available from the university for use by the private sector.

Public – private interaction

Between 2011 and 2014, the university partnered with several local seed companies. The involved parties signed contracts through which the university sold breeder seed to the seed companies, which received non-exclusive rights for multiplication, upscaling and commercialization.

Amount paid to Egerton University by seed companies: 5% of gross sales

Outcome

The breeder seed was used by the seed companies to produce certified seed which was sold to farmers through agro-dealer shops. In this case, the system worked well and EGS was not a hurdle to making a new variety available.

Case study 2: The EGS hurdle for a bean variety high in iron and zinc

Levels of micronutrient deficiencies in Kenya could be reduced through the consumption of crops, such as beans, that are biofortified with higher nutrient levels, but this is not an urgent need.

Early Generation Seed

A local university has developed a bean variety high in iron and zinc using breeding lines provided by the International Center for Tropical Agriculture (CIAT). The variety was registered in the Kenya seed catalogue in 2012 but is not yet commercially available due to lack of access to EGS to produce certified seed.

Zn Zinc · Fe Iron

Public – private interaction

A local seed company approached the university with a request for breeder seed and non-exclusive rights to sell the variety. However, the company was unable to reach an agreement with the university due to prohibitive contract requirements regarding EGS.

The prohibitive contract requirements:

The total fixed cost of licensing and royalties: 33% of the seed price

40x more: amount of EGS required to be purchased by the proposed contract vs. amount the company requested

Outcome

The bean variety that is high in iron and zinc remains uncommercialized and unavailable to Kenyan farmers.

Improved coordination among the system actors is necessary to reduce the barriers surrounding EGS provision and production, and thereby strengthen climate-adaptive and adaptable seed systems. Greater cooperation is needed among stakeholders to overcome the hurdles and can be achieved by: building of trust among actors, establishing public-private partnerships (PPPs) for breeder seed production, designing clearer policies on EGS maintenance and supply and ensuring commitment from funders to plan through breeding to commercialization.

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Climate change and seed systems of roots, tubers and bananas

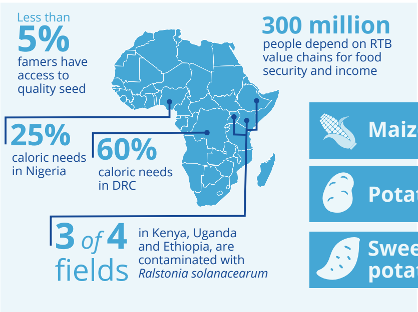
The cases of potato in Kenya and sweetpotato in Mozambique

Monica L. Parker, Jan W. Low, Maria Andrade, Elmar Schulte-Geldermann and Jorge Andrade-Piedra

Approximately 300 million poor people across the humid tropics in sub-Saharan Africa (SSA) depend on root, tuber and banana (RTB) value chains for food security, nutrition and income. Here, we present two case studies that describe experiences with potato in Kenya and orange-fleshed sweetpotato (OFSP) in Mozambique that address the implications of climate change, particularly varieties adaptable to variable rainfall, drought and increased temperatures, and associated challenges in their delivery through seed systems.

Root, tuber and banana (RTB) seed systems

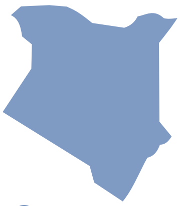
In the humid African tropics, root, tuber and banana (RTB) crops are the most important staples, however they are not unleashing their full potential to contribute to national food needs as a consequence of low productivity, due to under-developed seed systems that are unable to disseminate clean seed of climate-smart varieties of RTB crops.



Propagation of potato vs. sweetpotato vs. maize

	Consumed plant part	Most common propagation material	Multiplication ratio	Bulkiness	Storability of harvested seed	Seed cost ($/ha)	Causes of seed degeneration
Maize	Seeds	Seeds	1:300	20kg/ha	Up to 1 year	$16-27/ha	Contamination by pollen from other varieties
Potato	Tubers	Tubers	1:7.5-10	2,000kg/ha	Up to 6 months	$818-2,527/ha	Potato viruses and bacterial wilt
Sweet potato	Roots	Vine cuttings	1:3	666kg/ha	2-3 days	$76/ha	Viruses; weevils also cause damage and are transmitted through seed

Kenya
Potato



2016-2017 drought caused erratic rainfall

2% of demand is met by certified seed production

56% reduced yields by seed potato multipliers

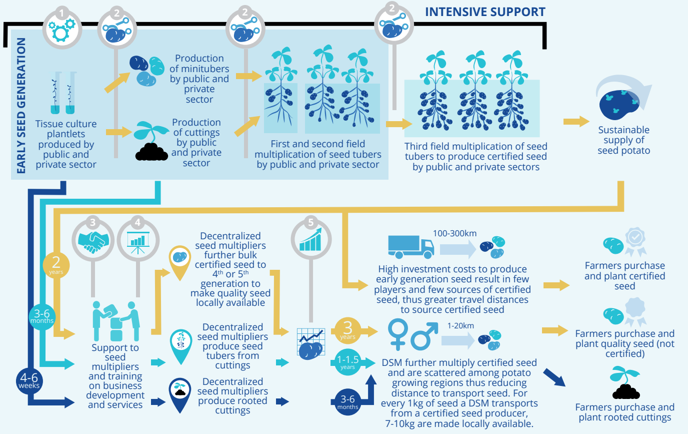
Climate-smart varieties

15 potato clones were tested for water-stress tolerance over three seasons (2013-2015), at three locations (1,300 to 1,700 m.a.s.l.) where seasonal precipitation averaged 295mm. Overall, clones registered higher yields compared to existing varieties.

CONTROL: Existing potato varieties yield **15.5 t/ha**

Production yields of clones	% greater than existing varieties
5 clones 22.9 t/ha	+40%
5 clones 20.7 t/ha	+30%
4 clones 19.4 t/ha	+20%
1 clone 18.3 t/ha	+10%

Potato seed system

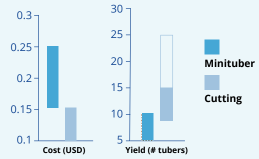


Diversification of seed system

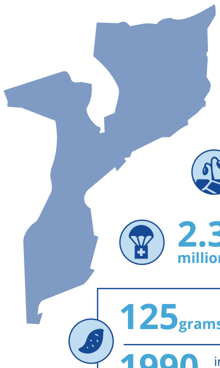
Apical cuttings

1. Apical cutting is produced through vegetative means, rather than allowing plantlets to mature and produce minitubers
2. Apical cuttings are planted in the field
3. Produce field seed tubers for 1-3 successive generations of field multiplication

At a cost of 0.15-0.25 USD, a minituber produces 5 to 10 tubers, while a cutting produces 10-15+ tubers at a cost of 0.12 to 0.15 USD/cutting



Mozambique
Sweetpotato



71.2% children under 5 with Vitamin A deficiency

13 significant droughts since 1979

2.3 million needed humanitarian assistance in Jan - Mar 2017

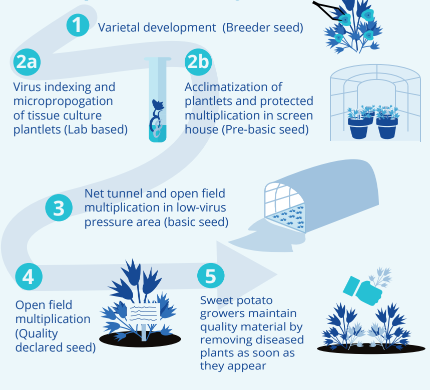
125grams one root can meet the daily vitamin A needs of a young child

1990s introduced beta-carotene rich sweetpotato

Climate-smart varieties

- **2000** Released 9 OFSP varieties
- **2002** Widely distributed OFSP varieties in southern Mozambique
- **2005**
  - Significant drought over 50% of sweet potato production lost
  - Use of ABS (Accelerated Breeding Scheme) to reduce breeding cycle
- **2011** Released 15 new drought tolerant varieties
- **2016** Released 4 drought tolerant varieties

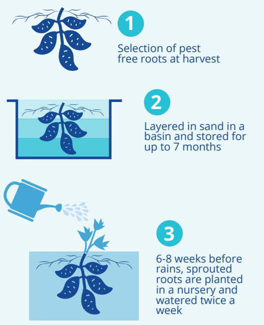
Sweetpotato seed system



Diversification of seed system

Triple S (Storage in Sand and Sprouting)

Produces approximately 40 cuttings per root, yield gains from 25-300%



Functional seed systems are essential for delivering climate smart varieties to smallholders. New breeding approaches are revolutionizing the way alternatives are delivered to adapt to climate change. Clear links among climate change, improved varieties and seed systems show the importance of interdisciplinary collaborations to ensure that the scientific and technical, and socio-economic and gender aspects are considered in such interventions. Developing functional seed systems to deliver climate-smart varieties requires a multi-stakeholder approach that needs to be sustainable through well-targeted partnerships.

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The infographic is based on The CSA Papers, funded by a grant from Vuna and developed by ICRAF, CCAFS and CIAT under its Partnerships for Scaling CSA (P4S) Project.

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Delivering perennial new and orphan crops for resilient and nutritious farming systems

Ian K. Dawson, Stepha McMullin, Roeland Kindt, Alice Muchugi, Prasad Hendre, Jens-Peter B Lillesø, and Ramni Jamnadass

There are new opportunities arising to integrate perennial new and orphan crops (NOC) into food systems which align closely with UN Sustainable Development Goals to reduce poverty, promote the accessibility and use of nutritious foods, and contribute to food security. Here, we look at how greater use of perennial NOC foods could help support food system resilience, taking into account climate change in eastern and southern Africa (ESA).

Can perennial NOC contribute to the resilience of food systems?

A means to improving food nutritional quality in ESA that is supported by governments in the region is the diversification of food systems. One crop diversification approach is based on promoting NOC that include many perennial foods; these are novel or traditional crops that although important to consumers and farmers have been largely neglected by researchers and businesses.

Annual and perennial crops

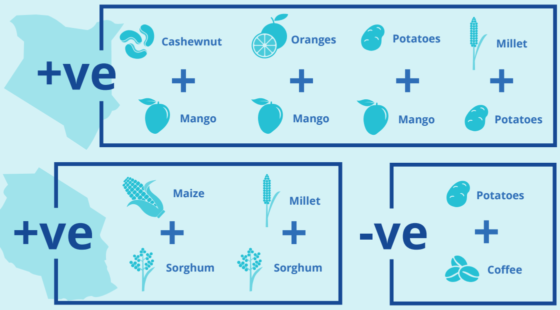
Least stable production yields: 1st, 2nd — Data available for crop and country: ✓

	Annual crops						Perennial crops (NOC or NOC models)					
	Chick peas	Maize	Millet	Sorghum	Potatoes	Groundnuts (with shell)	Coffee (green)	Cashew nuts (with shell)	Mangoes, mangosteen and guavas	Coconuts	Oranges	Dates
Ethiopia + Eritrea	✓ (2nd)	✓	✓	✓ (1st)			✓					
Kenya		✓	✓ (1st)	✓ (2nd)	✓		✓	✓	✓		✓	
Malawi	✓	✓ (2nd)		✓ (1st)	✓	✓	✓		✓			
Mozambique		✓ (1st)		✓ (2nd)	✓	✓		✓		✓		
Somalia		✓ (2nd)		✓ (1st)		✓				✓	✓	✓
Sudan + South Sudan	✓ (1st)		✓ (2nd)	✓	✓	✓					✓	✓
Uganda	✓ (2nd)	✓	✓	✓	✓	✓	✓ (1st)					
Tanzania	✓	✓ (2nd)	✓	✓	✓	✓	✓	✓ (1st)	✓	✓		
Zambia		✓ (1st)	✓	✓ (2nd)	✓	✓					✓	
Zimbabwe		✓ (1st)	✓ (2nd)	✓	✓	✓					✓	

Only 2 perennial crops had the least stable yields, suggesting that perennial crops display more stable production characteristics than annuals.

Case Study: Kenya and Tanzania

We looked at correlations of the directions in yield change across year-to-year intervals for each possible pair of crop combinations in Kenya and Tanzania. Positive: yields for a pair of crops statistically significantly correlate in the same direction (either increase or decrease) over tested yearly intervals in a nation. Negative: yield for one member of a pair of crops increases and yield for the other decreases over yearly intervals. Negative crop pairs, such as potato and coffee in Tanzania, could be deliberately combined to support resilience to variable seasonal conditions. Coffee indicates the value of perennial crops in country-specific compensatory combinations

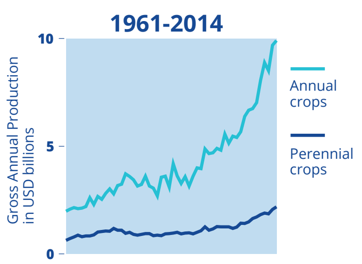


Filling harvest and nutrient gaps with perennial crops in Siaya County, Kenya

Analysis was based on a survey of 275 farm households. Perennial crops that fruited in the most food insecure month (April) with high or medium levels of both pro-vitamins A and C were mango and papaya.

Measures needed to drive perennial NOC integration into food systems

There is an increasing trend to rely on a global set of less diverse and less nutritious foods in the region, with research efforts focused on a few major annual crops.



The African Orphan Crops Consortium was set up to develop advanced breeding methods and related resources for NOC. Measures to support production improvements include:

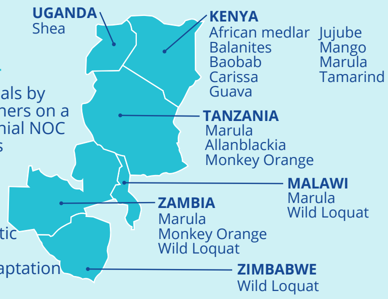
Building capacity by training plant breeders

The African Plant Breeding Academy linked to AOCC has trained more than 80 breeders

>50% From ESA countries

Funding crop improvement programmes

Current field trials by ICRAF and partners on a range of perennial NOC also function as living gene banks that maintain resources for future genetic improvement and climate adaptation



Developing improved delivery systems for perennial NOC

Challenges faced in improving delivery systems:

- wide range and variety of tree species
- range of different germplasm sources and planting materials
- time trees take to mature
- large amount of offspring from one tree
- low planting densities during cultivation

Developing production stands of improved germplasm and supporting the participation of small-scale commercial planting material providers operating at local levels are the key issues

A systems-oriented approach is crucial in future research, in which the many additional current barriers limiting NOC integration are properly considered, including market constraints and consumers' behaviour. The creation of interdisciplinary research and development teams to address multiple system-level constraints, across geographic scales, and targeted to different future challenges of which climate change is only one, is thus a priority.

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The infographic is based on The CSA Papers, funded by a grant from Vuna and developed by ICRAF, CCAFS and CIAT under its Partnerships for Scaling CSA (P4S) Project.

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Options for speeding the adoption of climate smart varieties:
What works and what does not work — experiences from Tanzania

Atugonza Luta Bilaro, George Muhamba Tryphone and Nickson Elia Peter Mkiramweni

Climate smart or resilient varieties help to mitigate climate change impacts in agriculture. However, adoption of these varieties in Africa is below the expectations. Here, we examine the role of extension and government services in driving the adoption of new climate smart varieties using sunflower and pigeon pea in Tanzania.

The role of government and extension services

Extension services

It acts as a link between farmers and research:

- **creating awareness**
- **communicating farmer's needs to researchers**
- **demonstrating new innovations developed by researchers to farmers**
- **translating information and innovations generated by research into simple, user friendly messages suited to local circumstances**

Government

In most cases the traditional role of the state in the seed sector is regulatory:

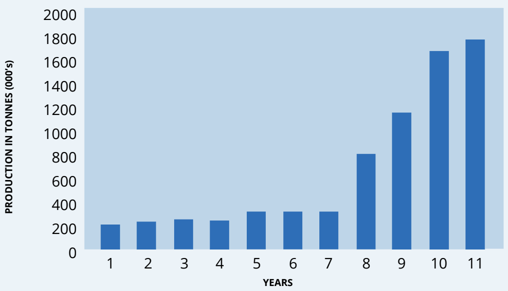
- **ensuring standard procedures are followed**
- **creating an enabling environment for other actors along the seed value chain to function properly**
- **ensuring variety release protocols for quality declared seed (QDS)**
- **enacting seed policies to support the growth and expansion of small seed companies operating at national level and policy incentives that will attract investment in the seed sector**

Factors for successful adoption of sunflower and pigeon pea varieties

Sunflower

Sunflower in Tanzania is believed to grow well in almost all regions but it does well in the drier areas of the central regions. High incidences of drought forced the government to adopt a number of policy interventions to promote sunflower production these areas.

Sunflower seed production trends for Tanzania (2004-2014)



In Tanzania, an enabling environment to private sector has shown positive contribution in enhancing adoption of sunflower production in semi-arid regions where other traditional crops have been failing due to climate change.

