The 8th AFMA Congress

Peer Reviewed Papers

Theme:

"Repositioning African Agriculture by Enhancing Productivity, Market Access, Policy Dialogue and Adapting to Climate Change"

MOI UNIVERSITY PRESS

An Economic Analysis of Precision Application of Climate at Reduced Rates

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Abstract

Acidity is among the problems that affect crop production in Zambia. The problem is no longer restricted to the traditional agro-ecological region III but has now become widespread in all parts of Zambia. The problem is exacerbated by continuous use of chemical fertilizers and mono cropping. More than 700,000 small scale farmers are troubled by acid soils. The only available and most common way of preventing and ameliorating the problem is through use of lime in the fields. At the recommended rates of about 2 tons, small scale farmers cannot afford. Using data from on-station and demonstration plots carried out by Golden Valley Agricultural Research Trust (GART) and Conservation Farming Unit (CFU), the study determines the yield and financial gains smallholder farmers can achieve if lime was precisely applied at reduced rates in the agro-ecological zones I and II. The results from the marginal analysis show that at reduced rates, lime use is profitable in maize at Batoka research station and in soybeans and groundnuts at Chisamba GART research station. Compost and lime synergy in groundnuts at Chisamba GART research station was profitable with marginal returns of over 150%. Lime could therefore be recommended for use even at reduced rates as the yields are on average higher than where it is not used and the returns were positive.

Key word: Lime, reduced rate, marginal returns, Zambia

Introduction

Soil acidity is a soil fertility problem that is widespread in Zambia and is one of the factors negatively affecting crop production (Munyinda, 1985; Ragnar, 1987). Soil acidity is not only limited to the regions that were initially known to be acidic, it is present in almost all parts of Zambia with 51% of maize production taking place in soils with less than 4.3 pH. The recent physical and chemical characterization of the soil resources in agro ecological zone I and II have shown an overall decline in fertility status of many soils, in particular the soil organic matter and soil pH (Chipeleme *et al.*, 1998; Banda *et al.,* 2001 in GART 2002). This is a result of different land use practices that farmers engage in that lead to acidity. The extent of soil acidity or rather the pH is measured by the amount of hydrogen and aluminium present in the soil. Hydrogen (H^+) is formed through the oxidation of organic matter and residues, root respiration and the oxidation of ammonal fertilizers (Thiubaud, 2000).

Liming is the most known and most accessible method of both preventing and ameliorating acidity problems. Despite its known benefits in terms of preventing and curing the acidity problems, the practice is not very much embraced by small scale farmers in Zambia and no policy measures have been undertaken to address it (Burke *et al.,* 2012), making even the fertilizer subsidies ineffective to a certain level. Shitumbanuma and Simukanga (In Mitchell *et al.*, 2005) estimated the consumption to be around 40,000 tons per annum and this was mainly from the large or commercial farmers which far below the latent consumption estimated at 150, 000 tons per annum. To achieve the required level of liming, it will require promotion of the benefits ensuing from liming to small scale farmers especially.

On the side of small scale farmers, sometimes the benefits are not known and affordability is a problem. Mitchell *et al.* (2005) say the commonly held views by small scale farmers for not using lime in their fields is that it is expensive and difficult to get and they don't see the benefits. Farmers also see lime and fertilizer as substitutes in the extreme case, high costs for field level tests (these test are centralized in Lusaka), and most importantly for this study, the recommended rates of 2 tons per hectare are inhibitive. Farmers have to follow the commodity (lime) to towns and the transport costs might not allow, making the commodity inaccessible.

The Conservation Farming Unit of the Zambia national farmers has recommended use of lime at reduced rates so as to reduce on the unaffordable high rates of about 2 tons per hectare (CFU, 2007). The reduced rates can be applied on the crop or in the basin, or in the furrow (precision application) for ox farmers instead of broadcasting it over the field. Other studies have shown improvement in soil properties upon use of lime (GART, 2001). Other studies [Mitchell *et al.* (2005), Ragnar (1987)] have shown financial benefits with value cost ratios greater than 2.0 for different application rates at different levels of acidity. However, the knowledge gap that still exists is whether the reduced rates can be profitable in agro-ecological zone (AEZ) I and II. The objective of this paper is to determine profitability of lime application, at reduced rates and the synergistic benefits with other nutrient sources like compost and manure.

