Original Article

Bulletin of Environment, Pharmacology & Life Sciences
Volume 1, Issue 4, March 2012: 27 - 38
Journal's URL: www.bepls.com
Online ISSN 2277-1808
[Revised 18 February; Accepted 24 March 2012]

Adoption and Efficiency of Selected Conservation Farming Technologies in Madziva Communal Area, Zimbabwe: A Transcendental Production Function Approach

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ABSTRACT
Low productivity, land degradation, inadequate farming resources and inappropriate farming techniques characterise communal farming in Zimbabwe. Government and Non Governmental Organisations have traditionally responded to these challenges by providing seeds, fertilisers and food aid. The root problems have not been addressed. Lifelong strategies including conservation farming technologies have been identified and significant take up in some parts of the country have been noted. This has however not been the case in Madziva where the study aimed at analysing agroeconomics of three conservation farming systems. Survey approach was used on 75 purposively selected farmers. Questionnaires, Focus Group Discussions and key informant interviews were conducted. Marginal Physical Product (MPP) and Value of Marginal Product (VMP) indicated technical and economic efficiency. A transcendental production function was constructed. The conservation farming techniques were technically efficient (MPP>0). VMP values showed economic efficiency. Farmers can recover initial investment outlay in 1 to 2 years. Investment in conservation farming is worthwhile. There was low adoption (27 %) of the technologies. Age, land size, duration and education level significantly affected conservation farming technology adoption decision. For successful adoption of conservation farming, the communication function should be enhanced to ensure understanding of all aspects pertaining to the production systems.
***Key words**: adoption, efficiency, conservation farming, communal, farmers*

INTRODUCTION

Background

Communal farming faces a double challenge of attempting to increase production as well as preserving natural resources. Most communal farming areas in Zimbabwe are characterized by poor soils as well as inappropriate crop and animal management techniques [1]. Due to growing human and livestock populations in Madziva, land is becoming scarce. Superior land management practices have to be implemented so that the resource will not be over-exploited. Over-exploitation may result in loss of local plants, soil erosion and gully formation, thus compromising sustainability.

[1] observed that over the last decade, food security and income for many small holder farmers in Sub-Saharan Africa has declined significantly. In response, governments in collaboration with NGOs and the private sector have been advocating for adoption of sustainable farming practices including conservation farming. This approach can sustainably increase yields of cereal, legume and cash crops. Various conservation farming practices are based on principles that preserve natural resources such as land and water, the fundamental inputs into production of crops and livestock [1; 2;3). Conservation farming is now being practiced on more than 95 million hectares worldwide and the technology is showing increasing interest by farmers. The countries with the biggest area under minimum tillage are the USA, followed by Argentina, Canada, Australia and Paraguay.

South Africa is one of the African countries which first adopted conservation farming, and it was successful in boosting productivity and improving livelihoods of farming households through increased creation of employment and reduced poverty [2). Since 2004, conservation farming has been embraced in Zimbabwe with particular focus on smallholder farmers. The aim was to wean them from the dependency syndrome of reliance on food aid to improve their livelihoods. This approach has been found suitable to areas such as Madziva where the soils are sandy, less fertile, and susceptible to water loss and soil erosion since there is little vegetation cover.

In 2007, the government together with non- governmental organizations led the initiative of intensive facilitation of the dissemination of conservation farming technologies through workshops, extension methods and seminars. About this time the first farmers in Madziva communal area took up the technology. Farmers were given seeds as incentives for participation. Among the dominant conservation farming methods are the use of ripper tines to farmers with draught power and digging planting basins using hoes.

Problem Statement

In Zimbabwe, many development initiatives were targeted towards the highly mechanized large scale commercial farmers in the high potential farming regions. This left smallholder farmers, mainly dependent on hand or animal powered choices which would make them produce less even to sustain their livelihoods. Conservation farming, also called resource efficient agriculture has merits as observed in Asia, America, South Africa and some parts of Zimbabwe. However despite all these principles and merits, adoption of conservation farming in smallholder communal areas of Zimbabwe [1] including Madziva has been marginal and in some cases is experiencing a downward trend and a high drop rate. It is therefore imperative to assess the factors causing these trends and to assess efficiency of these practices in the context of Madziva communal area.

Justification

According to [4], it takes time for the soil and the planting system to reach a new equilibrium. Long term research is therefore required. Understanding efficiency of conservation farming practices creates a basis for advocacy by stakeholders since objective presentations will be made. This will encourage farmers to take up the technologies, clearly knowing the benefits in their localities. It is also important for the stakeholders to understand the dynamics of adoption of any intervention. As such, assessing the determinants of adoption becomes of paramount importance so that there is communication between farmers and the advocators for adoption of the technologies. This creates a mutual platform for cooperative action in terms of modifying the approaches to suit the farmers and changing the mindsets of farmers to appreciate the technologies. Literature of conservation farming will also be enhanced by the findings of this study.

