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Factors Influencing Adoption of Conservation Agriculture: A Case for Increasing Resilience to Climate Change and Variability in Swaziland

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Abstract
Conservation agriculture technologies have been extensively promoted to mitigate against drought as well as improve agriculture productivity for over a decade. Despite the extensive extension and investment Conservation agriculture technologies have been less widely adopted by farmers in Swaziland. Low adoption and lack of continued use of adapted and improved agricultural production technologies amongst farmers has been identified as one of the main reasons for the low agricultural productivity in the country. There is no in-depth analysis of the determinants of Conservation agriculture adoption, this study therefore assessed factors that influenced adoption and continued use of conservation agriculture in the Lowveld agro ecological region of Swaziland Results from 200 farming households practicing conservation agriculture indicated farmer characteristics such as age, gender, levels of education, extension and wealth influence adoption of Conservation agriculture. Likewise, the linear regression model results show that if the household head had some form of education, there were three times more likely to adopt conservation agriculture than a household head without any form of education. As the number of people contributing to agricultural labour increased households there was a 165% chance that these households were more likely to adopt conservation agriculture. Knowing factors that influence adoption will allow development of strategies, policies and plans that take advantage if the main influences of adoption so as to increase adoption and sustainability of use of Conservation agriculture.
Keywords: Conservation Agriculture, Technology adoption, Extension, Climate change, Resilience

1. Introduction

Climate change and variability is evident in Swaziland, as it manifest itself in many forms, including hydrological disasters, change in rainfall regime as well as extreme weather conditions (Manyatsi, Mhazo, and Masarirambi, 2010). The rapid pace of climate and its anticipated large negative effects on many agricultural systems suggests a broader and pressing need for adaptation (Burke and Lobello, 2010). Agriculture is at the heart of the Swaziland economy, accounting as much as 17% of Gross Domestic Product, 27% of employment and 33% of foreign exchange earnings (Moyo, 2013). With the continued increase in population in Swaziland, the demand for food is increasing bringing pressure on agriculture. The sustainability of agricultural production in the face of increased food demand and climate change and variability, comes with many challenges that necessitates technological innovation and farmer adaptation.

Technical change promoted through the generation of agricultural technological research and their dissemination to end users plays a critical role in boosting agricultural productivity in developing countries (Mapila, 2011). Technical change through adoption of improved agricultural production technologies has had positive impacts on agricultural productivity growth in the developing world (Nin *et al.*, 2003). Conservation agriculture (CA) amongst other agriculture technologies has been acclaimed as a practice that will enhance sustainable and intensified agricultural production. It is being promoted in the Africa and beyond through a set of principles and practices that make a contribution to sustainable agricultural production intensification (FAO, 2008).

1.1 The Adoption of Conservation Agriculture

The dependence of Swaziland economy on rain-fed agriculture emphasizes the importance of CA for drought mitigation and disaster risk reduction (DRR). An estimated 30% of smallholder farmland in Swaziland is in a state of degradation (Moyo, 2013). Conventional agriculture, which often involves intensive tillage, has been claimed to cause soil degradation, particularly when practiced in areas of marginal productivity. Through adoption of CA principles and practices a significant contribution can be made towards sustainable production (FAO, 2008). It is from this background that the use of CA becomes relevant for Swaziland and Africa in general (Moyo, 2013).

Many of the advantages arising from the individual CA practices have been known for many years. It is therefore reliably known that changing from tillage-based agriculture to no-tillage CA systems eliminates unsustainable elements in the current tillage-based systems and replaces them with CA elements that make the production systems ecologically sustainable (Kassam *et al*., 2014). Notably, there has been increasingly rapid adoption of CA systems during the past 20 years (Wall 2007). The use of improved technologies such as CA may be in place as farmers seek to achieve gains in the face of harsh climatic conditions (Twomlow and Hove, 2006). Reduced vulnerability to effects of drought, less erosion, and lesser extremes of soil temperatures represent a managed adaptation of CA systems to climate change effects (Kassam *et al*., 2009).