Government intervention

- Initiated and supported production of quality declared seed (QDS) at village level to ensure timely availability at an affordable price.
- Increased participation of private sector through the agricultural sector development programme (ASDP) providing start up capital for the establishment of agro industries.
- Credit guarantee scheme for agro-processing and agro-business sector
- Increased participation of NGOs and other financial institutions through incentives
- Supported contract farming through Rural Livelihood Development Cooperation (RLDC) helping sunflower farmers to gain access to agro inputs and reliable markets and processors

Outcome

As a result, currently in Singida region alone there are:

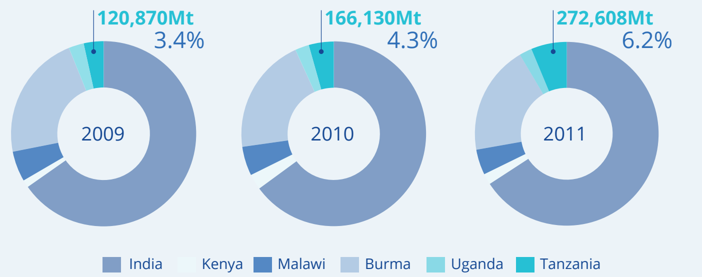
64 small sunflower processing factories

1 big sunflower processing factory

Pigeon pea

Pigeon pea is a drought tolerant crop that is currently widely grown in northern regions of Tanzania. It is an important source of income among farmers in Arusha, and Manyara regions with market opportunities in Kenya, the Middle East and the European Union. About 70% of pigeon pea produced in Tanzania is exported. Originally, pigeon pea production was confined to high rainfall areas due to lack of early maturing and drought tolerant varieties.

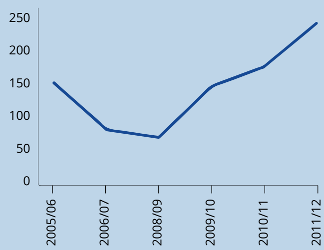
World Pigeon pea production (2009-2011)



In Tanzania, market opportunities have acted as an incentive in the adoption of drought tolerant varieties, guaranteed markets have been a driving force in their adoption. There are market opportunities in Kenya, the Middle East and the European Union and about 70% of pigeon pea produced in Tanzania is exported.

The assurance in market has increased the number of farmers growing the crop. As a result, pigeon pea production is rapidly spreading in other semi arid areas particularly Dodoma, Morogoro and Southern regions such as Mtwara and Lindi. Availability of drought resilient varieties have helped to increase adoption.

Pigeon pea production trend in Tanzania 2005/06 — 2011/12



Outcome

In Northern Tanzania, varieties such as ICEAP 00040 and ICEAP 00053 have a reported adoption rate of above 60%.

16 released varieties

300,000MT estimated annual production

In order to enhance adoption of climate smart varieties of crops, the farmers' livelihood needs need to be considered. Extension services are a prerequisite for adoption and can help farmers in making the right decision with regard to variety and management practices for better results. By putting in place attractive seed policies, government can encourage private sector investment in seed business, hence increase farmer access to quality seed.

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The infographic is based on The CSA Papers, funded by a grant from Vuna and developed by ICRAF, CCAFS and CIAT under its Partnerships for Scaling CSA (P4S) Project.

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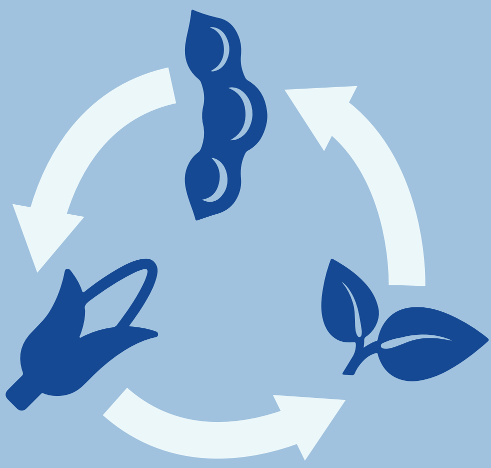


Theme 3: The Climate-Smartness of Technologies

What is the evidence base for climate-smart agriculture in East and Southern Africa?

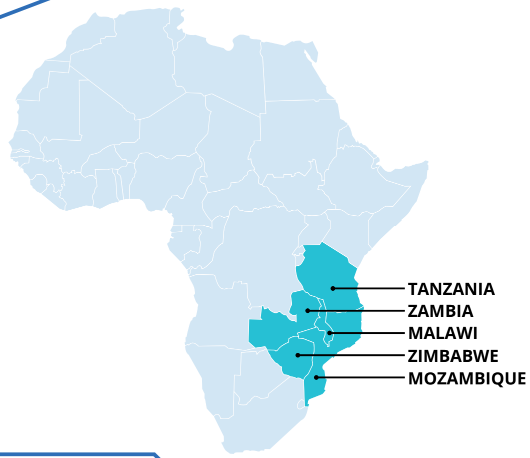
Todd Rosenstock, Christine Lamanna, Nictor Namoi, Aslihan Arslan and Meryl Richards

Development practitioners often aim to create evidence-based programs and policy to increase effectiveness and efficiency of efforts. Here we analyze what evidence is available.

$ More than 500 million will be invested in Climate-Smart Agriculture (CSA) programs across Sub-Saharan Africa

A systematic approach

A quantitative systematic review to map the published evidence on the effectiveness of field and farm-level management practices to achieve productivity, resilience and mitigation objectives in the five Vuna countries.



PAPER SEARCH TERMS: 102 management practices

58	15	19	5	5
Agronomic	Agroforestry	Livestock	Energy	Postharvest

PAPER INCLUSION CRITERIA:

- tropical developing country
- comparison between conventional and improved management
- primary data
- field experiment

Web of Science SCOPUS

The evidence

A first appraisal of the evidence base for CSA in East and Southern Africa revealed a wide range of information.

313 studies in Vuna countries | **>150** studies met inclusion criteria | **12,509** datapoints observed

Distribution of studies

Most studied country **TANZANIA**

10x No. of studies COMPARED TO

Least studied country **MOZAMBIQUE**

58% of data was generated from research stations as opposed to farmers' fields

Distribution of agricultural products studied

39 Agricultural products studied

Sorghum	Others (21 products)	Legumes	Maize
0.8%	<2%	7%	78%

Distribution of outcomes of CSA pillars

82% of studies observed data on productivity pillar

17.5% of studies observed data on resilience pillar

CO_2 **0.5%** of studies observed data on mitigation pillar

Number of CSA pillars included in studies

- **>67%** studied 1 pillar
- **32%** studied 2 pillars
- **<1%** studied 3 pillars

Distribution of CSA practices studied

63 individual CSA practices studied

27.5%	15.1%	10.1%	47.3%
Inorganic fertilizer	Intercropping	Tree management	Others

Our systematic map provides a first appraisal of the evidence base to assess the contributions of a wide set of field level technologies to CSA objectives in East and Southern Africa. Despite more than 50 years of agricultural research, this database shines a light on potential skew in our knowledge base and also identifies key areas for future investments in research.

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The infographic is based on The CSA Papers, funded by a grant from Vuna and developed by ICRAF, CCAFS and CIAT under its Partnerships for Scaling CSA (P4S) Project. The research for this book chapter was led by CIFOR, IFAD and FAO.

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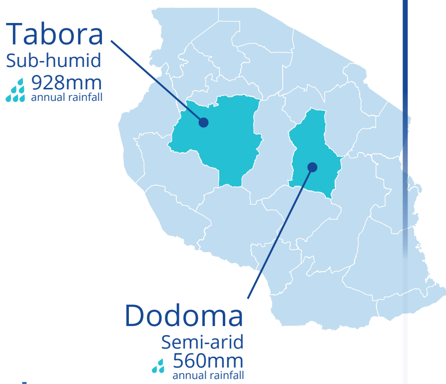
CIFOR | IFAD Investing in rural people | Food and Agriculture Organization of the United Nations

Understanding the multi-dimensionality of climate-smartness

Examples from agroforestry in Tanzania

Anthony A. Kimaro, Ogossy Sererya, Peter Matata, Götz Uckert, Johannes Hafner, Frieder Graef, Stefan Sieber and Todd Rosenstock

Climate-smart agriculture (CSA) has three goals—productivity, resilience and mitigation. However, rarely is this multi-dimensionality evaluated. Here, we analyse the ability for two intercropped agroforestry systems to be climate-smart in Dodoma and Tabora, Tanzania and how scientists can investigate CSA multi-dimensionally.



Data collected from three previously unpublished experiments:

- **Agroforestry in Dodoma:** 110 farmers studied in Chamwino district and Kongwa district.
- **Intercropping in Dodoma:** 275 famers in 3 villages in Kondwe district.
- **Intercropping in Tabora:** 90 farmers in 3 villages in Uyui district using the mother-baby plot approach.

Production and mitigation benefits of agroforestry and intercropping in Dodoma

Evaluating the climate-smartness of establishing wood supply from agroforestry (shelterbelts, boundary tree planting, contours planting, and Gliricidia sepium intercropping)

Ilolo, Molet, Mlali, Laikala and Chitego villages (Dodoma)

Fuelwood yield

depending on the species and spacing

The range of wood biomass production in shelterbelt, farm boundaries, intercropping and on contour bounds: **0.5–8** tonnes/ha

The range of economic benefits in terms of cost savings of on-farm wood supply: **90–750** USD/ha

Household wood consumption

relative to the traditional three stone firewood stove (TSF) and improved cookstoves (ICS)

- **23%** less firewood
- **20%** reduced fuelwood collection time
- **32%** reduced cooking time

Fuelwood acquisition costs in Dodoma

TSF USD**14.80** ICS USD**7.20**

The reduction of GHG emissions of ICS relative to TSF ranged from 60-62%

Crops production in alleys between shelterbelts

Maize grain yield in the alleyways between shelterbelt strips: **2.3–3.2** tonnes/ha

Crop yields slightly declined in shelterbelt areas under the influence of trees, but were similar in yield to that obtained in maize monoculture in Dodoma.

Diversification of production (crops and wood) options and income sources through agroforestry contribute to building community resilience.

Maize farming under monoculture and intercropping with pigeonpea

Mlali, Laikala, Chitego villages (Dodoma)

Productivity in trials in farmers' fields

The range of yield in Laikala, Mlali and Chitego suggesting variations in site and weather conditions: **1.2–3.2** tonnes/ha

50% higher overall maize yield in baby trials than the farmer practice yield of 1.5 tonnes/ha in the same areas

Laikala, Mlali lower potential sites due to greater degradation

Chitego higher potential site

Maize/pigeonpea intercropping in 1:1 ratio was less sensitive to site and year heterogeneity suggesting greater resilience. Higher legume proportions (1:2 ratio) was more beneficial to farmers in Mlali, a lower potential site, than in Chitego, a higher potential site, but in the year of poor precipitation and yields. Thus, Intercropping pigeonpea at the appropriate proportions based on local site conditions is a promising strategy to optimize yields and build resilience in mixture.

Productivity and resilience benefits of cassava based intercropping in Tabora

Cassava farming under monoculture, intercropping and rotations with pigeonpea

Mbola, Itebulanda and Utenge villages (Tabora)

Cassava yields

comparing the mother vs. baby plot yields

Mother plot cassava yields reduced when intercropping with:

- Canavalia 30%
- Cowpea 55%

Baby plot cassava yields reduced when intercropping with:

- Cowpea 50%

Rainfall use efficiency

Reduced rainfall use efficiency in both mother and baby plots

Soil moisture

Low soil moisture content in intercropping as compared to monoculture in both mother and baby plots

There are differences between research and farmer managed trials. Cassava is sensitive to competition and was adversley affected by intercropping. Apparently, monocultures or rotations of drought-tolerant crops like cassava with legumes provide a promising strategy to enhance farm production and to build resilience. This study has only been conducted for one season so far. However, it already illustrates the importance of conducting CSA options from a farmer-centric perspective.

Participatory evaluation of technology is critical for validating and downscaling research results under farmer management conditions and for farmers to appreciate the benefits of CSA prior to wide scaling. Overall, results of our analysis of CSA benefits illustrate key principles when considering multi-dimensionality of CSA including: the need to select appropriate indicators, ensuring designs are robust for heterogeneity, examining trade-offs and participatory evaluation of CSA on farmers' field site.

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The infographic is based on The CSA Papers, funded by a grant from Vuna and developed by ICRAF, CCAFS and CIAT under its Partnerships for Scaling CSA (P4S) Project.

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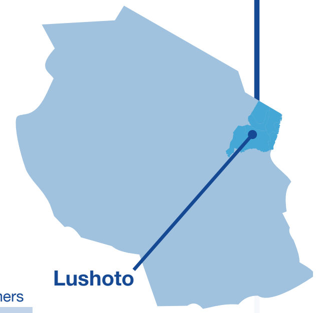
A participatory approach to assessing the climate-smartness of agricultural interventions *The Lushoto case*

Lucas T. Manda, An M.O. Notenbaert and Jeroen C. J. Groot

Climate change has affected the living standard of people as well as the performance of important sectors of the Tanzanian economy. Here, we describe a new participatory protocol that involves stakeholders throughout all stages, starting from indicator selection, indicator weighting and evaluation for assessing the climate-smartness of agricultural interventions in smallholder agriculture in Lushoto, Tanzania.

The participatory protocol was tested among 73 farmers implementing a variety of CSA interventions in Lusothos, as part of an initiative lead by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).



Under the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), agricultural practices that are may be climate smart have been promoted in seven villages in Lushoto district, Tanzania. As part of this program, farmers implemented various CSA practices.

The number of farmers implementing CSA practices:

14 farmers	21 farmers	6 farmers	5 farmers	15 farmers	11 farmers
improved forages	improved drought tolerant varieties	terracing	composting	tree planting	indigenous knowledge on weather forecasting

Farmers' perspectives on CSA

We performed a literature review and held discussions with extension staff and experts to identify relevant indicators to the food security and adaptation pillars of CSA. Then the importance of different indicators was assessed by the Lushoto farming community.

14 relevant indicators identified

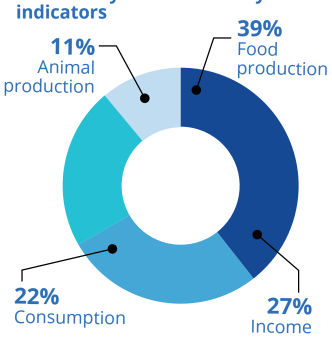
Food security

- Food production
- Animal production
- Income
- Consumption

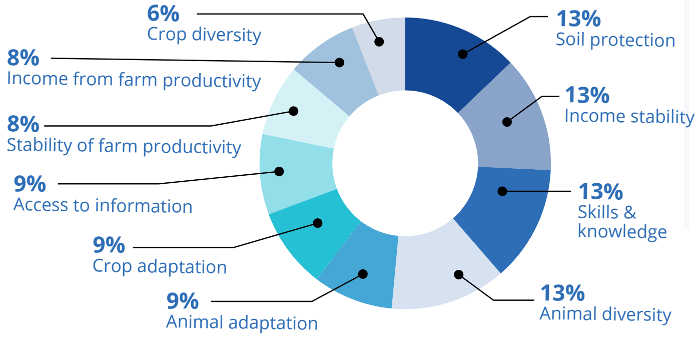
Adaptation

- Skills and knowledge
- Access to information
- Crop adaptation
- Crop diversity
- Animal diversity
- Soil protection
- Farm productivity
- Stability of farm productivity
- Income stability
- Animal adaptation

Importance to the farming community of food security indicators



Importance to the farming community of adaptation indicators



Trade-offs and synergies of interventions across the two pillars

	Improved forages	Improved drought tolerant varieties	Terracing	Composting	Tree planting	Indigenous knowledge on weather
Food security	0.4	0.5	0.2	0.6	-0.2	0.2
Adaptation	0.5	0.3	0.4	0.4	0.2	0.5

Theft, less cooperation among farmers, high labour and energy demand contributed to the low adoption rate of tree planting and terracing interventions that led into farmers to withdrawal from implementing named interventions in Gare, Boheloi and Milungui.

CSA interventions with win-win scenarios: Improved forages; Improved drought tolerant varieties; Composting

In promoting CSA practices, there is often limited inclusion of stakeholders' perspectives and therefore little buy-in and lack of wide-scale adoption as well as a lack of clear and workable criteria and methods for assessing the actual climate-smartness of these interventions. The proposed tool can be used as a starting point for assessing the climate smartness of the interventions and has the potential to increase the effectiveness of a wide range of CSA initiatives as it contributes to the monitoring, evaluation and learning process. The tool is now ready and available for use. However, the mitigation potential of the interventions does not lend itself to participatory approaches and needs to be complemented with science-led GHG emissions estimations. Such complementary study would add value to the overall assessment of climate-smartness of tested interventions.

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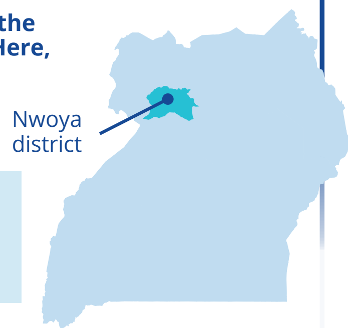
Household welfare effects of drought tolerant varieties in northern Uganda

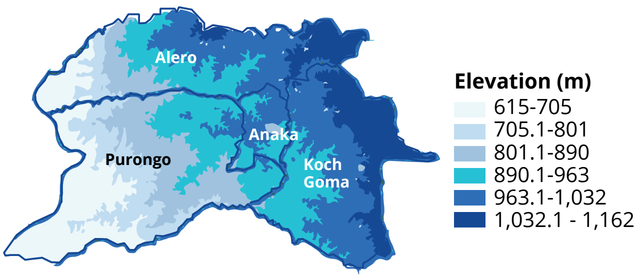
Chris M. Mwungu, Caroline Mwongera, Kelvin M. Shikuku, Mariola Acosta, Edidah L. Ampaire, Leigh Ann Winowiecki and Peter Läderach

Climate smart agriculture (CSA) technologies such as drought tolerant varieties have the potential to increase productivity and reduce poverty levels of smallholder farmers. Here, we assess the welfare effects of adopting drought tolerant varieties for maize, beans, cassava and groundnuts in Nwoya district, using per capita crop income as a proxy to measure farmer's welfare.



