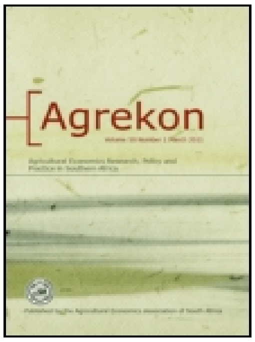

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Determinants of fertiliser use by smallholder maize farmers in the Chinyanja Triangle in Malawi, Mozambique and Zambia

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DETERMINANTS OF FERTILISER USE BY SMALLHOLDER MAIZE FARMERS IN THE CHINYANJA TRIANGLE IN MALAWI, MOZAMBIQUE AND ZAMBIA

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ABSTRACT

Farm surveys in Malawi, Zambia and Mozambique were carried out to assess the determinants of fertiliser use given continued low yields, low organic matter and general poor soil health in southern African soils. Regression modelling showed that fertiliser use was influenced by household and farm characteristics. In addition, it was also influenced by social and human capital and farmers' perceptions of the effect of fertilisers on soil fertility. Farmers who perceived fertilisers as bad for their soil were less likely to adopt their use. This is a key result, as the emerging discussions on a green revolution for Africa, as well as the continued food crisis discussion, are prompting increased fertiliser use as an immediate intervention for increasing nutrient inputs into agriculture in the developing world. Increased policy efforts should be placed not only on increasing access to fertilisers but also on evolving farmers' perceptions and attitudes towards fertiliser use.

Keywords: African green revolution, farmer perceptions, fertiliser subsidies, fertiliser use, human capital, social capital

JEL Classification: Q12, Q16

1 INTRODUCTION

Economies in southern Africa depend heavily on agricultural production, with the sector contributing 20 to 60 per cent of gross domestic product (GDP), 30 per cent

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of exports and over 60 per cent of all employment (Beintema *et al*., 2004; Obwona & Chirwa, 2006). Despite the dependence and high priority placed on agriculture by government, agriculture productivity has been declining due to natural resource degradation, low access to fertilisers, population pressure, fragmentation of land and poor soil fertility management practices (Beintema & Stads, 2004; Kumwenda *et al*., 1996).

To sustainably increase crop productivity, increased investment in nutrient additions to the soil are essential and globally agreed upon. However, intense discussion occurs on how this should be done, through the use of inorganic fertilisers or through low input and organic systems. Whichever side of the argument one supports, the increased need for nutrient inputs to sub-Saharan farming systems is irrefutable. Some argue that there is need for substantial increases in the use of appropriate inorganic fertilisers, as they offer the most effective means of increasing crop productivity, especially in the short term (FAO, 2007; Wilchens, 2006; IFPRI, 2003; Weight & Kelly, 1998). The green revolution led to increased incomes by increasing returns to land, and as a result between 1970 and 1995 real per capita income in many Asian countries almost doubled. In southern Africa, substantial accomplishments have also been made, with improvements in farmer incomes arising from programmes that work towards improving seed systems, soil fertility, farmer organisation and the functioning of markets (AGRA, 2009). In addition, the number of people living in absolute poverty fell from 1.15 billion to 825 million despite a high population growth rate (IFPRI, 2003). Although inorganic fertiliser use offers an option for increasing agricultural production, it does not provide the whole solution. It is essential that complementary technologies are provided that will enhance rural incomes and achieve household food security (Barrett, 2008; Wilchens, 2006; Crawford *et al*., 2005). These technology options include increased additions of organic matter, improved seeds, soil and water management technologies, expansion of irrigation and water resources and increased provision of extension services.

Despite the potential impacts of inorganic fertilisers, the African continent consumes less than 3 per cent of world fertiliser per annum and sub-Saharan Africa (SSA) accounts for only 1 per cent of this amount (Earth Watch Institute, 2006; Kelly, 2005). For the periods 1980–1989 and 1996–2000, fertiliser use intensity increased by only 5 per cent in SSA (Crawford *et al*., 2005). In order to curtail nutrient mining and increase crop productivity in SSA, there is a need to increase the average intensity of fertiliser use in the region by more than 300 per cent in the next 10 years (Weight & Kelly, 1998; FAO, 2004). The challenge remains, therefore, to promote efforts to increase the use of inorganic fertilisers, alongside research to determine the factors that affect its supply and use at regional, national and household levels.

Malawi implemented a Starter Pack Initiative (SPI) in the 1998/99 and 1999/2000 cropping seasons, providing a pack of fertiliser, maize and legumes sufficient for 0.1 hectares of land, targeted at rural smallholder farmers. It subsequently reached 2.9 million beneficiaries (Mangisoni, 2007; Statistical Services Centre, 2007; World Bank, 2006). In the 2000/2001 seasons, the SPI changed and became the Targeted Input Programme (TIP). The TIP provided the same package as the SIP but the target beneficiaries were mainly the poorest farmers and, in its first year, it benefited 1.5 million people, reducing to 1 million in its second year (Mangisoni, 2007; Statistical Services Centre, 2007; World Bank, 2006).

