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Farmers' perceptions about conservation agriculture: A case study of the livelihoods for improved nutrition project in Southeast Zimbabwe

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ABSTRACT

Conservation agriculture (CA) has been widely promoted in sub-Saharan Africa (SSA) in the past decades to address declining soil and crop productivity, and as an adaptation strategy to climate change. Low CA adoption has raised questions on farmers' perceptions about CA. Determining farmers' perceptions is essential in assessing realistic chances of CA adoption and in addressing any misunderstandings farmers might have pertaining to CA. A study was carried out at the beginning and end of the Livelihoods for Improved Nutrition (LIFIN) project in Chipinge district to capture farmers' perceptions about CA. Data was collected using focus group discussions, key informant interviews, direct observations and a questionnaire survey to 300 households. Most respondents (91%) disagreed that labour concerns affected their CA adoption decisions. The majority of farmers (94%) perceived that CA resulted in higher yields than the conventional hand-hoeing practice. There was no association between the decision to practice CA which we used as the proxy for CA adoption, and factors such as agro-ecological region, household labour availability, gender of the household head, education level of the household head and draught power ownership. There was a significant improvement ($p<0.05$) in how farmers perceived CA at the beginning and at the end of the LIFIN project. Input incentives and farmers' perception about CA explained adoption decisions, as famers practicing CA had a more positive view of it than those not practicing it. However, we postulated that farmers are still experimenting with CA and actual adoption can only be recorded after the active promotion of the LIFIN project, when farmers are longer receiving input incentives. We concluded that the prospects of CA adoption by LIFIN project beneficiaries are high since farmers have a positive perception towards CA.

Key words: conservation agriculture; farmers' perceptions; food security; agro-ecological regions; adoption; livelihoods

1. INTRODUCTION

Food insecurity has become more intensely pronounced in recent years with the threat posed by climate change and variability, which has caused frequent droughts, as well as ecosystems degradation and biodiversity loss exacerbating these problems (Gukurume et al. 2010; Thierfelder et al. 2015). Smallholder farmers in semi-arid regions, who also lack inputs such as fertilizers and improved seed varieties, are the most affected. In response to this crisis, Zimbabwean farmers are given food aid or free agricultural inputs to enable them to establish their cropping enterprises (Twomlow et al. 2008). However, most farmers have not been able to translate these relief investments into sustained gains in crop productivity and incomes due to inappropriate land and crop management practices (Rockström et al. 2009). This has led to a call for relief assistance to target sustainable crop production techniques that also aim at improving soil fertility and water management. One technology option for improving soil fertility and water management that has been promoted is conservation agriculture (CA).

In Zimbabwe, CA has been promoted through numerous relief and recovery interventions with the aim of improving food security of vulnerable smallholder farmers, since 2004 (Twomlow et al. 2008). Conservation agriculture is a sustainable way of crop production based on the simultaneous application of three principles; namely, zero or minimum soil disturbance, permanent organic soil cover and crop rotations (Govaerts et al. 2009; Kassam et al. 2009). There is substantial variation in how the three CA principles are practiced by smallholder farmers (Corbeels et al. 2014), and the principles of crop rotation and residue retention are rarely implemented under smallholder farmer conditions (Pittelkow et al. 2014). Therefore, CA needs to be tailored to local biophysical and socio-economic conditions of the farmers (Knowler and Bradshaw, 2007; Giller et al. 2009; Erenstein et al. 2012; Corbeels et al. 2014). The most familiar type of CA being promoted in Zimbabwe is based on the establishment of planting basins using hand hoes (Mazvimavi and Twomlow, 2009; Nyamangara et al. 2014).

Despite its widespread promotion, the adoption of CA in SSA has been limited (Giller et al. 2009; Kassam et al. 2009), although an increasing trend in adoption has been reported in Malawi, Zambia and Zimbabwe (Wall et al. 2013). There is limited information about farmers' perceptions on CA in SSA as there are many experiences of high CA adoption during the active promotion of CA projects followed by dis-adoption (Baudron et al. 2007; Giller et al. 2009; Mazvimavi and Nyamangara, 2012; Arslan et al. 2014). Moreover, conflicting perceptions about CA have been recorded from other studies in Zimbabwe, where CA has been referred to as dig and eat (Diga udye) and dig and die (Diga ufe), (Gukurume et al. 2010), emphasizing high labour requirements for CA. Thus, farmers may be viewed by development practitioners as reluctant to invest in agricultural innovations that have the potential to improve their livelihoods when farmers themselves are more interested in their livelihood security than any other stakeholder. It is the farmers' perceptions about the appropriateness, relevance and profitability of the new technologies that drives their adoption decision (Adesina and Zinnah, 1993; Adesina and Baidu-Forson, 1995; Pannell et al. 2006; Thierfelder et al. 2015). Perceptions are subjective in nature (Dalton et al. 2014) and they refer to a range of attitudes, beliefs and judgements (Slegers, 2008). Misperceptions indicate where knowledge may be improved through the provision of objective information (Dalton et al. 2014). Thus, identifying misperceptions is important for informing where education, research and extension programming might intervene to reduce knowledge gaps that hinder CA adoption (Joshi and Pandey, 2005; Dalton et al. 2014). Therefore, understanding farmers' perceptions is needed to address any misconceptions about CA, tailor future CA promotions to local conditions and consequently enhance its adoption (Kirkegaard et al. 2014).

