International Journal of Development and Economic Sustainability
Vol.3, No.2, pp.80-93 , May 2015
Published by European Centre for Research Training and Development UK (www.eajournals.org)

THE ROLE OF FENCING ON MARGINAL PRODUCTIVITY OF LABOUR, LAND AND CAPITAL IN ASAL REGIONS OF KENYA

Irene C. Asienga[i], Roger Perman[ii] and Lawrence K. Kibet[iii]

ABSTRACT: *Good land management strategies are known to play an important role in improving agricultural production. There lacks empirical studies that have evaluated the contribution of fence as a productive investment in Kenya. Fencing was treated as a productive input in the production function alongside capital, labour and land. Cross-sectional primary data is used to achieve the objectives of the study. The Cobb-Douglas (CD) specification was used in measuring the contribution of fence to production and in measuring its role in the marginal productivity of labour, land and capital in semi arid Kenya. Ordinary least squares (OLS) regression results indicated that fencing improves agricultural production and that it improves the marginal productivity of land. The policy implication is that since fence has led to a series of positive benefits, there is need for the government to recognize the positive impact of fence and empower those communities who would wish to fence their land.*

KEYWORDS: fencing, marginal productivity, labour, land and capital, ASAL regions, Kenya

INTRODUCTION

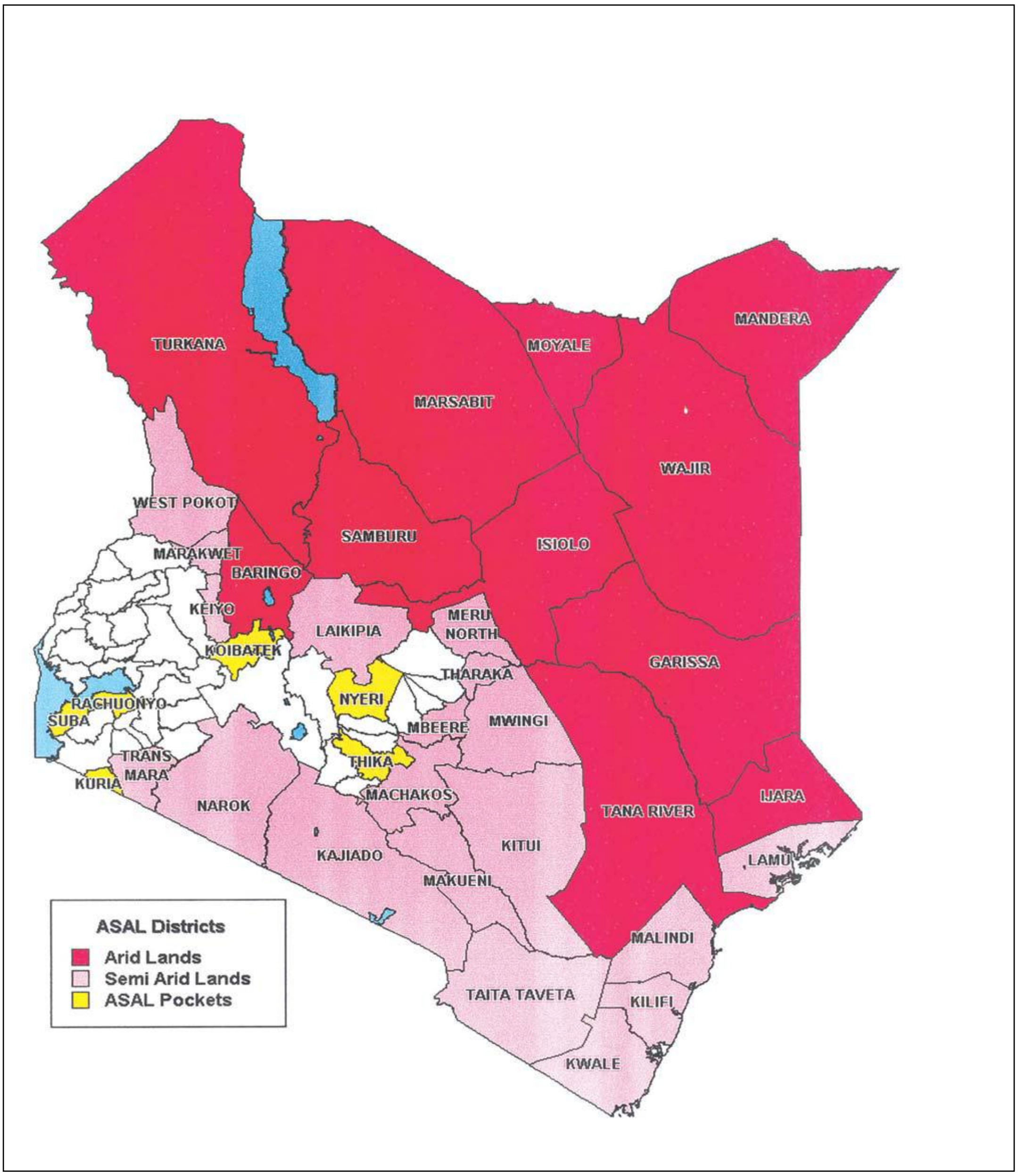
The ASALs are predominantly inhabited by migratory pastoralists although semi-pastoral and farming communities exist as well. Some of these communities are recent immigrants from the more densely populated, high agricultural potential areas of the country (Muniafu *et al*., 2008; Government of Kenya, 1993). The Kenyan ASALs poses greater challenges in terms of their productivity and vulnerability to droughts and flush floods. It is also estimated that in the ASAL regions there has been recurrent major droughts every 5 to 7 years in the last three decades (Government of Kenya, 2003). As a result therefore, it is noted that ASAL's livelihood systems do not adequately recover well enough to withstand the next drought. Hence, any small shock such as a prolonged dry spell has a much bigger impact on people's livelihood strategies (Government of Kenya, 2003). In addition, the incidence and prevalence of food insecurity is more severe in ASALs due to lack of adequate resource endowment, necessitating periodic government intervention in the provision of relief food (Government of Kenya, 2007).