Objectives

The main objective is to examine the adoption and efficiency of conservation farming technologies in Madziva communal farming area as well as the implications on farmers' livelihoods.

The specific objectives are to:

- Determine factors affecting adoption of selected conservation farming practices in Madziva communal farming area.
- Assess the economic and technical efficiency of selected conservation farming practices in Madziva communal farming area.

Research questions

The guiding questions to this research are:

- What are the factors affecting adoption of selected conservation farming practices in Madziva communal farming area?
- Is conservation farming economically and technically efficient in the context of Madziva communal farming area?

LITERATURE REVIEW

The concept of adoption

[5] defined adoption as an act of accepting with approval. It can also be defined as act by which farmers take up a technology and continue with without dropping it on the way. There is need for a radical change when one decides to adopt a technology since the decision is influenced by a spectrum of internal and external factors. There is need for one to familiarise with the systems before adopting the concepts. Inevitably it is a learning process which needs a significant amount of management and time especially in the first years [6]. Fig 1 shows a conceptual framework of the conservation farming technologies adoption dynamics.

Conservation farming: An overview

[7] stated that, conservation farming is a dynamic technology which develops and changes with time. Stakeholders need to align themselves to these changes and overcome obstacles in aspects including soil opening, seed placement and fertilizer bending. In Argentina, benefits of the practices have been evident in production, economic and environmental aspects.

