A smallholder farmer level decision support system for climate resilient farming practices improves community level resilience to climate change. No 2: Impact of climate resilient practices on rural livelihoods

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Introduction

A current Water Research Commission adaptive research process entitled "Collaborative knowledge creation and mediation strategies for the dissemination of Water and Soil Conservation practices and Climate Smart Agriculture in smallholder farming systems" is exploring best practice options for climate resilient agriculture for smallholders and evaluating the impact of implementation of a range of these practices on the resilience of agriculture based livelihoods. Alongside this, a decision support methodology and system has been designed to assist smallholders and the facilitators who support them to make informed and appropriate decisions about choices of a 'basket of options' for implementation at a local level.

The research process is broadly divided into three elements for purposes of clarity, although all three elements are tackled concurrently:

1. Community climate change adaptation process design
2. **Climate resilient agricultural practices and**
3. A decision support system.

In this article we focus on the CRA practices and the impact of implementation of these practices on rural livelihoods.

Climate resilient agriculture (CRA) practices for smallholders

The approach is to work directly with smallholders in local contexts to improve practices and synergise across sectors. The emphasis is thus at farm/household level. Here CRA aims to improve aspects of crop production, livestock and pasture management, natural resource management, as well as soil and water management as depicted in Figure 1 below.

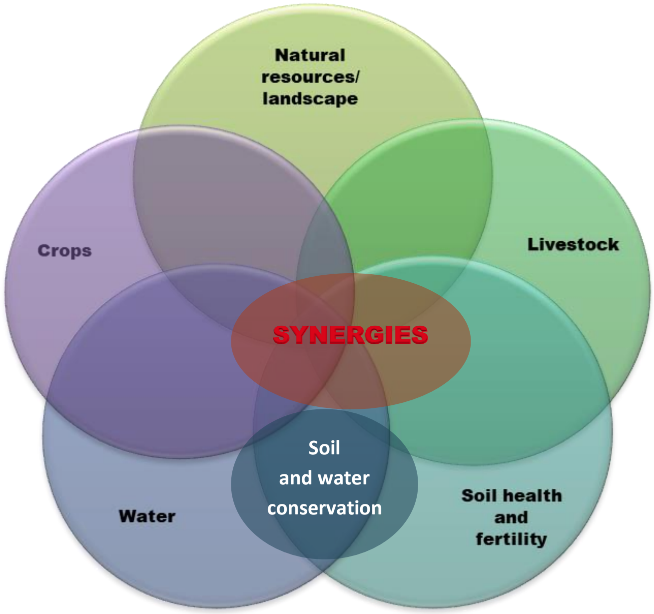


Figure 1: Household level implementation of CSA integrates across sectors (adapted from Arslan, 2014)

A database of 66 different practices falling into the categories mentioned in the figure above has been compiled, based on local suggestions and best bet options from experience and literature.

A selection of the practices is shown in the table below. Farmers decide on practices to try out and implement depending on their own situations and preferences as well as suggestions made by the facilitation team.

Table 1: a summary of a selection of CRA practices considered and implemented by smallholder farmers

Gardening	Field cropping (Conservation Agriculture)	Livestock management
Intensive gardening techniques: including trench beds, mulching, liquid manure, mixed cropping, planting of nutritional herbs and multifunctional plants, fruit production, seed saving	Diversification of cropping: including legumes and cover crops (sunflower, millet, sunn hemp, black oats, fodder rye and fodder radish)	Fodder production and management for livestock
Soil and water conservation techniques: including swales, furrows and ridges, stone bunds, check dams	Intercropping and crop rotation; strip cropping options and spacing	Local feed production options
Tunnels; Shade cloth structures for microclimate control	No till planters	Chicken tractors
Rainwater harvesting; in field methods and storage options, small dams	Mulching, manure and organic options	Winter supplementation

For each practice, a 1-page summary has been put together, that can be presented to smallholders in the climate change adaptation workshops, for consideration by the smallholder farmers as a new idea or innovation to experiment with. Below are three illustrative examples

Tower Gardens

- Greywater management
- Gardens
- <0,1ha,
- Low -medium cost, low-medium skills, including learning and mentoring, local resources
- Low maintenance – but bags will need to be replaced after some time (3-5 years)

DESCRIPTION

- Tower gardens are built up from the ground by using four poles and wrapping a tube of 80% shade cloth around these poles.
- In the centre of the bed, a stone column is built up using a bottomless bucket as a ring
- The bed is filled in with a pre-prepared mixture (1/3 soil, 1/3 manure, 1/3 ash (It needs a lot of ash to clean the greywater used)
- Small holes are made in the side of the bag and seedlings are planted vertically into these small holes- usually spinach or another leafy vegetable
- The top of the bed can be used for planting other crops – tomatoes are good as they can be staked to the poles.
- The bed is watered by pouring the greywater onto the stone column in the middle