Methods and Materials

Data Source

Two datasets are used to achieve the stated objectives. The first is from GART, CFU unit that managed demonstration plots for soybeans, maize and groundnuts. This was at Chisamba in agro ecological zone II, the baseline pH was 4.6. This was in the agricultural season, 2008/2009. The treatments included; control, lime only at 100 kgha^{-1}, compost only at 8 tons ha^{-1}, compost and lime at 8 tons/ha and 100 kgha^{-1} respectively, fertilizer only at 200 kgha^{-1} (DC and urea), fertilizer and lime at 200 kg/ha (both top and basal) and 100 kg/ha (lime). The second dataset coming from agro-ecological zone I is from Batoka, with baseline pH of 4.5. The main treatments were the five fertilizer application rates with D compound (DC) and Urea while liming and none liming were the sub treatments. The fertilizer rates were 100kg ha^{-1} DC only (10 kg N ,20 kg P, 10 kg K); 200 kg/ha DC + 100 kgha^{-1} urea (56 kg N,40 kg P,20 kg K); 300 kg ha^{-1} DC+200 kg ha^{-1} urea (122kg N,60kg P, 30kg K); 400kg ha^{-1} DC +300kg ha^{-1} urea (178kg N,80 kg P, 40 kg K); 500 kg ha^{-1} DC + 400 kg ha^{-1} urea (234 kg N, 100 kg P ,50 kg K). Lime rate was 500 kg ha^{-1} at Batoka.

Prices for crops and inputs were collected from AMIC (2009/10) were (in ZMK/kg); maize-1300/kg, groundnuts-4330, soybeans-4000, compos-40, lime-140, fertilizer (urea and DC)-4000.

Analysis of Variance

Analysis of variance was undertaken for the Chisamba demonstration to determine which factors had contributed significantly to the yield of maize, groundnuts and soybeans. The use of analysis of variance is not new, but can be seen even from Kabwe *et al.* (2002). The model was as below and was estimated in Stata. The analysis of variance helps to know which factor and by how much it explains the differences in yield. Through this, it is possible to know how much you can increase or reduce yield by varying the factors that contribute. The factors were analyzed in a partial factorial design so as to determine even the effect of their interactions on yield. $Y_{pqr} = \mu + \tau_p + \beta_q + \delta_r + (\tau\beta)_{pq} + (\tau\delta)_{pr} + \varepsilon_{pqr}$ (1) as the equation, where Y_{pqr} = observed yield for maize or groundnuts or soybeans, μ = the grand mean for maize or groundnuts or soybeans, τ_p = the p^{th} lime effect on yield. β_q = the q^{th} compost or manure effect on yield, δ_r = the r^{th} fertilizer effect on yield, , $(\tau\beta)_{pq}$ = the interaction effect between the p^{th} lime effect and q^{th} compost or manure effect on yield, $(\tau\delta)_{pr}$= the interaction effect between the p^{th} lime effect and the r^{th} fertilizer effect on yield. ε_{pqr}= the error term for the model.

The above model was applied to the CFU 2008/2009 agricultural season data set to help determine the synergistic benefits through the interaction of the terms. and determine the incremental (in yield) effect of lime. For the 2010/2011 Batoka data set, the synergy was between lime and fertilizer was dropped and hence the analysis only involved testing whether there was a significant difference in yield at various rates of fertilizer with a fixed (500kgha^{-1}) lime level.

Economic/profitability Analysis

CIMMYT (1998)'s recommended method for calculating financial gains in any agricultural technology is the marginal analysis technique. In this vein, the partial budgeting based on the technique was used to compare the financial benefits of different lime application rates both in AEZ I and II. When a partial budget is being constructed, it concentrates on the inputs that lead to variation in the costs between the different inputs. In this case, cost of lime varied (purchase and application). The marginal rate of return is calculated as; $MRR_{a-b} = \frac{\Delta N\ B_{a-b}}{\Delta S\ F_{a-b}} * 100$ (2). Where; MMR_{a-b} = marginal rate of return for moving from treatment *a* to treatment *b*. $\Delta N\ B_{a-b}$ = change in the net benefit for moving from treatment *a* to *b*. $\Delta S\ F_{a-b}$ = change in the scarce factor for moving from treatment *a* to *b*. The incremental benefits are computed as: Net incremental benefits = (yield * estimated field price) – (field costs of all inputs) (3). The field costs are given by: Field costs of all inputs = Σ (field price of each input * quantity of that input) (4).