Factors influencing farmers' perceptions can be grouped into three broad sets namely; (1) information about the technology, (2) characteristics of the new technology and (3) characteristics and circumstances of the farmers within the target area (Pannell et al. 2006; Siziba, 2007). Information facilitates awareness of soil degradation problems (Pannell et al. 2006) and possible technological options like CA. Information affects perception since every technology requires some level of knowledge for its use, as such; low education levels and technology complexity may increase its learning costs (Siziba, 2007). Thus, availability of information on CA greatly lowers its learning costs. Farmer characteristics and circumstances shape farmers' goals and influence their capacity to adopt CA technologies and they include variables such as age, gender, experience, farm size, household size, income levels and educational levels. Characteristics of the technology compare the new technology to the existing technology in terms of its relative advantage, feasibility, divisibility into various components, complexity and the economic benefits (Pannell et al. 2006; Siziba, 2007). Thus, farmers' perceptions are context and location specific due to heterogeneity in factors that influence them such as culture, education levels, gender, age, resource endowments and institutional factors (Ervin and Ervin, 1982; Posthumus et al. 2010). Even though there is no conclusive evidence in literature, agro-ecological constraints on soils and climate are likely to affect CA adoption (Arslan et al. 2014).

Development projects in SSA have often been unsuccessful because they introduced practices that community members did not perceive to be immediately relevant (Quinn et al. 2003; Gukurume et al. 2010). This limits technology adoption as farmers are important sources of information to neighboring farmers and they initiate local technology diffusion and adoption (Dalton et al. 2014). In Zimbabwe, the decision to start CA has not been, in most cases, voluntary as farmers who first participated in CA promotion were selected by non-governmental organizations (NGOs) as vulnerable households facing production constraints (Mazvimavi and Twomlow, 2009). Under these programs, farmers who participated were given seeds, fertilizers and technical advice (Twomlow et al. 2008), which worked as incentives. Adoption of technologies like CA is however based on subjective perceptions and not objective truth (Pannell et al. 2006). Adoption studies should therefore include farmers' subjective perceptions, since they are at the core of farmers' decision making process (FAO, 2001; Pannell et al. 2006; Thierfelder et al. 2015).

In 2010, *Action Contre la Faim* (ACF), a French NGO introduced a 3 year Livelihoods for Improved Nutrition (LIFIN) project in Chipinge District to 2 000 households. The LIFIN project promoted CA based on hand-hoe made planting basins as one of its interventions. This study sought to explore and understand farmers' perceptions about CA in the LIFIN project. This is critical because perceptions influence adoption of technologies like CA. Thus, understanding farmers' perceptions would enable adaptation of CA and tailoring of future CA promotions to local conditions for possible enhancement of CA adoption. Moreover, identification of misperceptions farmers might have pertaining to CA influences policy formulation by determining the direction of extension and training programs.

2. RESEARCH METHODOLOGY

2.1 Study site

This study was conducted in wards I, 4 and 22 of Chipinge district (20º S, 32º E) in southeast Zimbabwe (Figure 1). The LIFIN project was implemented in agro-ecological region V in ward 1 and 22, and in agro-ecological regions III, IV and V in ward 4. These regions are all characterized by low, erratic and uni-modal annual rainfall starting in November and ending in March with high probability of a mid-season dry spell, mid-season drought or a full season drought (Vincent et al. 1960). The annual average rainfall is 650 – 800 mm, 450 – 650 mm and less 450 mm for agro-ecological regions III, IV and V respectively. The district is dominated by granite derived sandy soils (Nyamapfene, 1991), classified as Arenosols (IUSS Working Group WRB, 2007). Crops grown include sorghum (*Sorghum bicolor*), maize (*Zea mays*), pearl millet (*Pennisetum glaucum*), groundnuts (*Arachis hypogaea)*, cowpeas (*Vigna unguiculata L*.) and cotton (*Gossypium hirsutum)*.