The introduction of CA in Swaziland began in 2002 and was intended to alleviate food shortages and ensure food security among the less privileged rural households (Oladeebo and Mkhonta 2013). Conservation Agriculture is said to be one of the best strategies introduced as a method of soil conservation in Swaziland, yields have increased at the same time cost of production has been minimised (FAO, 2007). It generally has been promoted to maintain and improve yields and resilience against drought and other hazards while at the same time stimulating biological functioning of the soil practices such as direct sowing, zero-tillage or minimum tillage, and the establishment of cover crops help to protect organic matter and soil fertility Kassam *et al*., 2014).

Due to the benefits of CA that include sustainable land use, increased yields, increased incomes, timeliness of cropping practices, ease of farming and ecosystem services, the global area under CA systems is increasing (Kassam *et al*., 2009). It is estimated that, worldwide, there are now some 156 million ha of arable crops grown each year without tillage in CA systems (FAO, 2015). Adoption of CA in Africa is relatively low (Nyanga, 2012) despite more than 30 years of promoting CA in the continent. Any programs designed to upscale CA has to consider factors that affect behaviour change and enabling policies and institutional support to both producers and input supply chain service providers (Friedrich and Kassam, 2009).

Despite the many global positives, the agricultural sector Swaziland according to the Ministry of Agriculture and International Relief and Development (IRD, 2012), is characterised by low agricultural production which is associated with low CA technology adoption and unsustainable use of promoted technologies. Despite experiential results and long term effort of Government and Non-Governmental Organisations in Swaziland to systematically introduce CA, there has been no empirical evidence presented as to what extent the technology is being adopted and what factors have influenced adoption or the lack of it. Though a number of studies have been conducted elsewhere across the world on the adoption of the technology, there is little available literature on the specific factors that influence adoption of CA in Swaziland.

1.2 Factors Affecting Adoption of Innovations

Adoption of innovations has been defined as the decision to apply an innovation and to continue to use it (Rogers and Shoemaker, 1971). Different factors determine the adoption of different agricultural innovations and technologies (Akudugu *et al*., 2012). Agriculture extension agents and economists have long been interested in understanding the importance of the adoption of new agricultural technologies by rural smallholder farmers and several factors have been identified as influencing the adoption behaviour of farmers from qualitative and quantitative models (Oladele, 2006). Economic, social, physical, and technical factors and dynamics influence the adoption of various agricultural technologies. Rao and Rao (1996) found a positive and significant association between technology adoption, age, farming experience, training received, socioeconomic status, cropping intensity, aspiration, economic motivation, innovativeness, source of information and agent credibility.

Gabre-Madhin and Haggblade (2001) in their study on maize farming observed that large commercial farmers adopted new high yield maize varieties more rapidly than small holders. Family size was reported to have a positive and significant relationship on adoption (Arene, 1994). Literature on CA has shown that 80% of farmers adopted CA as a condition for receiving subsidized inputs packages (Arslan *et al.,* 2013). Other determinants of CA adoption included involvement of extension services and rainfall intensity (Arslan *et al.,* 2013), labour availability (Haggblade and Tembo, 2003: Umar *et al*., 2011 and household size (Chomba, 2004).

Langyinto and Mungoma (2008) noted that due to resource limitations and gender discrimination in extension message delivery, female farmers are less likely to adopt CA technologies. In Burkina Faso (Adessina and Baidu-Forson, 1995) found that age positively influences sorghum adoption. Igodan *et al* (1988) found that farmers in Nigeria who are more exposed to formal extension information have a high propensity towards adoption than those with less exposure. Ehler and Bottrell (2000) in their publication on integrated pest management in the United States of America found that technology complexity has a negative effect on adoption. In Zambia, the level of education was hypothesized to positively contribute to technology adoption (Chiputwa, 2011). Asfaw and Admassie (2004) through studies in Ethiopia showed that life cycle effects such as age, and adult labour availability are important drivers of agricultural technology adoption. Adessina and Zinna (1993) regarded young farmers to be more amenable to change traditional practices than older farmers due to more knowledge and awareness of latest technologies.

