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Contribution of Public Extension to Food Security of Smallholder Farmers in Limpopo Province, South Africa in an Era of Climate Variability

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ABSTRACT The paper examined the effectiveness of public extension support for dryland smallholder grain producers. Both probability and non-probability sampling procedures were used to select districts, Local Agricultural Offices and farmers from 20 villages of Limpopo province, South Africa in January 2014. Data was collected from field-level extension agents and farmers using semi-structured questionnaires. Descriptive and inferential statistics were applied to analyze the data. Results show that most agents promoted conservation agriculture as a climate variability coping strategy. Furthermore, public extension support made a difference in farmers' yield over non-extension recipients' yields, though small. Forty percent of maize producers who received extension support bought extra maize meal for home consumption indicating maize yields from farmers' own production was insufficient to ensure household food security. Findings also suggest non-farming sources contributed more to respondents' household income than farming. Extension support, therefore, needs improvement to effectively support farmers' production in light of climate variability.

INTRODUCTION

There have been extensive discussions on the controversy regarding extension impact on productivity gains and the methodological problems associated with these impacts (Wang 2014; Anandajayasekeram 2008; Davis 2008). Despite methodological challenges, the positive impact of agricultural extension on agricultural output is generally acknowledged (Wang 2014; Hasan et al. 2013; Davis et al. 2010). Improved yields make a potential contribution towards farmers' food security (Irz et al. 2001). The importance of extension in change and as a change or diffusion agency has also been ascertained by Rogers (2010). Against this backdrop, the South African government sees an improved Agricultural Extension Services playing an important role in its Integrated Food Security Strategy to increase the participation of food insecure households in productive agricultural sector (Department of Agriculture 2002). In many places around the world, agricultural extension services for producers, however, have come to be seen as ineffective (Ragasa et al. 2013 citing Birner et al. 2009). In South Africa, sentiments have been expressed on the ineffectiveness of public extension services in the provinces to respond to the needs of land redistribution beneficiaries (William et al. 2008).

In light of these concerns, Agricultural Extension's ability in supporting government's objective of household food security through increased crop production by smallholder producers is even more suspect in an era of climate change and variability. It is indicated that climate change and variability is expected to increase food insecurity, exacerbating poverty among rural communities in South Africa (Madzwamuse 2010; FAO 2008). Findings indicating the negative impacts of climate change and variability on agricultural production in South Africa are a source of concern and need urgent attention. This is because agricultural production for most small and medium producers in most developing countries including,

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South Africa, depends largely on rainfall. This is the case in Limpopo province where only twenty-five percent of crop production is under irrigation (D' Haese et al. 2011). Reports of a lack of public Extension support for farmers and Extension personnel's limited knowledge about how to derive the benefits of locally available climate observational data appear pervasive. Such problems have been reported in Zimbabwe (Mberego and Sanga-Ngoie 2014) and the Amazon (Brondizio and Moran 2008).

The study aims to answer the question: How effective is the Limpopo province extension service in supporting dry-land smallholder grain farmers' crop production in light of climate variability?

The purpose of this study therefore, was to determine the effectiveness[1] of public extension support including the climate variability information (hereafter referred to as public extension or extension) for dryland smallholder grain producers' crop production. The central study hypothesis was that public extension support including the climate variability strategies promoted for dry-land smallholder grain producers' crop production is effective.

A comparative study of recipients and non-recipients of public extension support, including climate variability information using cross-sectional data, addressed this problem. This approach was necessary because of a lack of panel data on yields of recipients of extension support. The study has a practical significance for extension management decision-making by linking extension support to farmers' yields.

Study Objectives

The objectives of the study were to:

1. Assess respondents' livelihood sources' contribution to household income.

2. Determine the climate variability coping and adaptation strategies promoted by the public extension service in the survey area to support farmers' crop production system.

3. Assess the effectiveness of public extension support including the climate variability coping and adaptation strategies promoted for dry-land smallholder grain producers' crop production in the year before the survey.