A minimum rate of rate of 8.5% was computed based on the fixed deposits for six months from banks. This was the comparison basis for all the rates of return.

Results and Discussion

Maize, Groundnuts and Soybeans Yields under Lime

The maize model, using ANOVA (Table 1) showed that there were no significant differences in the yields across the different treatments. The overall results further indicate that the model was not significant. This could be due to the overall good clay loamy soils in Chisamba where maize tends to do well and this could have resulted in overall good yields and suppress the marginal changes brought about by the different inputs. Again, since the partial factorial ANOVA results do not show any statistically significant difference in the yields of maize, differential effects are not performed. For Batoka, the yields for lime in all cases against the non-limed blocks, no significance difference was found. This could be due to the huge amounts of fertilizer applied, suppressing the marginal effect of lime. However, lime increased maize yield by 36% from 1.4t ha $^{-1}$ to 1.9t ha ha^{-1}.

The results for groundnuts in table 1 indicate that the model for groundnuts was significant. All the three factors, thereof compost manure, lime and fertilizer were independently significant at 95% confidence level. The interactions of lime and compost and lime and fertilizer were not significant.

Table 1: Partial factorial ANOVA results for compost, lime and fertilizer under maize, Groundnuts and Soybeans 2008-2009

	Maize		Groundnuts		Soya beans	
Treatment	**F-test**	**P-value**	**F-test**	**P-value**	**F-test**	**P-value**
Compost only	1.62	0.2506	7.73	0.0320**	0.20	0.6742
Lime only	0.02	0.9058	13.65	0.0102**	8.09	0.0294**
Fertilizer only	2.75	0.1481	12.43	0.0124**	0.06	0.8092
Lime x compost	0.06	0.8122	1.17	0..3209	0.01	0.9325
Lime x fertilizer	0.38	0.5584	0.35	0.5748	7.20	0.0363**

Source: Own analysis.

***statistically significant at 95% confidence level.*

Equally the same model for soybean partial factorial ANOVA was significant. Yields under compost only, fertilizer only and lime x compost interaction were not significant. However, the interactions of lime and fertilizer and lime only showed that there was significant difference in yields at $\alpha = 0.05$ for both of them as the p-values (0.0363 and 0.0294) were less than the stated alpha value.

The effect of each of the variables above was further analyzed in table 2.

Table 2: Differential effects results for soybeans and groundnuts, 2008/09.

Crop Contrasts	Soya beans		Groundnuts	
	Estimate	P-value	Estimate	P-value
Control vs. lime only	-361 (168)	0.075*	-36 (44)	0.4642
Compost only vs. comp & lime	-382 (168)	0.063*	-102 (44)	0.0601*
Fertilizer only vs. fertilizer & lime	277 (168)	0.15	71.5 (44)	0.1563

Source: Own analysis.

** Statistically significant at 90% confidence level.*

() the numbers in parenthesis are standard errors.

The application of lime to a fertilized field of groundnuts showed that yields could decrease as the estimate value was positive. The decrease in yield is not in contrary with the expectations, it is expected that the yield should increase. This decrease is not significant. These decreases could not be explained by the model, but the interaction and release of nutrients could be one cause and other external factors like the location of the treatment, pests etc. The expectations were confirmed when it came to compost and lime synergy. The compost lime combination resulted in higher yields than compost only treatment as is shown by the negative estimate value. The effect of lime in increasing yields was significant at $\alpha = 0.10$ since the p-value was less than the alpha value.

Given that nothing is applied and the farmer decides to apply lime to soybeans, the yields are expected to increase as shown by the negative contrast value (-361). The increase in yield brought by addition of lime is significant at 90% confidence level as the p-value is less than the (0.10). When lime is added to compost only, the yields also increase and the increase is significant, having the same explanation as the former. The higher yield of lime only compared to the control could be that the lime helped in the releasing of the nutrients that the soil could not otherwise. The compost and lime synergy showing higher yields is no surprise as lime helps in the quick release of nitrogen held by the compost manure. No differential effects were computed for Batoka data as the yields were not significantly different.