1.3 Theoretical Perspectives

Rogers (2003) highlighted that adoption takes place when one has decided to make full use of the new technology as the best course of action for addressing a need (Thangata and Alavalapati, 2003). Rogers (1995) demonstrated that adoption of technologies depended on technology characteristics: compatibility with the existing values and norms, complexity, observability, trial ability, and relative advantage. Numerous models have been used to explain adoption decisions; however, there is no single model able to explain all aspects of adoption. Rogers' innovation diffusion theoretical perspective identified information as a key factor influencing adoption decision making (Rogers, 2003). He further stated adoption is influenced by many factors such as socio economic, environmental and mental needs, and knowledge about the technology and individual perceptions about the methods used to achieve those needs (Thangata and Alavalapati, 2003). Culture also influences attitudes and behavioural intention towards technology and innovation, which have been shown to affect decision to adopt (Eseonu. and Egbue, 2014).)

The adoption-decision process is seen as a linear sequence of stages and is attained after an innovation-decision process that occurs in a five-step sequence namely: knowledge; persuasion; decision; implementation; and confirmation (Rogers, 2003). Knowledge stage is when a farmer gets information and knowledge about an innovation, persuasion phase is when a farmer forms an attitude towards the innovation, decision stage is when a decision is made to adopt or not to adopt, implementation is when there is an overt behavioural change by using the new innovation, adapting or reinventing the innovation to suit the local conditions. The final stage is the confirmation stage where farmers may either decide to continue if they are satisfied with the outcomes of implementation or abandon the innovation if not satisfied (Rogers, 2003; Nyanga 2012

2. Methodology

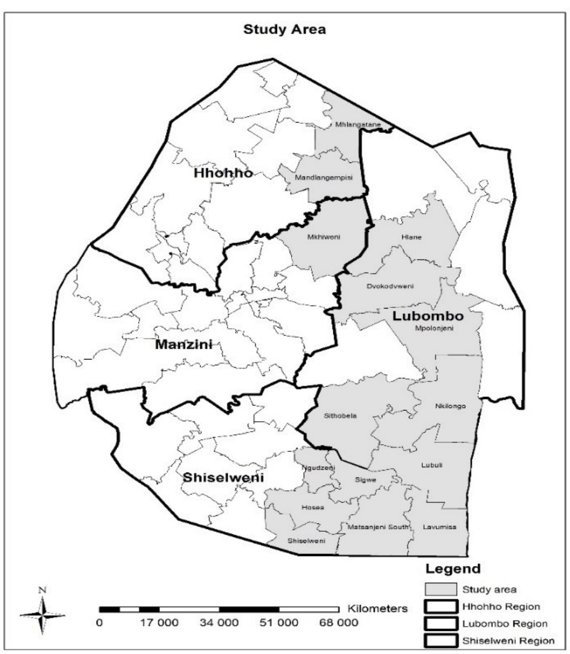

Figure 1. Study area

2.1 The Study area

The study was conducted in Shiselweni, Hhohho, Manzini and Lubombo administrative regions of Swaziland in fifteen constituencies (Mhlangatane, Madlangempisi, Mkhiweni, Hlane, Dvokodvweni, Mpolonjeni, Nkilongo, Lubuli, Somntongo, Matsanjeni, Hosea, Shiselweni, Sigwe, Ngudzeni and Sithobela) where International Relief and Development a Non-Governmental Organisation funded by USAID/OFDA has been implementing food security and agriculture programs between 2012 and 2015. The study area (Figure 1) is located in the Lowveld which is the largest region covering about 40% of the country, and is also subtropical and is the hottest and driest zone and the most vulnerable to drought. During drought years, while the whole country is affected, the Lowveld is normally the most severely impacted because it already experiences higher temperatures and lower rainfall than other regions. The Lowveld has an altitude of between 200-400 m above sea level and the average length of length of the growing period is between 100-119 days.

