MANAGEMENT PRACTICES THAT AFFECT TECHNICAL EFFICIENCY AND COPING STRATEGIES OF SMALLHOLDER MAIZE IRRIGATION FARMER IN ZIMBABWE

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Abstract

The main objectives of this study were to find and interpret common factors of respondents' compliance with best management practices that affect the farmers` technical efficiency and coping strategies adopted by the smallholder maize irrigation farmers at Tokwane-Ngundu of Zimbabwe. Primary data were gathered using a questionnaire and factor analysis was done to explore the farmers` degree of compliance with best management practices. The factor analysis revealed that the farmers` compliance with best management practices fell into three categories of farming diligence, crop densities and water management. Labour shortages were the biggest maize production risk faced by the farmers who resorted to forming mutual aid groups to offset the risk. The policy implication of this study is the introduction and promotion of risk management measures as well as the putting in place of regulatory frameworks to support market based initiatives such as crop insurance schemes could be steps in the right direction in reinforcing the farmers` coping strategies against maize production risks.

Keywords: Best management practice; efficiency, smallholder farmers; coping strategies, factor analysis

1. Introduction

Smallholder irrigation schemes in Southern Africa including Zimbabwe instead of eradicating poverty, boosting food security and promoting sustainable livelihoods have often been criticized for their low agricultural productivity. The problem is that little information is available to adequately explain the reasons why the productivity of the smallholder irrigation farmers drops at very high rates. This conundrum has bothered Zimbabwean agricultural policy makers who would expect the smallholder irrigation farmers to use the irrigation technology to boost their productivity.

Tshuma (2009) assess the impact of the best management Practices (BMP) project on social and economic wellbeing at Zanyokwe Irrigation Scheme in central Eastern Cape Province using survey and found that BMP project to have an impact on social and economic well-being of households. There is a limited number of studies have been carried out to compliance with best management practices that affect the farmers` technical efficiency and coping strategies in Zimbabwe. Thus, currently there is little evidence of the scope for improving the technical efficiency levels of smallholder farmers by focusing on compliance with best management. The main objectives of this study were to find and interpret the common factors of respondents' compliance with best management practices that affect the farmers` technical efficiency and coping strategies adopted by the smallholder maize irrigation farmers at Tokwane-Ngundu of Zimbabwe.

2. Methodologies

2.1. Sample design and data collection

A factor analysis was done to explore the farmers` degree of compliance with best management practices when producing their maize while a focus group discussion was held to explore the farmers` coping strategies with maize production risks. Simple random sampling was used to come up with a sample of 57 smallholder maize irrigation farmers at Tokwane-Ngundu, 50 of the farmers answered the questionnaire while the remaining 7 participated in the focus group interview that investigated the farmers` coping strategies with maize production risks. Due to budget and time constraints the study focused on few smallholder maize irrigation farmers. The characteristics of respondents are shown in Table 1.

Table 1: Summary of the characteristics of respondents

Gender	Male	Female				Total
Frequency	33	17				50
Age	< 20	20-35	36-55	> 56		
Frequency	0	16	21	13		50
Household Size	4-6	7-9	10-12	13-15	>15	
Frequency	23	18	6	2	1	50
Educational Level	None	Primary	Secondary	Tertiary		
Frequency	8	14	25	3		50
Farming qualification	None	OFT*	AMFT**	Diploma		
Frequency	44	4	1	1		50
Extension service access	Weekly	Two weekly	Monthly	Quarterly	Never	
Frequency	7	13	20	3	7	50
Extension service quality	Poor	Average	Good	Excellent		
Frequency	15	17	16	2		50
Off-farm Income	Formal Employment	Remittances	Informal Trading	Formal Trading		
Frequency	3	10	6	1		20

Note: OFT* ordinary farmer training and AMFT** advanced master farmer training

Source: Author's observation

In terms of gender, males dominated the ownership of the plots as they constituted 66% of the respondents. Participation of women in agriculture remains a challenge among maize farmers in Zimbabwe because of the gender stereotype that farming is a masculine preserve. The majority (68%) of the respondents were above 35 years old.

Educational levels in the study area were considerably high, 84% of the respondents had at least a primary education. This finding is consistent with Zimbabwe`s overall rating as one of the most literate countries in Africa. Farming experience did not show great variation as most of the farmers reported eight years' experience in irrigation farming.

The household sizes in the study area were relatively large, 54% of the households had at least seven members, and 3 households had 13 members or more. . A general consensus among respondents in the study area is that the larger the household size, the more labour will be available for irrigation maize farming activities. The average household size is consistent with the average family size in African tradition of a large family size, comprising about eight people, to provide farm labour during peak production periods (Maseatile, 2011). In terms of extension service access, 84% of the respondents have been visited by an extension officer at least once in a quarter. Only twenty (40%) of the respondents had access to off farm income.

