CLIMATE RESILIENCE THROUGH RESOURCE EFFICIENCY IN SMALLHOLDER VEGETABLE PRODUCTION IN SOUTH AFRICA

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Summary

Most of the vegetables grown in South Africa are irrigated. Smallholder vegetable farmers face water shortages and other constraints including low yields and high energy costs. This study sought to assist smallholder farmers to address these constraints through enhanced resource use efficiency. It also assessed relevance of these practices for building climate resilience. Data was collected from commercial smallholder vegetable farmers in Limpopo Province and analysed thematically. Farmers recognise the constant fluidity of their environment, noting shifts in rainfall patterns and amounts, increasing temperatures, frequent droughts; and increasing shortages of irrigation water. Higher temperatures necessitate more irrigation and exacerbate water shortages while increasing energy consumption. Competition for water from non-agricultural users is also an issue. Interventions instituted through the study include water conservation through mulching, efficient irrigation management, accurate irrigation scheduling; use of suitable infrastructure and equipment and good crop management. These interventions reduced water consumption and energy use while increasing yield and reducing production costs; and thus enhanced both water, energy and general resource use efficiency. Enhancing water, energy and general resource use efficiency are appropriate responses to climate change as they build resilience and could help sustain production in the face of climate change induced water shortages and rising energy costs. Impacts could be scaled up and sustained through training and capacity building targeted at individual farmer needs and bolstered by information and technical support. Agricultural advisory service providers need to be cognisant of opportunities for building climate resilience presented by generic problems faced by farmers.

Introduction

About 90% of the vegetables grown in South Africa are irrigated (Nieuwoudt et al. 2004). Limpopo province is an important vegetable production area, producing 60% and 40% respectively of the country's tomatoes and potatoes (Limpopo Information Directory 2016) and a variety of other vegetables. Smallholder vegetable production is an important livelihood activity in Limpopo province, contributing to household food security and local economies. Shortages of water affect smallholder vegetable production. Some areas of the province note a decline in agriculture which is ascribed to drought and water shortages (Greater Giyani Municipality, 2010). This situation is likely to worsen as climate change projections for Limpopo province indicate an increase in temperature (maximum, minimum and average) a decrease in summer rainfall, increased evapotranspiration and decreased soil moisture in the long term (up to 2100) (LEDET, 2016). Reduced recharge of groundwater and falling water levels in boreholes are also indicated (LEDET, 2016). Some of the implications of changing climatic conditions for agriculture include increased crop irrigation requirements due to increased temperature, decreased soil moisture levels as a result of changed runoff patterns and high vulnerability of certain crops due to decreased water availability and increased temperature. (LEDET, 2016). Other climate change impacts include increased water demand for irrigation and an increase in the spread of pests and pathogens, and an increase in extreme precipitation events which can cause crop damage (Zwane and Montmasson-Clair, 2016). This study aimed to assist smallholder vegetable farmers to address the constraints they currently face through adopting practices that enhance water and general resource use efficiency; and to identify opportunities for building resilience to changing climatic conditions through practices which enhance resource use efficiency.

Methods

Thirty smallholder vegetable farmers in the Mopani, Capricorn and Waterberg Districts of Limpopo Province participated in the study. The research process entailed (1) assessing the biophysical, economic and social operating environment of each farm, 2) documenting constraints, risks and vulnerabilities of each farm; (3) implementing interventions to address them; and (4) assessing opportunities for climate change adaptation and climate resilience linked to the interventions. A questionnaire survey, semi-structured interviews; farm observations and a desktop review were used to collect data. Thematic analysis was used for data analysis. For each farm constraints were discussed with the individual farmers concerned and interventions identified and immediately implemented whenever possible. Implemented interventions include water conservation through mulching, efficient irrigation management, accurate irrigation scheduling; use of suitable infrastructure and equipment, maintenance of infrastructure to minimise water leakages and improved crop management such as use of organic soil amendments, applying fertilisers on the basis of soil analyses and crop requirements. Farmers were also encouraged to keep records of income and expenditure and to use these to track financial performance on a regular basis.

Results

The farmers grow spinach, beans, tomatoes, okra, squashes, cabbage, cucumbers, onions and a variety of peppers. All the farmers produce for sale. Production occurs on plots ranging between 2 and 10 hectares. All the vegetables are irrigated, with boreholes being the main source of water and drip irrigation the most used method (Table 1). Most farmers use electricity (supplied through the national power grid) to pump water, and they are billed for the electricity they use. The attributes of the farms at the beginning of the study are summarised in Table 1. While all farmers noted that costs of inputs such as electricity were increasing, most (80%) did not keep records of their water use and spending on inputs such as electricity, fertilisers and pesticides. Those who filed their electricity bills and kept records of their spending on various inputs, did not analyse the records to identify fluctuations; and could therefore not link their practices or specific events in the production process with input costs.