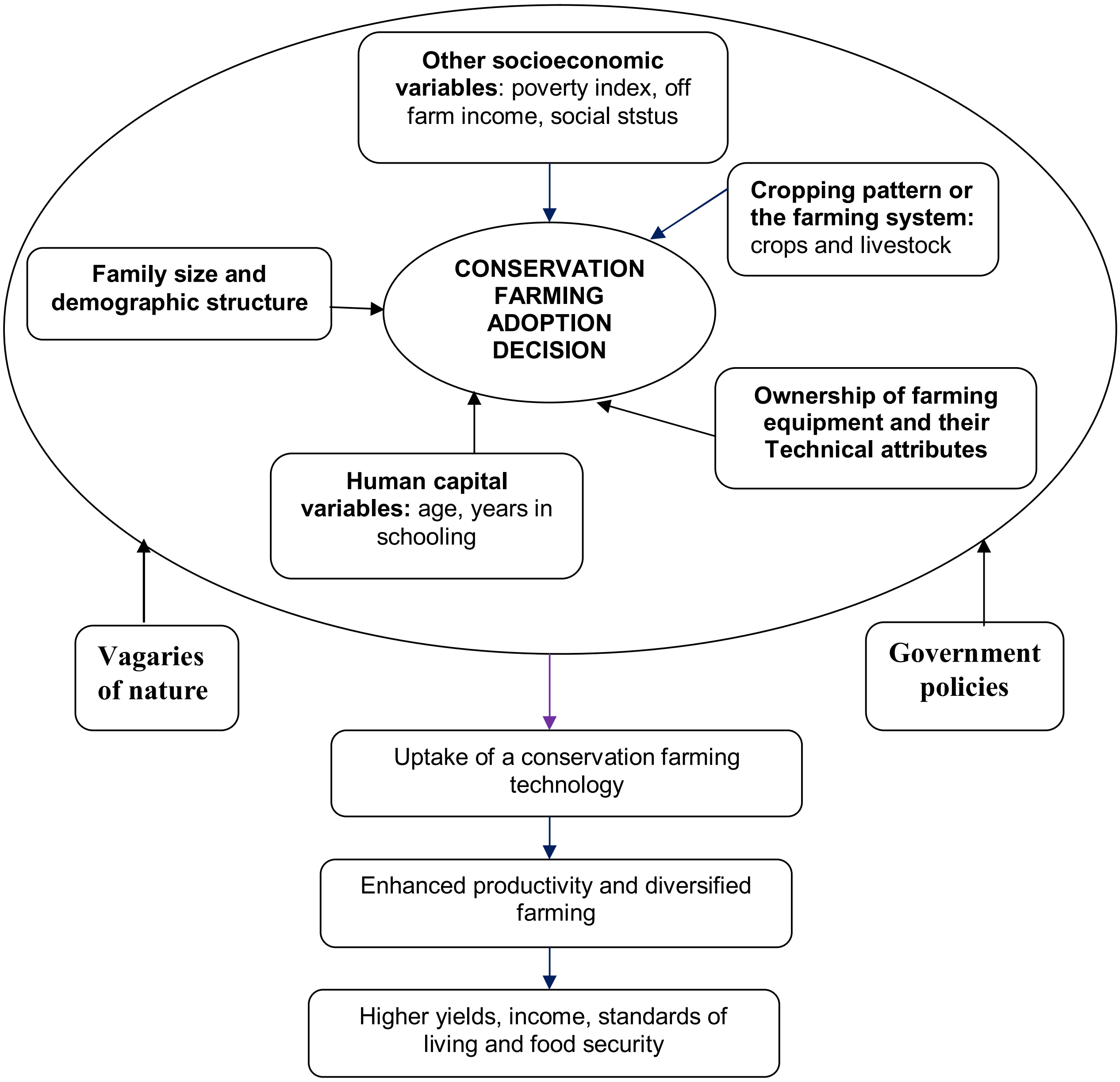

Fig 1: A conceptual framework of adoption of conservation farming adoption
Adopted from [5;2].

Conservation farming: An overview
[7] stated that, conservation farming is a dynamic technology which develops and changes with time. Stakeholders need to align themselves to these changes and overcome obstacles in aspects including soil opening, seed placement and fertilizer bending. In Argentina, benefits of the practices have been evident in production, economic and environmental aspects. There has been improvement in soil structure and water holding capacity of characteristically sandy soils. In most parts of the globe, the concept has been economical since less weeding is done with time hence less labour costs [8].
Both hand powered and animal powered options exist in conservation farming. Hand powered options include the planting basins and the furrow whilst farmers with draught power can make use of a ripper tine and direct seeding. Planting basins are small pits that can be dug with hand hoes without having to plough the whole field. They are a modification of the traditional pit systems once common in Southern Africa. The technology is highly appropriate in Zimbabwe [9;10] where a majority of smallholder farmers are resource constrained. As emphasized by [1], planting basins are prepared across the slope of a field along the contour between July and October. They enable the farmer to plant the crop after the first effective rains when the basins have captured rain water and drained naturally. Planting basins

enhance the capture of water from the first rains and enable precision application of organic and inorganic fertilizer as it is applied directly into the pit and not broadcast. Farmers with timely access to draught power and a mouldboard plough may choose to use ripping. Ripping is a reduced tillage method using a ripper tine attached to a mouldboard plough beam. A locally available plough share can also be used to open up a rip line. This is an option for farmers interested in animal powered conservation farming. Affordable conservation farming approaches enhance adoption in most countries [11]. The easier the approach the more farmers are also willing to adopt a technology.

The early practitioners and researchers were challenged by weed problems and fertility management techniques. They then realized that conservation farming practices created a moving target of maintaining structure and conserving moisture. The soil biological, physical and chemical properties changed overtime as well as the densities of weeds [4].

Global perspective of conservation farming

Conservation farming in South Africa mainly targeted communal farmers who had inadequate resources such as fertile soils. However, commercial farmers also adopted the practice [12]. It is estimated that 68 - 75% of farmed land (horticulture, cash crops such as maize and vegetables) are under conservation farming in South Africa. The resource conservation technologies (RCTs) have shown encouraging results of improving soil biodiversity, reducing air pollution and mitigation of environmental degradation after residue burning and carbon sequestration. The strategies were successful in meeting objectives of increasing total physical production levels, to meet local demand and excess for export.

South America has been experiencing evolution in changing traditional agricultural practices, directing its production systems towards permanent soil cover with conservation farming. In Spanish speaking countries, Brazil has the most rapidly growing adoption rate of conservation farming [13]. South America realized that the system resulted in soil and water conservation. It also resulted in conservation of the environment as a whole and higher yields and profits to farmers. Research clearly demonstrated that deep ploughing combined with intensive disking resulted in the generation of extensive soil displacement of farm land subject to erosion [14]. It also demonstrated that production technologies such as conservation farming existed that could be employed to reduce the incidence of soil erosion on cultivated land. However, adoption of conservation farming systems was slow and resistance was high among many farmers [15]. They were not eager to change production systems, unwilling to spend their time learning new skills and moreover spend their time and effort to secure new farming skills unless they were given inputs for free. In America the barrier to the adoption of emerging conservation production systems was the level of uncertainty associated with adoption of new farm technologies. Any change in farming production systems will introduce higher levels of uncertainty into the farm business hence, smallholder farmers are not willing to take that kind of risk where production will fall below the norm [16;17]. That is the case with conservation farming where significant changes of improvement are noticed after a period of three years.