Making the soil, manure ash mixture for filling the tower garden

Placement of the stone column – in the small bottomless bucket in the middle of the bed

Building up the tower- filling in the soil mix around the stone column and moving it up

A 'mature' tower garden planted to spinach and tomatoes

Watering into the central stone column

Making the small holes in the side of the bag for planting seedlings

Stone bunds

- Rainfall: >150mm/year
- Temperature: >5°C
- Topography: 0,5%-5%
- Soil: all types – where stones and rocks are easily available

- Gardens, fields
- <0,1ha, 0,1-1ha, >2ha
- Low cost, local resources,
- Labour intensive

DESCRIPTION

-Pack stone lines on contours to control water movement

- The stones are keyed into a shallow ditch and larger stones are packed downslope from the smaller stones to avoid stone lines form breaking and allow slow movement of water though the stone lines

-Planting can be done below the stone line as more water accumulates there, or just above the stone line in the accumulated silt and soil

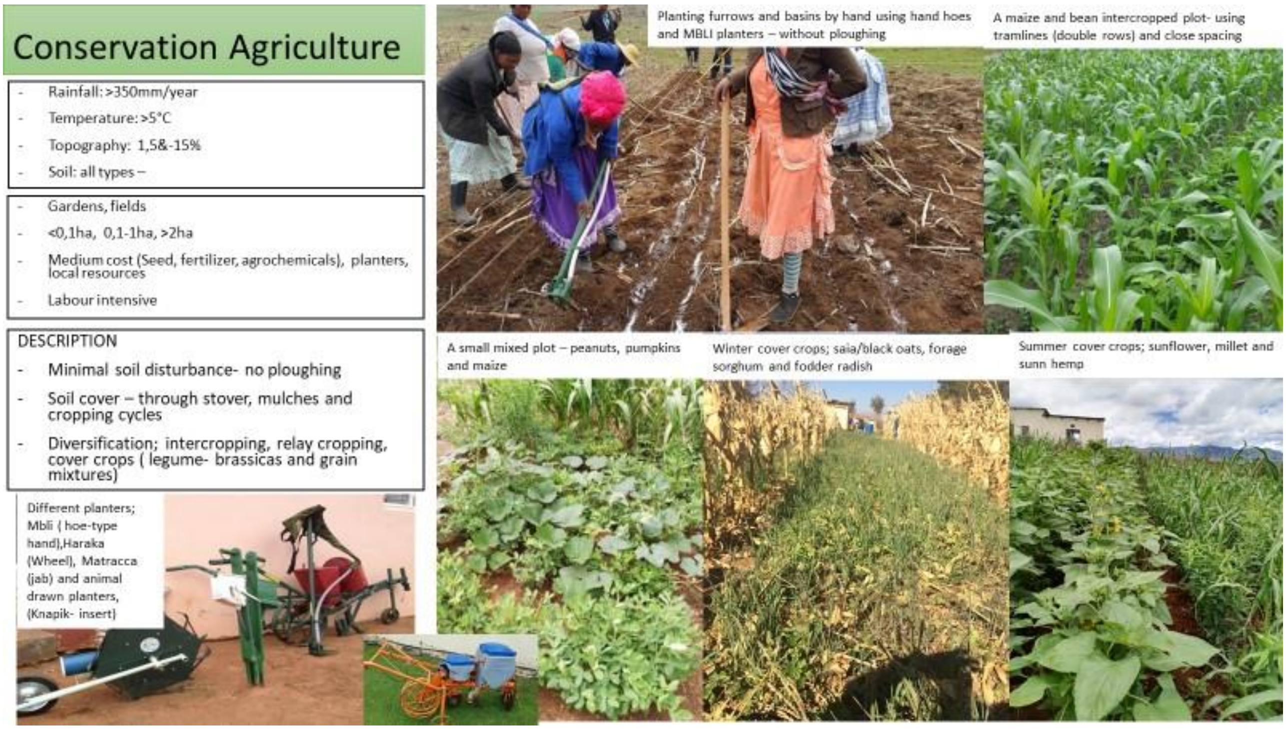
Stone lines are constructed on contour and can be done at any scale.

A view showing the stones keyed into a ditch with larger stones downslope of the smaller stones.

Small stone lines are used to control run-off form a road and channel water into the gardens

Brinjals planted in accumulated silt above a garden level stone line

Bananas planted below a substantial stone line



This database provides a resource to farmers and facilitators to choose appropriate climate resilient agricultural practices for their area and their particular situation. It is one of the input parameters for the decision support process.