Financial Benefits of Lime Use at Reduced Rates

The economic analysis for maize in table 3 below was done using estimates on the costs of labour from other trials that have been carried out. Though the data was collected on the costs of labour, it was not separated across the different treatments. The data for on-station was reduced to reflect the on-farm scenario that is usually lower than the on-station.

Maize on-farm trials did not do very well. Treatments were arranged in the ascending order of costs that vary. Lime only treatment was dominated because it had lower net benefits compared to the higher variable costs than the control. The compost and lime, fertilizer only, and fertilizer and lime treatments were dominated since they had higher costs that vary compared to their lower net benefits than the compost only treatment. Given the farmer is not applying anything in his/her field of maize in Chisamba, if these results are anything to go by, they would be getting ZMK134 for every ZMK100 spent in application of manure at two handfuls per basin. While compost only had relatively low costs in terms of the purchase price, thus the value it was given, the yields were relatively very good. Compost is not valued by most farmers as a potential fertilizer, but the results even in other research have indicated positive returns, like those for Langmead (2000). Well prepared compost is very reach

in nitrogen. For soybeans, the economic analysis showed that lime only treatments were the only one profitable. The rest of the treatments from lime only were dominated. Soybean had a good response to lime, and this could be biologically due to the longer roots that enable it to tap minerals made available through lime. Also the application of lime only at the rate of 100kg/ha had relatively low costs compared to other treatments that included compost or fertilizer which were applied at higher rates, raising the costs.

Net benefits came from compost and lime only treatment, which also had higher yields. The fertilizer only and fertilizer with lime treatments were dominated. The compost only treatment also was dominated because it had lower net benefits than the lime only treatment. The lower net benefits were due to low yields of groundnuts under compost only. Starting to apply lime in groundnuts assuming the farmer used no fertilizer at all, would earn ZMK2.15 for every ZMK1 that was used both in purchase and other costs involved in application of lime. If to this lime, the farmer introduced compost at the rate of two handfuls per pace or basin, they would yield a return of 163% to their capital outlay. The response of groundnuts to lime is in line with what has been found by Langmead (2004) who found that lime increased yields of groundnuts in agro-ecological region III by 22 percent. Even under lime and fertilizer treatment the yields were relatively high but the cost of fertilizer meant the profits were reduced.

The Batoka data showed that costs increased almost linearly with increase in fertilizer applied. The application of lime still was profitable even when couple with fertilizer, though higher levels increased the costs making the enterprise unprofitable as all were dominated.

Table 3: Profitability of lime use in maize, soybeans and groundnuts 2008-2009

	Maize				**Soya beans**				**Groundnuts**			
Treatment	Costs that Vary* (ZMK/ha)	Net benefits* (ZMK/ha)	D	MRR	Costs that Vary* (ZMK/ha)	Net benefits* (ZMK/ha)	D	MRR	Costs that Vary* (ZMK/ ha)	Net benefits* (ZMK/ ha)	D	MRR
Control	0	4752000			0	8852000			0	2173500		
Lime only	48550	4236000	D		48550	9647450		1631%	48550	2277950		215%
Compost only	273750	5118000		134%	273750	9186250	D		273750	2215700	D	
Compost and Lime	322300	4915000	D		322300	8661700	D		322300	2723250		163%
Fertilizer only	1885000	3517000	D		1885000	8123000	D		1885000	1022000	D	
Fertilizer and Lime	1933000	3780000	D		1933000	696450	D		1933000	649450	D	

Source: Own analysis from the CFU data (2009).

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Socio-economic Interfaces of African Indigenous Vegetables in a Subsistence Economy and the Implication for Food Security in Western Kenya

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Abstract

African indigenous vegetables (AIVs) play a crucial role in food nutrition and general livelihoods for both rural and urban populations in Africa. Vegetable production contributes substantially to household income and general household subsistence. Erratic weather conditions coupled with land pressure continues to inhibit supply of vegetables. Conversely, increasing awareness of the nutritional and medicinal value of the indigenous vegetables has triggered unequalled demand. Kenyans are smallholders relying mainly on farming as a source of livelihood where socio economic factors dramatically interact to influence significantly the decision they make in the production of the AIVs. Socio economic factors influencing AIV production among smallholder farmers were investigated. Employing a systematic random sampling, a total of 240 households were interviewed through a questionnaire. Cross tabulations, multiple regressions and correlation analyses were used to analyse the data. Majority of farmers use non-certified local market seeds and organic fertilizers. Agro ecological zone of the farmer, gender, and scale of production significantly influenced the size of land allocated to AIVs. Other significant factors included;