The study utilized an intra-household gender survey dataset collected in Nwoya district, Uganda in October 2014. Using data from a random sample of 585 households, a logistic model was estimated to assess the drivers for adoption of drought tolerant varieties. In addition, a propensity score matching model was employed to assess causal effects.

Nwoya district



Geographical area	Average population density	Temperature
4736.2km^2	36.99/km^2	18°C—34°C

Rainfall is bimodal, with the first rainy season lasting from March to June and the second rainy season lasting from July to November.

What are the drivers for adoption of improved varieties?

We looked at the extent to which different variables affect farmers' propensity to adopt new improved varieties

Household characteristics

Factors influencing adoption of improved varieties:

- Larger household size
- Higher literacy index
- Longer number of years lived in the village

Household wealth characteristics

Factors influencing adoption of improved varieties:

- Higher asset index

Climatic shocks

Factors influencing adoption of improved varieties:

- Floods and/or droughts

Perceptions of climate change and associated risks

Factors influencing adoption of improved varieties:

- Noticed change in climate

Institutional and access related characteristics

Factors influencing adoption of improved varieties:

- Access to Government extension service
- Access to information from NGOs
- Membership to an agricultural group
- Access to demonstration plots did not necessarily bring about increased adoption of the technology

What is the impact of adopting improved varieties?

We looked at the impact on household welfare of adopting new improved varieties

Drought tolerant varieties have the potential of increasing net crop income from between

$500 to $864 per year

18-32% increase

CSA interventions are context-specific, and so are the pathways for scaling up adoption of the interventions. There is a need to implement a bundled solution in scaling up adoption of drought tolerant varieties. Specifically, one that includes strengthened capacity of households to own farm assets and increased access to agricultural and weather information can be effective for adaptation to climatic risks in Northern Uganda.

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The infographic is based on The CSA Papers, funded by a grant from Vuna and developed by ICRAF, CCAFS and CIAT under its Partnerships for Scaling CSA (P4S) Project. This work was carried out by the International Center for Tropical Agriculture (CIAT) as part of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). The project, Increasing Food Security and Farming System Resilience in East Africa through Wide-Scale Adoption of Climate-Smart Agricultural Practices, is funded with support from the International Fund for Agriculture Development Grant number 2000000176.

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Considering religion and tradition in climate smart agriculture:
Insights from Namibia

Julia Davies, Dian Spear, Angela Chappel, Nivedita Joshi, Cecil Togarepi and Irene Kunamwene

Although some farmers have adopted climate-smart practices, others have been slower to transition toward new methods. This infographic considers the role played by religion and tradition in CSA adoption in Namibia.

A qualitative review of existing literature was complemented by empirical data collected from 60 semi-structured interviews, which were conducted with farmers in the semi-arid, north-central region of Namibia in July 2017.

ASSAR
Adaptation at Scale in Semi-Arid Regions research project

Namibia & Botswana since 2014

ASSAR's overarching research objective is to use insights from multiple-scale, interdisciplinary work to improve the understanding of the barriers, enablers and limits to effective, sustained and widespread climate change adaptation out to the 2030s.

Religious and traditional beliefs

Traditional and religious beliefs can prevent farmers from adopting practices that would reduce their vulnerability to climatic variability and change. These belief systems are 'software' barriers that need to be considered alongside factors such as financial, technological, policy or knowledge deficits if CSA is to be scaled up in southern Africa.

Religious and traditional beliefs can influence

- The use of seasonal climate forecasts
- Sale of livestock in times of drought
- Adoption of novel farming practices

	Beliefs	Perception	Behaviour
Limited use of seasonal climate forecasts (SCF)	"Traditional knowledge is more valuable/accurate than western science" "God controls the rain"	"Forecasts are meaningless"	Failure to use SCF
Reluctance to sell livestock during drought	"Livestock = wealth, prestige, status and security" "Owning livestock is what makes me a man" "I can only sell if the owner or the whole family agrees"	"If I sell my livestock I will lose my most valuable investment" "Selling livestock is not my choice or is a bad decision"	Failure to destock
Slow adoption of novel farming practices	"I have always farmed this way and believe in the methods that my parents taught me" "Humans cannot predict what will happen in the future" "Only God knows, God decides"	"New practices are unnecessary" "I trust that God will provide"	I intend to carry on farming as I always have

How can we work with religious and traditional belief systems to enable adaptation?

- **Position religious and traditional leaders as 'champions'**
- **Integrate science with traditional knowledge**
- **Change the framing of CSA to appeal to the specific values of local stakeholders**

Farmers that have strong traditional and religious beliefs could be prone to getting stuck in a space of not making more adaptive decisions. However, precisely because they play such an important role in agricultural decision making in southern Africa, these belief systems should be viewed as an opportunity through which to catalyse the dissemination and uptake of climate change information in general, and to promote CSA in particular.

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The infographic is based on The CSA Papers, funded by a grant from Vuna and developed by ICRAF, CCAFS and CIAT under its Partnerships for Scaling CSA (P4S) Project. The research for this book chapter was carried out under the Adaptation at Scale in Semi-Arid Regions project (ASSAR). ASSAR is one of four research programmes funded under the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA), with financial support from the UK Government's Department for International Development (DfID) and the International Development Research Centre (IDRC), Canada. The views expressed in this work are those of the creators and do not necessarily represent those of DfID and IDRC or its Board of Governors.

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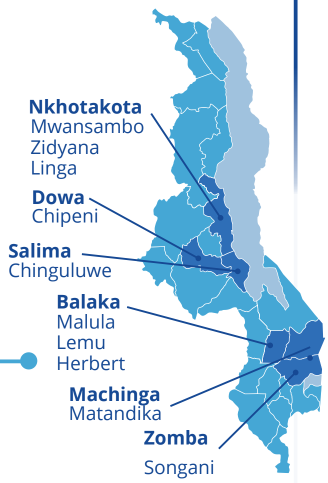
Development and practice of conservation agriculture in Malawi

W. Trent Bunderson, Christian L. Thierfelder, Zwide D. Jere and Richard G. K. Museka

Smallholder farmers in Malawi face many climate change challenges and conservation agriculture (CA) has been promoted to address these challenges. Here, we review the development and practice of CA, assess key barriers and drivers to adoption, and present an innovative participatory model of research and extension to scale-up CA as a transformative technology for smallholder farmers in Malawi and the region.



Long term on-farm trials were established in different parts of Malawi to compare maize and groundnut yields under CA with conventional ridge tillage. All trials were managed by farmers with technical support from the project organisers. The number of on-farm trials and sites generally increased over time and each has been monitored annually.

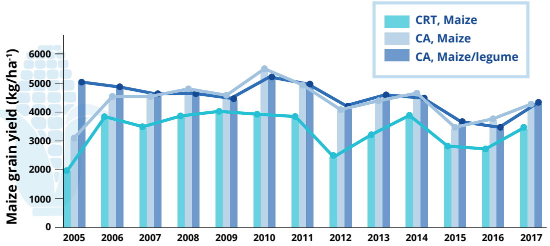
13 Years of study

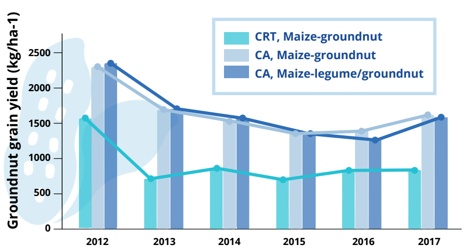
Three plot types for each trial:

- Conventional ridge tillage (CRT) with maize, and removing residues (traditional practice)
- CA with maize and retention of residues
- CA with maize and a legume intercrop with retention of residues

Conservation agriculture vs conventional ridge tillage

In addition to producing greater yields for both maize and groundnut across, results demonstrate that yield decreases during dry years were lower under CA than CRT, which appeared due in part to improved soil moisture conservation.





Overall, the higher and more stable yields of cereals and legumes under CA indicates positive impacts on household food security, nutrition and income, especially in years of low rainfall. Labor data were collected from the on-farm trials and the results reflect that CA Maize has the greatest labor savings.

% of labor input required

CA Maize	CRT Maize	CA Maize + Legume
0%	47%	33%

Barriers and drivers to adoption

Selected survey results of 1360 households under several TLC projects spanning all 3 regions of Malawi. The gender breakdown of respondents was 51.3% male and 48.7% female.

% represents % of households surveyed

Awareness about CA	
Yes	98%
No	2%

Households practicing CA	
Practicing CA	71.7%
Tried CA but stopped	2.8%
Never tried CA	25.5%

Number of years practicing CA	
One year	44.0%
Two years	45.3%
More than 2 years	10.7%

Reasons for practicing CA	
Increases food security/yields	39.3%
Saves labor	23.9%
Saves moisture to alleviate dry spells	14.8%
Increases soil health/fertility	11.2%
Increases income/lowers costs	6.5%
Saves time	3.6%
Improves crop growth	0.7%

Reasons for never trying CA	
Lack knowledge/information	53.3%
Lack labor/tools for CA	16.2%
CA considered unnecessary	13.7%
Lack of biomass to cover soil	10.5%
Resistance to change	3.6%
No cash for loan deposits	1.6%
No trust in herbicides	1.1%

Reasons for dropping CA (3% of farmers)	
No access to inputs/residues-biomass	42%
Problems with applying herbicides	27%
No access to tools	19%
Lack knowledge of CA	7%
No longer interested/no benefit	5%

Land tenure	
Customary land	97%
Leased land	1%
Private land	2%

Sources of CA extension support	
TLC extension staff	60.6%
Community workers/Lead farmers	37.4%
Staff from other NGOs	2.0%

Sources of inputs for CA	
Own resources	62.3%
Govt subsidy (FISP)	18.2%
Credit	16.7%
Project handouts	1.7%
Gifts/remittances from relatives	1.0%

Challenges with herbicides	
Ineffective	30.4%
No access, shortage or late delivery	27.0%
No protective gear	18.2%
Limited access to or lack of sprayers	11.5%
High cost	6.8%
Limited knowledge on use	4.1%
Limited to certain crops	2.0%

Drivers of increased yields	
Good moisture retention	33.3%
Improved soil fertility	27.1%
Better weed control	22.0%
Improved crop varieties	11.4%
Timely planting	6.1%

Change in income due to CA	
Increase	*90.6%
No change	8.8%
Decrease	0.6%

*Mean increase in income from CA was 39.8%

Change in land area farmed	
Significant increase	52.4%
Slight increase	20.2%
No change	27.4%

Key recommendations to address the challenges to promoting CA:

- Strengthen knowledge and support for CA among all stakeholders with compelling evidence of its benefits and application with major crops across different farming systems and agro-ecologies;
- Develop and deliver certified training courses on CA for lead farmers and extension staff;
- Harmonize and simplify extension messages on best practices among implementers;
- Facilitate access to basic inputs and tools by farmers by improving linkages with agro-dealers and micro-finance;
- Promote innovative participatory systems of extension and explore animal and mechanized ripping services as a modern method of CA.

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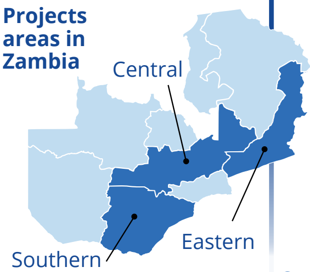
Conservation agriculture and food security:
Successes and trade-offs

Progress H. Nyanga, Bridget Bwalya Umar, Douty Chibamba and Wilma S. Nchito

With the advent of climate change and its potentially negative impacts on smallholder farming systems in Eastern and Southern Africa (ESA), conservation agriculture (CA) is considered as a form of Climate Smart Agriculture (CSA). Here, we present the successful aspects of conservation agriculture on household food security and the associated trade-offs using a food systems perspective in Zambia.

Projects areas in Zambia



The empirical basis is drawn from several studies conducted between 2006 and 2016 in Zambia: Conservation Agriculture Programme (CAP) I (2006-2011), Conservation Agriculture Programme II (2012-2014), International Development Aid and Conservation Agriculture (2014-2016), and Farming Systems and Food Security (2015-2016). Data collection for each of these four studies included panel surveys, key informant interviews, focus group discussions and observations of farmer practices.

What is conservation agriculture?

Conservation agriculture encompasses the simultaneous application of the three principles of:

- minimum mechanical soil disturbance
- diversified crop rotations or associations
- permanent organic soil cover either from a growing crop or crop residues

In smallholder farming systems in Zambia, CA entails several key practices and technologies:

- leguminous crop rotations
- agroforestry
- early and continuous weeding
- retention of crop residues in the field
- dry-season land preparation using minimum tillage systems
- precise input application (hybrid seeds, mineral fertilizers, herbicides, manure, and lime) in fixed planting stations or along ripped furrows

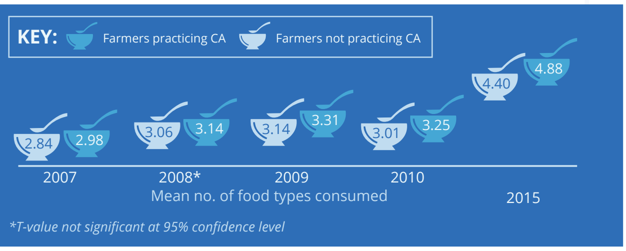
Conservation agriculture and food security

Food security was assessed by calculating the number of different food types that the household had consumed in the last 24 hours. The food categories were carbohydrates, animal proteins, plant proteins, vegetables (both cultivated and wild) and fruits (both cultivated and wild).

Benefit — Farmers practicing CA had significantly higher dietary diversity, compared to those engaged in traditional agriculture; this could be due to an emphasis on diversified cropping systems in CA.

Tradeoff — Yet higher dietary diversity is reportedly threatened by increased use of herbicides in CA, which completely kills off leafy vegetables (e.g., blackjack) of high dietary and traditional value to the rural Zambian household.

Solution to address tradeoff — Allow farmers to use other methods of (selective) weeding such as light mechanical weeding.



*T-value not significant at 95% confidence level

Conservation agriculture and hunger peak period

Benefit — Farm households practicing CA started consuming fresh maize 10-14 days earlier than those that did not practice CA, likely because maize fields under CA are planted much earlier than those under conventional agriculture. The result is a reduction in the pervasive hunger period usually experienced from November to February.

Tradeoff — Extreme dry spells in early phase of the rainy season can lead to germination challenges and replanting thus increasing production costs and threatening food security.

Average days from end of previous year to start of maize green harvest

	Conservation agriculture	Conventional agriculture
2014	55.5*	64.6*
2017	51.0**	65.1**

* -5.88 T-value
** -8.82 T-value

Conservation agriculture with trees (CAWT)

Benefit — Food trees also contribute significantly to soil fertility increase.

Tradeoff — Promotion of CAWT in Zambia has mainly concentrated almost exclusively on soil fertility trees such as winter thorn (*Faidherbia albida*), known for its soil fertility improvement benefits, while households were generally used to plant food trees (citrus, fodder trees or woodlots).

Solution to address tradeoff — To enhance the adoption of CA with trees, there is a need to increase farmers' choice by providing trees with a variety of benefits.

There is a positive and significant correlation between food trees diversity and dietary diversity

(R=0.20, p-value=0.001)

Crop choices in CA: lessons from beans, cowpea and guar

Velvet beans and cowpeas

For CA promoters, velvet beans constituted a solution to soil infertility and an opportunity for good fodder. For most farmers, these represented a new source of income (velvet beans were not part of their food system).

The promotion of cowpeas, soybean and groundnuts towards the end of Conservation Agriculture Programme I and II increased the growing of legumes both for subsistence and sale purposes as these were already common in Zambia. This also enhanced the adoption of diversified crop rotations.

However, **+50%** farmers planted the velvet beans in 2006/7 season but a year later they stopped cultivating it, due to lack of markets.

Guar

Guar is a leguminous drought resistant crop grown as fodder or vegetable. The gum from the seed has both food and non-food industrial use. It is not part of the Zambian food system and thus had least potential for contributing directly to household food security.

Due to availability of markets and favourable pricing, the growing of guar has increased in the last 3-5 years. Although not part of the local food system, guar is turning out to be a better source of income as compared to the staple crop maize. The importance of market linkages in CA for increased livelihood security can be seen by this case study.

CA has the potential to contribute to CSA objectives, especially to food security. However, given the heterogeneity of the bio-physical and socio-economic environment of small-scale farmers in Zambia and Africa at large, CA promoters need to tailor the options (practices, crops and agroforesty species) to local contexts, allowing farmers to choose the technologies, modify and adapt them to their conditions, so as to successfully bring CA to scale.

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Theme 4: Climate-Resilient Value Chains

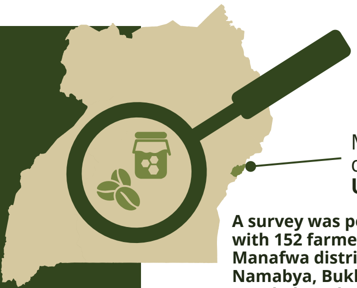
The role of farmers' entrepreneurial orientation on agricultural innovations in Ugandan multi-stakeholder platforms

Carlos Barzola Iza, Domenico Dentoni, Martina Mordini, Prossy Isubikalu, Judith Beatrice Auma Oduol, Onno Omta

Here, we examine entrepreneurship as part of the broad debate surrounding when and why farmers adopt agricultural innovations, especially in the context of multi-stakeholder platforms (MSPs) and similar organizations seeking to scale climate-smart agriculture (CSA) practices.