Conservation farming in Zimbabwe

Smallholder communal farmers usually encounter problems to produce enough for family consumption. Most of these areas are characterized by low and in adequate soil and crop management techniques [15]. In most cases, land preparation is often less standard, planting is often delayed and yet the area receives low rainfall, high temperature moreover, the soils are sandy. Relief programmes have been over time introduced in smallholder communal farming areas in Africa and Zimbabwe is no exception. Conservation farming is technique which covers a wide range of minimum tillage systems, integrated pest, soil and water management practices [18]. The dominant conservation farming techniques adopted in Zimbabwe include the application of planting basins which concentrates limited water and nutrient resources available for the plants [4]. This has been so because the most vulnerable communal households that have limited access to draught power can implement it. Farmers practicing conservation farming methods have achieved yields from 15% to 75% greater than their conventional farming method [19].

Economics of conservation farming

Conservation farming influences both short term and long term economics of farm production. Short term issues relate to farm costs, returns and yields. Long term economic factors are concerned with natural resource protection, maintaining soil chemical and physical fertility as well as minimizing land degradation and environmental pollution. Long term viability of conservation farming will be determined by short term practices which in turn determine the health and productivity of the land [14].

Although conservation farming has been practiced in the top end for a relatively short time, there are clear indications that crop yields are at least equal to those of conventional farming methods and significantly higher in areas with rainfall below average [19]. Conservation farming reduces labour and machinery costs but in some cases, herbicide expenses may increase over the long term. However, the overall benefits are that the practices result in greater flexibility, lower production costs, more reliable yields and better protection of natural resources.

Promoting conservation farming: Who should be on the platform?

Conservation farming is applicable to all crops including annual crops, horticultural crops and tradable crops. It is a holistic approach to farming and includes integrated diseases and pest management techniques. In Argentina, Brazil, Paraguay, USA, Canada and Australia, improvements have been made at several levels to increase farm productivity, reduced fuel use, reduced labour as well as reduced requirements of external inputs [13]. Conservation farming is now most widely recognized worldwide as a viable concept towards sustainable agriculture. In Africa, there is still room for further adoption opportunities given that the farmers are educated. This calls for the need to bring on board various stakeholders including farmers, farmer organizations, government and its agents, NGOs, the private sector. The will be involved in various aspects in influencing the adoption of technologies [20].

Aspects required when introducing farmers to conservation farming

- Exposure of farmers to different conservation farming practices, through participatory activity and on farm demonstrations to show the benefits and practicality of new techniques such as the use of a direct seeder as well as the ripper for minimum soil disturbance.

- Training in the practical use of new technologies, combined with flexible funding mechanisms and incentives, particularly during the period of transition.

- Development and use of farmer achieving and publicizing improvements in land productivity, reducing farming costs and environmental benefits (e.g. carbon sequestration) resulting from application of conservation farming practices [4].

Working with farmers: The broader goal

Implementing conservation farming involves more than simply training but, a change in attitude has to take place regarding what they believe to be the correct way of farming. This is not only true to farmers, but also among extension providers, researchers and policy makers [21]. In Zimbabwe the key principles of minimum soil disturbance, soil cover and implementation management challenge the way Zimbabweans have farmed for many decades [1; 19; 4]. In smallholder communities, the whole community and existing structures need to be involved in conservation farming extension programmes.

If farmers learn how conservation farming can solve some of their problems they are more willing to adopt the technologies. Extension workers or NGOs involved need to describe the benefits, principles and practices of conservation farming. Demonstration plots can be used; lead farmers can also be used as they will be relating the practices with their previous experiences. Even if an organization may target specific groups in the community, such as vulnerable households it is important that the technology is introduced to every farmer in the introductory meeting. If some social groups are excluded at this early stage, it may hold back adoption by the wider community later. Conservation farming is for all farmers who would like to increase farm productivity and profitability whilst preserving the environment for future generations.

Challenges and opportunities of conservation farming

Apparently in Zimbabwe, considerable efforts have been made to develop effective conservation farming among smallholder farmers. According to [4], adoption of conservation farming technology is however still relatively low. The low adoption of these soil and water management technologies was observed to be affected by socio-economic and socio-cultural factors [20]. These include lack of adequate resources, erratic and variable performance of the techniques themselves, labour, draft power and implements.