Conceptual Framework of Study: Assessing Vulnerability to Climate Change and Variability

Various definitions of vulnerability exist in the climate change and variability literature (for example, the Inter-Governmental Panel on Climate Change, (IPCC) 2001). A common thread in these definitions is that susceptibility to climate change and variability is a function of the character, magnitude and the rate of climate variation to which a system is exposed, its sensitivity and adaptive capacity. Two major vulnerability conceptualizations either based on the biophysical drivers (biophysical vulnerability) or the socio-economic drivers (social vulnerability) exist in the literature. An integrated and therefore, a more holistic approach to vulnerability assessment combine both views: social vulnerability (adaptive capacity) and biophysical vulnerability (exposure and sensitivity) (Gbetibouo and Ringler 2009). For this reason, this study uses the IPCC (2001) definition of vulnerability[2] to climate change and variability to assess smallholder crop farmers' food production system vulnerability to climate variability because it takes into account both conceptualizations.

Following Nelson et al. (2010), this study used the Sustainable Rural Livelihoods framework (Department for International Development 1999) as the conceptual framework to analyze the adaptive capacity[3] of crop farmers to climate variability and extreme weather conditions. Adaptive capacity was measured in terms of farmers' capital assets. Similarly, following Daze et al. (2009), the impacts of climate-related factors such as loss in agricultural yield, human life, damage to agricultural land or crops or livestock were taken as the sensitivity[4] indicators.

Difficulties associated with obtaining data on the forecasted probabilities of future climate extremes enforced the very simple assumption that given a constant level of hazard over time (exposure) to climate change and variability, the vulnerability of farming households' crop production systems will be highly influenced by their sensitivity and adaptive capacity.

In view of the long-term continuous nature of change associated with climate change as opposed to the yearly fluctuations characteristic of climate variability and the short period of recall of weather events (10 years) by respondents, the analysis in this study of farmers' adaptation strategies was assessed with respect to climate variability.

The effectiveness of a household's adaptation measures (proxy for vulnerability) in this study was, therefore, assessed as a function of its sensitivity to climate variability and its adaptive capacity.

METHODOLOGY

The study adopted a survey approach. Both probability and non-probability sampling procedures were used to select districts, LAO and crop farmers from 20 villages of Limpopo province, South Africa in January 2014.Two districts, Capricorn and Sekhukhune were purposively chosen because each had a municipality that was either prone to drought (Blouberg) or had undergone a government food security program, Fetsa Tlala (Makhuduthamaga) (E. Zwane pers. comm. January 2014). For these reasons, these two LAO were also purposively selected while simple random processes selected the other two, Aganang and Fetakgomo. Five villages were then selected per LAO by a simple random procedure. Ten crop farmers were randomly selected from a list of grain farmers per village.A total of 200 smallholder dry-land grain farmers were selected for interviews. However, the final number interviewed for the study was 194 due to logistical challenges.This number was made up of 72 Extension-support recipients and 122 non-recipients.

Semi-structured questionnaires were used in personal interviews to collect data from the selected farmers. Self-administered questionnaires were used to collect data from 24 field-level extension agents from the four selected municipalities of the two districts.

The researcher trained enumerators and the questionnaires were pretested. Data collected from farmer respondents include demographic information, crop yields for the year preceding the survey, sensitivity to climate variability (human and livestock fatalities), damage to cropping land experienced in the last 10 years before the survey, as well as capital assets that make their crop production resilient and less vulnerable to climate variability (adaptive capacity). Agricultural extension agents' data include their demographic information and climate variability coping and adaption strategies promoted. Food availability arising from farmers' crop production (yield/ha) in the year preceding the study was the dimension of food security that was assessed in the study. Farmers' crop yield (ton/ha) in the year before the survey was used as a proxy for the effectiveness of public extension support for farmers' crop production, and therefore, the contribution of Extension to farmers' food security. This was achieved by a comparison of yield of extension services recipients and that of non-recipients. The long-term continuous nature of change associated with climate change as opposed to the yearly fluctuations characteristic of climate variability and the short period of recall of weather events (10 years) by respondents, necessitated an analysis of farmers' adaptation strategies with respect to climate variability.