Studying farmer entrepreneurship and innovation

The research examined the role of farmers' entrepreneurial competences on farm input, process and market innovations in the context of Ugandan coffee and honey MSPs



Manafwa district, **Uganda**

A survey was performed with 152 farmers in the Manafwa district (Mukoto, Namabya, Bukhofu and Namboko sub counties)

Key tested relationships among the variables of interest: entrepreneurial orientation, farm characteristics and farmer innovations

Entreprenurial orientation → **Farmers innovation**

- Innovativeness
- Proactiveness
- Entreprenurial intentions

A Confirmatory Factor Analysis revealed that risk-taking did not fit the model to test for entrepreneurship in our context

Farm characteristics → **Farmers innovation**

- Socio demographic (Education level, Gender, Age)
- Farm size
- Access to resources

Farmers innovation

- Product innovation
- Process innovation
- Market innovation

What we found

1st regression model test

We considered farm characteristics and entrepreneurial orientation together with interaction variables.

- **Entreprenurial orientation has no significant impact on farmers' innovation.**
- **The farm charcateristics which have a significant impact on farmers' innovation are education level, farm size and access to resources.**

2nd regression model test

We separately included each entrepreneurial orientation dimension (innovativeness, proactiveness, risk-taking and entrepreneurial intentions) together with all of the farm characteristics.

- **Education level has a significant impact on process innovation.**
- **When taking into account proactiveness or intentions a higher education level has a significant effect on process innovation.**

Excluding education level from the regression models

When we exclude education from the regression models, entrepreneurial orientation showed a positive effect on farmers' innovations.

- **With higher innovativeness, smaller farms have a positive impact on all forms of farm innovation.**
- **If the interaction between farm size and innovativeness increases, process innovation decreases.**

When access to farm input resources increases, process innovation increases as well, when entrepreneurial competencies are also considered.

No other variable influences process innovations as much as a farmer's education level.

- **Entrepreneurial orientation can be seen as a mindset that can develop over time and not not as a personality trait fixed early in life.**
- **The development of a proactive and innovative mindset can be encouraged through workshops and other training activities for farmers.**
- **MSPs can act as spaces for engaging in entrepreneurship training and supporting the development of entrepreneurial ecosystems.**
- **Training focused on shifting the mindsets of farmers can lay the groundwork for agricultural innovation.**

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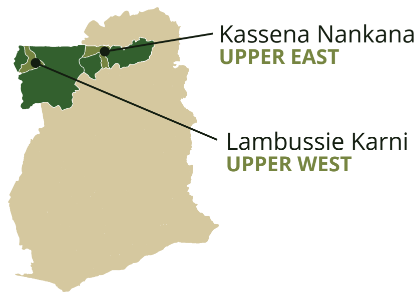
Shea butter: a pro-poor, pro-female route to increased income?

Jim Hammond, Mark van Wijk, Tim Pagella, Pietro Carpena, Tom Skirrow, Victoria Dauncey

The poorest, most vulnerable people are often the most difficult to reach. Low education, undernourishment, and lack of cash means they are often unable or unwilling to adopt new practices. This infographic explores how a program aimed at enhancing the shea butter value chain helped increase the resilience of the extremely poor in Northern Ghana.

Northern Ghana Non-Timber Forest Products (NTFPs) trade programme (2012 – 2017)

The objective of the programme was to increase incomes for communities by enhancing shea butter production and developing trade links between small scale producers and national and international buyers



The interventions

Shea 'unions' were formed, giving members access to tools and machinery, training in shea butter production and business development. storage warehouses, and credit schemes.

The impact on households was assessed using the Rural Household Multi Indicator Survey (RHoMIS), which gives a rapid overview of farm systems and household welfare across a landscape.

The population survey

223 households surveyed using RHoMIS survey tool in March 2017, randomly selected from **26** villages

- **101** project beneficiaries
- **122** not beneficiaries *(control group)*

Poverty clasifications

above the poverty line	Total value of activities above US $1.90
below the poverty line	Total value of activities below US $1.90
below the calorie line	Below 2,500 kcal per day

Household livelihoods and farm characteristics

2ha median land owned per household, with 1.6 ha cultivated in the last year

8 persons — Median household population

The main crops grown (% of the population):

ground nut	85%
maize	82%
millet	58%
rice	53%
sorghum	25%

Non Timber Forest Products (NTFP) harvested:

Shea nut	72%
Fuelwood	65%
Baobab	19%
Mango	8%
Charcoal	5%

80% of the population keep some form of livestock, mainly:

goats	65%
chicken	48%
sheep	39%
cattle	28%

Evidence of pro-poor benefits

The poorest of the poor had been made less poor by the shea value chain interventions.

	Daily calories	Daily cash income	Households below the calorie line
Beneficiary	3,885 kcal	US $0.14	35%
Non-beneficiary	2,558 kcal	US $0.05	49%

Beneficiary households made significantly more income from sale of shea butter

Annual income for beneficiaries (Mean)

US $40	US $3	US $3	US $3	US $12
Shea butter	Shea seed	Shea fruit	Fuelwood	Non-shea

Annual income for beneficiaries below the calorie line (Mean)

US $42	US $2
Shea butter	Non-shea

This is due to more shea production per person and more people producing shea butter amongst beneficiaries.

amount of shea butter produced

Beneficiaries	Non-beneficiaries
37 kg/yr	13 kg/yr

Shea products

Control of the income from shea mostly went to women, who tend to reinvest money into household welfare.

	women	men
Provide labour	70%	21%
Control income	70%	11%

Shea was already culturally familiar, abundant and available during the lean season. It was therefore easily adoptable at low cost and low risk. Furthermore it was already viewed as a female and poor households' commodity, which meant it could be used to effectively benefit those groups.

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One size does not fit all: *Private-sector perspectives on climate change, agriculture and adaptation*

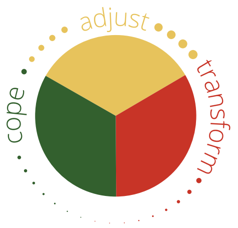
Kealy Sloan, Elizabeth Teague, Tiffany Talsma, Stephanie Daniels, Christian Bunn, Laurence Jassogne and Mark Lundy

Agricultural research rightly understands the lack of one-size fits all solutions to production issues given farmer, climate and soil variations. We provide some insights into how private sector firms from different parts of the supply chain view, understand, and engage with climate change and the promotion of CSA practices.

50+ Semi-structured interviews conducted with private firms in 2017

From exposure mapping to action

A major challenge facing the scientific community active in climate change and agriculture is how to best share insights without overstating results and, at the same time, incentivizing action. We approached this issue through four key steps



1. User-friendly climate exposure maps to identify the climate change risk in terms of cope, adapt and transform
2. Organization of multi-stakeholder platforms by exposure gradient
3. Development of a menu of potential climate smart actions and a cost benefit analysis of their returns over time
4. Design of investment portfolios by exposure gradient for public, public-private and private investors

The Private sector: roles, needs and perspectives

Different private sector roles

catalyst

- work at high level on climate issues
- rely on secondary sources of information
- look at the bigger picture, even outside of their own value chain
- may provide funding for research or services provision
- rarely implement programs on the ground
- need broad origin information and risk mitigation information to inform global strategy

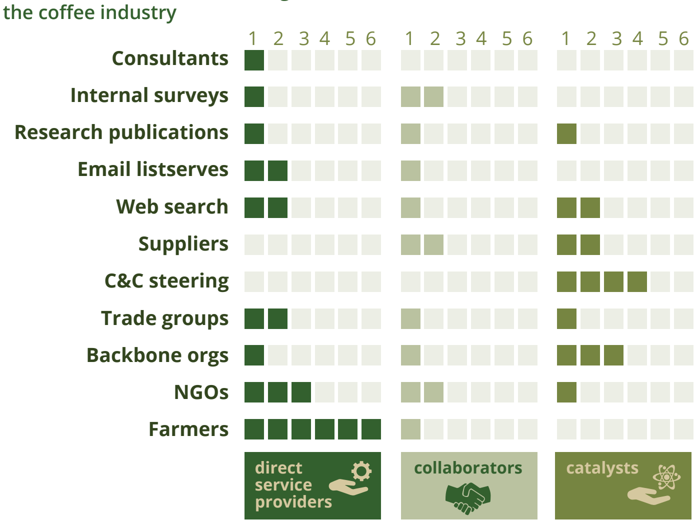
collaborator

- work with direct service providers to deliver services to smallholder farmers
- depend on the direct service providers for information to shape their program design and implementation
- work in collaborations at a slightly higher level, looking to area-specific climate maps and case studies on successful programming to inform a broader strategy
- need more targeted climate data to their specific sourcing region(s)
- need more information about the return on investment of climate smart agriculture programs and cost of inaction

direct service provider

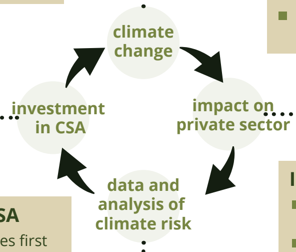
- provide holistic services to smallholder farmers to increase productivity and make farming a viable option for today's farmers and an attractive option for the next generation
- have the most access to detailed farm-level data
- need more local information to supplement their knowledge, such as changing local weather patterns and site-specific good agricultural practices (GAPs) that pair with the specific climate risks

No. of sources of climate change information for various actors within the coffee industry



The business case for CSA

Climate change leads to complex challenges for smallholder farmers



Impact on private sector

- ability for farmers to make a living
- security of supply of smallholder crops
- reputation of the private sector actors

Information needed

- quality granular information for improved diagnostics
- information to help measure and manage climate risk
- information related to specific, practical technologies to build resilience
- easier access to quality, digestible information
- less long academic papers that are difficult to read

Investing in CSA

- profitability comes first
- emphasis on the business case, return on investment and cost of inaction
- better collaboration across sectors and pooling of resources
- longer-term investments

Our research highlights the need for the scientific community to provide more detailed, actionable information to incentivize companies' investments in CSA. Understanding the role each company plays in the supply chain—as direct service providers, collaborators or catalysts—can help define the type of information needed. Insights and approaches that effectively connect long-term climate projections with short-term productivity and weather variability are still needed to increase alignment between existing productivity focused approaches and effective CSA investments.

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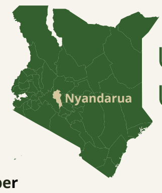
Climate-smart agricultural value chains:
Risks and perspectives

Caroline Mwongera, Andreea Nowak, An Notenbaert, Sebastian Grey, Jamleck Osiemo, Ivy Kinyua, Miguel Lizarazo and Evan Girvetz

Value-chain analysis can help untangle the complex relationships and inform climate adaptation and mitigation. Climate-change assessments often focus on production while neglecting other components of the value chain. In response to these shortcomings, the International Center for Tropical Agriculture (CIAT), in collaboration with the Government of Kenya, developed the climate risk profiles (CRP) approach. Here, we look at the necessity of including a value-chain approach in the identifying adaptation actions with a case study of Nyandarua County, Kenya.

The study relied on desktop research, climate-data analysis, focus groups, key informant interviews and a stakeholder workshop attended by farmers, private sector and representatives of governments and NGOs. Data were collected between June and September 2016.

Land area: 3,245 km²
Population: **596,268**
Temperatures: **12°C to 25°C**
Annual rainfall: **700mm - 1700mm**
Wet seasons: **January - June**, **September - December**



69% **people employed in agriculture**
USD170 million **from crop production**
USD70 million **from livestock keeping**
39% **affected by food insecurity**
35% **of children under 5 years stunted**

Value chain approaches to climate change

Climate change impacts on dairy and pea value chain and options for adaptation

Dairy (cows)

	Input provision	On-farm production	Harvesting, storage and processing	Product marketing
Flood impacts	Poor access to inputs; poor pasture quality.	Increased incidence of pests & diseases; lower milk production due to low quality animal feed.	Damage to road infrastructure hinders access to storage & processing facilities; damage to fodder and milk storage structures.	Reduced incomes from milk production; reduced market activities and opportunities; job losses (processors & transporters).
Magnitude of impact	Major-Moderate	Moderate	Major-Moderate	Moderate
Farmers' current strategies to cope with risks	Use of locally available breeding bulls; feed conservation; drainage in fodder fields; use of traditional herbs; road repairs.	Use of traditional herbs and concoctions for pest and disease control; digging trenches for flood water drainage.	Feed conservation; community efforts at road repair; value addition (powdered milk, fermentation).	Sale of milk at low farm gate prices.
Other potential options to increase farmers' adaptive capacity	Climate-proofed infrastructure; provision of relief inputs; capacity building in fodder production and conservation.	Improved disease and pest surveillance; capacity building in soil and water conservation & drainage.	Establishment of decentralized milk collection and processing plants.	Establishment of community-based milk collection & storage facilities; improved access to insurance; contract milk marketing.
Drought impacts	Poor quality/ insufficient pasture/ fodder; high cost of breeding; high cost of feed; reduced access to credit.	Increased pests & diseases due to impaired immunity and poor feeding; emaciation of livestock.	Increased operational costs (collection of milk and bulking of pastures/fodder); increased milk spoilage.	High operational costs incurred by traders in milk sourcing; reduced marketing activities due to milk scarcity.
Magnitude of impact	Severe-Major	Severe-Moderate	Major	Major-Moderate
Farmers' current strategies to cope with risks	Use of organic residue for feed; feed conservation; diversifying feeding strategies.	Administration of locally available drugs; on-farm diversification (crop production, goats).	Reduced/controlled milk delivery to bulking centres.	Sale of milk at low farm gate prices.
Other potential options to increase farmers' adaptive capacity	Drought tolerant fodder/breeds; strategic reserves for feed production and conservation; supply of concentrates training on fertility cycle monitoring; input subsidies; improved feed production & conservation; establishment of emergency fund to cushion producers.	Improved access to veterinary services and insurance; improved disease surveillance systems.	Establishment of decentralized milk processing plants.	Improve access to niche markets; contract farming; access to insurance products.

Peas

	Input provision	On-farm production	Harvesting, storage and processing	Product marketing
Flood impacts	Increased input costs due to limited access (damaged roads); incidence of planting seed spoilage during transportation.	Poor stand establishment; challenges in land cultivation; high production costs; high pre/post harvest losses.	Seed sorting and grading challenges; lack of access to storage facilities.	Low farm gate prices due to poor quality and low quantity of produce.
Magnitude of impact	Severe-Major	Severe	Severe-Major	Severe-Moderate
Farmers' current strategies to cope with risks	Seed transportation by motorcycle or donkey; use of terraces to drain excess water; seed recycling; local seed multiplication.	Use of chemicals to reduce labour costs; changing planting calendars; weeding using hoes; rogueing (of weeds); field water drainage.	Use of raised beds for sorting and drying; transportation (animal/motorcycle/ bicycles); communal road repair.	Household consumption of products; sale to middlemen at farm gate.
Other potential options to increase farmers' adaptive capacity	Climate proof roads; raised seedbeds; construction of cut-off drains).	Construction of drainage channels; increased use of IPM technologies; improved weather forecasts.	Improved storage facilities; value addition.	Improved access to new markets.
Drought impacts	Poor seed quality due to pest infestation.	Deteriorated soil properties; increased pest and disease incidences; low seed germination; increased need for irrigation (drip); high production costs (labour/disease control).	Poor harvest (quality & quantity); increased pest infestation during harvest and storage; high transport costs (low economies of scale).	Low level of product supply.
Magnitude of impact	Major-Moderate	Severe	Major	Severe-Moderate
Farmers' current strategies to cope with risks	Use of pesticides; seed recycling; local seed multiplication; manure utilization.	Dry planting; changing planting calendars; conservation agriculture; agroforestry; cover crops; intercropping; planting without fertilizer; irrigation; livelihood diversification.	Home cleaning of harvested seed; use of motorcycle for seed transportation; application of storage chemicals.	Sale at farm gate/local market.
Other potential options to increase farmers' adaptive capacity	Use of IPM technologies; irrigation; training on composting and seed multiplication and drought-tolerant varieties.	Conservation agriculture and agroforestry practices; increased use of irrigation technologies.	Climate proofed infrastructure e.g. closed vehicles.	Strengthening of farmer associations/ cooperatives; real-time market information integrating ICT.

Perspectives

- **Both on-farm and off-farm adaptation actions are needed to build resilience in agricultural value chains.**
- **There is need for more comprehensive risk analysis in order to protect and build value chains. Climate-risk analysis must go beyond analysis of only on-farm production impacts and adaptation options, as climate hazards have impacts across each stage of the agricultural value chain.**

What drives adaptation actions in the value chains?

- Some impacts are perceived to be isolated and non-severe (e.g. reduction in cropping cycle, rising temperatures and changes in growing season) resulting in limited adaptation response.
- Low awareness of potential adaptation options for managing risks.
- Low understanding of the Kenyan government's climate-related policies and how they support adaptation at local level.
- Failure to take advantage of the infrastructure and services (road networks, storage facilities, microfinance, and insurance) that might help reduce climate risks— either due to lack of awareness or unaffordability.
- Low institutional capacity and a weak policy environment.
- Focus primarily on input acquisition and on-farm production stages, missing the advantages of a value-chain approach.
- Lack of adequate guiding principles on climate change suited for the local context.
- Limited coordination among stakeholders.
- Other institutional challenges: insufficient finances to enable wider project coverage, poor targeting of beneficiaries, poor monitoring and evaluation of the initiatives, and failure to properly engage stakeholders.