[i]*Corresponding author: Lecturer and Director, Nairobi City Campus, Kabarak University, P.O. Private Bag- 20157, Kabarak, Kenya: email:, ikoech@yahoo.com*

[ii] *Reader, Department of Economics, University of Strathclyde, Glasgow, UK : email:* r.perman@strath.ac.uk

[iii] *Senior Lecturer, Department of Economics, Egerton University, Kenya email: kibetlawrence@gmail.com*

ISSN: 2053-2199 (Print), ISSN: 2053-2202(Online)



Source*: Arid Lands Resource Management Project (ALRMP 1993), Office of the President, Nairobi*

Figure 1: Extent of arid and semi-arid lands (ASALs) in Kenya

The development of ASALs however still remains a major challenge. Despite challenges of underdevelopment of the livestock sector, the Ministries of Livestock and Fisheries have only absorbed, on average, about 40 percent of their allocated budgets in recent years (Kenya Economic Report, 2009). With the planned increased investment in the livestock sub-sector, there is need to ascertain the major constraints that have previously limited use of allocated funds and with proper management of funds, fencing can be enhanced in ASALs.

Given the fact that the Government is committed to the development of ASALs and due to increasing population, the ASALs which can accommodate up to 12 million (36 percent) of the population (Government of Kenya, 2009b), have therefore ended up being used to

ISSN: 2053-2199 (Print), ISSN: 2053-2202(Online)

cushion the continuously increasing population pressure which has been rising at an exponential rate. As per the 1991 Population Census, Kenya's population stood at 30.4 million with an annual growth rate of 2.9 percent and this is expected to rise to 55 million by 2050 (Government of Kenya, 2007).

To keep up with these demands, agricultural production needs to double or triple in the next 30 to 40 years (Foley, 2009). Atwood (1990) also assert that population pressure is a cause of increasing scarcity of land in many rural areas of sub-Saharan Africa. The scarcity of arable land has an effect on agricultural production and what this means is that, increased agriculture production needs to rely heavily on productivity growth (Kenya Economic Report, 2009).