In addition, qualitative and quantitative indicators have been explored to physically assess the impact of these practices. These have included for example run-off, infiltration, water holding capacity in the soil profile, and water productivity as well as a number of soil- based parameters such as organic matter content, soil fertility and microbial activity.

As an example, a farmer level experimentation process consisting of production in trench beds, inside and outside of shade cloth tunnels was conducted. The control for this experiment was the farmer's 'normal' gardening practice – in this case raised beds.

Above left to right: Spinach grown in a trench bed inside a tunnel, in a trench bed outside a tunnel and in a control bed (raised bed), by Phumelele Hlongwane

Farmers kept careful records of the amount of water applied (irrigation) and their harvests (yields), alongside the research team who worked with local weather stations and soil moisture measurements to assess the water productivity of these practices.

The table below outlines the resultant water productivity calculation for this experiment. Both conventional WP calculations and a simpler format suggested by farmers that only uses their water applied were used.

Table 2: Water productivity for production of spinach inside and outside shade cloth tunnels for 2 smallholder farmers in KNV, Bergville

Bgvl June-Sept 2018	Simple scientific method (ET)			Farmers' method (Water applied)		
Name of famer	water use (m^3)	Total weight (kg)	WP (kg/m^3)	water use (m^3)	Total weight (kg)	WP (kg/m^3)
Phumelele Hlongwane trench bed inside tunnel	1,65	21,06	12,76	1,85	21,06	11,38
Phumelele Hlongwane; trench bed outside tunnel	0,83	5,32	6,45	1,75	5,32	3,04
Ntombakhe Zikode trench bed inside tunnel	1,65	17,71	10,73	2,37	17,71	7,47
Ntombakhe Zikode; trench bed outside tunnel	0,50	3,35	6,76	0,53	3,35	6,33

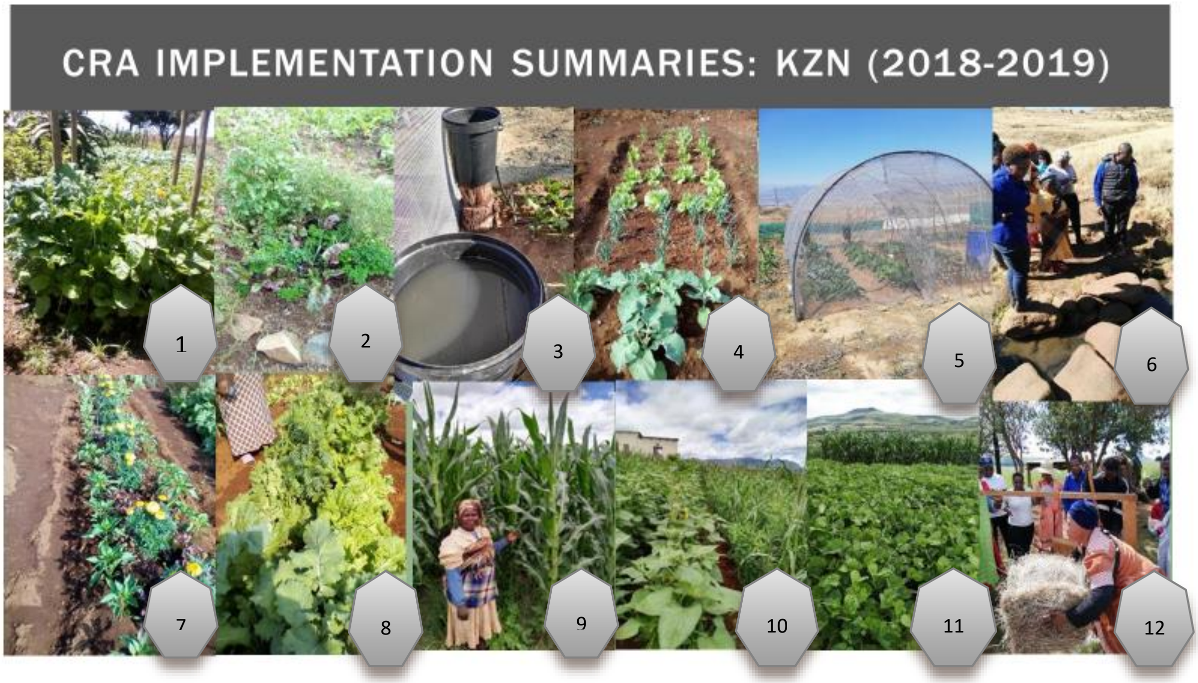
The control plots are not included here, as the two farmers realised quite early in the season that their normal production methods required too much water and opted to focus only on the trench beds. Water productivity is 60-100% higher for trench beds inside the tunnels when compared to trench beds outside the tunnel – using the more scientific approach that also takes into account evapotranspiration and leaching. This is a highly significant result, indicating the potential of micro-climate control in adaptation.