A linear multiple regression model was specified to study the relationship between farmers' crop yield and their capital assets and sensitivity to climate variability (Greene 2008).

The model was specified as,

$$Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 ... \beta_n X_n + \mu_i .... (1)$$

Where,

Z = Yield (tons/ha)

β_0 = the intercept or constant term

$\beta_1, \beta_2, ... \beta_n$ = regression coefficient

$X_1, X_2, ... X_n$ = independent variables

μ_i = Error or disturbance term.

The independent variables were specified as follows:

X_1 = Natural capital

X_2 = Social capital

X_3 = Human capital

X_4 = Financial capital

X_5 = Sensitivity

An independent samples t-test was further conducted to compare the statistical significance between the yield differences for the survey respondents who reported receiving extension support and those who did not. Data analysis was done using SPSS. Statistical techniques that were applied include descriptive statistics and inferential statistics.

RESULTS

Promotion of Climate Variability Coping and Adaptation Strategies

In Table 1, most agents (92%) indicated promoting measures among their crop farmers in the last five years of the study to help them deal with current and future climate variability-relat-

Table 1: Percentage distribution of agents promoting coping and adaptation strategies (N= 24)

	Yes	*No*
Promotion of coping and adaptation strategies	92	8

ed problems (coping[5] and adaptation[6] strategies respectively).

Conservation agricultural practices[7] such as soil tillage techniques (soil ripping and zero tillage), crop rotation, mulching, and cover cropping appear to be the most popular forms of coping strategies promoted by most agents (67%) to support farmers' crop production system (Table 2). The use of improved seed is also promoted to some extent by agents (21%). Very few of agents (4% -8%) however, promoted other strategies such as encouraging farmers to listen to radio or watch climate variability-related television broadcasts, adoption of water harvesting techniques or application of pesticides.

Table 2: Coping and adaptation strategies promoted by public extension agents

Strategy	*Respondents (percent)*
Coping Strategy	
Conservation agriculture (n=24)	67
Use of improved/certified/hybrid seeds (24)	21
Do climate change awareness campaign (24)	08
Encourage farmers to listen to and /or watch television broadcasts on climate change (n=24)	04
Promote water harvesting (n=24)	08
Rehabilitate project structures to prevent strong winds (n=24)	04
Application of pesticides (n=24)	04
Adaptation Strategy	
Discourage deforestation (n=17)	35
Plant indigenous trees/agro-forestry (n=17)	12
Control invasive, alien plants (n=17)	12
Control veld fires (n=16)	06
Discourage planting of exotic plants (n=16	06
Construction of irrigation dams (n=17)	06

To help farmers adapt their crop production to future climate variability situations, a slight majority of agents (35%) discouraged producers from deforestation. About twenty-nine percent of agents also indicated holding meetings, information days and farmers' days to inform producers to prepare them for future climate variability situations. A further twelve percent of agents encouraged producers to plant indigenous trees or control alien plants.

Sources of Livelihood

The major sources of livelihood investigated that give indication of respondents' sensitivity to climate variability include income from farming, trading/business, remittances and salary from formal employment. Table 3 indicates that for most respondents (83%), farming activity compared with all the other sources (non-farming), does not contribute to the total household income.

Table 3: Contribution of livelihood sources to total household income (N= 194)

Source of livelihood	*Respondents (percent)*	
	Yes	*No*
Farming	17	83
Trading/Business	19	81
Remittances	88	12
Salary	47	53

The contribution of a household's food production system to its food consumption needs and therefore, its vulnerability to climate variability and food security, appears to be minimal for most respondents. This is indicated by the fact that most respondents (76%) of the maize farmers (N= 136) (both Extension-support recipients and non-recipients)in the survey indicated buying extra maize for home consumption in the year preceding the survey. Sixty percent of these maize producers who bought extra maize for home consumption came from farmers who did not receive extension compared with forty percent who received extension support (Table 4).