2.2. Conceptual framework

2.2.1. Factor analysis of best management practices that affect the farmers technical efficiency

According to Cornish (2007), the basic idea in factor analysis is to represent a set of variables by a smaller number of variables, called factors. The first step of performing a factor analysis is to determine whether it actually is necessary and/or worth the while to perform the factor analysis. This can be done by measuring the adequacy with which the different variables can be sampled.

2.2.1.1. Measure of sampling adequacy (MSA)

Anglim (2007) argued that, if MSA is too low, then factor analysis should not be performed on the data. Data need to be correlated to justify the use of factor analysis. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy can be presented as (Berghaus *et al*., 2005):

$$MSA(J) = \frac{\sum_{k \neq j} r_{jk}^2}{\sum_{k \neq j} r_{jk}^2 + \sum_{k \neq j} q_{jk}^2} \qquad (1)$$

Where MSA(J) is the measure of sampling adequacy for the J^{th} variable, r_{jk} represents an element of the correlation matrix R, and q_{jk} represents an element of the anti-image correlation matrix Q, which is in turn defined by the equation $Q = SR^{-1}S$, where $S = (\text{diag } R^{-1})^{-1/2}$. The MSA lies between 0 and 1 and is described by Kaiser as a measure of the extent to which a variable "belongs to the family" of the larger group of variables. A KMO value which is lower than 0.5 is considered "unacceptable". The next step in the factor analysis is to determine the number of factors that have to be specified in the factor analysis.

2.2.1.2. Number of factors to include in the analysis

The number of factors to use in the factor analysis was determined using principal component analysis (PCA). The Kaiser's criterion was used to determine the number of factors to be included in the factor analysis. When performing the factor analysis one has to be sure that some variables have not scored high factor loadings in more than one factor. Whenever a variable scored high factor loadings in more than one factor, the output can be rotated.

2.2.1.3. Determining if rotation is necessary

Rotation serves to make the output more understandable and is usually necessary to facilitate the interpretation of factors. Cornish (2007) noted that once the initial factor loadings have been calculated, the factors are rotated to find factors that are easier to interpret.

Rotation will alter the eigen values of particular factors and will change the factor loadings (Garson, 2008b). Varimax rotation is an orthogonal method of rotation that minimizes the number of variables with high loadings on a factor, thereby enhancing the interpretability of the factors. Orthogonal rotation results in factors that are uncorrelated. Varimax rotation tends to force each variable to load high on as few factors as possible. Ideally this will cause each variable to load high on only one factor (Habing, 2003).

The communality is the measure that indicates the amount of the variation in the variables that is explained by the specified factors.

2.2.1.4. Communality

Anglim (2007) pointed out that communalities represent the percentage of variance explained by the extracted components. It is the R-Squared value that would be achieved if this variable were regressed on the retained factors. The communality is the proportion of the variation of a variable that is accounted for by factors that are retained. If one squares the unrotated loadings for an item for each of the components and sums these, one gets the communality. Anglim (2007) also noted that if the communality is very low for an item, it suggests that it does not share much in common with the extracted components and this generally implies that the item is unrelated to the other items in the set.

Garson (2008b) concluded that the role is often greater when the communality is high. A communality that exceeds 1 however is an indication that there is a spurious solution which may reflect too small a sample size or the researcher may have too many variables. The last step in a factor analysis is to determine whether the internal consistency in each of the factors is reliable.

2.2.1.5. Reliability analysis scale alpha

Following from the work of Jordaan (2006), Cronbach's Alpha was used to calculate the overall reliability of internal consistency. Cronbach's Alpha value greater than 0.7 is an indication that the level of reliability is acceptable.

Cronbach's Alpha is calculate

$$a = \frac{K}{K-1}\left[1-\frac{\sum_{i=1}^{K}\sigma_{ii}}{\sum_{i=1}^{K}\sum_{j=1}^{K}\sigma_{ij}}\right] \qquad (2)$$

Where K is the number of items (questions) and $\boldsymbol{\sigma_{ij}}$ is the estimate covariance between items $\boldsymbol{i}$ and $\boldsymbol{j}$. Note that $\boldsymbol{\sigma_{ii}}$ is the variance (not the standard deviation) of item $\boldsymbol{i}$**.**

2.2.2.Analysis of farmers` coping strategies with production risks

The data of farmers` coping strategies with production risks was gathered using a focus group discussion with maize irrigation farmers. The smallholder irrigation farmers perceive their agricultural production risks in terms of dynamic, holistic and continuous processes in their vulnerability context; the capital assets at their disposal and the agricultural institutions; structures and policies that shape their agricultural lives.