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This infographic is based on work conducted by CIAT and The Ministry of Agriculture, Livestock and Fisheries in Kenya and is adapted for the CSA Papers. The CSA papers are funded by a grant from Vuna and developed by CCAFS, ICRAF and CIAT under its Partnerships for Scaling CSA (P4S) Project.

Nutrition-sensitive value chain development under a changing climate

Summer Allen and Alan de Brauw

Activities that increase resilience to climate change generally focus on staple crops rather than nutritious ones (such as fruit and vegetables), thereby ignoring the importance of diet diversity for development. This infographic provides examples of nutrition-sensitive value chains, showing how they can improve nutrition at the household level in Africa.

The impact of climate to food value chains

Climate change will strain current agricultural production systems, with negative consequences for food security. In this context, attaining the second Sustainable Development Goal (SDG) will be challenging.

Potential climate-related impacts to food value chains

Production & harvesting

- Yield losses due to temperature or precipitation variability
- Increased (or variation in) pests and diseases
- Lower nutrient content due to CO_2 concentrations

Processing & storage

- Potential damage to storage infrastructure due to weather events
- Faster spoilage, increased pathogens

Transportation & marketing

- Increased cold storage requirements due to increased temperatures
- Damage to transportation infrastructure due to flooding/weather events

Consumption

- Changes in availability of diverse diets for some consumers
- Increased prices faced by the consumer for nutritious foods

Tradeoffs and synergies for sustainable food chain development

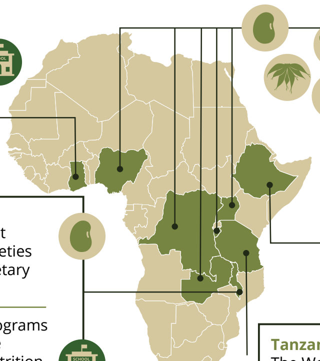
As the climate changes, these social, environmental, and economic trade-offs will shift with relative prices and the profitability of specific activities will adjust accordingly

Nutrition-sensitive value chains

Nutrition sensitive value chain interventions are a class of interventions that take place throughout a range of value chain actors to ensure more nutritious products reach consumers.

- **Increasing efficiency in value chains could contribute to more nutritious and sustainable diets as it will reduce loss and waste**
- **Increasing resilience to economic and environmental shocks**
- **Agroforestry to promote nutritious crops and sustainable production in terms of soil health and carbon sequestration**
- **Developing new nutritious crop varieties for heat and drought tolerance and ensuring more nutritious crops are resilient to climate variability**
- **Public-private partnerships to ensure that activities targeting more nutritious crop production and consumption are sustainable**

Lessons from the field



Ghana
Home-grown school feeding programs which sources food offered at schools from local producers and also use fortified foods

Malawi
CIAT and PABRA have found that adopters of improved bean varieties had higher yields and higher dietary diversity

Home-grown school feeding programs combined with behavior change communication can improve nutrition, support local agriculture, and improve attendance at schools and address malnutrition

DRC, Rwanda, Nigeria, Uganda, Zambia
HarvestPlus has released biofortified crops (maize, beans, cassava, sweet potato) and is working to support inclusion of those crops into value chains and the market systems in these countries

Nigeria and Zambia
Working with food processors to develop versions of products that can be marketed from the Vitamin A fortified yellow cassava and orange maize

Ethiopia
The Feed the Future supported partnership (the African Alliance for Improved Food Processing) with UNICEF and GAIN collaborating to fortify wheat flour and provide iodized salt

Tanzania
The World Vegetable Center evaluated the impact of heat-tolerant and disease-resistant tomato varieties in Tanzania and found the rate of return to seed improvement is as high as that of staple crops

Positive income returns for farmers were also found through access to improved pigeonpea varieties in Tanzania

The orange sweet potato

HarvestPlus and The International Potato Center (CIP)

Through partnerships with Feed the Future and private companies orange sweet potato has expanded to

14 sub-Saharan African countries

As of September 2016, orange sweet potato is estimated to have reached

2.89 **million households**

Climate change will strain current agricultural production systems, with negative consequences for food security and nutrition. However, links between climate change, increased yield variability and nutrition are not so well-documented. Value chain interventions are an attractive option, as they can overcome constraints on the use of inputs and support the development of transport and storage facilities for healthier products. Yet interventions will need to be tailored to the constraints and opportunities of specific regions, and attention must be paid to any social and environmental trade-offs that might be required.

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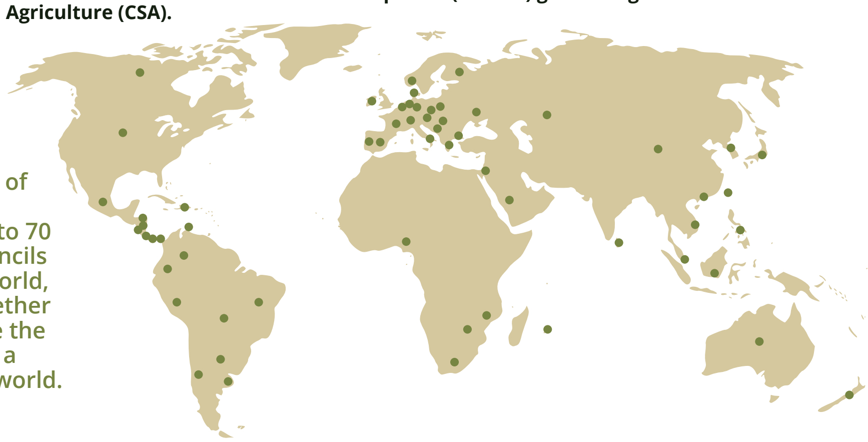
UKaid from the British people | Adam Smith International | International Food Policy Research Institute IFPRI

Realising ambitious targets and metrics for private-sector action on climate risks

Sonja Vermeulen

This infographic provides an initial analysis of progress towards the targets and the key potentials for — and obstacles to — measuring collective advances towards the World Business Council for Sustainable Development (WBCSD) global targets on Climate-Smart Agriculture (CSA).

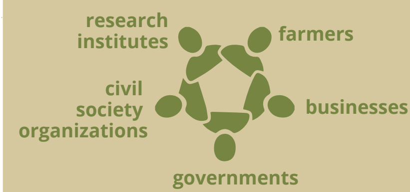
WBCSD is a membership organization of companies organized into 70 national councils across the world, working together to accelerate the transition to a sustainable world.



The WBCSD Statement of Ambition on Climate-Smart Agriculture (WBCSD 2015)

Attempts to harness the collective power of the private sector to create impact by setting global targets for private sector action by 2030.

It draws on the Sustainable Development Goals and regional consultations with:



Progress towards productivity, resilience and mitigation ambitions

Pillar 1: Productivity ambition

Commitment

Increase global food security by making 50% more nutritional food available through increased production on existing land, protecting ecosystem services and biodiversity, bringing degraded land back into productive use and reducing food loss from field to shelf.

To reach the 2030 target

1.9% **Annual increase in food production needed**

Snapshot assessment

Between 2010-2014 important food groups (cereals, vegetables, roots and tubers, fruit, meat, and milk) increased by

10.8% **global average production quantity** 2.7% **global average yield**

Pillar 2: Climate change resilience, incomes & livelihoods ambition

Commitment

Strengthen the climate resilience of agricultural landscapes and farming communities to successfully adapt to climate change through agro-ecological approaches appropriate for all scales of farming. Invest in rural communities to deliver improved and sustainable livelihoods necessary for the future of farmers, bringing prosperity through long-term relationships based on fairness, trust, women's empowerment and the transfer of skills and knowledge.

Snapshot assessment

More companies will need to provide quantitative information on indicators that cover both activities and outcomes.

There is too little data available

Pillar 3: Climate change mitigation ambition:

Commitment

Reduce GHG emissions by at least 30% of annual agricultural CO_{2e} emissions against 2010 levels (aligned with a global 1.6 $GtCO_{2e}$ yr reduction by 2030).

To reach the 2030 target

2.4%

Annual decrease in emissions needed

Snapshot assessment

Between 2010 and 2015, global agricultural emissions increased by

3.3%

Challenges and potentials

Key areas of action

- Amplifying complementary actions across a value chain
- Balancing group versus individual accountability
- Moving beyond dispersed local activities and outcomes to broader system-wide change

This early analysis reveals the gaps in data availability, transparency and standardization.

Much work needs to be done — on measurement but, more importantly, on action. WBCSD member companies have rightly set out an ambitious statement of intent to address the massive climate challenges that global society faces together. Lessons from this early analysis of progress can hopefully contribute to renewed impetus to scale-up action on climate risks and bring benefits to the more disadvantaged participants in agrifood value chains globally.

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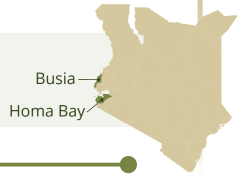
Developing climate-smart smallholder value chains in eastern Africa:

Emerging lessons from cassava and sorghum production systems in Kenya

Joab J. L. Osumba, Michael Okumu, Veronica Ndetu, Petra Jacobi, James Sinah, Andrew Kenda and Enock Syoley Mati

Climate change is impacting agricultural value chains and weakening coping capacities of smallholder farmers in Eastern Africa. However, very little information is available on best-bet strategies to seize emerging value chain opportunities in resilient production systems. Here, we look at the opportunities for climate-smart value chain development of sorghum and cassava in Kenya in the context of brewing low cost beer from the two crops.

The initiative was implemented within Lake Victoria Basin of western Kenya from January 2011 to June 2014. The baseline survey targeted 700 households randomly selected across varied Agro Ecological Zones (AEZ), including 200 villages in the two counties (Busia and Homa Bay).



The study in Homa Bay and Busia

Community vulnerability to climate hazards

	Serious	Very Serious
Busia county	Droughts; Excessive rainfall	Pests & diseases; Hail stones
Homa Bay county	Hail stones; Floods; Strong winds	Droughts

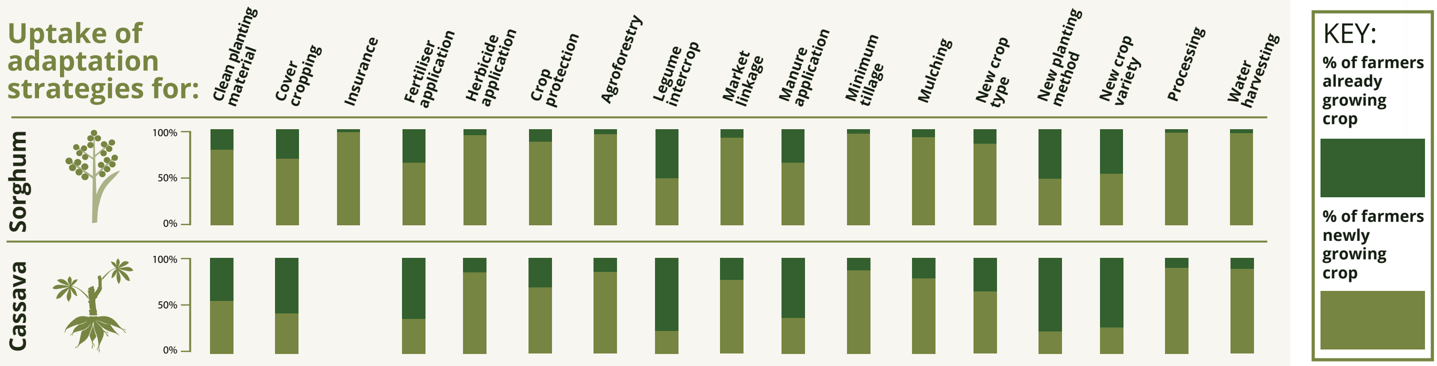
Community uptake of diversification strategies for sorghum and cassava

Crop diversification strategies of sorghum and cassava farmers in Homa Bay and Busia

Number of crops grown per farm and % of farmers

10 crops	9 crops	8 crops	7 crops	6 crops	2 crops	5 crops	4 crops	3 crops
0.5%	0.5%	0.5%	1%	2.5%	6%	6.5%	10%	16.5%

Uptake of adaptation strategies for:



The sorghum value chain

	Seed production	Seed storage/input supply	Crop production	Post-harvest handling	Manufacturing/ Milling	Distribution	Wholesalers	Retailers	Consumption
Actors	Seed growers/ producers (e.g. contracted farmers); seed companies	Seed suppliers (KALRO and AgriSeedCo); Department of Agriculture Programs; Agrovet shops; NGOs; seed bulking farmers; KEPHIS	Sorghum growers; contracted farmers/groups	EAML agents; farmer groups; NGOs; Aggregators; Traders	EABL Millers; Feed companies; EABL Uganda Ltd; Nile Breweries Ltd; Spectre International Ltd; Unga Ltd; Tapioka Ltd	EABL dealers; food processors and feed millers	None	Bar owners; shops	Beer drinkers; World Food Programme; individual consumers
Inputs	Basic seed (sorghum); bulking material (cassava); fertilizer; agrochemicals	Grower seed (Gadam and SC Sila); cassava cuttings; rent; labour; fertilizer and energy	Land; seed; casual workers; family labour; water; energy	Grain (White sorghum)	Grain (White sorghum)	Beer	Beer	Beer	Disposable income
Processes	Farm operations	Purchases; storage; sales	Farm operations	Produce processing (Threshing, cleaning, washing, peeling, chipping fermenting, drying, winnowing); collection; bulking; storage; transportation, purchases; sales; payments	Manufacturing; milling; packaging; dispatching	Purchases; distribution	Purchases, wholesaling	Purchases; retailing	Purchases; consumption
Value addition	Land; labour; conversion of input into another product	Transportation; licenses and other utilities; wages and rent	Conversion of input into another product; transportation; licenses and other utilities; wages and rent	Transportation; licenses and other utilities; wages and rent	Conversion of input into another product; licenses and other utilities; wages and rent	Transportation; licenses and other utilities; wages and rent	Licenses and other utilities, wages and rent	Licenses and other utilities, wages and rent	None
Enablers	Input service providers; creditors	Licensers; other utility service providers; landlords; security	EUCORD; KALRO; Min. of Agr.; Devt. Partners; KEPHIS; NGOs; Insurance comapnies; Farm Concern International; One World Foundation; WFP	EUCORD; KALRO; Min. of Agr.; Devt. partners; NGOs; Equity Bank; Insurance companies; Farm Concern International	EUCORD; Equity Bank	Transporters	Transporters	WFP	None

In Eastern Africa, there is potential for sorghum and cassava production to improve livelihoods and help smallholder farmers to adapt to the impacts of climate change. The growing demand for these crops for industrial application requires the development of more formal value chains.

ACRONYMS:
NGOs: Non-governmental organisations
KEPHIS: Kenya Plant Health Inspectorate Services
EAML: East African Maltings Limited
EABL: East African Breweries Limited
EUCORD: European Cooperative for Rural Development
KALRO: Kenya Agricultural and Livestock Research Organization
Min. of Agr.: Ministry of Agriculture
Devt. Partners: Development Partners
WFP: World Food Programme

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The infographic is based on The CSA Papers, funded by a grant from Vuna and developed by ICRAF, CCAFS and CIAT under its Partnerships for Scaling CSA (P4S) Project. This specific contribution was made possible by State Department of Agriculture (SDA) of the Government of Kenya, with support from the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) through the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) in Kenya.

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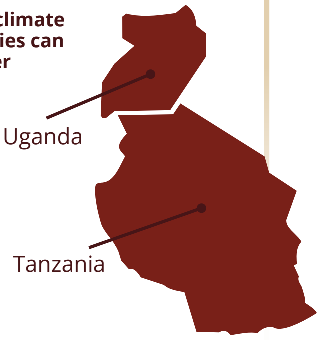
Theme 5: Taking Climate-Smart Agriculture to Scale

The role of multi-stakeholder platforms for creating a climate change policy environment in East Africa

Mariola Acosta, Edidah Ampaire, Perez Muchunguzi, John Francis Okiror, Lucas Rutting, Caroline Mwongera, Jennifer Twyman, Kelvin M. Shikuku, Leigh Ann Winowiecki, Peter Läderach, Chris M. Mwungu and Laurence Jassogne

With climate change increasingly threatening rural livelihoods in East Africa the importance of considering climate change adaptation and mitigation strategies in policy has risen. The sustainable scaling up of CSA technologies can seldom be achieved without an enabling policy environment. Here, we examine the role of Multi-Stakeholder Platforms (MSPs) in facilitating climate change policy-making in Uganda and Tanzania.

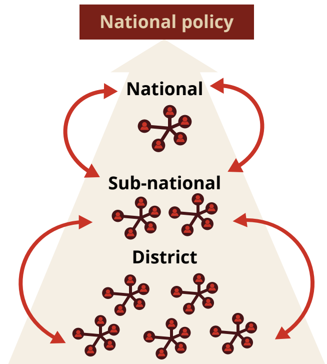


The empirical data was collected between 2014-2017 through:

- participant observation and minute meetings.
- questionnaires: Data was collected from a total of 29 stakeholders (31% females and 69% males) in Tanzania and 39 stakeholders (38% female and 62% males) in Uganda.
- social network analysis (SNA) data was collected using a multi-step process during the launch of Nwoya (n= 24) and Mbale (n=21) district platforms.

A closer look at MSPs

Multi-stakeholder platforms (MSPs) are interaction spaces that bring together representatives from different interest groups, often with different backgrounds, to discuss specific challenges, opportunities, policy actions and advocacy strategies to achieve set goals on topics of common interest to the group.