Dependable annual rainfall varies from 400-450 mm, with mean annual rainfall 550-625 mm (GOS, 1997). The topography in this region is characterised by an undulating plain and the main vegetation type is mixed savannah.

2.2 Sample size survey methods and statistical analysis

In each region the researchers made use of purposive sampling of beneficiaries of climate change and drought mitigation programs. From each community households were selected proportionally by random sampling. The final sample included the collection of data from 200 households through structured and unstructured interviews and using questionnaires and focus group discussions. Key informant interviews were conducted among international and local NGOs, government ministry officials, local community and traditional leaders. The research also involved a survey of the recent literature related to Swaziland, including literature on CA, agriculture and food production. Household questionnaire responses to CA technology adoption were treated and analysed using standard univariate and bivariate statistical techniques (frequency tables and cross-tabulations) using the software SPSS V22. Descriptive statistics were used to characterize households. Binary Logistic analysis was used to predict a binary response based on one or more predictor variables as well as estimating the parameters of a qualitative analytical response model.

2.3 Analytical Model

Using the binary logistic model, the factors that influence farm households' decisions to adopt conservation agriculture were estimated. The use of the binary logistic model for this analysis is consistent with the literature on adoption which describes the process of adoption as taking on a logistic nature. The logistic regression model explores the socio-economic, institutional and spatial factors influencing the adoption of CA. The objective of the research was to understand the relationship between dependent and independent variables in terms of adoption of CA. Since the adoption of CA is a dichotomous or binary dependent variable, with the option of either adoption or non-adoption, the binary logistic regression model was applied as the most applicable tool to examine how each independent variable affects the probability of the occurrence of events (Long and Freese, 2006).

The model attempted to establish a relationship among variables. In order to construct the regression model, both the information to be used to make the prediction and the information that to be predicted was obtained from the sample. The relationship between the two pieces of information was modelled with a linear transformation. The model used in this study was based a decision of a farmer whether to adopt a practice or not using the latent variable approach, where the farmer will adopt the conservation agriculture as a result of various factors influencing the decision. Various factors influencing adoption were incorporated into this model. We estimated the following relationship between conservation agriculture adoption, household and farm characteristics, as well as peer effects and farmer knowledge of crop practices. Peer effects captured information from external agricultural labour such as casual labour and communal labour practices from irrigated land holdings

$$\mathbf{Adoption_i = \gamma + \delta_1\ (Education\ Status) + \delta_2\ (Agricultural\ Labour) + \Pi\ X_i + \mu_i}$$

where Xi is a vector of controls (for example age of the household head, land holding, household annual expenditure on agriculture, productive equipment, draught power, and Household head education status) representing the variable relating to household head receiving some form of schooling at different levels. Agriculture labour captured the number of people available within the household to provide labour for agricultural activities. Productive equipment represented variables on the ownership of mechanized agricultural equipment used in conservation farming. Conservation agriculture adoption was defined as a binary variable.

3. Results and Discussion

Conservation agriculture in Swaziland has been promoted as technologies/ practices that help in mitigating drought, at the same time maintaining or increasing yields. The characteristics and associated variables influencing the conservation agriculture adoption are hypothesized and presented in Table 1. The table also compares these across the two strata of farmers–adopters and non-adopters of CA. Adoption of CA was measured depending on whether or not the use of the minimum principles of CA were practiced, maintained for a minimum of one year after exposure. CA technologies considered in the assessment were use of planting basins, pot holing, ox and tractor drawn rippers and jab planters, all which are promoted by various international development agencies, Food Agricultural Organization (FAO) in collaboration with government, through the Swaziland National Conservation Agriculture Task Force.