education level of the head of household, access to water for irrigation and extension services. Production of maize (staple food) and livestock compete with AIVs for limited land resource. Remarkably, the choice of seeds and the incidences of pests and diseases were positively correlated. Age, education, scale of production and off farm income also influenced allocation of resources and choice of technology in production of AIVs. It is recommended that to encourage increased production and productivity of African indigenous vegetables, farmers should be supported to adopt improved seeds and irrigation technologies. In addition the Government and NGOs should provide tailored agricultural information services to farmers in Western Kenya.

Keywords: *African Indigenous Vegetables, Subsistence Economy, Western Kenya*

Introduction

The debate as to whether African Indigenous Vegetables could break the jinx of food insecurity in Africa lingers. African indigenous vegetables have a potential to reduce the food shortage in Sub-Saharan Africa (Alistair, 2006 & NRCNA, 2006). Africa as a region is home to hundreds of indigenous vegetables that have fed Africans for tens of thousands of years. These plants are resilient enough and can thrive even in poor soil and well-suited to the small plots and resource constrained rural population. Over the years these species have received little or no attention from the research community. However, despite increasing research interests in the recent past, the vegetables are still overlooked by many scientists, donor community and policy makers in and outside the region. Efforts to explore the potential of such vegetables could lead to enhanced agricultural productivity, more-stable food supplies, and higher incomes in rural areas across the continent.

It is documented that, historically Africans depended mainly on traditional food plants until about five centuries ago, when adventurers and slavers sailing the western seaboard introduced a collection of American crops. These crops included maize, cassava, groundnut, sweet potato, tomato, common bean, chilli peppers, and pumpkin. During the subsequent centuries the crops spread across Africa as more farmers integrated them into their traditional livelihood strategies. The last two centuries, during the colonial era, indigenous crops further suffered neglect with the colonial policies advocating for a shift to familiar crops of mercantile interest, such as tea, cane, cocoa, coffee, cotton, among other crops. These crops were considered valuable in the target markets. Consequently, African indigenous crop were neglected because they were considered "poor people's plants." These subsistence crops were almost entirely ignored in organized agriculture. The valuable exportable cash crops were cultured, harvested, graded, and protected against rodents, insects, and decay with exceptional effectiveness and dispatch. Like grains and fruits, the historical discrimination did not spare Africa's ancient vegetables. It is noted that long ago, hundreds of leaves, roots, tubers, corms, rhizomes, bulbs, seeds, buds, shoots, stems, pods, or flowers were eaten. However, across Africa today the main vegetables are crops such as kales, sweet potato, plantains, cassava, peanut, common bean, peppers, eggplant, and cucumber where majority come from a mere 20 or so species with almost all of foreign extraction. Despite the focus on exotic vegetables, peasant crops, grown by poor people have been found to be robust, productive, self-reliant, and useful with great potential to food security and nutrition (NRCNA, 2006).

Climatic variations in the recent past have posed serious challenges in growing of traditional conventional food crops such as, maize beans and wheat (GoK 2010). Decreasing productivity of traditional crops, coupled with increasing population pressure impedes efforts to overcome food insecurity in Kenya. There is an urgent need to establish and develop alternative and new sources of food that could cope with the challenge. Research and policy has now shifted focus to the cultivation of Indigenous crops. These crops have been dubbed "emerging crops" or "neglected crops" or "orphaned crops". The Government of Kenya, in a bid to tap the potential of these crops, has since developed a policy on emerging crops.

The objective of this study was to investigate socio economic factors influencing African Indigenous Vegetables among smallholder farmers in Western Kenya. The paper is divided into four sections; section one presents the background information on African Indigenous Vegetables, section two shows the methodology that was followed in conducting the study. While section three presents the results and discussions, section four give the conclusions and recommendations.