MSP variables

- The MSP composition
- Linkages between stakeholders
- Institutional embedding
- Funding

The importance of MSPs

- Differing backgrounds provide better insights
- Create interdependence leading to collective action
- Lead to ownership of the solution

The role of MSPs

- Knowledge creation and capacity building
- Influencing sub-national and national policies
- High level policy engagement

The role of MSPs in promoting CSA

The Policy Action for Climate Change Adaptation (PACCA) Project aimed at influencing and linking policies and institutions from local to national level for the development and adoption of climate-resilient food systems in Uganda and Tanzania.

UGANDA

5 Learning Alliances

National: 1
Sub National: 4

Nwoya, Rakai
Luweero, Mbale

Uganda had a higher proportion of representatives from non-state actors in their MSPs

TANZANIA

3 Learning Alliances

National: 1
Sub National: 2

Lushoto
Kilolo

In Tanzania MSPs were disproportionately composed of government representatives

The role of MSPs in promoting CSA

% of MSP participants	Uganda	Tanzania
Are generally familiar with the impacts of climate change, with a high level of understanding	71%	83%
Have knowledge on locally appropriate adaptation options, with a low or medium knowledge	77%	58%
Have knowledge on policy formulation processes	21%	41%
Have knowledge on policy implementation processes	29%	45%

Policy engagement activities of the national climate change MSPs

Uganda

- Scenario guided policy review of the Uganda National Agricultural Sector Strategic Plan (ASSP) Preparatory meetings to organize and ensure a coordinated approach of the Uganda position in the COP21.
- Participation in the Joint Sector Reviews of the Ministry of Water and Environment (MWE) and the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF).
- Informing the draft irrigation policy.
- Participation in a live national dialogue on climate change and women.
- Participation in several climate change workshops organized by other actors.

Tanzania

- Water use technology study used in a policy engagement meeting with the National Irrigation Commission, Basin Water Boards and the Ministry of Agriculture, Food Security and Cooperatives.
- Scenario guided policy review of the National Environmental Policy.
- Informing the development of the Intended Nationally Determined Contributions (INDCs).
- Participation in the development of the CSA Country Plan for Tanzania.

The role of MSPs in fostering CSA science-policy dialogue is important, however there is a need for greater knowledge sharing among stakeholders. The MSP platform composition is vital in shaping, directing and facilitating that knowledge exchange process. Further context-specific studies are needed on the optimal balance between non-state actors and government representatives in the platforms.

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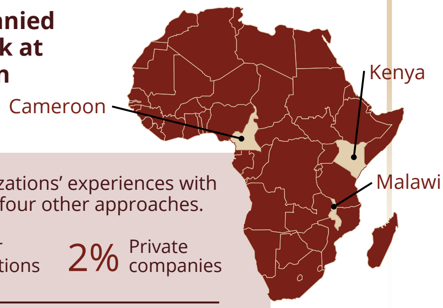
Farmer-to-farmer extension:
A low-cost approach for promoting climate-smart agriculture

Steven Franzel, Evelyne Kiptot and Ann Degrande

The rise in importance of climate-smart agriculture (CSA) has been accompanied by increased concern over how CSA practices can be scaled up. Here, we look at the potential of farmer-to-farmer extension (F2FE) to promote CSA, based on experiences in Cameroon, Kenya and Malawi.



This study relied on semi-structured surveys of extension program managers to assess 80 development organizations' experiences with F2FE in three countries. Most of the sampled extension program managers were using F2FE as well as three or four other approaches.

39% International non-governmental organizations (NGOs) | 35% National or local NGOs | 14% Government agencies | 10% Producer organisations | 2% Private companies

Cameroon
25 organizations | 5 Regions
160 interviews with randomly selected farmer-trainers

Malawi
25 organizations | 3 Regions
203 interviews with randomly selected farmer-trainers

Kenya
30 organizations | 3 Regions
*113 interviews with randomly selected trainees

Organizations promoting CSA: **4%** Cameroon **23%** Kenya **40%** Malawi

84% of trainers received an initial training

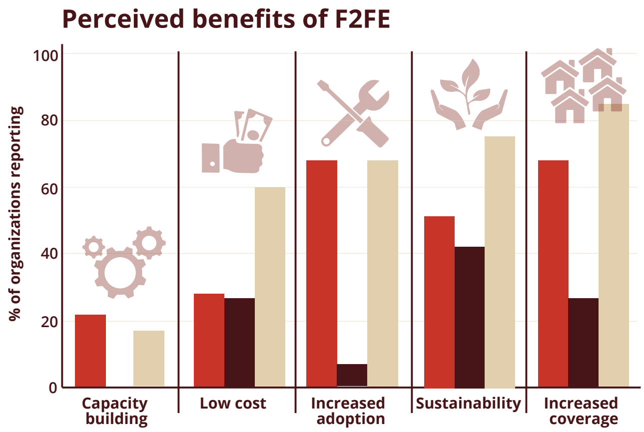
Nearly half received additional training after they had served for some time. Many hosted a demonstration plot.

72% of farmer-trainers in each country received training materials

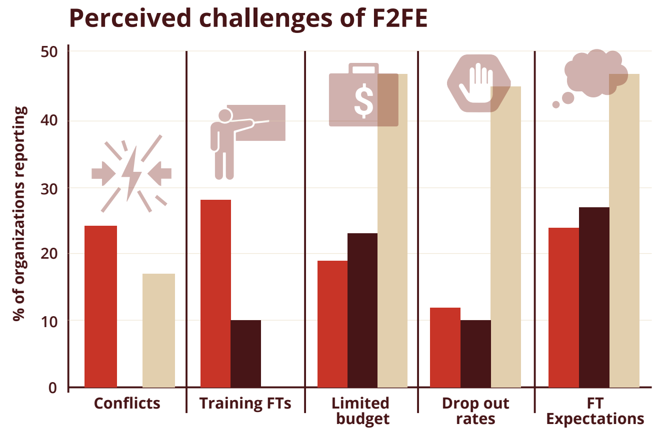
Farmer-to-Farmer Extension (F2FE) roles

In the face of increased demand for agricultural information and the reduced capacity of extension systems, many extension providers have been using farmer-to-farmer extension (F2FE), which is defined as the provision of training by farmers to farmers, often through the creation of a structure of farmer-trainers. In the surveys, the respondents expressed their perception of the benefits and challenges faced with using F2FE.

Perceived benefits of F2FE



Perceived challenges of F2FE



Effectiveness of the approach

Farmers trained on average:

Kenya 54
over one month

Cameroon 58
over one year

Malawi 61
over one year

Proportion of field staff and farmer-trainers who are women in organizations providing extension services including government, NGOs, private sector and farmer organizations

Extension staff

	Men	Women
Cameroon	72%	28%
Malawi	63%	37%
Kenya	67%	33%

Farmer-trainer

	Men	Women
Cameroon	70%	30%
Malawi	63%	37%
Kenya	57%	43%

Efficiency of the approach

Cost of training 400 farmers *Malawi example*	Model 1 Farmers are trained directly by extension worker	Model 2 Extension worker trains farmer-trainers who then train farmers
Front-line extension staff member	1 X $6,440 = **$6,440**	1 X $6,440 = **$6,440**
Training farmer-trainers	—	20 X $260 = **$5,200**
Training farmers	400 X $65 = **$26,000**	400 X $29 = **$11,600**
TOTAL	**$32,440**	**$23,240**
Cost of training a farmer	**$81.10**	**$58.10**

Scaling up of extension services is essential for helping farmers adapt to climate change, and F2FE has great potential for helping in these efforts. However, F2FE can never be used to compensate for a poorly performing extension service. Secondly, neither F2FE nor any single extension approach on its own can scale up CSA to millions of farmers. Rather, F2FE needs to be combined with other complementary approaches such as extension campaigns, farmer field schools or ICT approaches. Finally, more research is needed on whether F2FE is effective for promoting CSA compared to other extension approaches.

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Innovative partnership consortiums to scale up climate-smart agricultural solutions for smallholder farmers in Southern Africa

Mariam A.T.J. Kadzamira and Oluyede C. Ajayi

Many partnerships often die a natural death after donor funding has come to an end. The infographic highlights the practicalities of putting into use innovative partnerships in scaling up climate-resilient agricultural solutions in the Southern African region to ensure sustainability.

Partnerships for scaling-up climate-smart solutions

The Technical Centre for Agricultural and Rural Cooperation (CTA) with European Union funding initiated a three-year regional project (2017-2019) "Scaling-Up Climate-Smart Agricultural Solutions for Cereals and Livestock Farmers in Southern Africa" by using innovative partnerships to promote farmers' access to four types of climate-resilient solutions. The climate solutions were selected over multiple phases, in consultation with farmers and a range of stakeholders.

The four climate solutions are:

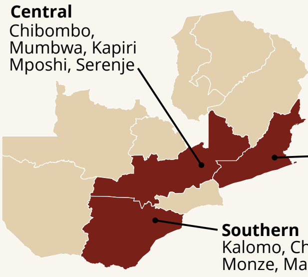
- Drought-tolerant seeds
- ICT-enabled weather information services
- Weather-based index insurance for smallholder farmers
- Diversified options through livestock

Zambia

trilateral partnership model

Zambia Open University
Musika Development Initiatives
Professional Insurance Company of Zambia (PICZ)

60,000 beneficiaries



Partner activities and responsibilities:

- Market facilitation; training agro-dealers in CSA to enable them to provide advice at point of sale
- Awareness campaigns to stimulate demand for stress tolerant maize seed and weather index insurance
- Agronomic and animal husbandry training for Lead Farmers
- Advisory services for integrated crop-livestock farming

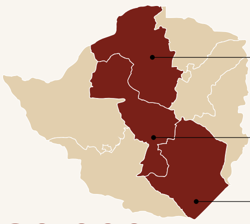
Outcomes

- **34,929** farmers registered on digital platform
- **3,591** farmers participated in seed fairs to show case drought tolerant seeds
- **331** government extension staff trained
- **132** agro-dealers trained
- **450,000** SMSs sent to farmers

Zimbabwe

bilateral partnership model

Zimbabwe Farmers Union (ZFU)
Econet Wireless



30,000 beneficiaries

Partner activities and responsibilities:

- Agronomic advisory services via SMS
- Dial-a-Mudhumeni: A phone-in facility for extension services
- Zimbabwe Farmers Union (ZFU)-EcoFarmer Combo: *A service bundle with funeral cover, ZFU membership subscription, weather information & advisory information, and weather index insurance*

Outcomes

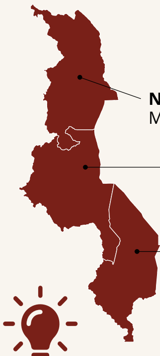
- **10,725** farmers registered on digital platform *(2nd generation farmers)*
- **134** insurance agents trained
- **66** farmers & stakeholders sensitized on the project
- **6** input suppliers engaged
- **900,000+** SMSs sent to farmers

Malawi

unilateral partnership model

National Smallholder Farmers Association of Malawi (NASFAM)

50,000 beneficiaries



Partner activities and responsibilities:

- Weather based index insurance
- ICT enabled weather info services
- Drought tolerant maize varieties

Outcomes

- **29,800** farmers registered on digital platform
- **670** farmers participate in seed fairs
- **143** field staff trained
- **976** farmers and stakeholders sensitized on project

Success factors for partnerships (preliminary findings)

- Private sector involvement
- Strong institutional leadership that galvanizes others to action and that leverages financial incentives
- Financial incentives for all partners
- Harnesses existing value chain innovations - efforts must build on existing and successful mechanisms and processes
- Clear mutual benefits for all partners
- Inclusive and participatory for all partners
- Transparency in project operations

Partnerships that are innovative and sustainable must not only be inclusive, participatory, mutually beneficial for partners and transparent; they must also have a clear and self-sustaining business case. Action research is needed to monitor and evaluate the extent to which partnerships – such as those presented here – deliver results and achieve impact.

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Rural finance to support climate change adaptation:
Experiences, lessons and policy perspectives

Ruerd Ruben, Cor Wattel and Marcel van Asseldonk

There is a large and growing literature on the potential use of rural financial instruments for stimulating the adoption of climate-smart land use practices and systematically anchoring climate-smart agriculture (CSA) production processes. Here, we look at how rural finance instruments can serve as mechanisms for enhancing CSA adoption and upscaling. We focus attention on the opportunities and constraints of managing local rural finance.

Impact pathways for financing CSA practices

Agricultural development is strongly influenced by access to and availability of rural finance. Meeting the financing requirements for implementing CSA is a significant challenge, since both technological innovations at different scale and socio-economic and institutional changes are required.

Rural finance

Interactions between pathways

- Pathway 1: Investments
- Pathway 2: Income generation
- Pathway 3: Risk behaviour

Impact pathways

- **Direct pathway:** Financial instruments for enhancing direct investments for CSA practices, ranging from short-term input loans up to medium- and long-term loans
- **Indirect pathway:** Economic incentives for supporting farm-household incomes that generate expenditure effects in favour of CSA practices
- **Behavioural pathway:** Incentive mechanisms that mainly influence risk behaviour and enhance resilience of revenue streams from engaging in CSA practices

CSA practices

The effect of financial services on the adoption of CSA practices for adaptation

Pathway 1: Input Intensification & Investment

CSA Practice	Case	Evidence
▪ Land management practices: (manure or compost, burning to clear the plot, contour ploughing, reduced tillage, intercropping or mixed cropping)	Pender and Gebremedhin (2008) on smallholders in Ethiopia	Credit is not strongly associated with the use of land management practices.
▪ Aquaculture practices (water management in ponds, shifting production calendar)	Arimi (2014) on fish farmers in Nigeria	Fish farmers with access to credit showed higher adoption rates of adaptation measures.
▪ Conservation practices that reduce soil erosion and increase yields	Marenya et al (2014) on small farmers in Malawi	Most farmers preferred cash payments to index insurance contracts, even when the insurance contracts offered substantially higher expected returns. More risk-averse farmers were more likely to prefer cash payments.

Key findings

- Access to rural finance is a key enabler and has a positive impact of credit on CSA practice adoption.
- Little distinction between different types of loans (formal/ informal), their terms and conditions (loan size and interest rate, collateral requirements and duration) and loan purposes. These have different effects on resource management practices and CSA outcomes.
- Sometimes access to credit can lead to land use specialization and intensification at the expense of climate-friendly technologies.
- For resource-poor farmers, credit constraints can lead to the adoption of more labour-intensive climate mitigation practices as an alternative to more expensive technologies. Broadening access to finance can help address such trade-offs between intensification strategies.

Pathway 2: Income & expenditures

CSA Practice	Case	Evidence
▪ Changing crop varieties ▪ Soil & water conservation ▪ Water harvesting ▪ Tree planting ▪ Changing planting & harvesting dates	Di Falco et al (2012), cereal farmers in Ethiopia	Access to formal credit had a positive but not significant effect on the adoption of the practices.
▪ Agroforestry ▪ Changing of planting dates ▪ Land terracing ▪ Drainages ▪ Cover cropping ▪ Ridges across slope ▪ Selling assets ▪ Loans ▪ Livelihoods diversification ▪ Short-term migration ▪ Etc.	Enete et al (forth-coming) on flood-coping strategies of small farmers in Nigeria	Access to credit had a negative relationship with selling of assets and short-term migration.
▪ Maize-legume inter-cropping ▪ Soil and water conservation measures ▪ Fertilizer ▪ High yielding maize varieties	Arslan et al (2016) on maize farmers in Tanzania	Positive effect of credit for practices that require liquidity (inorganic fertilizer, improved seeds). Negative effect of credit for intercropping (intercropping is perceived as a way to compensate for lack of fertilizers). Credit increases the use of modern inputs, but decreases maize-legume intercropping which has long-run benefits for soil health and adaptation.

Key findings

- Access to savings and other financial services (e.g., insurance, transfers and remittances) may be equally important for CSA adoption as access to credit.
- CSA practices become more attractive to smallholder farmers if stable (albeit low) revenue streams are guaranteed.
- Diversification can stimulate household savings and risk-coping investments and thus contribute to increased uptake of CSA practices.

Pathway 3: Risk mitigation

CSA Practice	Case	Evidence
▪ Diversity of climate change adaptation practices	Shackleton et al (2015) reviewing evidence from 64 case studies worldwide	The cluster "financial, technical and infrastructural barriers" is the most cited barrier to adaptation. This includes lack of cash, credit/ microfinance and inputs.
▪ Carbon sequestration ▪ Information communication (disaster management)	Wong (2016) reviewing evidence from a variety of case studies worldwide	Women face more obstacles in accessing credit and cash, preventing them from applying certain practices. The existing policies of CSA have not paid sufficient attention to the gender gap in access to land, capital and other productive resources.
▪ Crop diversification ▪ Adjustment of crop management practices or agricultural calendar ▪ Land use and management ▪ Etc.	Yegbemey et al (2014) on maize farmers in Benin	Access to credit allows farmers to choose adaptation strategies that require additional investments (larger doses of fertiliser, purchase of other seeds with a shorter gestation period, etc.). It does, however, require to be profitable, in order to repay the loan.

Key findings

- Improved risk management is the most common rationale for adopting CSA strategies that rely on a diversity of measures.
- Insurance (indemnity-based or index-based) represent a useful tool for incentivizing adoption of CSA practices.
- Lack of required inputs such as tree seedlings, seeds or fertilizers limit widespread adoption.
- Innovative means of input delivery [mobile phones and Information and Communication Technologies (ICT's)] - can improve availability and access of inputs and thus increase CSA uptake.
- Risk mitigation strategies can improve welfare and address gender gaps in intra-household bargaining and decision-making with regards to resource allocation and use.