Table 4: Distribution of maize-producing respondents who bought extra maize meal for home consumption (N= 103)

Recipient of public Extension support	*Percentage of respondents*
Yes	40
No	60
Total	100

Effectiveness of Public Extension Coping and Adaptation Strategies

Yield Comparison

A comparison was made of the crop yields obtained by respondents who received some support from public extension and those who did not receive, in the year preceding the study.

The support includes climate variability information. The comparison was to identify the effect of public extension on a household's food production, and therefore, food security. The results indicate that receiving some public extension service contributes positively to crop yield (Tables 5 and 6).

Table 5: Percentage distribution of respondents' crop yields according to use of public extension

Yield (ton/ha)	*Use of Public Extension*	
	Used (N= 68)	*Did not use (N=113)*
Less than 1	66.0	79.0
1-2.99	32.0	20.0
3-4.99	1.5	0.9

Table 6: Mean yield (ton/ha) differences between recipients and non-recipients of public extension support including climate variability information

Use of public extension for climate variability information	*Number*	*Mean*	*Std. dev.*
Received climate variability information from public extension	68	.845	.747
Did not receive climate variability information from public extension	113	.548	.607

An independent sample t-test was conducted to compare the statistical significance between the yield differences for the survey respondents who reported receiving extension support and those who did not. The results show a small difference in mean yields (p = .002; two-tailed t-test; eta squared = .05) (Pallant 2007 citing Cohen 1988).

Effect of Public Extension on Household's Food Production

To further test the effectiveness of public extension support for producers' crop production, a multivariate analysis was performed. The null hypothesis of no effect was tested.

The results (Table 7) show the model is significant (F=2.822; p= .019) and that contrary to the null hypothesis, receiving public extension, including climate variability information, makes a contribution to the yield of the producers in the survey (p=.011). The singular contribution of public extension support including climate variability information to R^2 is .05. This information indicates public extension support including climate variability information, which makes a big contribution to farmers' yield compared with all the other variables in the model.

Table 7: Multiple regression estimates of the effects of the independent variableson the yield of respondents (N=181)

Predictor	*Coefficient*	*P-value*	*Part*
Constant		.146	
Natural Capital			
Percentage of cropping land suitable for crop	.049	.579	048
Social Capital			
Access to markets for Production	.132	.131	132
Use of extension services for climate variability information	.227	.011*	.225
Human Capital			
Dependency ratio	.114	.102	.143
Financial Capital			
Access to production credit	.074	.402	.073

*1 percent significant level $R^2 = .107$

DISCUSSION

The study hypothesis was that public extension support including climate variability information contributes to farmers' production. This was confirmed. Study findings therefore, corroborate the wider extension literature that extension support enhances farmers' productivity (for example, Bruce et al. 2014; Wang 2014). Sasson (2012) indicates that the key cause of food insecurity is inadequate production. Increased yields should, therefore, improve a households' food security and reduce vulnerability to climate variability. This positive effect notwithstanding, the low yields (less than 3 tons/ha) obtained by most respondents (98%) as well as the small difference between the crop yields of extension support recipients and non-recipients are worrisome. This concern is against the backdrop that the most popular support promoted by extension agents was conservation agriculture. This situation leads one to conclude that the conservation practices are not being applied correctly and/or farmers are not applying what Extension agents are recommending to them. According to K. Ayisi (pers. comm. July 14, 2014), conservation agriculture field trials under similar conditions in one of the LAO (Makhuduthamaga) in the study area, however, indicate a potential yield of 5 tons/ha. It is, thus, possible that with proper application of conservation agriculture practices, producers' yield could approach this figure.