During the same period, Zambia also embarked on fertiliser market reforms to encourage effective private sector fertiliser distribution systems to serve the smallholder farmers. Alongside liberalising the market, the government also initiated programmes which targeted poor farmers by providing packs of fertilisers with complementary seeds under different programmes, such as the Fertiliser Support Programme, which provided fertiliser at 50 per cent subsidy and whose beneficiaries were rural farmers who were classified as vulnerable but with good productive potential. Other programmes in Zambia were the government's programme against malnutrition food security pack, the FAO emergency input programme and the FAO food security pack project (Mangisoni, 2007). The Zambia food security pack programmes accounted for the distribution of approximately 12 per cent of all fertiliser used in the country prior to 2000 (World Bank, 2006). Mozambique has mainly been implementing subsidy programmes in response to emergency needs through the use of input fairs. Input fairs are organised as roving markets to which various input dealers and traders are invited. Selected beneficiaries are given vouchers which can be used to purchase inputs at the input fairs. The input fair also includes other input traders and dealers who sell inputs on a cash basis, and as such the input fair increases the accessibility and availability of a wide variety of farm inputs for the beneficiaries.

Numerous studies have been conducted to review the trends and cross-country differences in fertiliser use and supply for countries in SSA during the 1990s (Crawford *et al*., 2003; Jayne *et al*., 2003; Neesem & Kelly, 1999). Other studies dealing with factors affecting the use of fertiliser have concentrated on country-level policy issues, such as pricing of fertiliser and other complementary inputs, private sector participation in input supply and the general marketing of fertiliser (Kelly, 2005; Camara & Heineman, 2006). Besides the low fertiliser use in SSA, fertiliser use varies considerably among farmers in the same sites. While most studies have focused on economic, household and farmer characteristics and how they influence fertiliser use (Knepper, 2002; Waithaka *et al*., 2007; Olayide *et al*., 2009; Olwande *et al*., 2009; Mapila *et al*., 2010; Zerfu & Larson, 2011), little attention has been paid to understanding the impact of social and human capital on fertiliser use (Isham, 2002; Njuki *et al*., 2008) or farmers' perceptions of fertilisers and their effects on soil fertility.

This paper looks at fertiliser use in southern Africa, specifically analysing the determinants and differences in fertiliser use within the Chinyanja Triangle covering parts of Malawi, Zambia and Mozambique.

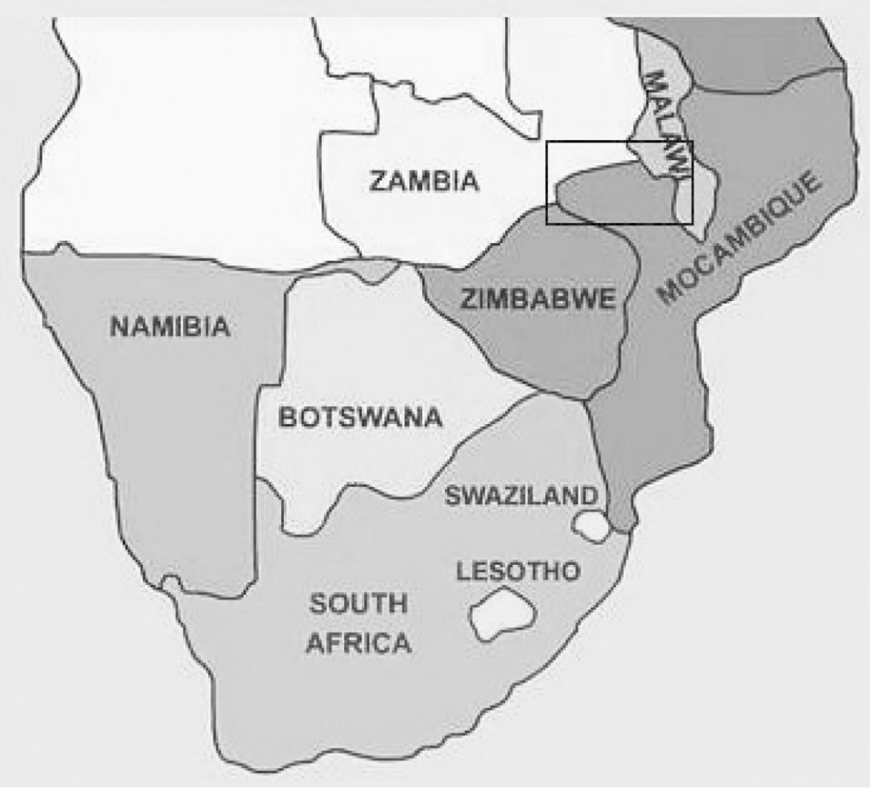

Figure 1: Map showing the Chinyanja Triangle
Source: http://images.bidorbuy.co.za/user_images

The Chinyanja Triangle has a similar agro-ecology throughout, but varies considerably in the socio-economic and policy environments, making it ideal for an evaluation of socio-economic factors that are influencing fertiliser use in southern Africa.