While these results presented in Table 1 compare differences between adopters and non-adopters of CA, they are unqualified and, thus, do not fully explain adoption. Table 2 presents the results of the binary logistic analysis for CA adoption. The model estimated the relationship between the adoption status of households and various factors that characterized the differences in households that adopted and that did not adopt. The model reported an overall accuracy rate of 93% from the classification table hence the model is useful. The four outliers that have standardized residuals of -2.58 or less were omitted from the analysis of the model. Since none of the independent variables in this analysis had a standard error larger than 2.0, we indicate there was no evidence of multi-co linearity.

Table 1: Characteristics for CA adopters and non-adopters: summary statistics

		Sub sample	
	Full sample	**Adopters**	**Non Adopters**
Sample	196	183	13
Household characteristics			
Age of household head	56,44	56,85	53,92
Total number of people living in your household	6,66	6,8	5,38
Level of education of household head			
No school	42,00	41,57	53,85
Some primary (grade 1-6)	31,60	33,71	7,69
Some secondary	17,10	16,85	23,08
Agricultural labour			
# of people contributing to agricultural labour- 19-60	0,59	0,92	0,54
# of people contributing to agricultural labour- 19-60	1,36	1,4	0,77
# of people contributing to agricultural labour-over 60	0,25	0,25	0,15
Livestock/ draught power			
Number of cattle	5,94	6,18	3,08
Agricultural assets			
Tractor	7,10	6,6	7,7
Hoe	96,90	96,7	100
Plough	23,00	24,3	74
Land size			
Total land holding size-rain fed	2,05	2,0847	1,7
Total land holding size-irrigated	0,11	0,116	0,0867
Household monthly expenditure			
Household monthly expenditures- (General)	988,03	1005,54	896,23
Household annual expenditures -Education	1456.78	1501,7	834,77
Household annual expenditures -Agriculture	1092.8	1113,5	806,15
Lack of adequate food			
2011/2012	60,50	58,3	84,6
2011/2013	60,20	58,6	68,9
2011/2014	69,80	67,4	76,9
No access to credit	90,7	90,6	92,3
Household monthly income > E 6000 (US 500)	3,78	3,3	16,7
CA adoption decision maker/s			
Wife only	56,6	57,5	40
Husband only	30,7	21,1	60

The average age of the household was 56, however, age of the household head did not influence the adoption decision, though there was a positive relationship with the adoption CA status of the households. Most household heads were male headed (67.9%), married (63.8%) and (32.1%) widowed. The average household size was 7 with 4 of the household members contributing to agriculture labour. Adopters had a higher household size of 6.8 (±2.99) than non-adopters who had a household of 5.38 (±2.93). For adopters the main decision making on whether to adopt CA or not were women 57.5% of the time, whereas men only made decisions 30.7% of the time.

The number of people contributing to agricultural labor was found to positively influence adoption of CA. Households with more members contributing to agricultural labor were more likely to adopt CA by 1.65 times compared to their counterparts as shown by the positive relationship in the model presented in Table 2. Large households normally have the capacity to relax the labor constraints required during CA land preparation. Larger household sizes will positively affect the decision to adopt specific CA technologies.

Table 2: Binary Logistic analysis on factors affecting adoption of CA

Variables in the Equation					
	B	S.E.	Wald	Sig.	Exp(B)
Age of Household Head	.023	.026	.763	.382	1.023
Number of people contributing to agriculture labour	.973	.376	6.706	.010	2.646
Total land holding size-rain fed	-.002	.229	.000	.993	.998
Total land holding size-irrigated	-1.837	1.160	2.509	.113	.159
Household annual expenditures -Agriculture	.000	.000	.230	.632	1.000
Household head education status	1.132	.763	2.202	.138	3.103
Number of draught power available	-.148	.206	.513	.474	.863
Number of productive equipment	-1.279	.990	1.671	.196	.278
Constant	12.173	11.077	1.208	.272	193414