Focus group interviews were principally used as a data collection method during this study in order to explore "multiple viewpoints or responses" concerning a specific issue (De Vos *et al*. 2009). For the focus group discussion the following procedure followed: generating categories, themes and patterns; coding the data; testing the emergent understandings; searching for alternative explanations and writing the report.

3. Results and discussion

3.1. Factor analysis farmers compliance with best management practice

3.1.1.Measure of sampling adequacy

The suitability of the KMO for individual variables for use in the factor analysis is aimed at measuring the sampling adequacy of the 12 items in the questionnaire regarding the farmers` compliance with best management practices. The results show that all the variables had KMO values way above 0.5 with the least of the values being 0.673 relating to sufficient irrigation and the highest being 0.994 relating to ploughing depth showing that factor analysis was well suitable for the study. The KMO-values of the variables that were included in the factor analysis are presented in Table 1.

Table 1: Results of the Kaiser-Meyer-Olkin Measure of Sampling Adequacy

	Variables	**KMO-Value**
1	Ploughing depth	0.944
2	Land disking	0.850
3	Inter-row spacing	0.814
4	Intra-row spacing	0.753
5	Timely irrigating	0.888
6	Sufficient irrigation	0.673
7	Weeding practices	0.944
8	Soil analysis	0.909
9	Crop rotation	0.939
10	Leaching prevention	0.885
11	Pest control	0.839
12	Disease prevention	0.908

Source: Author's estimation

3.1.2.Determining the number of factors

The number of factors to use in the factor analysis was determined using principal component analysis (PCA). The eigen values of the principal components are shown in Table 2. Three principal components had Eigen-values greater than 1 and explained 74.5 percent of the variance in all the respondents` compliance with best management practices. As a result three factors were specified for factor analysis. Once it has been determined that the factor analysis is worthwhile and the number of factors that have to be specified in the factor analysis.

Table 2: Results of PCA showing number of factors to include in factor analysis

	Initial Eigen Values		
	Total	**% of Variance**	**% of Cumulative**
1	**6.614**	55.117	55.117
2	**1.245**	10.377	65.495
3	**1.079**	8.992	74.486
4	0.591	4.923	79.409
5	0.562	4.683	84.092
6	0.468	3.899	87.991
7	0.415	3.454	91.445
8	0.288	2.404	93.849
9	0.269	2.244	96.094
10	0.207	1.729	97.882
11	0.146	1.214	99.036
12	0.116	0.964	100.000

Source: Author's estimation

3.1.3.Factor analysis

Two of the variables had factor loadings that were greater than 0.50 in absolute value for more than one factor. This suggested that the variables are strongly related to more than one factor, and suggested the use of Varimax rotation. The factor loadings after Varimax rotation are presented in Table 3. In Factor 1, eight variables had factor loadings above the 0.5 threshold. These variables were pest control; leaching prevention; soil analysis; weeding practices; ploughing depth; crop rotation; disease control and land disking. Consequently these variables were lumped together into Factor 1.

Table 3: Factor loadings after varimax rotation

Rotated Component Matrix			
Variables	**Components**		
	Farming diligence	**Crop density**	**Water application**
Pest control	**0.874**	0.199	0.004
Leaching prevention	**0.869**	0.099	0.247
Soil analysis	**0.798**	0.306	0.149
Weeding practices	**0.785**	0.230	0.270
Ploughing depth	**0.718**	0.451	0.200
Crop rotation	**0.626**	0.410	0.305
Disease control	**0.599**	0.209	0.422

Land disking	**0.596**	0.478	-0.313
Inter-row spacing	0.215	**0.890**	0.275
Intra-row spacing	0.278	**0.856**	0.160
Sufficient irrigation	0.065	0.208	**0.866**
Timely irrigating	0.464	0.118	**0.603**

Source: Author's estimation

Given the nature of the variables that load high in Factor 1, Factor 1 was called Farming diligence. Factor 1 can be explained as the farmer who conducts regular soil analysis; ploughs to the recommended depth; will disk his field after ploughing; actively rotates his cropping patterns; actively prevents the leaching of important soil nutrients. The diligent farmer will therefore increase his or her productivity by a combination of hard work; smart farming choices and protecting the yield against the pest and disease elements.