2 METHODOLOGY

2.1 Site description

The Chinyanja Triangle comprises the Eastern Province of Zambia, southern and central regions of Malawi and Tete Province of Mozambique, where the predominant language is Chinyanja (Figure 1). The area has an annual rainfall of 900–1300 mm and agriculture is the predominant source of livelihood (Hijmans *et al*., 2005; Myburgh & Brown, 2006). The area is landlocked, not easily accessible and fertilisers are transported over long distances, making them very expensive. Population density is generally high and the average land holdings are less than one hectare (Ajayi *et al*., 2003; Myburgh & Brown, 2006).

2.2 Sampling approach

A three-stage cluster sampling technique was used to select 630 farming households. In the first stage of sampling, five sites were purposefully selected from five districts across the three countries. The sites were selected based on the criterion that several research and extension institutions are working in those districts to promote soil fertility management through the use of improved technologies, including the appropriate use of inorganic fertilisers. Two sites were selected from Malawi (Lilongwe and Kasungu districts), two from Mozambique (Tsangano and Angonia districts), and Chipata district from Zambia. In the second stage of sampling, eight villages were selected within the pilot sites for the USAID-funded Livelihoods Improvement Programme. The third stage involved random selection of 630 households from within these sites, with 367, 135 and 138 farming households from Malawi, Zambia and Mozambique, respectively. The number of sampled households from each country depended on the total number of households that participated in the livelihood improvement programme, thus Malawi had a larger sample as more households participated in the programme as compared with either Zambia or Mozambique.

A semi-structured questionnaire was used to collect information pertaining to access, availability, utilisation and marketing of inorganic fertilisers for the 2005/06 and 2006/07 cropping seasons. Information collected was both from limited records (very few households had these) and from recall memory of the participants. With the latter, efforts were made to ensure that decision-making members of the households were available for the interview. In addition, information on the knowledge of other soil fertility management practices, use of those technologies, crop and livestock production, income-generating activities, markets and agro-enterprises, food security and dietary diversification, human, social capital development and gender relations were collected.

2.3 Data analysis

A logistic regression model was used to determine the factors influencing the decision to use fertiliser in the different countries. This approach was chosen as it can deal with a large number of random explanatory variables (Sykes, 1993) and is appropriate when the exogenous variables are a mix of continuous and categorical variables. More importantly, logistic regression modelling is relevant due to the binary nature of the dependent variable. Separate models were estimated for fertiliser use for Malawi, Zambia, Mozambique and the relationship between fertiliser use in the different countries was conceptualised as follows (Gujurati, 1992:423):

$$\text{In} \quad (P_i/1-P_i) = \beta_0 + \beta_1 X_1 + \ldots\ldots + \beta_{19} X_{19} + e$$

Where:

P_i	is the probability of using fertiliser (0 = No, did not use, 1= Yes, diduse fertiliser)
β_0	is the intercept
β_1 to β_{19}	are the parameter estimates
X_1 to X_{19}	are the independent variables
e	is the error term

Model estimation and variable selection for the model were based on a combination of key groupings of variables that strongly influence fertiliser use by smallholder farmers and were influenced by the hypothesis that a household's decision to use inorganic fertiliser is influenced by three main underlying factors. These are the potential profitability to the household of using fertiliser, the willingness, and the ability of the household to purchase fertiliser (Morris *et al*., 2007). According to Morris *et al*. (2007), a household's potential profitability from using fertiliser is determined by the responsiveness of the crop to which fertiliser is applied, the prices of fertiliser on the market, and the prices of both substitutes and complements as well as output prices. Furthermore, the ability of a household to purchase fertiliser is determined by the household's purchasing power, which is determined by different factors, including the availability of cash or credit and the proximity of the household to the point of sale of fertiliser and access to subsidised fertiliser.

Lastly, the willingness of a household to purchase fertiliser is determined by the household's perceptions of profitability, and this is shaped by the household's level of knowledge and skills regarding fertiliser technologies and their capacity to evaluate the potential gains from fertiliser use. Thus, farmer perceptions as well as social and human capital variables were included in the model. Social capital has been found to have an influence on the adoption of soil fertility management technologies (Njuki *et al*., 2008). Membership of groups implies that farmers without enough resources to purchase fertiliser can pool their resources for bulk purchases of fertiliser. Group extension has also become an important feature of extension services in the region and farmers who belong to groups are more likely to access extension and educational services compared with farmers working on their own. Many development organisations and extension departments find it easier, and more cost effective to work with groups of farmers as opposed to individual farmers. Studies also show a relationship between social capital and adoption and diffusion of technologies and information (Isham, 2002; Padmaja *et al*., 2006).