The probability and degree of adoption of CA was directly related to the education of the household head. If the household head has some form of education, they are 3 times more likely to adopt conservation faming than a household head without any form of education as shown by the exponential coefficient of the results. Forty two percent of households had not attended any form of formal education whereas 17% had attended some secondary education. This reflects to Lin's (1991) findings in China hypothesized that farmers with relatively high level of education may have a higher probability of adopting new technologies than those with relatively little education. Similarly Weir and Knight (2000) in a study in Ethiopia found that household-level education influenced whether a farmer is an early or late adopter.

The average land holding size was 2.05 ha, the adopters having more land (2.08 ha ±1.49) than non-adopters (1.7 ha ±1.35). From the study, though adopters had more land, there was no statistical significance between land holding size (irrigated or rainfed) and CA adoption. On the contrary, farm size was postulated to be positively related to the adoption of the technology (Lin, 1991), however Filho (1997) concluded that adoption was negatively related to farm size. According to Hassan *et al.*, (1998), small farmers usually take longer to adopt a new seed type than larger farmers.

Despite 60.5%, 60.2% and 69.8% (Figure 2) of the respondents not having adequate food in the 2010/2011, 2011/2012 and 2012/2013 agricultural seasons, the adoption rates in then 2011/2012, 2012/2013 and 2013/2015 agriculture seasons were 15.25 %, 55.9 % and 35.8% respectively, showing that having inadequate food did not influence the adoption of CA. Access to CA information helped to explain farmers decision to or not to adopt a particular promoted technology. Of the 200 respondents, 97.4% were exposed to CA information through direct training by extension officers, demonstration plots (field days and exchange visits) by lead farmers, media and farmers to farmer information sharing.

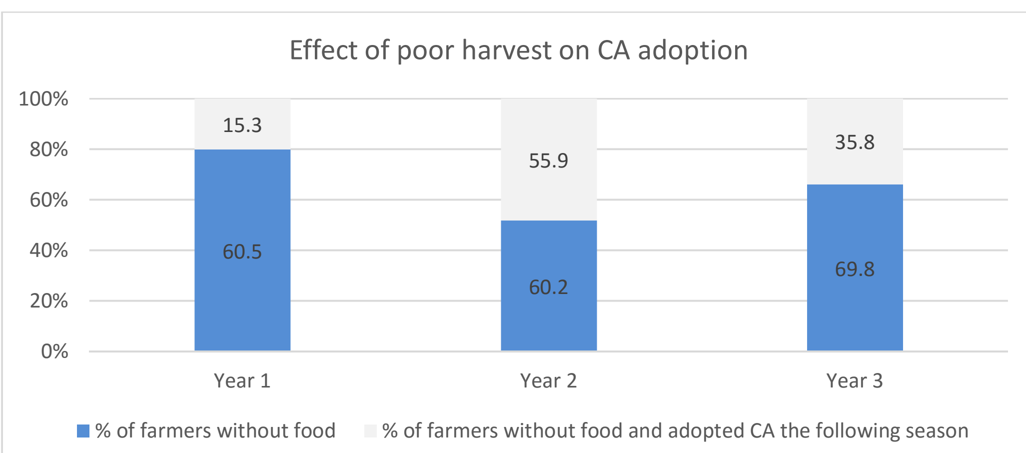

Figure 2: Effect of poor harvest on adoption

Foster and Rosenzweig (1995) found that initially farmers may not adopt a new technology because of imperfect knowledge about management of the new technology; however, adoption eventually occurs due to personal experience and that of one's neighbour. This emphasises the influence of peers with respect to knowledge-sharing and sharing of experiences between farmers. The model further supported this conclusion as the peer factors represented by agricultural labour in the form of casual labour and education status of household head enhancing the ability to share information with other farmers from previous experiences. Over the last 3 years, 93.3 % of the farmers trained on CA information adopted the techniques while 6.7% did not adopt in the same period. There are three main types of innovation-decisions: independent individual decisions, collective decisions, and authority imposed decisions (Toborn, and Harvesting, 2011). In married families, the woman (56.6%) was the main decision maker for CA adoption, man (husband) (37.7%) and (10.6%) joint decision.