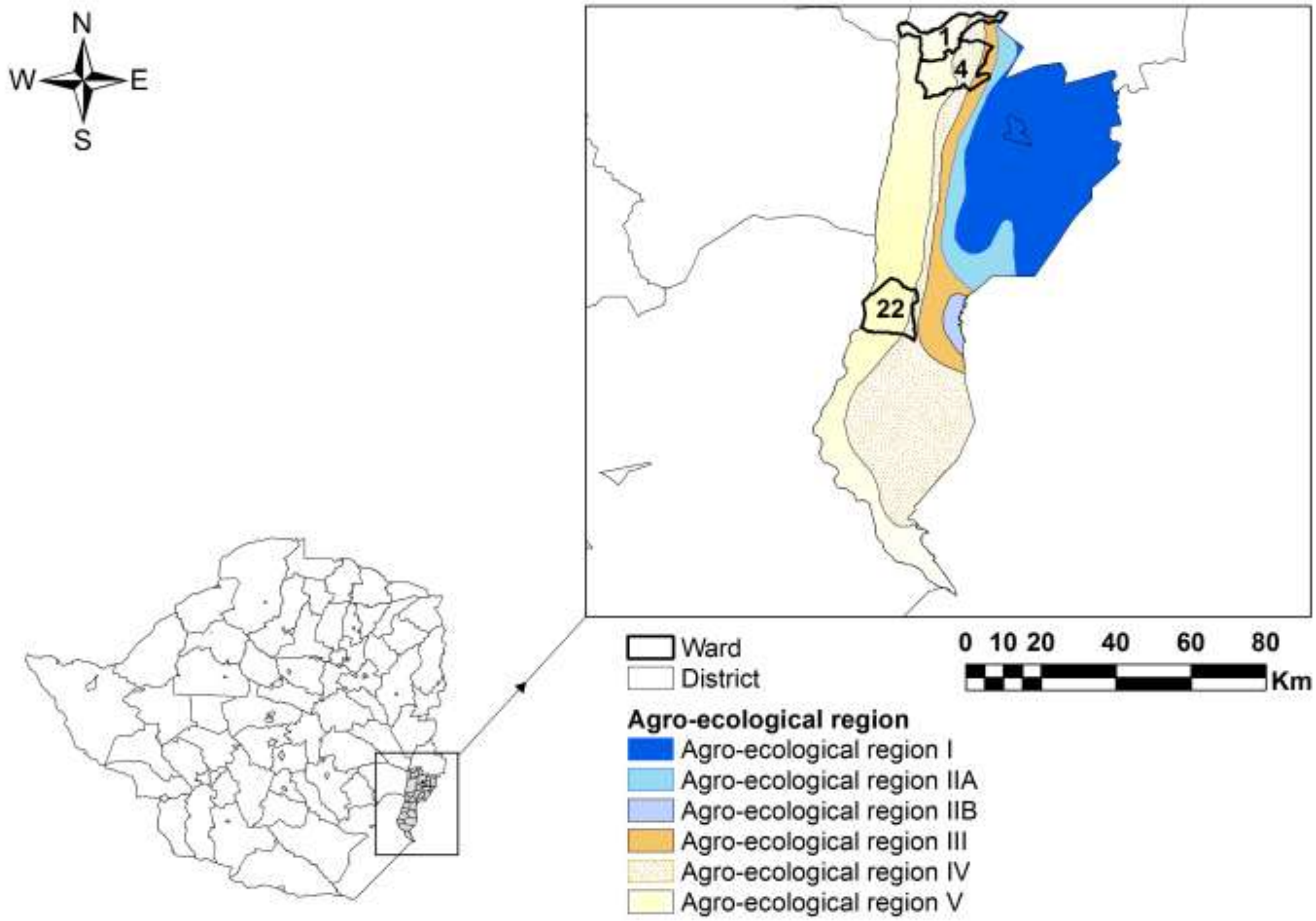

Fig.1. Location of the Livelihoods for Improved Nutrition project in Chipinge District, Zimbabwe

2.2 Data collection

Data was collected at the beginning (October 2010) and at the end (October 2012) of the LIFIN project through the use of questionnaires, focus group discussions (FDGs), key informant interviews, informal interviews and observations. The credibility and validity of the results was increased through triangulation which allowed capturing of different dimensions of the same phenomenon and data cross-validation.

A questionnaire survey was administered to 300 farmers to obtain information on farmer perceptions on different aspects related to CA. Of the 300 respondents, 90 were non beneficiaries of the LIFIN project, for comparison of perception differences between beneficiaries and non-beneficiaries. Stratified random sampling was used for an even distribution of respondents across the three agro-ecological regions (Table 1). A sample size of at least 30 respondents is valid for statistical analyses in social science research (Baker and Edwards, 2012). Questions on farm size, location, demography, crop production systems; gender responsibilities in CA were also included since they have been found to influence perceptions (Posthumus et al. 2010). The key decision maker of agricultural activities was interviewed for each household. Farmers' perceptions were captured on a five point Likert scale (Nhongonhema, 2009; Rejesus et al. 2013) of strongly agree through to strongly disagree. The questionnaire used both qualitative and quantitative research approaches (Bryman, 2008) for household data collection.

Community perspectives about CA, use of CA principles and how farmers cope with local limitations to CA were also captured through focus group discussions (FDGs). A total of ten FGDs were held, comprising about 15 to 20 mixed farmers (mixed in terms of gender, age, resource endowments and level of education), (Nyanga et al. 2011). Key informant interviews were done with ward councilors, village heads, agricultural technical and extension services (AGRITEX) officers, ACF officers and lead farmers. Continuous observations and informal interviews during the life span of the study were used to verify information gathered from interviews and discussions.

2.3 Ethical considerations

The research was under the LIFIN project which was cleared by the government of Zimbabwe. We sought permission of chiefs, ward councilors, village heads and individual farmers to collect data.

Selection of respondents was random and no one was excluded or included because of their socio-economic status. The purposes and procedures of the study were fully explained, after which informed consent was sought. Respondents were also made aware of their right to accept or decline participation and to ask for clarifications. Allowing people to withdraw is followed in research and in this study the privilege was not restricted.

2.3 Data analyses

The responses from the questionnaires were post coded and analyzed using the Statistical Package for Social Sciences (SPSS version 16). Descriptive statistics such as means, frequencies and cross-tabulation analyses were done. Likert scale data was combined into two nominal categories of Agree and disagree to enable us to run Chi-square test (Willis et al. 2013). Dichotomizing variables meant that the neither agree/disagree response was excluded from the analysis, as it would have been inappropriate to merge this response with either Agree or Disagree outcome levels (Willis et al. 2013). Perception statements were subjected to Pearson's Chi square test for independence ($p < 0.05$) to determine existence of association between them and whether a farmer was practicing CA or not. When there was a significant association, Fisher's exact test was used to determine the significance of the association at 5% level. Practicing CA was used as a proxy indicator for the adoption of CA. Chi square independence test was also used to test the association between choices on practicing CA and factors like level of education of the household head, age of household head, gender of the household head, draught power ownership and labour availability. Content analysis was used in the analysis of qualitative data (Bryman, 2008).