Materials and Methods

Theoretical Model

Microeconomic theories of the households attempt to capture the intricate structure of household and its distinctive behaviour. According to Mattila-Wiro (1999) information on demographic structure, decision making process, resource allocation, income earning mechanisms and gender division of labour is prerequisite for understanding the effects of public and private sector interventions at the micro level as well as their macro level consequences. Classical economic models assume that household is a rationally behaving unit and that the households attach value of consumption and production of goods as determined by market mechanisms. The view of households in traditional consumer theory is twofold; as a consumer and producer. Akin to a competitive firm in a market economy; households also face production possibility frontier, limited resources with alternative uses and fixed technologies. In a semi-subsistence economy household land is a major constraint and household decision in allocation of the resource is influenced by several demographic and external factors.

Specification of Empirical model

Land ratio allocated to African indigenous vegetables is used as a proxy for the decision to produce the vegetable. The ratio of land to various enterprises is also entered as independent variables to capture how the decision of household in allocating resource to other enterprises influences the decision of AIVs.

Focusing on factors influencing allocation of land resource to alternative farm enterprises, multiple regression analysis is specified as follows:

$$Y = \alpha + \sum \beta_i X_i + \mu$$

Where:

Y=Percentage of land size in acres allocated to African indigenous vegetables

X_i=Socioeconomic variable influencing the size of land allocated to AIVs

α = is the constant and β_i is the coefficient with the sign either negative or positive for all variables.

Specification of the Variables used in the Regression Model

X_1 =Agro Ecological Zone

X_2 =Age of the Head of Household

X_3 =Education Level of the Head of Household

X_4 =Off Farm Income

X_5 =Distance to the Nearest Market

X_6 =Gender of the Head of Household

X_7 =Employment of the Head of Household

X_8=Overall Land Size

X_9 =Fraction of Land Size allocated to Exotic Vegetables

X_{10} =Fraction of Land Size Allocated to Maize

X_{11}=Fraction of Land Size Allocated to Livestock

X_{12} =Extension Services Received

X_{13} =Access to Water for Irrigation

Data collection and analysis

The data was collected from a population of farmers in western Kenya. A household survey of small holder farmers in Keiyo North, Lugari and Central Bungoma districts of western part of Kenya was conducted during the month of July, 2010. Questionnaires were used to collect primary data. The choice of the district was based on three major agro ecological zones of High, Medium and Low altitudes in Keiyo, Lugari and Bungoma districts respectively. The actual households were sampled out from these areas.

Sampling process started by identifying and naming all the provincial boundaries (divisions and locations) within each district as units in the population from which to obtain the sample. From the sampling frame, the actual units of sampling were picked for the final sample using systematic random sampling where every fourth household was picked. Since in statistics a sample size>30 approximates normal distribution where inference can be statistically drawn, a sample size of 30 from each of the locations in the three districts was picked. A total of 240 farm households were interviewed.

Data was analysed using SPSS V17.0. Descriptive statistics was used mainly to present exiting relationships between variables. Cross tabulations, charts and tables were used to summarize the results. Regression and correlation analyses were used to obtain specific relationships.

Results and Discussions

General Farmer Characteristics

Majority of the farmers in the three districts are mainly subsistence smallholders with few farmers renting out their farms to other farmers while others rent from other farmers. Most of the respondents interviewed in the three districts were heads of households (66 percent) implying the reliability of the household information obtained. Table 1 below presents descriptive statistics of mean farm size, market distance and the size of land rented.

Table 1. Descriptive statistics

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Market Distance(Km)	239	0	65	12.30	13.537
Farm Size(hectares)	239	0	14.8	1.52	1.8588
Size Of Land Rented (Hectares)	240	0	2	0.06	0.2284
Source: Authors survey data					

Members of the households interviewed were between 5 to 10 members. However, the number of adults aged between 18 and 60 years were between 2 and 5 members per household meaning that majority of the household members were aged below 18 and/or above 60 years implying a higher dependence ratio among the households in the district. This has implication for the household labour. Gender, as expected had more male than female (table 2), but more households in Bungoma district were dominated by female.

Table 2: Gender of Head of Household

District	FEMALE	MALE
KEIYO	17	26
LUGARI	24	27
BUNGOMA	59	31
TOTAL	10	90

Source: Authors' survey data, 2010

Given the land size and the reliance on farming highlights the significance of small scale farming in general household livelihood of the household in these economies. This is compounded further by the level of education, land tenure and the role of gender. With majority of heads having limited professional training implying inaccessibility to formal employment, hence low off farm income. Communal land ownership is frequently considered a constraint to farm productivity; farmer's effort may be side-tracked in a bid to balance socio-cultural obligations with the demands of commercial agriculture (Kingi and Kompas, 2005). Lack of security may also impede access to credit services that accrue due to other tenure systems.