Local rural financial services are multi-facetted in nature and require different resources for specific types of CSA adaptation practices. For the initial adoption of these CSA practices it might be sufficient to address specific binding resource constraints. But a wider and more scalable process of climate adaptation will require more comprehensive interventions at system level (i.e., integrated and dynamic), that finally result in more substantive changes in terms of poverty (income) and (risk) behaviour.

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Private sustainability standards as market-based tools for mainstreaming climate-smart agriculture (CSA)

Kevin Teopista Akoyi and Fikadu Mitiku

The global effects of climate change has driven the private sector to develop innovations in global value chains at technical, commercial and institutional levels, giving rise to Private Sustainability Standards (PSS). Here we give an overview of how PSS implemented in contract arrangements with smallholder producers can be used in scaling up Climate Smart Agriculture (CSA) practices. We use results from case studies on the smallholder coffee sector of two East African countries, Uganda and Ethiopia.

Private Sustainability Standards

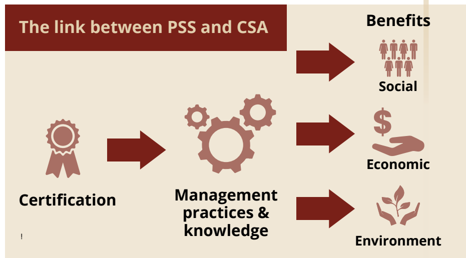
Private Sustainability Standards (PSS) are usually set by private companies and non-state actors and enforced through third-party certification. PSS are independently verifiable voluntary market based mechanisms through which value chain actors demonstrate that they have taken action on specific sustainability concerns of consumers.

Fairtrade **emphasises farmer empowerment, social development and long term business relationships**

Organic **focuses on healthy planet, ecology and care for future generation**

Rainforest Alliance **concentrates on biodiversity conservation**

UTZ **focuses on sustainable agricultural practices and sourcing**



The case for Private Sustainability Standards in Uganda and Ethiopia

The evolution of PSS on coffee farming in Uganda and Ethiopia

Uganda | 2 coffee exporting companies

1994 — Certification started in the coffee sector with Fairtrade

2000 — Since 2000, Gumutindo Coffee Cooperative Enterprise (GCCE), has been implementing Fairtrade and later a double Fairtrade-Organic certification scheme based on a cooperative business model

2006 — Since 2006, Kyagalanyi Coffee Limited (KCL) has been implementing a triple Utz-Rainforest-4C coffee certification programme in the Mount Elgon region

2014 — By 2014, certification spread rapidly and 216,000 farmers producing coffee on 131,000 ha were certified

KCL had six washing stations in the Mount Elgon region serving 6,048 producers, organised in 258 Producer Organisations (POs)

GCCE started with four Growers' Cooperative Societies (GCSs) and by 2014, the survey year, it had a network of 16 GCSs across the region with across the region, with 7599 members

Ethiopia | 6 cooperatives (3 certified and 3 non-certified) in Kaffa zone and 1 Rainforest Alliance certified cooperative in Jimma zone

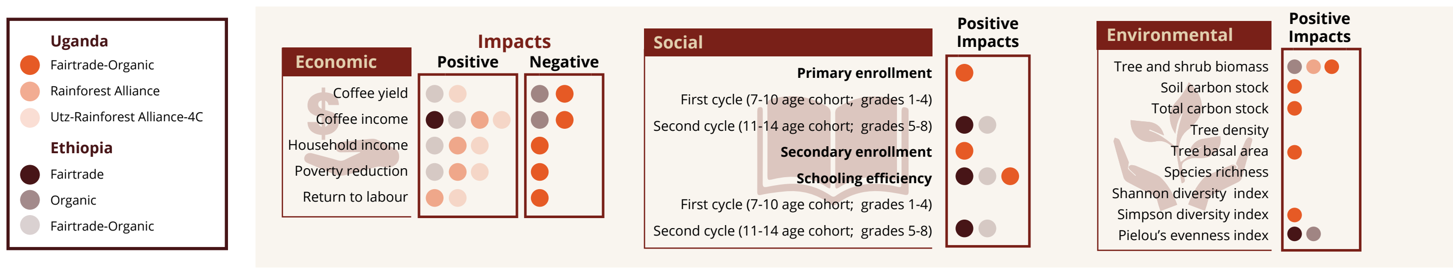
2000s — Coffee certification emerged in the early 2000s to certify democratically organized smallholder producer cooperatives

2005 — Fairtrade and Organic certification schemes started

2007 — Rainforest Alliance certification scheme started

2014 — By 2014, 316,043 ha of land, 301,857 producers, organized into 115 cooperatives were in compliance with at least one of the three standards. They produced 69,202 metric tons of coffee.

The impact of PSS in Uganda and Ethiopia on economic, social and environmental sustaianability dimensions



- **PSS have the potential to contribute to CSA — however, standard setting organisations and adopters should embark on a collaborative effort to either harmonise key CSA indicators or differentiate the standards well enough, corresponding to specific sustainability challenges.**
- **Harmonisation should be coupled with flexibility in PSS definition which allows implementing organisations to adapt standards to context specific needs.**
- **All value chain actors need to collaborate in order to reduce the cost of certification by involving local actors in monitoring and inspection, raising the overall competitiveness of certified value chains and more equitable distribution of benefits.**
- **It is crucial to make more investment in awareness raising for all stakeholders involved in implementation of PSS, in order to enhance their capacity for adaptation.**
- **It will be important to inform and mobilize key stakeholders in specific global agri-food chains, especially consumers in high income countries towards effective demand for certified products as their contribution to developing CSA.**

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Business promotional approaches for scaling up drought tolerant maize varieties: *Evidence from Eastern and Southern Africa*

Kingstone Mujeyi

In the face of climate change, the availability, accessibility and affordability of climate smart agricultural technologies to the most vulnerable smallholder farming households is critical for adaptation and resilience to risks. Here, we present a business development approach to promoting the scaling up and out of promising drought tolerant maize (DTM) varieties in East and Southern Africa (ESA).

The Drought Tolerant Maize Seed Scaling (DTMASS) Project

To popularise the DTM varieties as a climate smart agriculture (CSA) technology in ESA, CIMMYT, with support from the United States Agency for International Development (USAID) has been promoting a business development approach to seed production, processing and marketing under the DTMASS Project.

Using secondary data and empirical evidence from the DTMASS Project at CIMMYT, we conduct a critical appraisal of the business development approach in six project countries in ESA (Ethiopia, Kenya, Mozambique, Tanzania, Uganda and Zambia).

The business development approach

The approach has fostered country level business partnerships and networks that have boosted sustainable production, processing and marketing (scaling up) of improved DTM seed through:

financial and technical support

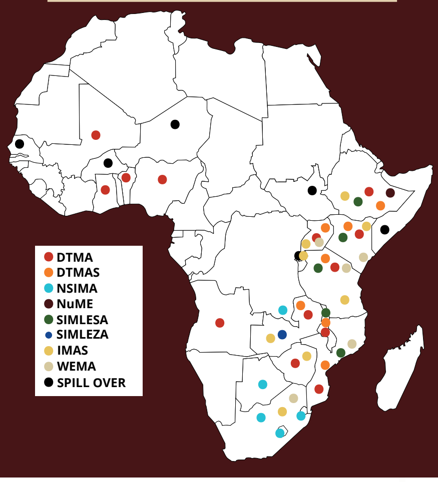
- Free acess to high quality germplasm
- Support to establish demonstration plots and host field days
- Production and disitribution of promotional materials
- Sub-grants for procurement of special seed processing and packing equipment, seed storage infrastructure etc.
- Sub-grants for capacity strengthening for agro-dealer distribution network expansion

capacity building

- Training and technical backstopping for private actors (seed companies and agro-dealers, including their respective associations) and public sector staff to enhance their skills in seed production, processing and marketing.

CIMMYT interventions with DTM varieties in Africa 2007-2017

+200 DTM varieties released from 2007-2016



DTMASS project outcomes 2013-2016

	ETHIOPIA	KENYA	MOZAMBIQUE	TANZANIA	UGANDA	ZAMBIA
No. of DTMASS partners	6	6	6	6	12	7
No. of seed varieties released	7	12	17	13	13	13
Qty of DTM seed produced (mt)	7,920	700	480	2,090	700	1,500
Qty of DTM EGS supported (mt)	222	40	16	12	35	65
No. of farming households reached	186,454	38,356	11,116	42,471	54,264	65,502

Impact evaluation of the business development approach

Zimbabwe

(initially Zaka Super Seeds and later on Zimbabwe Super Seeds)

Community seed business developed by the Seeds and Markets Project (SAMP), which is managed by GRM International in Zimbabwe.

Drought-tolerant maize seed produced, processed and sold by the enterprise in metric tonnes

Season 1: 26
Season 3: 151

Ethiopia

Growing liberalization and investment in marketing systems has facilitated increased participation of both the private sector and farmers' cooperatives in the seed industry and hence the adoption of modern technologies by farmers has accelerated.

DTM variety, BH661 produced in metric tonnes

2012: 6 (1 state enterprise)
2014: 2,900 (5 SMEs)

Tanzania

AgriSeed

Production of early generation (foundation) seed for its own new hybrid, WE2112, which has set the company on a massive growth and sustainability path.

WE2112 produced and sold in metric tonnes

2016: 3
2017: 50

Mozambique

Phoenix Seeds Company

Capacity building of owners, agronomists, marketing personnel and agro-dealers and augmented by financial and technical support.

DTM produced and sold in metric tonnes

2016/17 season: 110

The case of CIMMYT's DTMASS project in ESA provides a compelling case for scaling up. The business promotional approach has proved to be effective in nurturing SME seed companies and fostering strong agro-dealer networks for improved supply and affordability of certified DTM seeds. However, it is important to note that although the DTM varieties are necessary for mitigation of climate change impacts, on their own they are not sufficient for solving the farmers' problems. There is need for the farmers to be assisted to adopt other good agronomic practices for the desired outcomes to be achieved.

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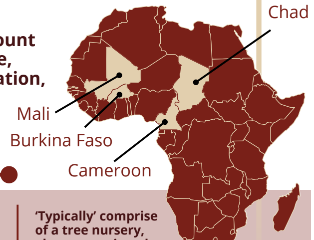
Making rural advisory services more climate smart:

Can community-based approaches help?

Ann Degrande, Djalou-Dine Arinloye, Alain Tsobeng, Patrice Savadogo

While the essential role played by rural advisory systems in reducing poverty and hunger is increasingly recognised, agricultural extension in many African countries continues to offer single size interventions that do not take into account the increasingly complex nature of farming systems in the face of global challenges, in particular climate change. Here, we examine the ability of Rural Resource Centers (RRCs) to foster and nurture the process of co-creation, experimentation, co-learning and adaptation of innovations by farmers, which is deemed crucial for dissemination and uptake of CSA.



A new model of extension and advisory services for scaling CSA

The RRC approach has been under development since 2006 in West and Central Africa as a response to challenges faced by the World Agroforestry Centre (ICRAF) and partners, with the design, evaluation and wider dissemination of agroforestry practices and climate-smart agriculture (CSA).

Key services that Rural Resource Centres provide:

- Seeds, seedlings and other inputs
- Skills development
- Information on new technologies and innovations
- Access to market information and micro-finance opportunities
- Links with market actors
- Forum for exchange of information among and between farmers and other stakeholders

'Typically' comprise of a tree nursery, demonstration plots, a permanent water source, a training hall, a small library and office spaces. Accommodation, catering facilities, and agricultural processing units may also be part of the RRC depending on available resources, opportunities and needs.

RRCs foster local capacity to innovate in the face of climate change

Capacity to identify and prioritise problems and opportunities

RRCs are sensitive to the environment in which they operate and accountable to their clients as they are run by actors that have a strong local anchorage and high proximity to the communities.

Local indigenous knowledge → RRCs ← Strong community links

- Respond to specific local needs & wants
- Organise small-scale producers for collective benefits

Chad

Promotion of climate-smart practices (integrated soil and water management) to address poor soil fertility and low tree and shrub cover.

Cameroon

Production and distribution of tree seedlings to protect watersheds (370,000 tree seedlings produced by 5 RRCs between 2011 and 2013).

Burkina Faso

- Promotion of climate-smart practices (integrated soil and water management)
- Negotiation with private sector to supply ingredients for the cosmetic industry
- Establishment of tree nurseries (248,388 tree seedlings produced by 4 RRCs in 2015, generating incomes of CFA 1.2 million (~US$ 24,800)

Mali

- Training of farmers on reading, understanding and using climate information (use of rain gauge)
- Negotiation with private sector to supply ingredients for the cosmetic industry
- Establishment of tree nurseries (in 2016 and 2017 the tree seedlings produced and sold by 18 RRCs generated incomes of more than US$ 60,000 and US$ 56,000, respectively)
- Training of private nursery operators in villages surrounding these RRCs on production of high quality tree planting material

Capacity to assess trade-offs between alternative social & technical options, experiment & adapt

The specific capacity to test, experiment, adapt and assess in an iterative and interactive way with farmers, makes RRCs suitable to extend complex and innovative technologies than conventional extension services.

Participatory technology development

RRCs: Provide demonstrations, training & technical assistance; Provide infrastructure and technical expertise

Bring together researchers and farmers

RESEARCHERS — **Capacity building & institutional support**

FARMERS — **Feedback on technology development**

Cameroon

Beneficial interactions facilitated by RRCs, between researchers, extension workers and farmers for the scaling-up of sustainable land management practices.

Burkina Faso & Mali

RRCs have been set up to demonstrate different options of agroforestry and climate-smart practices under local conditions that are recognisable to farmers.

Chad

RRCs established experimental plots demonstrating a range of improved varieties of millet, sorghum and cowpea, as well as different soil fertility improvement and conservation techniques.

Capacity to network, learn and share knowledge

RRCs create networks with a multitude of stakeholders through dynamic links either permanently or for a well defined period.

Upstream
Sectorial ministries through their decentralised services, local authorities, development partners, research centres and universities
Provide institutional, strategic, financial and material support

Same level
Other RRCs
Share information & experiences.

Downstream
Producer organisations, municipalities, faculties and agricultural technical schools, community radio stations, primary and secondary schools, and private businessmen
Benefit from services offered by RRCs.

Cameroon

Two RRCs in West (CIEFAD, Bangangte) and North-West (KUGWE, Batibo) Cameroon showed dynamic links between RRCs and a multitude of stakeholders with about half of the realtionships formalised.

Burkina Faso, Mali, Chad

Network analyses have not yet been done for RRCs as their creation is rather recent.

RRCs propose unconventional and complementary extension and advisory services to African farmers. They allow the development of new competencies and help mobilize existing ones, to cultivate farmer-centred innovation suitable to rapidly changing biophysical and socio-economic conditions, including climate variability and change. The approach is innovative, as it allows to identify and prioritize problems and opportunities, to evaluate and adapt different social and technical options, and to promote learning and knowledge sharing among different actors.

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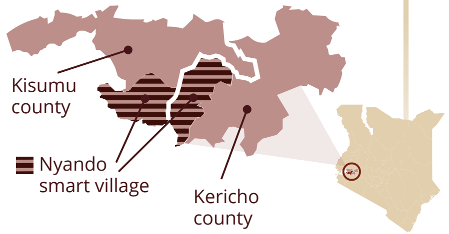
Informal institutions and adoption of CSA practices:
Evidence from Kenya

Rapando Phoebe Nancy, Evans Kituyi, Atela Joanes and Ouma Gilbert

Uptake and upscale of climate-smart agriculture (CSA) at the local level is lagging behind. We explore the types and role of informal institutions in scaling CSA, looking at examples from Kenya.

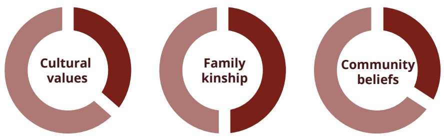
The project was carried out in Western Kenya in the "Nyando climate smart village", which spans 10 km across Kericho and Kisumu counties. The study was conducted between the months of October 2016 to June 2017. We conducted 20 semi-structured key informant interviews and 4 Focus Group Discussions (FGDs) with key actors (group and community-based organizations, village leaders and chiefs).



Existing informal institutions and their role in CSA uptake

- **% of people rating the variable as important**
- **% of people rating the variable as unimportant**

Culture



- Community beliefs on climate change is based on what the people value most
- Interventions which reflect the voices and views of the community are more likely to prevail

Clear mechanisms of inclusion of cultural aspects need to be developed so that the community relates to the new practices.

Social networks

Community collectivism is highly important in rural communities in Nyando and is reflected through:
- Formation of self help groups
- Pooling of resources e.g. labour, seed, livestock, etc
- Financial pooling through merry-go-rounds "chamas"

Social networks are a key informal institution in CSA uptake and actors need to be cautious about managing interactions well to avoid conflicts and exclusion by the community.

Community governance

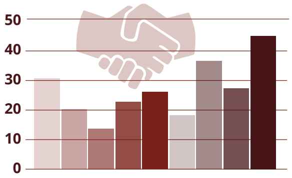
Tradition and group decisions are mechanisms for community governance; They include:
- Sanctions and curses by elders aimed to resolve conflicts
- Constitutions and unwritten byelaws that entail fines
- Interaction between communities and local authorities through Nyumba kumi systems promoting participation and communication

Community based governance mechanisms need to be recognised and included in any intervention as they are key to linking community intitatives with local governance systems.