Hence, the following variables (Table 1), which have been grouped according to social and human capital (SC), farmer's perceptions (PER), household characteristics (HC) and farmer characteristics (FC), were included in modelling the decision to use fertiliser in the Chinyanya Triangle as they shape and affect either positively or negatively a household's willingness and ability to buy fertiliser as well as the potential profitability of using inorganic fertiliser.

Table 1: Description of exogenous variables

Variable	Description	Expected effect on decision to use fertiliser
sc_grp	Membership by household head in farmer groups (0= Not a member, 1= Yes, a member).	+
sc_training	Participation in agricultural related trainings and study tours (0= No participation, 1= Yes, has participated)	+
fc_constraints	Household faces constraints in accessing and utilising inorganic fertiliser (0= some kind of constraints are faced, 1= No constraints exist)	-
fc_landsize	Total farm size (in acres)	+
fc_subsidy	Access to subsidised fertiliser (0= No, did not receive coupon, 1= Yes, received coupon)	+
fc_harvest	Duration of the harvested maize crop for a household (in Months)	+
hc_savings	Savings by household (0= No, does not have savings, 1= Yes, has savings)	+
hc_sexhh	Sex of the household head (0= female headed household 1= Male headed household)	-
per_fertliser	Perception that fertiliser is bad for the soil (0= Has no perception, 1= Yes, fertiliser is bad for the soil, 2= No, fertiliser is not bad)	-
per_poverty	Perception of the household's level of poverty (0 = very poor, 1= poor, 2= not poor)	-

sc= social capital variable, per = perceptions, fc= farming characteristics; hc=household characteristics;+ positive influence; - negative influence

This study captures social capital in the variables for participation in farmer groups; and participation in agricultural-related trainings and study tours. It should be noted that there are different types of variables that can be used to capture social capital. This is because it is defined differently in the literature. Putman (1993) and Lochner *et al*. (1999) define social capital as the aspects of society which facilitate collective action and which act as resources for individuals. These include social networks, trust as well as norms of mutual aid and reciprocity. Lochner *et al*. (1999) further add that social capital has a collective dimension as it is external to the individual, and the structure of social capital is hence different from economic capital (money, financial capital) or human capital, such as education and training, which are more individual. Social capital captures network-based processes or aspects of social structure that generate communal benefits through norms and trust (Durlauf & Fufchamps, 2004). It is the establishment of norms that permit people to work in groups, hence social capital is the consequence of intensely rooted cultural habits (Fukuyama, 2004), and as a result, it is defined differently in different cultural settings.

3 RESULTS AND DISCUSSION

3.1 Descriptions of households

The average age of household heads was 40 years for all three countries, with household heads in Zambia being significantly older than those in Malawi and Mozambique (Table 2). Total average land size was 1.7 ha and this did not differ significantly across the countries. Households cultivated an average of two plots, with the largest average number of plots (2.75) cultivated in Mozambique. Income from the top three priority sources of income was significantly lower for Malawi compared with Mozambique and Zambia, but the income from all three countries was below the poverty line level of US$1 per day. In Malawi and Mozambique, a majority of the respondents (76 and 74 per cent, respectively) perceived themselves as poor. This percentage was much less in Zambia, where only 59 per cent of the respondents perceived themselves as poor. The proportion of farmers with savings was greatest in Malawi (55.2 per cent), followed by Zambia (40 per cent) and Mozambique (42 per cent). This was despite the farmers in Malawi having the lowest incomes for the three countries. Malawi had the lowest number of months (8.9 months) of food availability from the 2005/06 season compared with Zambia (10.5 months) and Mozambique (10.7 months) of food availability.

Table 2: Household descriptive statistics in Malawi, Zambia and Mozambique

Farmer Characteristics	Malawi (n=357)	Zambia (n=135)	Mozambique (n=138)	F-Value
Average age of head of household in years	38.6	44.5	39.4	7.923***
Average farm size in ha	1.7	1.8	1.6	0.567
Average annual income from top 3 priority sources of income (USD)	178	250	287	2.574*
Average distance to source of fertiliser (km)	12.2	14.7	15.4	3.111**
Number of months that harvested main food lasted in the last season	8.9	10.5	10.7	22.723***
Household Attributes	**Malawi**	**Zambia**	**Mozambique**	**All countries**
Percentage of heads of households with primary education and above	86.2	87.3	73.7	83.7
Percentage of male headed households	81.0	64.4	84.1	78.1
Percentage of households with savings	55.2	40.0	42.3	49.1
Percentage of households using manure	54.6	83.0	41.3	57.8
Percentage of households that have participated in agricultural training	33.9	60.0	20.4	36.6
Percentage of households that perceive themselves as poor	76.1	58.5	74.3	71.9
Percentage of households that perceived fertiliser as bad for the soil	30.0	52.6	23.4	32.2
Percentage of households that belong to a group	29.4	68.1	48.2	41.8
Percentage of households with access to subsidised fertiliser in the 2005/06 season	21.8	NA	23.9[1]	-
Percentage of households with access to subsidised fertiliser in the 2006/07 season	46.2	NA	26.8	-
Percentage of farmers using irrigation	49.9	71.9	70.6	59.1
Percentage of farmers growing maize for cash or for both cash and food	22.5	43.7	27.7	28.2