Table 1. Baseline situation at the beginning of the study

Attribute	**Situation at the beginning of the study**
Area under cultivation on each farm	2.5 to 10 ha
Source of irrigation water	• Borehole only (83%) • River only 11% • Borehole and river: 6%
Source of energy for pumping irrigation water	• Electricity (grid): 89% • Diesel: 11%
Irrigation method	• Drip only: 89% • Furrow only: 0% • Drip and furrow: 11%
Basis of irrigation decisions (when to irrigate and duration of irrigation)	• Routine and discretion of farmer: 100% • Soil water measurements or crop water requirements : 0%
Marketing	All farmers sell produce to informal and formal markets
Inorganic Fertiliser use	All farmers use inorganic fertilisers
Organic soil amendment use	• 83% use (mainly chicken and cattle manure) • 17% do not use organic amendments
Basis of fertilisation decisions	• Soil analysis results: 17% • Farmer discretion: 72% • Generic fertiliser manufacturer recommendations: 11%
Use of water conservation practices	• 28 % use mulches • 72% do not practise water conservation
Water pumping practices	• 53% always pump into reservoir and then irrigate

	• 29% have pump directly from water source to crop field • 28% sometimes pump into reservoirs and at other times irrigate directly from water sources
Pest control	100% chemical pesticide use
Basis of pesticide application decisions	• Scouting (precise assessment of pest pressure and state of crop): 67% • Schedules recommended by pesticide suppliers: 11% • Scouting and recommended schedules: 22%

Farmers recognise that the environment they operate in is constantly changing and they note a shift in rainfall patterns, increasing frequency of droughts, increasing temperatures and frequency of heat waves. A general decline in water availability from both boreholes and surface reservoirs was noted over the years irrespective of rainfall. Farmers also reported an increase in the frequency and severity of crop pest and disease outbreaks. The costs of energy (for pumping water) are increasing; while higher temperatures necessitate more frequent irrigation, and exacerbate the water shortages and further increase energy costs.

Farmers face two categories of risk and vulnerability: (i) those emanating from environmental conditions such as water shortages; and (ii) those that are related to the way farmers manage their operations, and these include the *ad hoc* irrigation decisions which compromise both water and energy efficiency and lax agronomic management and poor record keeping as detailed in Tables 1 and 2. The risks emanating from environmental conditions are expected to worsen under changing climatic conditions characterised by lower rainfall and increasing temperatures. One year after implementing the interventions, farmers noted changes (these varied from farm to farm) (Table 2). There was a decline in water consumption (this ranged from 5 to 50%). Yields increased by 20 to 200% while gross income increases ranged from 13% to 192%. Electricity costs fell and the range for different farms was 17% to 64%. The interventions improved resource use efficiency and could improve climate resilience (Table 2).

Table 2. Implications of interventions to address issues currently faced by farmers for resource efficiency and climate resilience

Current situation	**Interventions to address current situation**	**Result**	**Implications for Resource efficiency**	**Implications for resilience in a warmer and drier climate**
Increasing frequency and duration of irrigation due to high temperatures	• Mulching to reduce soil water loss • Irrigation during coolest part of day to reduce evaporation	Reduced water consumption	Increased water use efficiency	Minimising soil water loss contributes to meeting crop water requirements -
Increased energy costs due to increased frequency and duration of irrigation	• Mulching • Irrigation during coolest part of day	Reduced energy consumption	Increased energy use efficiency	Improved production stability
Pumping water directly from boreholes to fields and using pumps during whole duration of irrigation	Pumping water into storage reservoirs and using gravity to convey water to fields	Reduced duration of pumping, reduced energy use	Increased energy use efficiency	Reduced energy costs lower, production costs – increased production stability
Shortages of irrigation water	Water conservation – mulching and irrigation during coolest part of day	Reduced water consumption	Increased water use efficiency	Reduced water use – sustaining production in a drier climate
Ad hoc irrigation (not informed by crop water requirements)	Conduct basic tests to determine necessity to irrigate and only irrigate based on crop water requirements	Adequate water supply to crops	Increased efficiency of use of water and other inputs	• Reduced water use • Optimal yields

Poor infrastructure maintenance – leaking pipes & tanks	Maintaining equipment and infrastructure to minimize water losses	Reduced water losses	Increased water use efficiency	Reduced water use – sustaining production in a drier climate
Low use of water conservation practices	• Use of mulches • Appropriate timing of irrigation	Reduced water losses	Increased water use efficiency	Reduced water use – sustaining production in a drier climate
Poor agronomic practices : • Ad hoc fertiliser application • Random pest control • Little use of organic soil amendments	• Correct fertilisation • Accurate and timeous pest control • Use of organic soil amendments	Optimum crop growth and yield	Increased efficiency of use of water and other resources	Sustaining optimal crop production in a drier climate

The interventions instituted to address problems currently faced by farmers resulted in reduced water and energy consumption and enhanced yields, and these factors are relevant for climate change adaptation and building climate resilience in farming operations (Figure 1).