Kenya has different land tenure system and cultural norms relating to land. This coupled with a fast growing population have led to the subdivision of very potent land into small plots that are too small to be economical for meaningful agricultural activities in high and medium potential land. The Land Policy of Kenya encourages individual demarcation, registration and private ownership of land (Government of Kenya, 2008). However, this is an area that needs to be addressed at policy level so that there is reasonable minimal land size subdivision for sustainable agricultural production.

Various studies such as Dolan (2009), Boones *et al.* (2004), Boone and Coughenour, (2001) and Platt *et al.* (1999) have pointed out that fencing can be useful in controlling access either by humans or animals, protecting gardens and landscaping. Field (1984, 1985) argues that fencing may be seen as a way of preventing environmental degradation and at the same time enhancing private ownership of land.

In addition, they are a source of products such as live stakes for new fences, timber, firewood and fruits. Fencing also fulfils service functions within the farms such as the provision of shade and wind protection. They further argue that shade is important for cattle in that it reduces heat stress particularly in the dry season resulting in higher weight gain, milk production and reproductive rates. However fencing may also have a drawback in that too much shade may reduce grass productivity hence overall productivity.

Semi-arid districts are used for the empirical analysis because arid areas are in the main deserts and minimal agricultural activity takes place due to unfavourable rainfall patterns. Moreover, the communities who live there are predominantly pastoralists. On the other hand, in the productive areas, it has been observed that individual ownership of land is widespread and fencing of farmlands is highly developed. This is due to the fact that the colonial powers chose to settle in these places rather than in the arid and semi-arid regions as it was classified as being productive.

Although the early studies explain the role of fencing in the production process, none has attempted to demonstrate empirically the value of fencing as a productive input. It is with this background that this paper aims to fill this research gap by investigating the role of fencing on marginal productivity of labour, land and capital in ASAL regions of Kenya with the aim of offering possible policy prescriptions for increased farm productivity.

ISSN: 2053-2199 (Print), ISSN: 2053-2202(Online)

The general motivation of the study is to evaluate the role of fencing in the marginal productivity of labour, land and capital in semi arid Kenya. Owing to the many factors that go into productivity, the following specific objectives of the study have been developed:

- To relate how fencing impacts on marginal productivity of labour, land and capital.
- To draw conclusions and recommendations for improving farm productivity in semi-arid regions of Kenya and the greater Africa with possible incorporation into policy.

LITERATURE REVIEW

Ellis (1988) states that the neoclassical economic theory assumes that the farmer is an individual decision maker concerned with questions such as how much input to allocate to the farming of crops and whether or not to use procured inputs amongst other choices the farmer has to make. The farmer can generally vary the level and kind of farm inputs and outputs. In addition, he distinguishes between 3 types of relationship among farm inputs and outputs that are normally known as encompassing the economic decision making ability of the farmer. These 3 relationships also tally with the 3 key steps in the construction of the theory of the farm firm and they are firstly, the factor-product or input-output relationship also known as the production function, secondly, the factor-factor relationship also sometimes referred to as the method or technique of production and thirdly, the product-product relationship also termed as the enterprise choice. This paper however places emphasize in the production function

Fencing and productivity

It is argued that individualised tenure which could come about as a result of fencing land, typically defined as demarcation and registration of freehold title is viewed as superior to communal land tenure when land has scarcity value. This is because owners of the land are given incentives to use land most efficiently and thereby maximise agriculture's contribution to social well-being (Barrows *et al.*, 1990). It can thus be hypothesized that individualising land tenure increases security and agricultural investment and this can be resolved empirically instead of just theory. It is worth noting that neo-classical theory has been used to analyse the evolution of African land-tenure systems. Under conditions of very low population density the supply of land exceeds the demand even at zero price and so individual rights to property are exercised (Ault and Rutman, 1979). The neo-classical model can thus be said to generate hypotheses about economic behaviour such as individualisation of land tenure increases tenure security of the landholder, thereby reducing economic costs of legal action over land disputes .This hypothesis may also imply that fencing reduces disputes in that as a result of individualisation, disputes in form of communal land ownership reduce. Evidence from Kenya show that land-holders in East Kadianga sub-location in Nyanza province witnessed a higher incidence of land disputes and enclosures and it became common to fence holdings to protect crops from straying livestock. It is also documented that the shift from clan to individual rights over land started among the Luo long before World War II (Barrows *et al.*, 1990). Another hypothesis generated by the neoclassical model is individualisation increases investment by improving tenure security and reducing transaction costs. Higher tenure security implies that expected investment returns will increase thus leading to an increase in the demand for capital for investment and evidence from Kenya supports this hypothesis. This hypothesis again may imply that fencing increases investment