According to [20], operations such as planting and weeding have high labour demands, with which farmers find themselves unable to cope. The resettlement program by the government has put resettled farmers under pressure in terms of labour and draught power constraints. Most farmers find themselves with 2-3 labour people per household while at the same time draught power remains a challenge. This compels farmers to consider alternative ways of managing their labour and draught power resources. Conservation farming techniques come in as alternatives. Given the right macro-economic environment and favorable incentives and effective extension services, farmers who are resource constrained find conservation farming as a viable alternative to their conventional cropping systems [19].

METHODOLOGY

Study area

The study was carried out in Mazivandagara (Ward 6), area in Madziva (Mashonaland Central Province). The area lies in natural region III and according to it receives rainfall between the ranges of 600-700mm annually the temperatures range from 18^0C-30^0C all year [2]. Agriculture dominates the livelihoods of households in the area were the major crops grown include maize, soya beans, groundnuts, and sorghum. Horticultural crops such as tomatoes and vegetables are also grown.

Research design

Sampling and data collection

Purposive sampling was used to select the study area because that was where conservation farming was being introduced. Proportionate sampling yielded 75 farmers (20 adopters and 55 non adopters). The questionnaire was the main primary data collection tool. This was augmented by Focus Group Discussions and observations. Secondary data were also collected from AGRITEX and NGO offices.

Data analysis tools

Data were processed in the SPSS and LIMDEP computer programs.

Transcendental production function

Estimation of technical and economic efficiency of the conservation farming techniques and the agronomic inputs was done using the transcendental production function. This enabled the derivation of marginal productivities. The function may be presented as:

$$Y = AX_1^{\alpha_1} X_2^{\alpha_2} X_3^{\alpha_3} \ldots X_n^{\alpha_n} \times e^{\left(\gamma_1 X_1 + \gamma_2 X_2 + \gamma_3 X_3 \ldots \gamma_n X_n + c_1 C_1 + c_2 C_2 + \ldots c_n C_n + \gamma_{12} X_1 X_2 + \ldots \gamma_{ij} X_i X_j\right)}, \quad (1)$$

Where:

Y is the output

Xs are the agronomic inputs (continuous variables). The included inputs are weeding cost ($/ha), seed cost ($/ha), pesticide (l/ha), nitrogen (kg/ha), phosphorus (kg/ha) and potassium (kg/ha).

C is a dummy for the three conservation technologies (planting basins, ripping and direct seeding).

The function in (1) can be transformed to:

$$\ln Y = \ln A + \sum_{\alpha_i} \ln X_i + \sum_{i} \gamma_i X_i + \sum_{i} \sum_{j} \gamma_{ij} X_i X_j + \sum_{l} c_l C_l \quad (2)$$

where Y is output,

α_i is a measure of elasticity

X_i measures the level of continuous variable *i*

γ_i is the rate of change of elasticity

γ_{ij} indicates the interaction effects between continuous variables *i* and *j* (*i* ,*j* = 1,2,…,n)

c_l is a measure of the effect of the conservation farming technologies.

Optimisation rules were employed to define efficiency [22]. On the basis of the yield optimization problem, optimality conditions require that the efficient region of production is where the gain in yield per extra unit of X_i is increasing i.e.:

$$\frac{\delta Y}{\delta X_i} = MPP_i \geq 0, \quad (3)$$

Where:

MPP_i is the Marginal Physical Product of the variable input X_i.

The point beyond which yield starts to decrease with additional units of the variable input ($MPP_i < 0$) is where the region of inefficiency begins [23]. The condition for economic efficiency is derived from optimality conditions for a profit maximizing firm, where profit (Π) is computed as:

$$\Pi = P.Y(X) - x'R, \quad (4)$$

Where P is the output price
Y (X) is the production function in (1)
X and R are vectors of inputs and input prices respectively.
Conditions for profit maximization require that:

$$P.\left(\frac{\delta Y}{\delta X_i}\right) = P.MPP = VMP_i = R_i. \quad (5)$$

This implies that it is economically efficient to continue using more input units up to the point where the value of the Marginal Product of an extra unit of the variable input equals its cost.

Logit regression model

The term adoption refers to various processes and stages as one makes use of an innovation. However in this context adoption is defined to mean use of at least one of the three conservation farming technologies on whole or part of their fields during the duration of the study. This created a binary dependent variable since any farmer would either be an adopter or non adopter. The specification of the logit model (derived from the logistic regression function) allowed for the assessment of the determinants of the adoption decision [24;25].

$$P_i = \Pr(Y_i = 1) = \frac{\exp(Z)}{1+\exp(Z)}, \quad (6)$$

$$Z = \beta_0 + \sum_i^m \beta_i X_i, \quad (7)$$

Where P_i is the probability that the i^{th} farmer is an adopter ($Yi = 1$)
β_0 is the intercept
β_i's are the slope parameters, and X_i's are the independent variables.
The natural log transformation of (6) results in (8):

$$\ln\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \sum_i^m \beta_i X_i, \quad (8)$$