3. RESULTS

3.1 Household and farming system characterization

The average household size was 6 members, with most (80.1%) households having between 4 and 9 members. About 12.4% of the households had between 1 and 3 members and 7.1% had more than 9 members. Most households (85%) had family members working out of the country, mostly in South Africa. There was no association between labour availability (number of household members involved in agricultural activities) and decision to adopt CA (Table 2).

Most of the 300 respondents (97%) reported that they have family labour constraints. Farm labour was mainly provided by family members across all the three wards and the emigration of the working population out of the communal areas has worsened the labour constraints. The labour challenges were mainly overcame by reducing the area of land cultivated (66%) and by spending more time on particular farm activities such as land preparation, planting and weeding (24%). Labour activities were not designated according to gender.

Most households (85%) are male headed and there was no association ($p < 0.05$) between the gender of the household head and the decision to or not to adopt CA (Table 3).

Only 10% of the household heads did not receive formal education. There was no significant relationship ($p < 0.05$) between the level of education of the household head and the decision to adopt CA (Table 4).

Households owned land averaging between 1.9 hectares (ha) and 2.6 ha across the three wards. Households grew a variety of crops, including sorghum, maize, millet, groundnuts, cowpeas and cotton. Cropping patterns vary by ward, with wards 1 and 4 having a similar pattern and ward 22 having a different pattern from the other two wards. In ward 1 and 4, sorghum accounted for more than 50% of the cropped area. Maize and millet were the other cereals and they accounted for 25% of cropped area in the two wards. In ward 22, cereals accounted for more than 70% of the cropped area, with sorghum accounting for 37% of the area, followed by maize which accounted for 35% and millet was not grown. Cotton production accounted for 18% of the cropped area. Cotton was not grown in wards 1 and 4.

Farmers used a combination of tillage methods. The most common tillage method was shallow hand-hoeing where farmers use hand hoes to clear the field (more like surface scrapping or weeding) and cover seeds dropped in the field. This was practiced by 100% of the interviewed households. Other tillage practices include mouldboard ploughing, hand hoe holing-out (which entails digging shallow planting stations in unploughed land) and the promoted CA based on 15 cm long x 15 cm wide x 15 cm deep hand-hoe made planting basins.

Inorganic fertilizers and manure (cattle, goat, poultry) use was low across all the three wards. Only 4% of the responding households were using manure and fertilizers prior to the LIFIN project despite being given inorganic fertilizers by various NGOs and the government in some instances. Use of fertility amendments in Chipinge district is not common, even when the fertility amendments are readily available. Farmers believed that manure and fertilizers could burn their crops in these semi-arid regions. All LIFIN beneficiaries admitted to be using fertility amendments in their CA plots but only 46% had extended this to their farmer practice plots by the third season of the LIFIN project. Only 6% of the LIFIN non-beneficiaries were using fertility amendments in their fields.

The most common asset owned by households across all the three wards was a hoe, with all respondents showing they had enough hoes. Agricultural asset holding differed across all the three wards (Table 5). There was no association between owning an ox drawn plough and choices on CA adoption (Table 6).

The ownership pattern of livestock varied across the three wards (Tables 7). All farmers had a source of organic fertility amendments. There was no association ($p < 0.05$) between owning draught power and practicing CA (Table 8).

Table 1. Number of respondents practicing CA or not in each agro-ecological region

CA status	Agro-ecological region III	Agro-ecological region IV	Agro-ecological region V	Total
Practicing CA	70	70	70	210
Not practicing CA	30	30	30	90
Total	100	100	100	300

Table 2. Labour availability against decision to or not to adopt CA

CA status	Number of household members providing labour	
	1 to 5	6 to 10
Practicing CA	112	98
Not practicing CA	35	55
Pearson’s Chi square = 1.54 P value = 0.214		

Table 3. Gender of the household head against practicing CA or not

Sex	Practicing CA	Not practicing CA	Total
Male	177	78	255
Female	33	12	45
Total	210	90	300
Pearson Chi-square = 0.28 Probability = 0.597			

Table 4. Level of education of the head household head against CA adoption decision

CA status	No education*	Primary education	Secondary education	Tertiary education
Practicing CA	22	72	80	36
Not practicing CA	8	34	42	6
Chi-Square = 6.45				
P value = 0.09				

*No education = 0 years of formal education, that is nothing beyond preschool/nursery school; Primary education = primary school education (Grade 1-7 in Zimbabwe); Secondary education = secondary/high school (Form 1-6 in Zimbabwe); Tertiary education = any course after secondary/high school education e.g. certificate, diploma, degree or vocational training.

Table 5. Proportion (%) of household owning asset in ward 1, 4 and 22 in Chipinge District

Ward	**plough**	**hoe**	**Wheel barrow**	**rake**	**shovel**	**Pick/ mattock**	**Scotch carts**	**Knapsack sprayer**	**axe**
1	74	100	42	22	64	55	26	30	79
4	60	100	9	9	51	45	15	13	78
22	58	100	6	6	41	36	44	16	76

Table 6. Relationship between owning a plough and choices on CA

CA status	Own an ox drawn plough		Total
	Yes	No	
Practicing CA	110	100	210
Not practicing CA	42	48	90
Total	152	148	300
Chi-Square = 0.82			
P value = 0.36			

Table 7. Proportion (%) of household owning livestock in ward 1, 4 and 22 in Chipinge District

Ward	Cattle	sheep	Goats	donkey	chicken	Guinea fowl	turkey	pig
1	33.3	2.8	83.3	0	79.6	8.3	0	2.8
4	65.2	0	90.3	4.3	90.3	4.3	0	0
22	65.7	9.8	64.7	22.5	90.2	11.8	3	2.9