There were variations in the percentages of land allocated to various enterprises of the overall land size against individual enterprises reflecting possible intercropping among some enterprises in the farm and renting of land outside the farm as noted earlier. Input use in AIV production varied as indicated in figure 2. African indigenous vegetables occupy about 9.6 percent of the total land size on average in the three districts. Moving from up lands to lowlands, Keiyo district allocated the highest percentage of land size to the AIVs. Comparatively farmers grow less exotic vegetables (Kales e.g. Cabbage and *Sukumawiki*) with an average of 6.61 percent of the total land cultivated. Keiyo district still had the highest percentage allocation of average land size of 15.82 percent followed by Bungoma and Lugari at 8.2 percent and 7.6 percent respectively

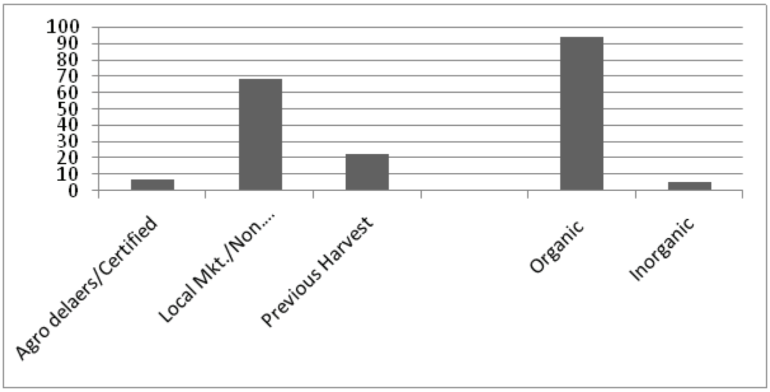

Figure 1: *Seeds and Fertilizer use in AIV production*

Keiyo district with the least average land had a higher percentage of land allocation to both AIVs and Banana production. Unpredictably, Sorghum and Millet production exceeded that of traditional cereals such as Maize and Common beans.

Factors influencing AIV Production

Multiple regression analysis was used to determine socioeconomic factors influencing household decision to allocate land resource to African indigenous vegetables. Table 2 indicates the variables influencing farmer's decision.

Table 3: Estimated parameters of Factors influencing Land Allocation to AIVs

Estimated parameters of Factors influencing AIV Land Allocation		
Variables	**Coefficients**	**Std. Error**
(Constant)	38.111	(4.316)***
Agro Ecological Zone	-5.253	(0.991)***
Age of the Head of Household	-0.016	(0.212)
Education Level of the Head of Household	2.420	(1.098)**
Off Farm Income	0.995	(1.779)
Distance to the Nearest Market	0.039	(0.059)
Gender of the Head of Household	-6.299	(2.397)***
Employment of the Head of Household	-1.450	(2.249)
Overall Land Size	-0.534	(0.157)***
Fraction of Land Size allocated to Exotic Vegetables	0.063	(0.075)
Fraction of Land Size Allocated to Maize	-0.293	(0.041)***
Fraction of Land Size Allocated to Livestock	-0.313	(0.053)***
Extension Services Received	3.528	(2.025)*
Access to Water for Irrigation	-4.495	(1.804)**
R^2= 0.471 Adjusted R Square=0.428 Model F-Value 11.654*** Level of significance denoted as *, **, *** representing 10%, 5% and 1% respectively		

Source: Authors Survey Data, 2010

Agro ecological zone significantly influenced the ratio of the size of land allocated to indigenous vegetable. Moving down the zones, a farmer in

Keiyo is likely to allocate more land compared to a farmer in Lugari and Bungoma districts respectively. Indigenous production is influenced by the gender of the head of household. Female headed households are likely to allocate more land and by extension more resources to indigenous vegetables.

Indigenous vegetables compete for land resource with maize (staple food) and livestock production. Remarkably, as the scale of production increases, the ratio of land allocated to indigenous vegetables diminishes. While education level of head of household favoured the production of indigenous vegetables, poor access to water for irrigation discouraged its production. Farmer's access to extension services also evidently influenced production of the vegetables.