Water productivity calculate only from yields compared to water applied, shows a larger variation in results for the two participants. They both applied more water to their trench beds outside their tunnels, than inside; working on the assumption that the reduced growth for the crops outside the tunnel was due to water stress. This experimentation process assisted in their learning that plant stress also includes other factors such as temperature, wind and insect damage.

Participatory Impact Assessments

After a cycle of experimentation with the basket of CRA practices (one season/ 6 months), the process is reviewed and a participatory impact assessment process is conducted with the learning group members. It is important for community members themselves to develop the impact indicators/criteria

The diagram below provides a summary of all the practices that were tried out for the KZN learning groups for the 2018-2019 season



1: Tower garden; using greywater for irrigation, planted to kale, spinach and tomatoes
2: Eco-circle with a 2litre bottle (with holes) used for in situ irrigation and planted to a mixture of herbs and vegetables
3: Bucket drip kits inside a shade cloth tunnel
4: raised bed with mixed cropping planted as a "normal practice control" when comparing with trench beds
5: A Shade cloth tunnel with 3 5x1m trench - beds
6: Inspection of a locally protected spring
7: A shallow trench bed planted to a mixture of green peppers, chillies and marigolds
8: A deep trench bed planted to a mixture of kale, rape, mustard spinach and Chinese cabbage
9: A maize and cowpea intercropped conservation agriculture (CA) plot
10: A CA plot planted to summer cover crops; sunflower, millet and sunnhemp
11: A CA plot planted to Dolichos beans
12: Making bales of hay with a small manual baler

Community members work in small groups to analyse for themselves the impact of the climate resilient agricultural practices they have been implementing.

Right: Participants from 4 learning groups work together in assessing the impact of their implementation (KZN, March 2019)

Below is the result of a matrix ranking exercise conducted during this session. The research team were incredibly impressed with the depth of analysis participants undertook and with the impact indicators participants developed. It also indicates that smallholder farmers use integrated and systemic indicators to make their decisions and not just production and income data, commonly used in agriculture.

Table 3: Particiatory impact assessment of CRA practices by KZN participants, March 2019..

IMPACT INDICATORS PRACTICES	**Soil;** ***health and fertility***	**Money;** ***income and savings***	**Productivity;** ***acceptance of practice, saving in farming – equipment, labour***	**Knowledge;** ***increased knowledge and ability to use***	**Food;** ***how much produced and how healthy***	**Water;** ***use and access***	**Social agency;** ***Support, empowerment***	**Total**
Conservation Agriculture	22	21	26	28	18	23	18	**156**
Savings	6	15	14	15	12	11	15	**88**
Livestock	19	11	18	7	5	12	11	**83**
Gardening	14	15	12	13	15	17	21	**107**
Crop rotation	16	12	13	12	12	15	10	**90**
Intercropping	12	13	15	12	11	11	9	**83**
Small businesses	11	17	15	10	20	11	9	**93**

Positive impact of CRA and associated practices in order of importance: Conservation Agriculture, gardening (tunnels, agroecology), small businesses (farmer centres, poultry), savings, livestock (integration – fodder, health)

The resilience snapshot put together from individual interviews for these same participants, gives a very strong indication of the benefit of CRA to the livelihoods of the rural poor. Climate change adaptation for these participants has resulted in increased availability of food, incomes and social agency and has provided hope for a more positive future for these participants.

Table 4: Resilience snapshot for KZN participants, March 2019.

Resilience indicators	Rating for increase	Comment
Increase in size of farming activities	Gardening – 18% Field cropping – 63% Livestock – 31%	Cropping areas measured, no of livestock assessed
Increased farming activities	No	Most participants involved in gardening, field cropping and livestock management
Increased season	Yes	For field cropping and gardening- autumn and winter options
Increased crop diversity	Crops: 12 new crops Practices: 8 new practices	Management options include; drip irrigation, tunnels, no-till planters, JoJo tanks, RWH drums,
Increased productivity	Gardening – 72% Field cropping – 79% Livestock – 25%	Based on increase in yields

Increased water use efficiency	25%	Access, RWH, water holding capacity and irrigation efficiency rated
Increased income	13%	Based on average monthly incomes
Increased household food provisioning	Maize- 20kg/week Vegetables – 7kg/week	Food produced and consumed in the household
Increased savings	R150/month	Average of savings now undertaken
Increased social agency (collaborative actions)	2	Villages savings and loan associations and learning groups
Increased informed decision making	5	Own experience, local facilitators, other farmers, facilitators, extension officers
Positive mindsets	2-3	More to much more positive about the future: Much improved household food security and food availability

In conclusion

A farmer level innovation approach to implementation of CRA practices in smallholder farming systems provides a powerful tool for community based climate change adaptation and improvement of rural livelihoods.