* Significant at 10% level; ** Significant at 5% level;
*** Significant at 1% level

Zambia had the highest proportion of female headed households with 35.6 per cent followed by Malawi with 19 per cent and Mozambique with 15.9 per cent. Zambia had the largest proportion of farmers who belonged to a farmer group and farmers who had received training in agriculture or participated in a study tour and had an extension officer within the village.

3.2 Frequency and intensity of fertiliser use

In order to make comparisons across countries, fertiliser use was limited to use in maize production, which is the main staple across the Chinyanja Triangle and to which farmers preferably apply fertiliser (Camara & Heineman, 2006). From the 630 respondents in the interview, 60 per cent used fertilisers in the 2005/06 growing season. This increased to 72.2 per cent in the 2006/07 growing season. Zambia had the highest number of farmers who used fertilisers, with 83 per cent and 87.4 per cent of farmers using fertiliser in the 2005/06 and 2006/07 seasons, respectively. This can be attributed to the consistency of input support programmes that are in place in Zambia. Mozambique had the lowest proportion of respondents using fertilisers (41.3 per cent in the 2005/06 season and 44.9 per cent who used fertilisers in 2006/07), which can be attributed to the lack of an intensive fertiliser subsidy programme. In Malawi, there was a significant increase in farmers using fertilisers from 54.6 per cent in 2005/06 seasons to 77 per cent in the 2006/07 season. This can be attributed to the implementation of the full fertiliser subsidy programme in the 2005/06 season.

In addition to having the largest percentage of farmers who used fertilisers, Zambia also had the highest average amount applied per ha of maize, with farmers applying 52.2 kg per hectare in the 2005/06 season and 50.5 kg/ha in the 2006/07 season (Table 3). Despite the increase in farmers using fertilisers, the intensity of fertiliser application in Malawi declined considerably from 44.2 kg/ha in the 2005/06 season to 33.1 kg/ha in the 2006/07 season. This represents a decrease of 25.11 per cent fertiliser use intensity between the two cropping seasons. There were significant differences ($p=0.001$) in amounts of fertiliser applied across the three countries in the 2006/07 season, with farmers in Zambia applying significantly higher amounts of fertiliser than farmers in either Malawi or Mozambique. The differences in intensity of fertiliser application for the 2005/06 season, across the three countries, were not significant, however.

Table 3: Use of fertilisers on maize in Malawi, Zambia and Mozambique

	Malawi	Zambia	Mozambique	F statistic
Quantity of fertiliser use – 2005/06 season (kg/ha)	44.2	55.2	31.79	1.264
Quantity of fertiliser use – 2006/07 season (kg/ha)	33.1	50.5	32.3	17.088***
% of farmers using fertilisers in 2005/06 season	54.6	83.0	41.3	
% of farmers using fertilisers in 2006/07 season	77.0	87.4	44.9	

* Significant at 10% level, ** Significant at 5% level,
*** Significant at 1% level

The average fertiliser use intensity for all three countries was much higher than the reported values, particularly for Zambia. Crawford *et al*. (2005) reported relatively low rates of fertiliser application in Zambia and Mozambique (8.4 kg/ha and 3.2 kg/ha, respectively), with Malawian farmers using an average of 30.8 kg/ha. The intensity is also much higher than that reported for 1999 of 23 kg/ha, 10 kg/ha and 2 kg/ha in Malawi, Zambia and Mozambique, respectively, and for Malawi it is quite similar to that reported by Snapp *et al*. (2003) of 40 kg/ha. The higher fertiliser use could be attributed to two factors. Firstly, the study targeted villages that were part of the Livelihood Improvement Programme, which aimed at improving agricultural productivity and accelerating economic growth in the area through an integrated approach comprising different components and partners. Secondly, the Chinyanja Triangle straddles the borders of the three countries and this could facilitate the creation of parallel markets and informal cross-border trade, which can lead to greater accessibility and availability of inorganic fertiliser that may not pertain in areas that are further from the international borders.