Table 8. Relationship between draught power ownership and CA adoption decisions

CA status	Frequency of number of cattle owned			Frequency of number of donkeys owned		
	0	1-5	> 6	0	1-5	> 6
Practicing CA	130	45	35	195	10	5
Not practicing CA	45	27	18	78	9	3
Chi-Square = 3.86 P value = 0.572				Chi-Square = 3.21 P value = 0.201		

3.2 Knowledge about Conservation agriculture

Farmers' knowledge of CA improved during the course of the LIFIN project as farmers implemented the CA technology. Information about CA was made available to farmers through CA training like the use of paired plots demonstration, field visits and field days. Each ward had one AGRITEX officer and one ACF officer offering CA training and extension. Each demonstration plot consisted of 2 plots each measuring 2 500 m^2 for CA and the conventional farmer practice of hand-hoeing. In each plot 2 000 m^2 was allocated to cereals and 500 m^2 to legumes. For this study the paired plot demonstration layout was mimicked in farmers' fields. All respondents in wards 1, 4 and 22 in Chipinge District showed adequate knowledge about CA, its benefits and constraints.

All farmers in semi-arid areas of Chipinge district viewed moisture stress and soil infertility as the main factors limiting crop production. Farmers perceived that CA can raise crop yields by solving these constraints through soil moisture conservation and precision in the application of fertility amendments. Conservation agriculture was described as consisting of three principles, namely; minimum soil disturbance, crop rotation and mulching. However, only the principle of minimum soil disturbance was being practiced by all farmers interviewed. Minimum soil disturbance was achieved through the use of planting basins. Farmers reported constraints in implementing crop rotations and mulching and this is discussed in the following section under characteristics of CA. Farmers perceived that the learning costs of CA are low since information is readily available from AGRITEX officers and ACF field officers.

3.3 Area of land under Conservation agriculture

Farmers were asked on their intention to increase the area under CA from the initial 2 500 m^2 and their responses varied across the agro-ecological gradient. The majority of farmers (80%) in agro-ecological region III, 67% in IV and 35% in V, reported that they planned to increase the area under CA in subsequent seasons. However, by the third season only 8%, 5% and 2% in agro-ecological region III, IV and V respectively, had increased the area under CA by at least 1000 m^2. The majority of farmers (72%) had increased the CA area by less than 50 m^2. Inadequate inputs were cited as the major reason for not extending the CA plots by a greater margin.

3.4 Farmers' perception and use of conservation agriculture principles

Minimum soil disturbance through the use of planting basins was used by all LIFIN project beneficiaries. Farmers were knowledgeable on when and how planting basins are dug. All farmers perceived soil erosion as a problem and agreed that minimum soil disturbance, through planting basins, reduces erosion. Farmers also indicated that basins have a water harvesting effect. Labour requirements for digging basins were perceived to decrease from season to season, if permanent planting basins are maintained. Farmers deliberately delay starting digging basins to the months of September even up to November, as opposed to the recommended July to September period. Farmers reported that digging basins early would result in them re-doing the work as basins can be destroyed by free roaming animals and dust storms which are common in Chipinge district. A total of 10 farmers spontaneously used planting basins through learning from neighbors and were subsequently included into the LIFIN project by the NGO.

Crop rotation was never practiced during the course of the LIFIN project in all the three wards, though it was perceived as an important crop management practice. Most farmers (98%) claimed that they had just started CA and had not yet attained the stage of rotating crops. Farmers argued that legumes cannot be planted on larger land portions as cereals are preferred for food security reasons. Planting basins and their spacing's were also deemed unfit for legumes.

Only 4 % of the farmers reported to be using mulch in their CA fields during some parts of the summer season. Most farmers (91%) understood that mulching conserves moisture by limiting evaporation. Unavailability of mulching material was the major reason for not mulching in field crops and this was cited by 99% of the respondents. Mulching was also perceived to bring in termites by some farmers (30%), which can destroy succeeding crops. This limited use of mulching materials was similar across all the three wards and the three agro-ecological regions.

3.5 Perceived advantages of Conservation agriculture

Interviewed farmers perceived that CA offers economic benefits and this increases the prospects of its adoption. Farmers reported that CA short-term yield benefits were at least 100% when compared to the conventional farmer practice of hand-hoeing. Moreover, farmers perceived that this yield increase is realized in the first season of CA adoption.

Farmers perceived CA as better than the traditional hand-hoeing practice in addressing low crop productivity in dry agro-ecological regions. Conservation agriculture was perceived as a water harvesting technology which reduces moisture stress and leads to increased crop yields. Application of CA in the three agro-ecological regions was perceived to be feasible. Conservation agriculture was perceived to be divisible by all farmers across all the agro-ecological regions. Farmers perceived that CA can be divided into three principles which can be applied separately in their fields.
Farmers in Chipinge district perceives CA as a simple technology to implement with low learning costs. Farmers' perceived that it was easy to understand and implement CA as recommended by the LIFIN project extension officers.

3.6 Analysis of perceptions on the role of CA in addressing livelihood sustainability, food security and vulnerability

Respondents agreed that CA is more yielding than conventional agriculture and that CA is appropriate for semi-arid Chipinge District (Table 9). Farmers indicated that the major causes of crop failure were soil degradation and moisture stress which could be corrected by using CA. Farmers had positive perception on statements favoring CA adoption. The perception of famers on CA improved significantly ($p < 0.05$) during the course of the LIFIN project (Table 9) and there was no association between farmer perceptions and agro-ecological region. When farmers' perceptions were disaggregated by gender, there was no association ($p < 0.05$) between gender and farmer perceptions about CA (Table 10). Significant differences ($p < 0.05$) in farmers' perceptions were found when farmers' perceptions were disaggregated by whether a farmer was practicing CA or not. Farmers practicing CA completely agreed to perception statements whilst non practicing farmers had mixed feelings about CA, with almost the same number of farmers agreeing and disagreeing to most perception statements (Table 11). However, the majority (60%) of the LIFIN project non-beneficiaries believed that CA was not suitable to their area agriculture due to the prevalence of dust storms, inadequacy of mulching materials and limitations to crop rotations.