Changing farm production management activities have the potential to reduce exposure to climate variability-related risks and increase the flexibility of farm production to variability in climatic conditions. Crop production practices such as reduced tillage, maintaining ground cover or mulching has been found to reduce the impact of drought and improve crop yields. Maize yield was increased by sixty-one percent by simply adding crop residues to the soil in Ghana, while average maize yields have increased from 300 kilograms per hectare to more than 1.5 tonnes in Namibia (Boateng 2011; FAO 2011).

Production adaptations could include the diversification of crop varieties, and changes to the intensity of production. Altering crop varieties, including the substitution of plant types, cultivars and hybrids, designed for higher drought or heat tolerance, has the potential to increase farm efficiency in light of changing temperature and moisture stresses (FAO 2013 citing Africare et al. 2010; FAO 2012).

CONCLUSION

Public extension support has sometimes been said to be irrelevant to farmers and therefore, does not deserve large financial appropriations from government budgets. The study findings however, provide evidence to the contrary. Extension support including climate variability information has the potential to improve farmers' production as revealed by the findings in this study. Increased production could also improve the households' food security and, therefore, reduce their vulnerability to climate variability given the necessary resources. This positive effect notwithstanding, the low yields obtained by most respondents in the study and the fact that most maize producers bought extra maize for home consumption indicates that farmers' production system under the current climate variability Extension support still leaves them vulnerable. This is further indicated by the fact that under the current climate variability support provided by public extension, farming production does not contribute to most producers' household income, which has the potential to improve their food security.

The most popular support promoted by extension agents is conservation agriculture. The small yield improvement over non-extension service recipients leads one to conclude that there might be poor or non-application of extension information including conservation agricultural practices by farmers.

RECOMMENDATIONS

Public extension's impact on farmers' production needs to be increased. This can be done through provision of adequate financial resources to provide logistical support and training for extension agents in needed knowledge areas. In view of the fact that most farmers in both farming systems employed conservation agriculture to reduce the negative impacts of climate variability on their production, field trials involving extension agents, farmers and researchers are needed to investigate the most appropriate and cost-effective means to apply conservation agriculture. This will help to ensure that farmers benefit from the widely reported positive impacts in both developed and developing countries of conservation agriculture on crop yields. For smallholder farmers with little access to irrigation facilities, conservation agriculture appears to be a more effective means to mitigate the negative effects of climate variability, thereby ensuring food security. Appropriate production credit tailored to the needs of smallholder producers should be provided so that these farmers can purchase other necessary production inputs to complement the positive effects of conservation agriculture on crop yields.

Future research could employ a longitudinal survey instead of the cross-sectional approach used in this study to determine a more lasting effect of Extension support including climate variability information on producers' yields. Furthermore, future research should control for other private extension support to avoid over-estimation of the public extension's effect on recipients' productivity.

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NOTES

1 Measured in terms of comparison between crop yields (ton/ha) of public extension service recipients including climate variability information and non-extension service recipients in the year preceding the study.

2 The degree to which a system is susceptible, or unable to cope with adverse effects of climate change, including climate variability and extremes, and vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (Inter-Governmental Panel on Climate Change (IPCC) 2001).

3 It is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (Inter-Governmental Panel on Climate Change 2001).

4 It is the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. (Inter-Governmental Panel on Climate Change 2001).

5 Coping strategies were defined and used in the study as short-term responses to current climate variability while adaptation was defined as longer-term responses to future climatic variability (Warner et al. 2013 citing Birkmann 2011).

6 Adaptation strategies are longer-term (beyond a single rainfall season) strategies that will be needed for farmers to respond to a new set of evolving climatic conditions that they have not previously experienced i.e. responses needed in the long-term to deal with climate stressors (Warner et al. 2013 citing Birkmann 2011).

7 Minimal soil disturbance (no-tillage, minimum tillage) and maintenance of semi-permanent or permanent soil cover (mulch) combined with rotations, as a more sustainable cultivation system (Hobbs et al. (2008).

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