3.3 Factors influencing the decision to use fertiliser in the three countries

The results of the estimated logistic regression models for fertiliser use in the three countries are given in Table 4 below. The estimated logistic regression models correctly predicted 77.3 per cent, 88.8 per cent and 54.4 per cent of the total variation in fertiliser use for Malawi, Zambia and Mozambique, respectively. The robustness of the estimated model for Mozambique is lower than for Malawi and Zambia and this can be attributed to the fact that the majority of households in Mozambique had no written records or information pertaining to their farming enterprises as compared with households in either Malawi or Zambia. The availability of some form of written records in Malawi and Zambia was because more households were members of farmer groups as compared with Mozambique, and in those farmer groups members were encouraged and trained to keep some form of written records. In general, however, all the estimated models are good estimates of the decision to use fertiliser in each of the three countries, as each model has a Chi-square static that is highly statistically significant. In addition, each model has a Hosmer–Lemeshow (H–L) Chi square that is above 0.05, and that is significant. This indicates that the models are a good fit for the actual decision to use fertiliser, as the rule of thumb for accepting a logistic regression model is that the H–L static must be greater than 0.05 and it should show non-significance (Hosmer & Lemeshow, 1989).

3.4 Household and farming characteristics

The sex of the household head was found to be statistically significant at the 10 per cent level of confidence in influencing the use of fertiliser in Zambia, but was insignificant in both Malawi and Mozambique. This implies that for Malawi and Mozambique there are no gender differences in the use of fertiliser and that female headed households are as likely to use fertiliser as male headed households. This finding agrees with some empirical evidence which shows that differences in sex of the household head do not significantly affect the decision to use inorganic fertiliser (Knepper, 2002; Xu *et al*., 2006, Mapila *et al*., 2010). Zambia, on the other hand, had an odds ratio of 7.506 on the variable for sex of the household head, implying that if the household head is male then fertiliser use is likely to increase by a factor of 7.506. Sex of the household head is by far the most important factor influencing fertiliser use in Zambia as it has the largest significant odds ratio. The findings from Zambia agree with other empirical evidence which supports gendered differences in fertiliser use (Chirwa 2005 cited by Xu *et al*., 2006) arising from women's poor social and economic standing. The lack of consistency of the impact of the sex of the household head between Zambia and the other two countries is in line with the literature, which shows that there is a lack of agreement on the effects of the gendered differences in agricultural input use (Peterman *et al*., 2011).

The availability of savings was found to be insignificant in the use of fertiliser for all countries. This is in contrast to the expectations of the study, as it was hypothesised that the availability of savings by households enables them to purchase fertiliser and it is also likely that those households with savings are also wealthier and therefore able to purchase inputs.

In terms of farming characteristics, the results indicate that it is only in Mozambique in which farming characteristics are statistically significant in influencing the decisions to use fertiliser. As can be seen from Table 4, the land holding size and constraints faced in accessing and utilising inorganic fertiliser were found to be positive and statistically significant in influencing the use of fertiliser in Mozambique at the 10 per cent and 5 per cent levels of confidence, respectively. The implications of this are that households that do not face constraints in accessing and utilising inorganic fertiliser are likely to increase their use of fertiliser by a factor of 6.954 while an increase in the land holding size of the households is likely to increase use of fertiliser by a factor of 1.246. The non-significance of the land holding size on the decision to use fertiliser by households in Malawi and Zambia agrees with empirical evidence which shows that the probability of using fertiliser is unlikely to be influenced by the farm size (Minot *et al*., 2000). The findings for Mozambique, however, also agree with some empirical evidence which shows that households with small land holdings are more likely to use fertiliser than households with relatively larger land holdings (Aklilu 1980; Mapila *et al*., 2010). Table 2 above shows that there were no statistically significant differences between the land holdings sizes for the sampled households across the three countries. However, households in Mozambique had relatively lower average land holdings sizes. The effect of the farm size is weak, however, with constraints in accessing and utilising fertiliser use being the most important factors influencing the use of fertiliser in Mozambique, as the variable has the largest odds ratio. This could imply that when households are faced with constraints in obtaining fertiliser or in utilising it, they make the decision not to use fertiliser.

Access to a coupon for subsidised fertiliser was included as a variable for the Malawi and Zambia models and it was expected that farmers with access to subsidised fertilisers would use higher levels of fertiliser than those that had no access to the subsidy. It was, however, found to be statistically insignificant in influencing the decision to use fertiliser. This can be attributed to the fact that in the study area it was found that not all households that received a coupon actually used it to purchase fertiliser, but some sold their coupons for cash. As such, receiving a coupon for subsidised fertiliser did not imply that households actually used fertiliser. In addition, it emerged from discussions with farmers that the majority of farmers had not planned to purchase fertiliser in anticipation of the subsidised fertiliser from the government. Lower quantities of fertiliser were supplied per farmer in the subsidy programme, and few farmers were able to purchase fertiliser to augment the subsidised fertiliser they received. In Malawi, farmers buy fertiliser at an equivalent of US$22 per 50 kg of fertiliser while the subsidised fertiliser costs $6.8 per 50 kg bag. When preparing for the 2006/07 season, farmers had saved only enough money to buy the subsidised fertiliser and when this was not enough, they had no resources to purchase additional fertiliser, leading to either non-use or to use of lower quantities of fertiliser. One of the issues reported by