The marginal effect for the model is:

$$\frac{\delta P_i}{\delta X_j} = \frac{\exp(z)}{1+\exp(z)}\left(\frac{1}{1+\exp(z)}\right)\beta_j. \quad (9)$$

3.2.2.3 Description of the factors affecting adoption of conservation farming

The most common variables used in modeling technology adoption processes are human-capital variables (such as level of education, age), attributes of the technologies, biophysical and socioeconomic variables, tenure system, resource endowment, risk and uncertainty, social capital, and social psychological factors [2;5;6]. In the present case, the variables hypothesized to influence micro-irrigation adoption decisions are summarized in Table 1. The variables were selected based on literature reviews of the determinants of conservation farming adoption [19;4;11;14;7], own understanding of the socioeconomic setting of the study area, and the technical attributes of the conservation farming technologies prevalent in the study area.

Table 1: Description of conservation farming adoption variables

Variable	**Description**	**Units**	**Adopters**		**Non adopters**	
			Mean	SD	Mean	SD
Age	Age of household head	Year	39.2	11.2	55.3	13.7
Household size	Number of family members	Number	5.4	1.3	3.5	0.9
Land size	Size of arable land holding	Hectare	3.2	1.1	1.7	0.4
Years in school	Years of schooling by household head	Number	14.2	1.2	7.8	1.6
Dependency ratio	Proportion of dependant household members	Percentage	17.3	12.3	23.5	11.4
Off farm income	Access to off farm income	Percentage	4.9	12.6	6.5	14.1
Poverty Index		Score	0.4	0.7	-0.6	0.8

Source: Author's analysis (2011)

RESULTS AND DISCUSSIONS

Farming practices in the study area

The conservation farming technologies can be categorized into three groups based on their conservation attributes. These are soil, water or nutrient saving technologies.

Table 2: Types of agricultural farming systems observed in the study area

Farming practice	Area (ha)	%
Conventional	100	60
Planting Basin	21	13
Direct Seeding	27	16
Ripping	18	11
Number of fields	166	

Source: Author's analysis (2011)

Crop production based solely on conservation farming use is rarely found in Madziva. For adopters, conservation farming technology use was often complimented by conventional farming practices. The farmers use conservation farming technologies to:

- enable early planting so that the plant is already established at the time of the onset of rain,
- safeguard crops against crop loss or yield reduction due to dry spell or early withdrawal of rain, and
- reduce loss of soil through wind and water erosion
- retain soil moisture

Different kinds of traditional farming practices and conservation systems were identified in Madziva (Table 2). Among the traditional practices, deep ploughing was the most common. The proportion of fields under conventional farming was significantly higher than under conservation farming technologies.

Determinants of conservation farming technologies adoption

Table 3: Effect of factors affecting conservation farming adoption decision

Variable	*Coefficient*	*t-ratio*	*Marginal effect*
Constant	-8.31	1.461[a]	-0.8003
Dependency ratio	0.0072	-0.181	-0.0011
Household size	0.558	1.892[c]	0.1932
Age of household head	-0.0097	-0.0068[b]	-0.0034
Poverty Index	2.116	1.892	0.3774
Duration	0.0772	1.649[c]	0.0078
Land size	0.685	2.377[b]	0.0888
Years of schooling of household head	-0.444	1.003[a]	0.0391
Off farm income	-1.593	0.089[a]	0.0111
Log likelihood function		-61.883	
X^2 (df)	119.88(8)[c]		
Percentage of correct predictions	72.9		

Notes: [a] Significant at 10%, [b] Significant at 5%, [c] Significant at 1%

Source: Author's analysis (2011)

The successful adoption of conservation technologies requires the fulfilment of the following three basic factors:

- the technologies need to be technically and economically efficient,
- the target beneficiaries need to be aware of or knowledgeable about the technical and economic superiority of these technologies, and
- the technologies must be accessible to the potential users.

Most of the variables that were captured in the model (Table 3) had the expected signs. On average, well-to-do farmers (poverty index) are less likely to participate in conservation farming. In the context of the study the access to off farm and non-farm income had the expected sign. As the farmers' access to income from off farm and non-farm sources increases, the likelihood of participation increases upto some point [5]. This shows the importance of cash (for leverage) in the initial participation decision of farmers. However, at higher levels of off-farm and non-farm income, the farmers are less likely to participate in conservation farming because they have enough to finance their farming activities and still remain with enough for contingencies.