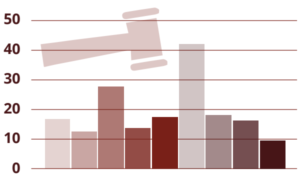
Mechanisms used to influence informal institutions

Average farmers who were affected by the mechanisms during uptake of the CSA practices:

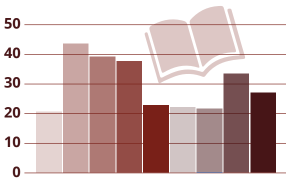
Participation and leadership (joint interplay)



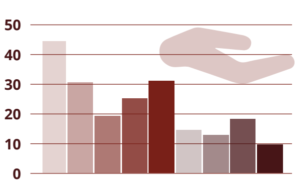
Regulatory (byelaws, entry and exit conditions)

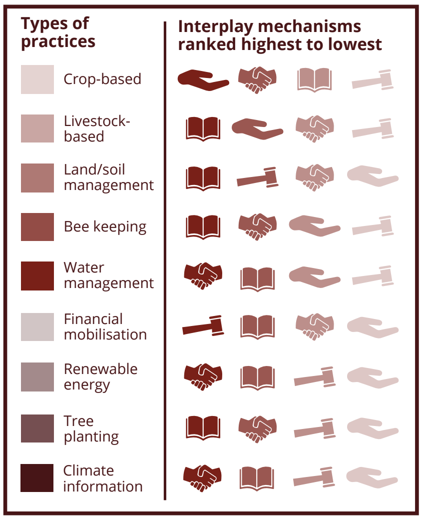


Knowledge management (cognitive)



Use of incentives (material, cash, infrastructure)





Cognitive mechanisms (knowledge) are key in ensuring that informal institutional perspectives connect with formal ones; however communities tend to doubt the new information they receive and resort to conventional practices, making knowledge diffusion a challenge.

Aspects of collective decision-making, action and good leadership (joint interplay) are equally important in scaling CSA. Joint planning ensures tribal voices are included in the entire process of developing regulations, making locals feel that their cultural views are respected and incorporated.

- **Perceptions of risks and responses to climate change are enabled/limited not only by exogenous forces but also by societal factors. Therefore, strategies for scaling CSA need to tap into existing informal institutions and mechanisms and identify and recognize implicit and hidden values.**
- **In places like Nyando, where adaptation is led by heavy scientific and research-based organisation, there is need of mechanisms that integrate existing local institutions (indigenous knowledge), to ensure bi-directional learning.**

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The infographic is based on The CSA Papers, funded by a grant from Vuna and developed by ICRAF, CCAFS and CIAT under its Partnerships for Scaling CSA (P4S) Project.

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Challenges and constraints to scaling up climate-smart agriculture:

Comparative analysis of Bangladesh, Ghana, India, and Vietnam

Suresh Chandra Babu, Alex De Pinto and Namita Paul

The negative impact of climate change on crop production is evident in several regions across the world. We provide examples of different climate-smart agriculture (CSA) practices and techniques currently implemented in Bangladesh, Ghana, India and Vietnam and we identify the major challenges faced in scaling these.

Scaling up CSA in Bangladesh, Ghana, India and Vietnam: Opportunities and challenges

All four countries are agriculture-based economies with most of the farms being small- and medium-sized and extremely vulnerable to climate change. Despite the continuous decline in agriculture as a percentage of GDP, agriculture remains highly important in all four countries.

Current situation	CSA practices (Selection)	Results	Constraints

Bangladesh

Current situation

- Agriculture is the country's key sector, providing livelihoods to about 60% of the population.
- The long coastline makes the country highly susceptible to climate change.

Climate vulnerabilities and risks:

Kurigram: flood-prone
Chapai Nawabjonj (NW): drought-prone
Bagerhat (SW): saline-prone. Soil salinizaion in river water and soil has increased over time and is further aggravated due to increase in sea level due to climate change

CSA practices (Selection)

- Alternate wetting and drying (AWD)
- Row cropping
- Adoption of stress tolerant and high-yielding seed varieties
- Urea deep placement (UDP)
- Aquaculture/ floating agriculture

Results

Impacts of AWD:

- Yields increased by 9-12% compared to farmers using conventional irrigation
- Water savings ranged from 22-26%
- Decreased green-house gas emissions

(Source: Pinto et al. 2017)

Constraints

- Inefficient water payment arrangements
- Lack of incentives for farmers
- Unleveled farm fields
- Low awareness of technology's benefits
- Lack of government support and lack of willingness to promote AWD nationally

Ghana

Current situation

- Agriculture is mainly rain-fed
- Rainfall distribution is considered the most important factor affecting agriculture

Expected climate change impacts:

- Rising temperatures
- Rising sea levels
- High incidence of weather extremes and disasters
- Declining rainfall totals and increased variability

CSA practices (Selection)

- Crop rotation
- Manure management
- Use of chemical fertilizer
- Organic pest management

Results

Expected results from the CSA Cocoa Initiative:

- Increase rural economic development and food security
- 50%-60% increase in yield
- Increase of US$1,000 per year in revenue

(Source: Forest Trends, 2013)

Constraints

- Adoption rates remains low due to low farmer awareness and poor access to knowledge on CSA implementation
- Limited capacity of the country's agriculture extension and advisory services to disseminate timely information

(Source: Peterson, 2014)

India

Current situation

Over the past six decades, Indian agriculture has seen a major transformation.

- Moved from aid dependence and food deficits to becoming a net exporter of food
- Maintaining an average growth rate of 3%
- Food security remains a top priority for the agricultural sector due to increasing population
- In 2008, India adopted the National Action Plan on Climate Change, a step ahead in addressing climate risks.

CSA practices (Selection)

- Laser land leveling (LLL)
- Crop insurance
- Weather advisory services
- Direct seeding
- Zero tillage
- Irrigation scheduling

Results

LLL technique has several impacts on climate change mitigation:

- Reduced emissions through decreased pumping time
- Decreased cultivation time
- Fertilizer savings
- Decreased irrigation time by 45-55 hrs/ha (rice) and 10-12 hrs/ha (wheat)
- Increased yields by 340kg /ha (rice) and 320 kg/ha (wheat)

(Source: Aryal et al., 2013; Gill, 2014)

Constraints

- Access to funding
- Limited capacity among technology promoters

(Source: Taneja, et al. 2014)

Vietnam

Current situation

- The government has committed to the agenda of UNFCCC and the Kyoto Protocol, directing its agencies to lay down a legal foundation for preventing and mitigating natural disasters and coping with climate change.
- The Ministry of Agriculture and Rural Development (MARD) issued a decision to promulgate an action plan for climate change, agriculture and rural development for 2011-2015 and also implemented the Action Plan Framework for Adaptation to Climate Change in the Agriculture and Rural Development Sector for 2008-2020.

CSA practices (Selection)

- AWD

Results

- Multiple studies reported a decrease in emissions by 6-39%
- Decreased production cost by 20% compared to conventional farmers
- Increased profit by 16-14% mainly due to decrease in irrigation and labor costs

Source: (Ha, 2014; Pandey et al., 2014; Narayan and Belova, 2013; Quicho, 2013)

Constraints

- Unleveled fields
- Inability for farmers to access incentives
- Lack of awareness about technology
- Limited support from government

(Source: Basak, 2016)

Targeted capacity building programs can play an influential role in preparing a country's agriculture sector to deal with increasing threats of climate change. Building these capacities and using current extension services to promote CSA practices among farmers can help bring CSA to scale and thus increase resiliece of the food systems and increase the overall adoption rate of different practices.

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Scaling climate-smart agricultural interventions for improved development outcomes: *Experiences from eastern Zambia*

Bridget Bwalya, Progress. H. Nyanga, Douty Chibamba and Wilma Nchito

Climate-Smart Agriculture (CSA) has been adopted as an approach for transforming and re-orienting agricultural systems to support food security under the new realities of climate change. Here, we describe different development aid modalities and highlight how they can affect the outcomes of CSA interventions, using Zambia as a case study.

Data for the three case studies was collected through a household survey with 428 randomly selected households in November 2015 in eastern Zambia. The survey was followed up with six focus group discussions and 12 key informant interviews in August 2016. The three organisations implementing CSA related programmes in Zambia:

1. **Conservation Agriculture Programme (CAP)**
Promoted CSA in **6** districts and trained **40,625** smallholder farmers.

2. **Community Markets for Conservation (COMACO)**
By 2015 worked in **12** districts and **65** chiefdoms in Eastern Zambia benefited **142,519** farmer households.

3. **China Africa Cotton Company (CACC)**
Operates in **5** districts in eastern Zambia engaged with **~50,000** smallholder cotton farmers (contract farming).

Approaches to CSA implementation and scaling

Characteristics of CSA projects and programmes promoted in the study area:

	Project areas and climatic conditions	Tillage systems promoted	Agronomic practices promoted	Agricultural inputs promoted	Access to implements promoted	Market linkages promoted	Gender mainstreaming promoted	Institutional collaboration promoted
CAP	Low-medium rainfall in eastern, southern and central Zambia	Basins, animal draft & tractor powered ripping	Dry season land preparation, early planting, spot input application, crop rotations, crop residue retention, manure & herbicide application, and agroforestry	Provided to farmer coordinators as remuneration for training farmers in CA	A few donated by project to member groups	Not part of programme design	Women are targeted as beneficiaries	Government agents, NGOs, international organisations and private sector in farmer trainings
COMACO	Low-medium rainfall in eastern Zambia	Basins, animal draft ripping	No residue burning, crop rotation, manure application	Provided on credit to members on condition that CA is practiced	A few donated by project to member groups	Provides markets to members for selected produce. and premium pricing for compliance	Women are targeted as beneficiaries	Mostly donor community
CACC	Low-medium rainfall in eastern Zambia	Flat culture, basins, ripping, ridging, ploughing	Accept both conventional agricultural practices and conservation agricultural practices	Provided on credit to both men and women farmers without any preconditions	Provided on credit to all contract farmers, in desired quantities	Provides markets to members for cotton	No gender considerations	No formal institutional collaboration but have strong linkage with China government

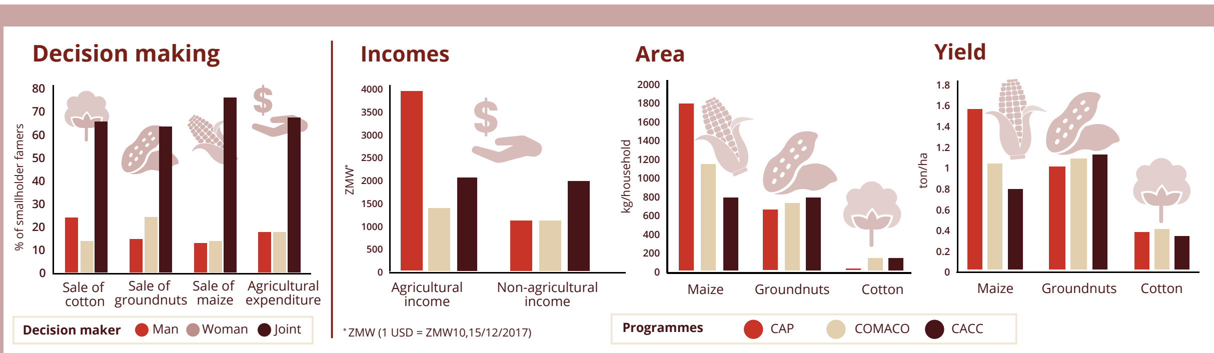
Development models and framings

A development model is a conceptual framework guiding how a development process is understood and managed.

	Support channels	Technical foci	Extension approaches	For whom?	Flexibility and payment	Food security entry points
Norwegian foreign aid model (CAP)	Both government and private organization.	Strong agronomic focus; No emphasis on integrated pest management; Community transformation towards sustainable production for improved environment and livelihoods; Most concerned with increasing the adoption of conservation agriculture.	Demonstration plots, field days, group training sessions.	Mostly the poor initially, but the focus shifted towards richer farmers over time. Women targeted to constitute 40% of the farm beneficiaries.	Farmers are not bound to the implementing organisation (CFU); Only field officers are paid monthly; Lead farmers (farmer coordinators) are given vouchers for inputs each season.	Emphasis on multiple crops for both subsistence and cash purposes.
Chinese foreign aid model (CACC)	Mainly private organization.	Strong business focus; More emphasis on integrated pest management; Driven by profits ; Most concerned with business opportunities.	Demonstration plots, field days, group training sessions.	Anyone as long as they conform to business model; Management willing to work with Conservation Farming Unit (CFU) to improve cotton yields; Mostly men are involved.	Farmers have contracts with the implementing organisation; Pay both route managers (equivalent of field officers) and chairpersons (equivalent of farmer coordinators) on a monthly basis.	Emphasis on cash crops (mainly cotton).

Outcomes of the three programmes

Findings from the study area reveal that gender roles are more fluid and household decisions are usually taken by women and men together. However, more men tend to be engaged in the sale of cash crops (cotton) compared to women, while women tend to decide more on the sale of groundnuts, compared to men.



Production and productivity of maize, cotton and groundnuts are still low and characterised by large variations among smallholder farming households, regardless of project affiliation. Maize yields were highest among CAP beneficiaries and lowest among CACC beneficiaries. This is largely determined by the agro-ecological conditions of the location (biophysical factors) but also to capacity strengthening components of the programmes. CAP farmers were trained in agronomic practices for improved maize, cotton and legume yields while CACC restricted its trainings to cotton. COMACO focused on groundnuts and rice trainings.

CSA has great potential for making the farming systems of smallholder farmers in Zambia more productive and climate resilient. Project developers need to promote CSA within an adaptive context, focusing on pragmatic and financially viable adoption pathways that also provide for partial or step wise adoption of flexibly designed CSA packages.

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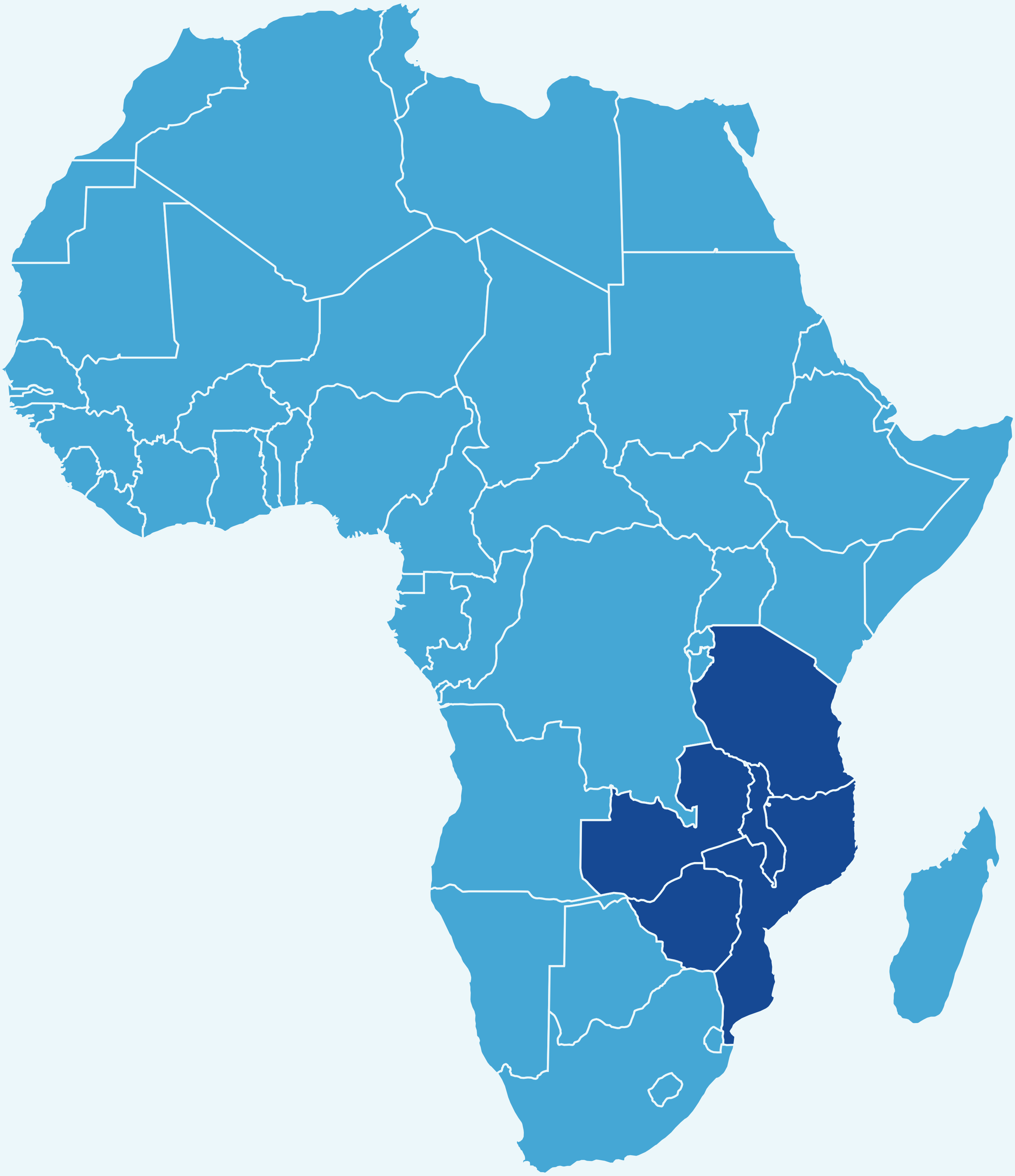
Vuna was a 3-year regional Climate Smart Agriculture programme, funded by UK-Aid (DFID) and implemented by Adam Smith International. Vuna works in Malawi, Mozambique, Tanzania, Zambia and Zimbabwe.



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