Crawford *et al*. (2003) as a potential cause of low input use in the presence of government programmes is the undercutting of the private sector, which increases the uncertainty of input marketing and in turn could lead to low availability of inputs to smallholder farmers. While the fertiliser subsidy programme was implemented through a government affiliated organisation in 2005, this was changed to include the private sector in 2006, with the aim of improving the distribution system and involving the private sector more. This greatly increased the access to subsidised fertilisers by farmers. Of the 357 households surveyed in Malawi, 21.8 per cent received government subsidised fertiliser in the 2005/06 growing season. This percentage increased to 46.2 per cent in the 2006/07 growing season. While the programme reached more farmers, it did not significantly lead to increased use of fertiliser by the targeted beneficiaries in some areas, such as those in this study.

Table 4: Results of the logistic regression models for Malawi, Zambia, and Mozambique

Explanatory variables	Country								
	Malawi			Zambia			Mozambique		
	β	Std. Error	Odds ratio	β	Std. Error	Odds ratio	β	Std. Error	Odds ratio
Constant	-2.842	1.008	0.058**	-4.201	2.007	0.15*	-4.921	1.249	0.007***
sc_grp	0.282	0.405	1.325	0.589	0.803	1.802	1.047	0.404	2.849*
sc_training	1.186	0.537	3.273*	-0.988	1.271	0.372	0.037	0.485	1.035
fc_ constraints	0.415	0.595	1.514	1.562	1.337	4.766	1.939	0.742	6.954**
fc_landsize	0.072	0.057	1.075	-0.077	0.148	0.926	0.220	0.091	1.246*
fc_subsidy06	26.374	2030	2.844	19.310	4706	2.434	-	-	-
fc_harvest	0.223	0.053	1.250***	0.475	0.137	1.608**	0.112	0.40	1.118*
hc_savings	0.091	0.370	1.095	-0.692	0.909	0.501	0.587	0.418	1.799
hc_sexhh	0.082	0.502	1.088	2.016	1.016	7.506*	0.175	0.299	1.191
per_fertliser	-0.446	0.287	0.640	-1.088	0.628	2.969*	-0.044	0.193	0.957
per_poverty	0.130	0.208	1.139	0.274	0.362	1.315	0.191	0.386	1.211
Model Chi-Square		167.830***		45.593***			29.743***		
H-L Chi-Square		5.665	ρ=0.685	3.553	ρ=0.895		8.033	ρ=0.430	
Log Likelihood		209.48		48.356			157.732		
% correctly predicted		77.3 %		88.8 %			54.4 %		

* Significant at 10% level; ** Significant at 5% level;
*** Significant at 1% level

Availability of food and the crop performance in one season have implications on farmers' decisions to use fertiliser in the succeeding season. Results from all three countries show that households with lower food reserves were less likely to use fertiliser than households with greater food reserves. Table 4 shows that in Malawi the duration of the maize harvest was highly statistically significant in positively influencing the decision to use fertiliser, with the odds of using fertiliser increasing by a factor of 1.250 the longer the maize harvest lasted. In Zambia, duration of the maize harvest was found to be statistically significant in positively influencing the decision to use fertiliser at the 5 per cent level of confidence, with the odds of using fertiliser increasing by a factor of 1.608 the longer the harvest lasted. In Mozambique, duration of the maize harvest was found to be statistically significant in influencing the decision to use fertiliser at the 10 per cent level of confidence, with the odds of using fertiliser increasing by a factor of 1.118 the longer the harvest lasted.

Additionally, the duration of the maize harvest is the only variable that was found to be statistically significant in all three countries. Since the results indicate that the longer the maize harvest lasts, the higher the probability of using fertiliser, it implies that households with smaller food reserves used up their savings and other available resources to bridge the food deficit at the expense of purchasing inputs. Conversely, it is possible that households that use less fertiliser achieve lower yields and have lower food reserves. Households with food deficits are also much poorer, have a low resource base and therefore not able to purchase capital-intensive inputs. Households' ability to purchase inputs including fertilisers is determined by their levels of resource endowment, assets, and disposable income (Crawford *et al*., 2003), and the poorer households have fewer of these resources at their disposal. Reardon *et al*. (1995) view expenditure on production inputs as a function of incentives and the capacity to purchase. Such incentives could include output markets as well as policy incentives. The food shortage is more critical in Malawi compared with either Zambia or Mozambique, which explains the lower levels of significance of the duration of the maize harvest in those two countries.