As per aprior expectations, duration in agricultural activities significantly influences the farmers' decision to participate in conservation farming practices. In the context of the study, most farmers had on average five seasons under contract. This is constructed in the social dynamics of the communities under review where there are observable trends of dependency on agriculture for survival [1]. Farmer's age had the expected negative and significant influence on the chances of farmers participating in conservation farming. The negative sign for the age variable could be understood from the commonly observed negative correlation between the age and adoption decision for most technologies in dynamic economic environments. In other words, younger farmers tend to be more willing to adopt than their older counterparts. With increase in age farmers tend to shun new farming practices for less demanding cropping systems with low transactional cost associated with them. Furthermore, older farmers tend to be risk adverse and may avoid innovations in an attempt to avoid risk associated with the initiative. This idea is supported by [15] who argued, that being older creates a conservative feeling among farmers and hence resistance to change. In his study, [14] however observed that chances of participation in conservation farming increased with age because youths have little appreciation on the importance of agricultural activities in most rural set ups and will take marginal effort to expand these activities.

Education level (as measured by the number of years of schooling by household head) significantly influence farmers' participation but with more years in schooling probability of participation tends to decrease. A possible explanation to this is that educated people tend to shun agriculture for white color jobs in Madziva and surrounding areas. Some households are more concerned with time value of money and will prefer projects with quick return and profitable like broiler production. However, these results differ from [4] who asserted that education influences household to process information and causes farmers to have better access to understanding and interpretation of information.

Land size significantly, influenced farmer participation in conservation farming. A possible explanation to this could be that farmers with large arable land size have the opportunity to spare some sections to try out new practices at less risk. [11] supported this by stating that the size of the land is important because the transactional costs are largely fixed cost that are spread across more potential output on large farms. There are also observable indications that increased participation in conservation farming is a function of land productivity. Large land size also implies that farmers can diversify into other crops and reduce the inherent risk that is in agricultural production [16]. Dependency ratio (i.e., the proportion of family members whose ages are less than 14 or more than 65), was introduced into the model as a surrogate for household size to indicate the status of labor availability in the household. The variable had a positive and insignificant effect on the participation decision. The higher the effective labour available the more likely the household is to participate since chances of labour shortages during peak times are low. This enhances the chances of favourable yields.

Yield responses

Table 4: The transcendental regression model results

Item	Variable	Maize		Groundnut	
		Coefficient	**t - value**	**Coefficient**	**t - value**
1	Constant	3.986	1.234[b]	-1.987	-0.346
2	Estimates of γ_i's(levels of agronomic inputs)				
	Weeding	-0.00478	-0.54[a]	-0.00333	-0.476
	Seed	-0.0001347	-0.368	-0.00982	-0.298
	Pesticide	-0.40912	-3.214[c]	-0.0134	-1.223
	Nitrogen	-0.03777	-0.782[b]	-0.0182	-0.832[a]
	Phosphorus	-0.00014	-0.993	N/A	N/A

	Potassium	-0.00378	-2.1421	N/A	N/A
3	Estimates of α_i's(agronomic inputs levels in natural log form)				
	Weeding	0.433	2.219b	0.139	1.116
	Seed	-0.079	-0.261	0.371	1.182
	Pesticide	0.5531	1.198	0.072	0.399
	Nitrogen	1.115	0.659	0.069	0.1927
	Phosphorus	-0.671	1.482	N/A	N/A
	Potassium	0.68	1.731c	N/A	N/A
4	Estimates of c_l's(conservation faming technologies)				
	Planting Basin	1.387	3.167b	0.512	1.673c
	Direct Seeding	1.246	2.652b	0.673	2.139b
	Ripping	2.153	1.337c	0.568	1.429a
5	Estimates of γ_{ij}'s(interactions of selected agronomic inputs)				
	Pest by seed	0.000121	1.783b	0.000716	1.555b
	Seed by weed	0.000082	0.561	0.006428	2.399a
	Pest by weed	0.000969	2.556b	0.000372	0.348
	Nitrogen by	0.005625	0.993c	N/A	N/A
	Adjusted R^2	0.489		0.401	
	F – Statistic	2.744c		4.773c	
	Dublin -	1.873	1.937		
	N	75			

Notes: [a] Significant at 10%, [b] Significant at 5%, [c] Significant at 1%

Source: Author's analysis (2011)