ISSN: 2053-2199 (Print), ISSN: 2053-2202(Online)

(Barrows *et al.*, 1990). People however tend to fence their land when they know it rightfully belongs to them (Pule *et al.*, 2004).

Besides, from the earlier discussion that fencing provides exclusive property ownership (Demsetz, 1967), fencing can serve as a public good but to a varying degree. This is for the reason that a neighbour may not be excluded from enjoying the part of fence constructed between the two properties. However, both owners are responsible for keeping the fence in good repair in case of wear and tear. Thus, it can be claimed that fencing has got a strong positive externality because of the positive spill over effect on the neighbour's homestead. However as noted by Barrows *et al.* (1990), there is little evidence to support the hypothesis that registration, through increased tenure security, has increased investment in agriculture. This paper has attempted to fill the gap by looking at it in terms of fencing.

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MATERIALS AND METHODS

Data used in this study represent cross-sectional primary data gathered directly from 251 households between the months of May to August inclusive 2010.Random selection was ensured[iv] with the aim of making sure that every household sampled had an equal chance of being selected. To the best of the researcher's knowledge, data on fencing is not available in Kenya. To this effect, the initial methodological approach was to collect primary data and employ it according to research objectives and hence for this purpose, a detailed questionnaire was used to collect the required information. The questionnaire was designed to collect information regarding economic and demographic characteristics of sampled households, total output, and the factors of production (capital, labour and land) as well as other variables of interest from both fenced and unfenced farms.

Regional sampling and analysis was carried out separately owing to the economic, social and cultural differences of the areas studied before aggregation. Kenya as a country is administratively divided into 8 provinces. Each of these provinces is mostly made up of people with diverse traditional and cultural practices. It is further subdivided into 47 counties as from August 2010, when Kenya changed its constitution. Out of the 47 counties, 13 are classified as being arid or semi-arid. It is therefore important to note that it would not be practical to survey the entire population of 13 semi-arid districts owing to restrictions of time, money and access. The main data is thus made up of five data sets spread wide apart to give a representation of the country's situation on collation. Data from the chosen districts was collected in stages.

The first stage in the sampling procedure involved identifying and selecting study counties, based on differences in traditional and cultural practices. Five counties of a total of 13 semi-arid counties were selected. The second stage involved selecting administrative divisions, locations and sub-locations within each of the five counties, based on agro-ecological diversity. The third stage involved selection of sample points (clusters), which was based on the total number of villages within a sub-location. One advantage however of using cluster sampling is that there are savings in travel costs and time as well (Kombo *et al.*, 2006). The fourth stage involved selecting the desired number of households from each cluster (village) after a simple household listing. In the final stage, the household head or a person with

[iv] The interviews were conducted by the researcher and so reduced the chance of interview bias.

ISSN: 2053-2199 (Print), ISSN: 2053-2202(Online)

information about the farming activities was interviewed along with other individual members where necessary in each selected household.

Households were selected randomly. Some had fenced their farm and some had not. Information was however collected from those without fence as well in order to serve as control for differences in production. In addition, a total of approximately 7 sub-locations in the chosen division were randomly selected for the administration of the questionnaire. At least 7 households in each selected enumeration area were randomly selected, after a simple household listing. A Cobb-Douglas production function is used to estimate quantitatively the effect of F upon the amount of Q and the model may be written as:

$$Q = \alpha_0 K^{\alpha_1} L^{\alpha_2} N^{\alpha_3} F^{\alpha_4} \quad (1)$$

$$0<\alpha_1< 1, 0<\alpha_2<1, 0<\alpha_3<1, 0<\alpha_4<1$$

Where: $Q =$ Value of output, K = Value of capital, L= Total work hours, N= Land area, F=Area of fence.