3.5 Social and human capital

Households that had participated in agricultural related training, which also included study tours, were found to be more likely to use fertiliser in Malawi, but not in Zambia or Mozambique. Participation in training and study tours was found to be statistically significant in increasing fertiliser use in Malawi at the 10 per cent level of confidence, with the odds of using fertiliser increasing by a factor of 3.273 if a household participated in training or a study tour. Kelly *et al*. (2003) also reported increased use of fertilisers in Nyanza Province of Kenya as a result of promotional strategies such as farmer training, demonstrations, and participatory input testing. Additionally, the results for Malawi can be attributed to the fact that Malawi has a more intensive extension system than either Zambia or Mozambique, and literature shows that extension service provision and extension intensity significantly and positively influence the use of inorganic fertilisers and adoption of other technologies generally (Kaliba *et al*., 2000; Okuro *et al*., 2000).

Membership of a farmer group was found to be statistically significant in positively influencing fertiliser use only in Mozambique, and not in Malawi or Zambia. In Mozambique, it was found that membership by the household head of a farmer group increased the odds of using fertiliser by a factor of 2.849, and this was statistically significant at the 10 per cent level of confidence. Both theory and empirical evidence have shown that membership of farmer groups increases the probability of fertiliser use (Minot *et al*., 2000), as farmer groups are the main mechanism through which credit is accessed in rural areas where farmers have no other forms of collateral. In Malawi and Zambia, farmer groups were found to be non-significant in influencing the decision to use fertiliser. It could be that information pertaining to fertiliser use is very widespread in both these countries via the extension service system and as such non-membership of a farmer group does not necessarily imply that farmers have less access to information pertaining to fertiliser use.

3.6 FARMER PERCEPTIONS

The perception of fertilisers as bad for the soil was found to be significant and negative for Zambia at the 10 per cent level of confidence. This implies that farmers who perceived that fertilisers were bad for the soil were less likely to use it by a factor of 2.969. More than 30 per cent of the sampled farmers across the three countries believed that fertilisers were bad for the soil. Out of these, 55.4 per cent were female. There were other misconceptions associated with fertilisers that have implications for the use of fertilisers by farmers. These included the belief that the use of inorganic fertiliser reduces soil fertility. Some of the misconceptions on fertiliser use could be attributed to lack of farmer training on the use of fertilisers by extension agents. This underlies the importance of farmer perceptions in the promotion of input use and the need for training.

4 CONCLUSION AND RECOMMENDATIONS

There has been growth in the use of inorganic fertilisers in southern Africa and especially in Malawi, Zambia and Mozambique, where interventions to improve access to fertiliser by smallholder farmers have been implemented. The greatest noteworthy change in the number of farmers using fertiliser (23 per cent) was in Malawi, due to the expansion of the successful subsidy programme in the

2006/07 cropping season. In Zambia, the consistency of government input support programmes have led to the majority of rural smallholder farmers utilising inorganic fertiliser. Government-supported input programmes are essential for promoting increased use of inorganic fertiliser in the region. In order for such programmes to be effective and sustainable in improving livelihoods, and in ensuring not only increased utilisation but also increased intensity of fertiliser use, there is a need for consistency in programme implementation and deliberate efforts in programme design to ensure not only increased utilisation but also intensification of fertiliser use and continued political will.

In addition, successes in the use of inorganic fertiliser in the Chinyanja Triangle can be improved by designing policies that focus on the impacts of social and human capital and farmer perceptions of fertiliser use and how they influence the use of fertiliser by smallholder farmers. Investments into promoting the use of fertilisers have largely focused on increasing access, but the results of this study clearly indicate that an increased focus on understanding and influencing farmers' perceptions towards fertilisers as well as social and human capital characteristics is critical if large-scale adoption of fertiliser is to be possible. For those promoting a new green revolution in Africa, this will require other strategies, such as training in the appropriate usage of fertiliser, changing farmers' negative perceptions of inorganic fertiliser and building farmers' saving capacity. In addition, for any of these strategies to be effective, they must be geared towards specially identifying and targeting vulnerable households such as those that are female headed and those that are food insecure.

Finally, fertiliser subsidy policy in the three countries is not set collaboratively. However, a key feature of the Chinyanja Triangle is the shared tribal norms and their geographical proximity, which is evidenced by the accessibility to subsidised coupons by Mozambican farmers. Further research needs to be conducted in this area to quantify the spill-over effects for Mozambique arising from the fertiliser subsidy programme in Malawi, the welfare and productivity losses for Malawi of cross-border subsidy spillage, the importance of geography versus social and cultural norms in transcending geopolitical boundaries in accessing subsidised fertiliser and the potential for intra-government collaboration in fertiliser policy design and implementation for Malawi, Zambia and Mozambique.

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NOTE

1 These are farming households in Mozambique who accessed subsidised fertiliser from Malawi as they live on the border and are able to register as village members on both sides of the border line.

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