The results of the transcendental production function fitted to the data to assess the yield responses of the different agronomic inputs are as in Table 4. For both crops considered (maize and groundnut) the use of conservation farming technologies generally resulted in a significant yield improvement over the traditional farming practices. [4] also reported similar observations. In addition, farmers reported that the use of direct seeding for groundnut is marred by low germination rates. The coefficients for the banana yield response to phosphorus suggest that the farmers are currently applying this input above the normally required rate. For maize, the highest responses were observed for pesticide and nitrogen, respectively. Most of the maize yield responses to agronomic inputs are statistically significant. Among these, the highest yield response was observed for pesticide use followed by nitrogen. The synergistic effect of the various agronomic inputs can be observed from the positive interaction effect coefficients. Pesticide-by-seed interaction effect is significant for maize and groundnut. This shows that the yield advantage of investments in pest control depends on the type of the variety used [26]. Similarly, the significant seed-by-weed interaction effect for groundnut shows that the response to the weeding efforts of the farmer depends on the weed competitiveness and yield potential of the cotton variety used.

Technical and economic efficiency

Table 5: The technical and economic efficiency of conservation farming systems

Crop	Conservation farming technology	MPP	VMP	Investment cost	Subsidised Investment cost
Maize	Planting Basin	3.29	3,129	3,339	1.456
	Direct Seeding	2.49	2,734	2,890	1.495
	Ripping	3.45	3,002	2,999	1.501
Groundnuts	Basin	3.11	3,193	3,002	1.349
	Direct Seeding	2.72	2,452	2,909	1.398
	Ripping	3.62	3,491	2,839	1.499

Source: Author's analysis (2011)

The technical and economic efficiency parameters (i.e. MPP and VMP) for the three conservation farming technologies generated from the fitted transcendental response functions presented in Table 5. The MPP values indicate an extra yield advantage that a farmer obtains when shifting from the traditional farming methods to conservation farming practice. The marginal physical productivity values shown in Table 5 indicate that the use of conservation farming technologies groundnuts and maize is technically efficient (MPP > 0. These technologies are primarily adopted to avert risk during drought years and extend the limited water (moisture) to as much area as possible.
It is however important to note that technical efficiency alone does not guarantee economic efficiency. A farmer may operate in the technically efficient region of the production function but may still be judged as economically inefficient. This will be on the basis of considerations of input–output price relations [23]. It is therefore imperative to evaluate the economic efficiency of the conservation technologies by considering the input–output price relationships. This can be achieved by calculating VMPs for the technologies. The generated values are then compared with their respective initial investment costs under two scenarios, i.e., the actual and the subsidized costs (see Table 5). From the results of the economic efficiency analyses the following inferences may be made:

- the conservation farming technologies are economically efficient and the farmers can recuperate their initial investment capital within 1–2 years since the VMP for the crops is almost equal to the initial investment cost
- subsidies further increased the profitability of investments in conservation farming technologies
- the magnitude of economic gains from investments in conservation farming technologies depends on the type of crop (producer price) [27]. Conservation farming use in groundnuts is more remunerative as compared to maize.

Problems faced by adopters

Conservation farming may not always be readily adopted by smallholder farmers because it conflicts with convectional farming practices which are inherent in farmers (i.e. these practices are mutually exclusive). Some of the problems arise from deep socio-cultural beliefs and downgrading of conservation farming. Below are some of the problems faced by farmers:

- In the first years of conservation farming there are labour constrains. Land preparation and weeding are labour intensive tasks and heavy work for those physically weak.
- Lacks of self confidence, vulnerable groups sometimes feel that their situation is hopeless, and that they may not be able to escape poverty and hunger. This is because most of them are resource constrained hence they aim lower production level.
- Lack of finance to purchase adequate inputs (fertilizers, seeds, and chemicals).
- Shortage of maize stalks to use as mulch for covering the ground. The available mulch was easily destroyed by termites hence farmers would cut (hyperania species) which is labourous. Some of the mulch was destroyed by cattle.
- Unfair distribution of implements by the headmen as well as shortage of equipments (direct seeder, ripper).
- Inability to get wire fencing to protect fields from thieves and animals.
- Attack of crops by crickets at vegetative stage.
- High weed and pest infestations in the first year

CONCLUSIONS

The study indicates that, for maize and groundnuts, averagely, using conservation farming technologies significantly increased productivity and economic rewards over the traditional farming methods. A number of factors including age, years in schooling and dependency ratio significantly affect the probability of adopting conservation farming technologies. This therefore, this means farmers need to be educated or trained more for them to accept the technology of conservation farming.

RECOMMENDATIONS

- The researcher therefore recommends smallholder farmers to be educated on sustainable technologies of farming such as conservation farming.

- This has long term benefits in sustaining livelihoods of those who are resource constrained.
- It is also worth investing in establishing an innovation platform for conservation farming technologies.

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