The main sources of knowledge and information that influenced adoption were NGO staff training (97.6 %) and farmer-to-farmer information exchanges. All farmers acknowledged to have heard about CA through various media and contact with friends, relatives and extension services. Mass media is effective in creating awareness of an innovation, whereas personal contacts, i.e. through extension, are more effective in forming an opinion about a new idea (Toborn, and Harvesting, 2011). Results are consistent with Nyanga (2012) whose CA adoption model showed that training in CA significantly increased the likelihood of CA adoption and area put under CA. Results are also consistent with Rogers (2003) innovation diffusion theory that hypothesizes that information access is pivotal in the method of innovation adoption.

The majority (74.4 %) of farming households were not members of a farming association and 90.6 % of adopters and 92.3 % non-adopters did not have access to credit for agricultural production. This means that all production inputs were derived from internal household income. Lack of access to cash or credit may constrain farmers from using technologies that require initial investments (Feder *et al*., 1985), such as tractor-drawn rippers, direct seeders, jab planters, use of improved seeds and fertilizer. The lack of access to cash or credit is often seen as an indication of market failures that government or NGOs should help to resolve (Doss and Doss, 2006). CA support for all the adopters was from international development agencies who provided inputs such as seed, fertilizer and access to tools. Importance of input support and access to credit was highlighted by Miller and Tolley (1989) who postulated that input subsidy policy helps increase the amount of land under new technology, reduces the land under old technology and consequently increases the marginal gain from the adoption. They also argued that the rate of adoption was dependent on how profitable the new technology was compared to the old (traditional) technology.

When farmers were asked what are the factors that motivated them to adopt CA, 97.6% of the farmers (Figure 3) indicated that of all the information sources, it was the quality and inspiration provided by the NGO extension worker who motivated them to adopt CA.

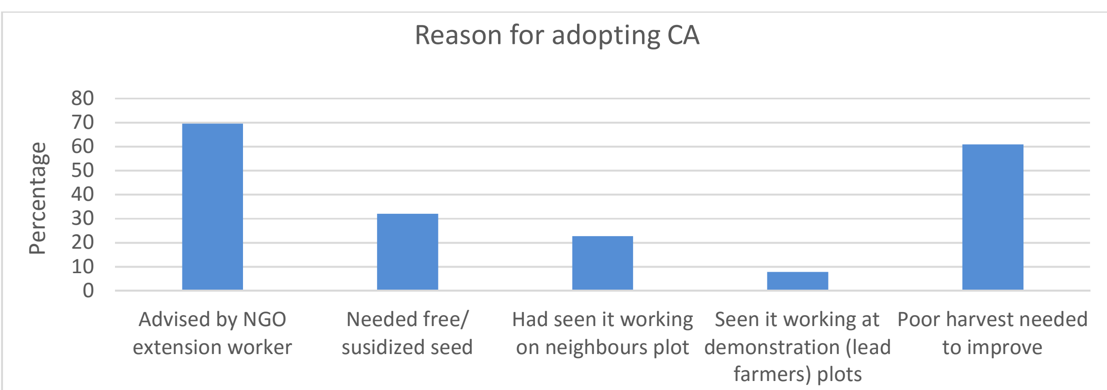

Figure 3: Reasons for adopting CA.

Besides the media sources, the main reasons for adopting CA were; being advised by the extension officer (69.6%) and; 32% needed the free/ subsidized inputs which were being provided by the development agencies. This further emphasises the role of extension services as well sending the correct messages regarding CA advantages, in motivating farmers to adopt CA.