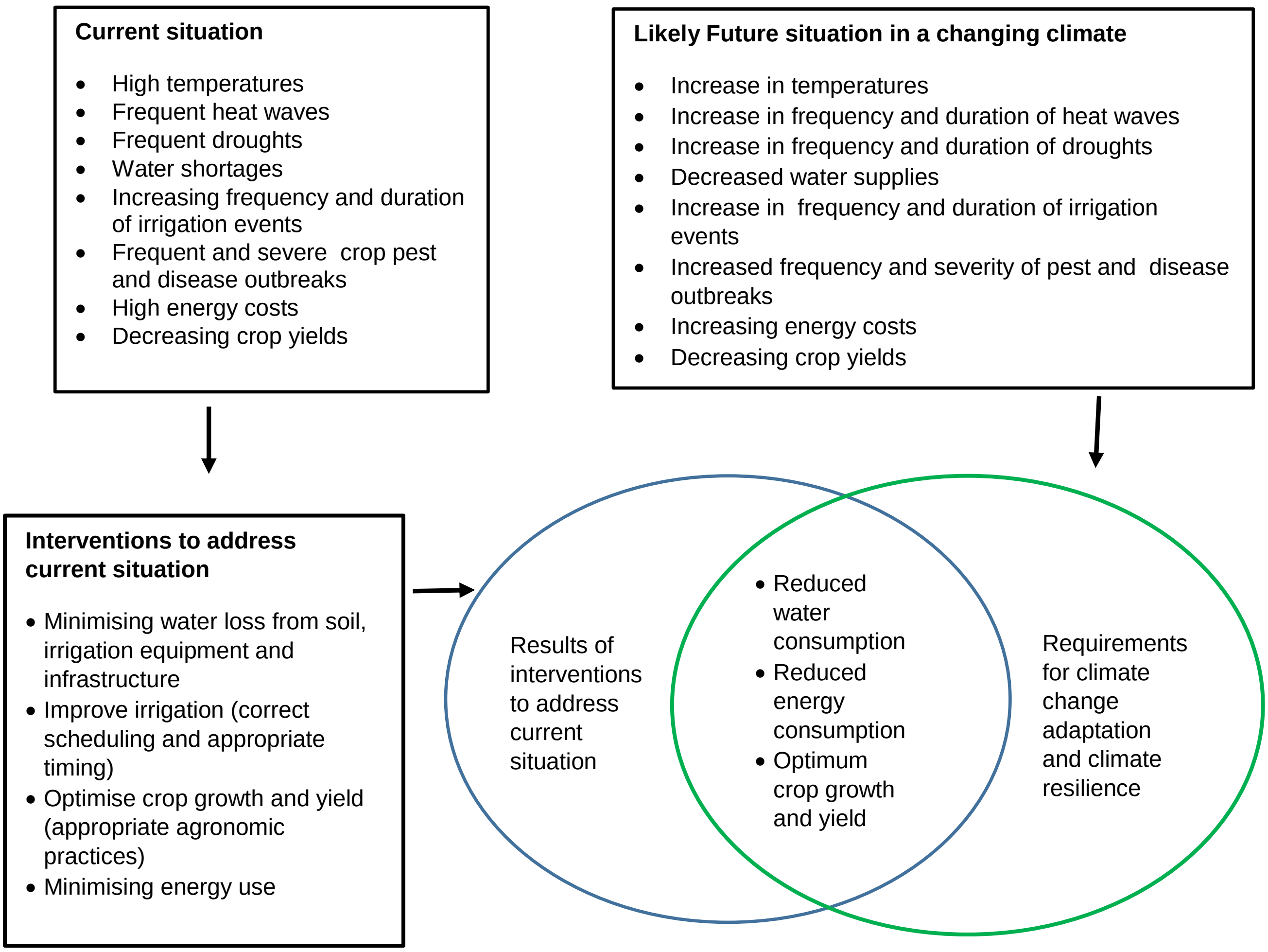

Figure 1. Convergence of outcomes of interventions to address current issues with requirements for climate change adaptation and climate resilience

Conclusions

Interventions which address immediate problems faced by farmers could facilitate building climate resilience in farming systems. Agricultural advisory service providers need to be cognisant of opportunities for building climate resilience presented by generic problems faced by farmers.
Interventions to address current problems faced by farmers included lowering water consumption and consequently energy use, resulting in enhanced water and energy use efficiency. Enhanced water and energy use efficiency, coupled with improved management incorporating appropriate agronomic practices and better irrigation management through accurate scheduling increased yield while reducing costs of inputs such as energy. These interventions not only address current problems faced by farmers, but are also appropriate responses to climate change as they built resilience and could sustain production in the face of climate change induced water shortages and and rising energy costs. Identified interventions are achievable through training and capacity building targeted at individual farmers' needs and bolstered by information and technical support. Interventions which address immediate problems faced by farmers could facilitate building climate change resilience in farming systems. Agricultural advisory service providers need to be cognisant of opportunities for building climate resilience presented by generic problems currently faced by farmers

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