Inter-row spacing and intra-row spacing had the highest admissible factor loadings (0.89 and 0.856 respectively) in Factor 2 hence they formed a sub-group on their own. Factor 2 was called Crop density. Factor 2 can be explained as the farmer who seeks to maximize his or her output by maximizing the density and quantity of the planted maize crops. This can be done by maximizing the quantity of the planted crops in one row and then keeping the space between the rows as short as possible. Sufficient irrigation and timely irrigation scored the highest factor loadings (0.866 and 0.603) respectively in Factor 3. Factor 3 was subsequently named water application. This factor can be explained as the farmer who seeks to maximize output by paying great attention to make sure that his\her maize crops receive adequate water at all the strategic and critical periods throughout their growing cycle.

3.1.4. Communality

The communalities of all the variables are higher than 0.5 which implies that the factors explain more than 50 percent of the variation in the variables. All of these variables also contributed to well-defined factors; hence the values were both high and acceptable. Table 4 provides a summary of the communalities. Once you are satisfied that all the variables that are included in the factor analysis contribute to well-defined factors, and that the factors explain the variation in the variables, you also have to test whether or not the variables within a factor measure the same underlying concept as the factor as a whole. Cronbach's Alpha was used to test the level of internal consistency within each of the factors.

Table 4: Communalities after varimax rotation

Communalities		
Variables	**Initial**	**Extraction**
Ploughing depth	**1.000**	0.759
Land disking	1.000	0.682
Inter-row spacing	1.000	0.835
Intra-row spacing	1.000	0.914
Timely irrigating	1.000	0.593
Sufficient irrigation	1.000	0.797

Weeding practices	1.000	0.741
Soil analysis	1.000	0.753
Crop rotation	1.000	0.653
Leaching prevention	1.000	0.827
Pest control	1.000	0.804
Disease prevention	1.000	0.580

Source: Author's estimation

3.1.5.Reliability analysis: Scale alpha

Two factors had a Cronbach`s Alpha value greater than 0.7. The first factor had a Cronbach`s Alpha value of 0.923 while Factor 2 had a value of 0.883. This is an indication that the internal consistency in the two factors is reliable and hence each item is measuring the same concept as the overall factor. Factor 3 had a low Cronbach's` value of 0.563 meaning that the level of reliability is below the acceptable threshold.

Among the twelve best management practices, there seems to be three groups into which the individual practices can be lumped. These three groups relate to the farmers` diligence; crop densities and water application to the crops. Compliance with the farming diligence best management practices requires the farmers to be diligent about controlling pests, preventing nutrients leaching, undertaking regular soil analysis, weeding the crops regularly; observing the correct ploughing depth, rotating the crops, controlling crop diseases and disking the land. Compliance with crop densities best management practices calls on the farmers to observe both inter-row and intra row spacing for optimum yields.

Timely and sufficient irrigation comprise the third group of compliance with best management practices relating to water application. The improvement of the farmers` compliance with the best management practices may spawn increases in their technical efficiency levels. This can lead to higher levels of maize output per hectare thus boosting the farmers` food and income security, thereby reducing their poverty levels. Steps must therefore be taken to encourage the farmers` compliance with the best management practices highlighted in this study through the use of mass media and robust extension services. The sharing of knowledge regarding compliance with the best practices must also be encouraged among the farmers under consideration.

3.2. Coping strategies adopted

The emphasis was on production risks because they have the potential to directly affect the technical efficiencies of the farmers. Results of focus group discussion revealed labour shortages (both human and animal), seed and fertilizer shortages, crop diseases, worms, wild pigs, birds, thieves, grasshoppers and water disconnections as some of the major kinds of production risks affecting maize farming in the irrigation scheme. The maize farmers explained that they tend to encounter more than one type of production risk in a particular cropping season.

4. Conclusions and recommendations

The aim of this paper was to find and interpret the common factors of respondents' compliance with best management practices that affect the farmers` technical efficiency and coping strategies adopted by the smallholder maize irrigation farmers at Tokwane-Ngundu of Zimbabwe. The results of factor analysis showed that the best management practices can be grouped into three sub-categories appropriately named farming diligence; crop density and water application.

The results of the focus group discussion showed that small-scale maize irrigation farmers are not passive onlookers in the face of production risks. Rather the farmers adopted some coping strategies in order to lessen the severity of the problems they encountered. The discussion revealed that the production risks that require special skills and chemicals like maize diseases and other pests pose the greatest challenges to the farmers who neither have the technical knowhow nor the chemical resources to address the challenge. The introduction and promotion of risk management measures as well as the putting in place of regulatory frameworks to support market based initiatives such as crop insurance schemes could be steps in the right direction in reinforcing the farmers` coping strategies against maize production risks.

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