Table 9. Farmers' perceptions about CA at the beginning and at the end of the LIFIN project

Perception statement	Beginning of LIFIN project		End of LIFIN project		Fisher's exact test
	Agree (%)	Disagree (%)	Agree (%)	Disagree (%)	
Relevant information on CA is easily obtainable	75	25	91	9	0.003*
As a farmer I am satisfied with the benefits of CA	79	21	94	6	0.002*
Labour concerns have affected my decision to adopt/not to adopt	22	78	9	91	0.018*
Soil degradation & moisture stress are the major causes of crop failure here	82	18	87	13	0.435
CA is applicable to all crops	60	40	84	16	<0.001*
I am well informed about conservation farming	67	33	93	7	<0.001*
CA can eliminate conventional farming problems e.g. soil degradation, draught power, pests and weeds	65	35	86	14	<0.001*
CA is more yielding than conventional farming	78	22	94	6	0.001*
CA is appropriate to your area agriculture	66	34	83	17	0.009*
CA is beneficial to women headed households who may not have labour and draught power	34	66	31	69	0.763
CA is appropriate to Zimbabwean agriculture	58	42	62	38	0.665
Conventional Agriculture production has decreased over the last years	55	45	57	43	0.779
Weed pressure is high under CA	44	56	32	68	0.109

*Significant at $p < 0.05$

Table 10. Gendered farmer perceptions about CA in addressing livelihood security

Perception statement	Gender	Agree (%)	Disagree (%)	Fisher's exact test (p<0.05)
CA is appropriate for your area agriculture	Male	84.5	15.5	0.475
	Female	82	18	
CA is beneficial to women headed households who may not have labour and draught power	Male	32.5	67.5	0.470
	Female	30.6	69.4	
CA is appropriate to households with chronic illnesses	Male	7.1	92.9	0.288
	Female	6.9	93.1	
As a farmer you are satisfied with the benefits of CA	Male	95.4	4.6	0.487
	Female	93	7	
CA is more yielding than conventional farming	Male	76	24	0.398
	Female	80	20	
Moisture stress and soil degradation are the major cause of crop failure in your area	Male	88	12	0.550
	Female	85.6	14.4	
Labour concerns have affected my decision to adopt/not to adopt	Male	24.6	75.4	0.445
	Female	23.2	76.8	
Labour concerns have affected my decision to increase/not to increase area under CA from the recommended 0.25 ha	Male	61	39	0.442
	Female	59	41	
Farmers in general have sufficient knowledge on CA	Male	45	55	0.235
	Female	53	47	

Table 11. Test of independence: Farmer practicing CA or not versus farmers' perceptions on CA

Perception statement		Practicing CA (%)	Not practicing CA (%)	Fisher's exact test
Conventional agriculture production has decreased over the years	Agree	80.0	50.5	0.031*
	Disagree	20.0	49.5	
CA is appropriate to Zimbabwean agriculture:	Agree	65.8	49.6	0.022*
	Disagree	44.2	50.4	
Labour concerns have affected my decision to adopt/not to adopt	Agree	15	19	0.451
	Disagree	85	81	
CA is appropriate to your area agriculture:	Agree	86.8	44.5	0.001*
	Disagree	13.2	65.5	
CA is beneficial to women headed households who may not have draught power	Agree	38.3	29.8	0.065
	Disagree	61.7	70.2	
Some of the problems encountered in conventional agriculture can be eliminated by CA	Agree	82	47.6	0.001*
	Disagree	18	52.4	
I am well informed about CA	Agree	84.8	50.0	0.010*
	Disagree	15.2	50.0	
Relevant information about CA is easily obtainable	Agree	90.2	59.8	0.001*
	Disagree	9.8	40.2	
CA is applicable to all crops	Agree	68.5	51.3	0.008*
	Disagree	31.5	49.7	
Soil degradation and soil moisture stress are the major causes of crop failure in our area	Agree	86.3	78.4	0.085
	Disagree	13.7	21.6	

*Significant at $p < 0.05$

4. DISCUSSION

Hand-hoeing was the most common conventional tillage method across all the three agro-ecological regions and this was attributed to the consistent shortage of pasture in these dry agro-ecological regions resulting in weak draught animals or even death of livestock at the beginning of the rain season. This forced even those farmers who own draught animals to use hand hoes on most parts of their land. If farmers are to use mouldboard ploughing, they have to wait for their animals to gain weight and this could result in late planting which has a marked yield effect in these drier environments. This makes basin-based CA a better option for early planting in semi-arid areas especially for households with limited draught power. This might explain why there is no association between owning a plough and draught power and the decision to adopt CA. Contrary to these results, Muchinapaya (2012) reported that in Guruve district adoption decision was influenced by number of cattle owned, indicating that factors influencing adoption are site specific.