In addition, because Equation 1 is deterministic, an error term, ε, to account for random or unexplained variations in output will be introduced. It is also assumed that the error term, ε, has expectation zero and the other inputs K, L, N and F are taken as given. Hence for the ith firm, we have

$$Q = \alpha_0 K^{\alpha_1} L^{\alpha_2} N^{\alpha_3} F^{\alpha_4} \varepsilon \quad (2)$$

$\alpha_0, \alpha_1, \alpha_3, \alpha_4$ are unknown parameters to be estimated. The parameter in equation 2 $\alpha_{0,}$ may be regarded as an efficiency parameter since for fixed inputs; the larger is $\alpha_{0,}$ the greater is the maximum output Q obtainable from such inputs. Hence, it can therefore be hypothesized that the larger the fenced area, the larger the output obtained from the farm. The coefficient on F in Equation 2 will thus measure the effect of fencing on the expected output if all the other variables are kept constant. Besides, in this research, fence is the variable of interest but the difference in K, L, N, is controlled.
Output (Q) is measured by the product of price and quantity of total yields, typically shown as:

$$Q = \sum_{i=1}^{n} py \quad (3)$$

Most studies have measured output by the product of price and quantity of total yields. For instance, Rick *et al.* (2007), Carter *et al.* (1999) and Shenggen (1997) calculated the output values by first multiplying the output quantity of each product by its price. Coelli *et al.* (2005) also use aggregates to measure output. Since in this study aggregates are formed across products that exhibit similar movements in relative prices or quantities, Coelli's approach then appears reasonable to use. Current prices are used in calculating values from the fact that it is a cross sectional study. Aggregate production can be defined as the amount of output that can be obtained from given levels of input in a sector or an economy. Therefore increases in production occur when output from a given level of inputs increases (Belloumi *et al.*, 2009).

ISSN: 2053-2199 (Print), ISSN: 2053-2202(Online)

Capital (K) in this study is defined as all the equipment available for use in farming activity. It is thus measured as the value of total equipment available for use directly in farming activity on repeated occasions. This for example includes agricultural machinery such as tractors, threshers, ploughs, sprayers among others. The researcher therefore calculates the value of (K) as the product of the total number of equipment by the current price of each unit of equipment (Coelli, 2003).

Different researchers have measured labour input (L) in various ways. For instance, Coelli *et al.* (2003;2005), Diewert (2008), Mefford (1986) and Carter *et al.* (1999) used a single aggregate variable of aggregate hours worked because of degrees of freedom limitations and the inconsistency of labour categorisation across different firms. They measured labour by considering the number of persons employed, number of hours of all people engaged in production and the number of days worked. This amounted to the aggregate hours and therefore in this study, labour is defined and measured by taking the total work hours

Land input (N) is defined as the total farm area (acres) in which there is a farming activity carried out. Land input (N) is thus measured by total farm area. It is assumed that the households practise some farming and that they have right to use the resource of land as the basis of their livelihood (Ellis, 1988). The estimation of (N) in this way is both practical and consistent with the works of other researchers such as Cornia (1985) and Shenggen (1997).

Having discussed the inputs of L, K, N, Q, fence (F) will be the next "other" input in the production function to be considered. In this study, a fence is defined as a barrier that has coverage of at least 75 percent and a height of between 1 to 2 meters. This description is consistent with the casual observation of the researcher in the study area. In measuring fence, only the area of the fenced homestead in square meters is considered and not the total fenced land. This is because in most cases in the ASALs of Kenya, it is the homestead that is fenced in order to keep out wild animals from livestock at night. Since fence has got zero observations from the fact that the data includes information from homesteads that are not fenced, a dummy variable is used in solving the zero problem .The dummy variable F will be equal to one if the homestead is not fenced and zero if otherwise. Also, in this study, a model that allows for changes in the slope is estimated. In this case, the dummy variable F will be equal to one if the homestead is fenced and zero if otherwise.