Farmers sampled adopted a variety and combination of CA technologies. The main technologies adopted however were; seed basins (75.1%), pot holing (20.6%), ox drawn rippers (30.9%), tractor drawn ripper (8.8%) and jab planter (1.7%). The reasons attributed to the adoption of specific technologies was the ease of use (86%) and availability (94%) of the technology (implements). Seed basins were used more because they only required household labour and the use of a hoe, which were available to 96.7 % of the farmers, whereas all other technologies required accessing tools from either the development agency, Rural Development Authorities (RDA), which are Ministry of Agriculture service centres stationed in selected communities, thereby making access to all the available tools at the RDA limited. Smallholder farmers are less able to invest in new equipment and are risk averse (Ngwira *et al*., 2014), this therefore only makes them adopt technologies that are easier and available to them.

Time is a critical aspect in the decision-making process, innovativeness and an innovation's rate of adoption (Toborn, and Harvesting, 2011). The majority (79.6 %) of the households adopted CA changes in the same season within which they were exposed to them, with only 12.2% and 8.3 % adopting one and two seasons after respectively. The average time between initial information and final adoption varies considerably by person, place and practice. Though various techniques have been developed for use in different climates and soils around the world, the three main principles generally promoted are: minimum soil disturbance, mulching the soil and covering crops and rotation and association of crops. Though adoption all the principles is encouraged to attain maximum benefit from CA, the study observed differences in the use of the principles by the farmers. The main principles adopted were minimum tillage (96.1%), crop cover (88.3%) and crop rotation (71.8%) association (86.7%). Though, not all farmers are implementing all the principles, it is encouraging to note that the majority of the farmers are implementing the three basic principles mentioned here.

4. Conclusions

In sub-Saharan Africa, where farming is characterized by poor soil fertility low rainfall distribution and low levels of agricultural technology use, understanding factors that influence technology adoption has become an important issue. The objective of this study was to determine the factors affecting adoption of conservation agriculture in Swaziland, a country where there is degradation of the natural resources and persistent variability of climate and weather patterns. Findings of this study are of interest to development stakeholders, including government agencies (research, extension, policy and planning), and Non-Governmental Organizations (NGOs). An awareness of the factors that influence adoption will allow development of strategies, policies and plans that take advantage of the main influences of adoption to increase adoption and sustainable use of CA. Adoption of CA is critical towards mitigating and making communities more resilient to the negative impacts of climate change and land degradation, while at the same time achieving food security through sustainable farming.

Our results suggest that, in the context of our study area, the probability of a farmer adopting CA increased, if the household head has some form of education and had a higher number of people contributing to agriculture labour. There was is a positive relationship between the age of the household, mean household annual expenditure and CA adoption. Availability of draught power and agriculture tools, such as tractors and ploughs did not however influence adoption. The availability of the hoe, however, influences the type of the technology adopted. The results indicate therefore, farmer characteristics such as age, gender, levels of education and wealth influence adoption decisions. Institutional factors, such as access to extension, as well as source of farmers' exposure had significant influence on CA adoption. The uptake of new technologies was influenced by the farmer's contact with extension services because extension officers provided inputs and technical advice. The finding that decision making was significant influenced by extension and famer contact is consistent with the literature. The results indicate the need to expand and strengthen the role of extension services, government and development agencies. Women were the main decision makers on adoption of CA, to increase adoption therefore, it is imperative that women should be encouraged to take lead and participate in all stages of technology development, implementation and evaluation.

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6. Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

7. Authors' contributions

D.H M (International Relief and Development and the University of the Free State) was responsible for the genesis of the idea and the tabulation, analysis and write up of the article. S. M. (International Relief and Development) was responsible for conducting the fieldwork, data entry and analysis and B. M (Southern Africa Development Community-Regional Vulnerability Assessment and Analysis) was responsible for empirical design and statistical modelling and analysis

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