Conservation agriculture was perceived as a simple technology to implement possibly because only the principle of minimum soil disturbance was being implemented. The manual CA being practiced does not require sophisticated knowledge and this could be the reason for no association between educational level and the decision to adopt CA. This disagrees with other authors who reported CA as complex and knowledge intensive technology (Ekboir, 2003; Siziba, 2007; Wall, 2007; Giller et al. 2009). Highly mechanized and complete CA packages, including the use of herbicides, might be considered complex and knowledge intensive, hence the differences in opinions. The absence of association between education and adoption is however supported by results from other studies under various environments (e.g. Posthumus et al. 2010; Muchinapaya 2012; Arslan et al. 2014).

The perceived feasibility of CA in agro-ecological regions III, IV and V of Chipinge district was linked to many factors. Only hand hoes, which they already use in their traditional farming practices, are required to start basin CA. Feasibility of CA was also improved by the provision of seeds, fertilizers and marked ropes for basin spacing by the LIFIN project. All farmers had at least a source of manure and could use manure as recommended under CA. Moreover, technical guidance on CA was readily available from both AGRITEX and ACF officers. The divisibility of CA into its three principles allowed farmers to test the most relevant components first (minimum soil disturbance using basins) and may decide on other components with time. The use of CA subcomponents allowed farmers to test the technology and have created a positive perception about CA. This is supported by results from other studies in Zimbabwe where farmers have been found to disassemble CA into different components and adopt what they perceive as the most relevant components first, followed by additional components with time (Mazvimavi and Twomlow, 2009; Chiputwa et al. 2011; Mavunganidze et al. 2013). The disaggregation of CA into subcomponents allows farmers to experiment with CA and this is critical as reduced trialability often considerably slow the diffusion of technologies like CA among targeted farmers (Pannell et al. 2006; Siziba, 2007). Farmers tend to adopt CA partially or incrementally as observed from other studies in Zambia (Haggblade and Tembo, 2003; Umar et al. 2011; Arslan et al. 2014) and Zimbabwe (Mazvimavi and Twomlow, 2009), and in many cases farmers are likely to adopt only the principle of minimum soil disturbance in the short term. More research and site specific adaptations have to be developed for these dry agro-ecological regions before significant uptake of crop rotation and the maintenance of permanent soil cover can be recorded.

Farmers reported limitations on the use of crop rotation and maintenance of a permanent soil cover, which are the other principles of CA. This agrees with the assertion by Pittelkow et al. (2014) that the implementation of these two principles is challenging under resource-poor smallholder farming conditions. Challenges in implementing permanent soil cover were linked to persistent low yields resulting in limited residues and communal grazing systems which destroys the available residues during the dry season (Aagaard, 2009; Mazvimavi and Twomlow, 2009). Constraints in implementing crop rotations were linked to legume seed shortages and farmers' preference of cereals for food security reasons. Crop spacing difference between cereals and legumes and farmers' preference to grow legumes in furrows rather than basins exacerbated these constraints. Similar limitations have been reported from other crop rotation studies in sub-Saharan Africa (Baudron et al. 2007; Mazvimavi and Twomlow, 2009; Grabowski, 2011). These challenges in the implementation of the other two principles of CA have important implications in the promotion of CA in arid and semi-arid agro-ecological regions. Promotion of CA in resource-poor and vulnerable smallholder farming systems should therefore target only the principle of minimum soil disturbance while research efforts try to adapt the other principles to smallholder conditions. This is critical as this partial adoption (of one principle) of CA can sometimes be superior to full adoption (Pannell et al. 2014), for instance the addition of mulching materials can reduce crop yields (e.g. Mashingaidze et al. 2012; Nyamangara et al. 2014). Thus, research needs to determine the sustainability of CA partial adoption for smallholder rainfed agriculture.

Willingness to increase the area under CA in successive seasons was reported for most farmers in all the agro-ecological regions probably because CA yield benefits were very clear across the three agro-ecological regions even in first season of practice. The percentage of farmers intending to increase the area under CA decreased from agro-ecological region III to V because of the high risk in investment as rainfall amount decreases. These results are in agreement with Mazvimavi and Twomlow (2009) where adoption of CA was higher in high rainfall than in low-rainfall regions. The adoption patterns by agro-ecological regions seem to contrast results from a study in Zambia where Haggblade and Tembo (2003) concluded that the highest adoption rates of CA using hand-hoe basins occurred in low and scattered rainfall regions, showing the location specificity of CA. However, farmers in the LIFIN project are still experimenting with CA and adoption patterns can as well change with time. Despite strong conviction of CA benefits among farmers, average land area under CA remains low. This contradiction of perception and actual practice, where farmers are convinced of CA benefits but rarely extends their CA plots have been recorded in literature (Grabowski and Kerr, 2014) and they have been linked to bias due to CA projects' promotional context that provide input incentives (Andersson and D'Souza, 2014).

Shortage of inputs was cited as the major reason of not extending CA plots by a greater margin and this is critical because CA cropping systems are likely to perform best when adequate weed control and fertility amendments (both organic and inorganic) are applied to achieve sufficient biomass and grain yields (Thierfelder and Wall, 2012). This is in line with the recommendation by Thierfelder and Wall (2012) that farmers in transition from conventional to CA cropping systems should concentrate available resources on smaller areas to first increase crop productivity and soil quality before expanding their CA plots (Thierfelder and Wall, 2012). This agrees with results from other studies where access to inputs was cited as the major determinant of plot size (Mazvimavi and Twomlow, 2009). However, this might also predict dis-adoption when input incentives are no longer provided as has been the case from past CA promotions in SSA (e.g. Baudron et al. 2007; Mazvimavi and Nyamangara, 2012; Muchinapaya, 2012; Arslan et al. 2014). Shortage of inputs has also been the reason for not expanding CA plots in other studies (e.g. Grabowski and Kerr, 2014; Ndlovu et al. 2013). Thus, research should provide evidence on the sustainability of CA without incentives especially inorganic fertilizers. Furthermore, more research and adaptation is needed for crop rotation and maintenance of permanent soil to be viable in low productivity rainfed agriculture. This resonates with the postulation that CA approach based strictly on the implementation of the three principles does not work in SSA heterogeneous smallholder systems (Kienzler et al. 2012) and there is need for significant adaptation and flexibility in its application (Thierfelder et al. 2015). The observed importance of inputs suggest that adequate and timeous supply of inputs through the government input scheme or through contract farming the private enterprises could sustain CA adoption beyond the LIFIN project life cycle.