When the ratio of land size allocated to AIVs is controlled for, partial correlation (table 4) shows that agro ecological zone of the farmer is positively correlated with the choice of seeds and the method of water abstraction for irrigation in AIV production. There was also a positive relationship between the choice of seeds and the incidences of pests and diseases. The method of water abstraction was also positively correlated with the education level of the head of household and scale of production. However, access to water for irrigation negatively correlates with the abstraction method. Farm size also negatively correlated with off farm income with a likely scenario that as the size of land decreases households become more dependent on off farm sources for their livelihoods.

Conclusions and Recommendations

Majority of farmers rely on farming as a source of livelihood and that socio economic factors dramatically interact to influence significantly the decision of farmers in the production of the African indigenous vegetables. Land is a common and key constraint among farmers with an average land holding of 1.52 hectares. AIV competes for limited farm resources receiving less attention compared to other crops in terms of land allocation and general crop husbandry. *Sucha (black night shade)* was found to be a widely grown vegetable in the region among all the AIV farmers. Organic fertilizers were also used by most farmers as opposed to inorganic fertilizers. Majority of farmers use non-certified local market seeds and organic fertilizers.

Production of AIVs in terms of decision of land size allocation is influenced by several socio economic factors within the household. Agro ecological zone of the farmer, gender, scale of production, production of maize (staple food) and livestock significantly influenced the amount of land the farmer allocated to AIVs. Other significant factors included; education level of the head of household, access to water for irrigation and extension services. Remarkably, the choice of seeds and the incidences of pests and diseases were positively correlated. Age, education scale of production and off farm income also influenced allocation of resources and choice of technology in production of African indigenous vegetables.

It is recommended that AIV value chain should be developed and farmers supported to integrate in access to both input and output markets. Specifically, the Government of Kenya and NGOs should intervene by supporting farmers to access and use certified seeds and water for irrigation. Varieties and production of certified seeds should be factored in the indigenous knowledge, and tests and preferences of the local consumers to ensure adoption. Affordable irrigation technologies should be provided also to reduce reliance on rain-fed AIV production. Ministry of Agriculture should also intensify extension services with the information tailored and packaged to target AIV husbandry through the socioeconomic agents as stated. Further studies could be done on the specific role of AIVs in the household dietary and food security.

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Appendix I

Table 4: Partial Correlations after controlling for Ratio of Land Allocated to AIVs

Variables	Correlation										
	Agro-Zone	Seeds	Fertilizer	PST/DSE	Irr.	Abstraction	Water	Age	Education	Farm Size	Off Farm Income
Agro-Zone	1.000	0.275**	-0.144	-0.014	-0.305**	.364***	-0.482***	-0.003	0.174	0.120	-0.017
Choice of Seeds	0.275**	1.000	-0.081	.256**	-0.162	-0.114	-0.197	-0.167	-0.013	0.088	0.088
Fertilizer Use	-0.144	-0.081	1.000	0.047	0.084	-0.112	0.163	-0.063	-0.143	-0.018	0.021
Pests & Diseases	-0.014	0.256**	0.047	1.000	-0.031	-0.122	-0.062	-0.179	-0.044	0.071	0.076
Irrigation Use	-.305**	-0.162	0.084	-0.031	1.000	-0.221	0.101	0.030	-0.172	-0.066	-0.022
Method of Water Abstraction	.364***	-0.114	-0.112	-0.122	-0.221	1.000	-0.275**	0.083	0.304**	0.349***	-0.028
Access to Irr. Water	-0.482***	-0.197	0.163	-0.062	0.101	-0.275**	1.000	0.160	-0.145	0.064	-0.015
Age of the Head of Household	-0.003	-0.167	-0.063	-0.179	0.030	0.083	0.160	1.000	-.256**	0.150	-0.271**
Education Level of the Head of HH	0.174	-0.013	-0.143	-0.044	-0.172	0.304**	-0.145	-0.256**	1.000	0.055	0.204
Overall Farm Size	0.120	0.088	-0.018	0.071	-0.066	0.349***	0.064	0.150	0.055	1.000	-0.344***
Off Farm Income	-0.017	0.088	0.021	0.076	-0.022	-0.028	-0.015	-0.271**	0.204	-0.344***	1.000

Source: Authors' Survey data, 2010