Farmers' perceptions were not influenced by agro-ecological region and this was linked to similarity in CA information availability across all the three agro-ecological regions. This made the prospects of CA adoption similar across regions since information is the precursor of technology adoption (FAO, 2001; Pannell et al. 2006). Information facilitates awareness of the technology and its practical relevance, thus enhancing the chances of its uptake by farmers. Similarity in perceptions was also linked to similar farmers' characteristics and circumstances since only one cultural group (the Ndau tribe) dominates in Chipinge district. This disagrees with reports that perceptions are context and location specific (Posthumus et al. 2010). This was linked to homogeneity in perception influencing factors such as culture, education, information availability and resource endowments.

Farmers in the LIFIN project have positive perceptions towards CA as they regard it as the most efficient farming technique in drought prone regions where there is shortage of draught power. This positive perception could be due to the perceived benefits of CA. The positive perception was reported at the beginning of the LIFIN project and it even improved during the course of the project as farmers gain experience from implementing CA. The positive perception was linked to farmers' preparedness to try new technologies in raising crop yields which have been consistently low under the conventional hand-hoeing tillage practice. Moreover, the majority of farmers had formal education and this might have enhanced their receptiveness to improved technologies like CA, since education plays a vital role in creating positive perception towards adoption of agricultural innovations (Knowler and Bradshaw, 2007). Contrarily, in Chivi ward 21, CA was perceived as a backbreaking program, which does not warrant the effort given to it (Gukurume et al. 2010). This difference is probably due to differences in the conventional farmer practice which is mouldboard ploughing and hand hoeing in Chivi and Chipinge respectively. Farmer's positive perception results agrees with reports by Friedrich and Kassam (2009) that farmers practicing CA tend to have a positive view of it and positive perception often leads to learning by experimentation (Pannell et al. 2006; Mapfumo et al. 2008; Corbeels et al. 2014; Dalton et al. 2014), which enhances adoption (Derpsch and Friedrich, 2009; Dalton et al. 2014). Thus farmers are experimenting with CA and this is vital as lack of experiential knowledge often hinders adoption (Milder et al. 2011), since farmers are important sources of information for technology adoption and diffusion (Adesina & Baidu-Forson 1995; Dalton et al. 2014).

The perceived higher yields with CA can be attributed to water harvesting effects of CA basins and precision application of fertility amendments within basins. The reported increased yield is supported by evidence from other studies (Mupangwa, 2009; Nyengerai, 2010; Marongwe et al. 2011). Thus, the prospects for CA adoption were high since farmers were convinced of its relative advantage and that it increases yields thereby improving their food security and livelihoods. Adoption of CA is likely, given its immediate economic impact since the final level of innovation uptake primarily depends on economic factors (Siziba, 2007; Corbeels et al. 2014). The prospects for CA adoption looks promising since its economic benefits were perceived to be realized within one agricultural season which is consistent with resource poor farmers' immediate needs and short planning horizons (Erenstein, 1999; Siziba, 2007; Corbeels et al. 2014; Pannell et al. 2014).

The failure of factors such as agro-ecological region, labour availability, gender of the household head, education level of the household heard and draught power ownership, to explain adoption decisions points to the fact that farmers are still experimenting with CA. As has been reported in literature, farmers experiment with any promising practice (Dalton et al. 2014) and full adoption can only be recorded once benefits of CA are perceived for the enhancement of their personal goals (Triomphe et al. 2007; Dalton et al. 2014). The failure of the aforementioned factors to affect adoption decisions is supported by conclusions by Knowler and Bradshaw (2007) that there are no universally significant factors affecting CA adoption. That's the decision to practice CA can only be explained by farmers' positive perceptions about CA. However, these positive perceptions might be a result of CA input incentives (Andersson and D'Souza, 2014).

5. Conclusion and recommendations

Farmers practicing CA in agro-ecological regions III, IV and V of Chipinge District have a positive view of CA. Conservation agriculture is perceived as a solution to food insecurity in these semi-arid environments. Thus, there are very high prospects for the adoption of CA in agro-ecological regions III, IV and V of Chipinge District. However, the adoption of crop rotation and maintenance of a permanent soil cover, which are the other two principles of CA, is unlikely in the short term. There is need for more innovations/adaptations to promote the uptake of crop rotation and the maintenance of a permanent soil cover e.g. through intercropping and cover cropping. The possible use of live fencing to protect CA fields from free moving animals can also be tested. Innovations of reducing in-row basin spacing by including one more basin between two basins when rotating with legumes to address issues of crop spacing and plant population can also be tested. Further studies to monitor whether CA will be adopted or abandoned after the active promotion of the LIFIN project could provide more information on actual adoption trends, as farmers might be experimenting with CA at the moment.

Conflict of interest

The authors declare that there is no conflict of interests regarding the publication of this article.

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