The OLS regression that explains the impact of fencing on output for a sample of 249 observations are estimated. The estimating Equation is 3 but since one of the explanatory variables, fence, has zero values, the study will adopt the method proposed by Battese (1996a) of estimating CD production functions when some explanatory variables have zero values. The zero values come about due to the fact that data on fence is made up of households with and without fence. Those without fence take a value of zero. And because households without fence form a significant proportion of the total number of sample observations, it is important to find a way of solving the zero problems as suggested by Battese *et al.* (1996a). Analysing only those farmers who have fence may not be the appropriate method of estimation because the data on households without fence may be useful in the estimation of parameters which are common to all farmers. Ahmad *et al.* (2002) and Battese *et al.* (1996b) used the same approach.

ISSN: 2053-2199 (Print), ISSN: 2053-2202(Online)

Battese *et al*. (1996a) thus proposed the use of dummy variable that is associated with the incidence of the zero observations such that efficient estimators are obtained using the full data set but no bias is introduced.
To use this method, we extend Equation 3. by introducing a dummy. Thus, the production relationships, involving one output and four inputs are defined by;

$$\ln Q = \alpha_0 + \alpha_1 \ln K_i + \alpha_2 \ln L_i + \alpha_3 \ln N_i + \alpha_4 \ln F_i + \ln \varepsilon_i, i = 1,2,..., n_i \text{..................(4)}$$

$$= \beta_0 + \alpha_1 \ln K_i + \alpha_2 \ln L_i + \alpha_3 \ln N_i + \ln \varepsilon_i, i = n_i + 1,..., n_1 + n_2 = n \text{...........(5)}$$

where

n_1 is the number of observations for which F>0

n_2 is the number of observations for which F=0

ε is the uncorrelated error term and

$\beta_0, \alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4$, are unknown parameters to be estimated

This model specifies that the relationship between the output and the inputs is such that the output elasticity with respect to all inputs is the same value for the observations involving positive and zero values of fence. It is also specified that the constant parameters, β_0 and α_0 are not necessarily the same, but the variances of the errors are the same.
Given that the production system is defined by Equations (4) and (5), the parameters are estimated by pooling the data, as specified in the following model:

$$\ln Q = \alpha_0 + (\beta_0 - \alpha_0) D_i + \alpha_1 \ln K_i + \alpha_2 \ln L_i + \alpha_3 \ln N_i + \alpha_4 \ln F_i + \ln \varepsilon_i, i = 1,2,..., n_i \text{..................(6)}$$

Where D=1 if F=0 and D=0 if F>0

ln denotes the natural logarithm

Q represents the value of output (in Kshs)

K represents the value of physical capital available for use in farming activity in Kshs

L represents total work hours by family members and hired labourers in crop and livestock farming

N represents the total amount of land on which farming is carried out (in acres)

F represents the area of fenced homestead in square meters.

ISSN: 2053-2199 (Print), ISSN: 2053-2202(Online)

The parameters of the production function as shown in Equations 4 and 5 are estimated by using ordinary least squares regression of the model specified by Equation 6. In addition, a test of the hypothesis that the intercepts are equal is obtained by a t-test on the coefficient of the dummy variable, D.

Equation 6 allows for a change in the intercept of the equation. A model that also allows for a change in the slope can be estimated by multiplying the dummy by the natural log of all inputs. Thus;

$$\ln Q = \alpha_0 + \alpha_1 \ln K_i + \alpha_2 \ln L_i + \alpha_3 \ln N_i + \alpha_4 \ln F_i + \alpha_5 D_i \ln K_i + \alpha_6 D_i \ln L_i + \alpha_7 D_i \ln N_i + \alpha_8 D_i \ln F_i + \ln \varepsilon_i \text{..................(7)}$$

RESULTS AND DISCUSSION

The parameters of the production function are estimated by using the OLS regression of the model specified by Equation 6.Fence variable which is the variable of interest in this study had a positive and statistically significant coefficient on output except for the OLS estimate in terms of livestock production which was positive but statistically insignificant. This finding implies that households with a larger area of fence report higher production than those without and hence the affirmation of the hypothesis that fencing enhances output. It is also noted that the coefficients of the natural logarithm of fence are not very different.

Capital showed a positive but insignificant coefficient in terms of crop, livestock and total output. The general observation thus from this result is that households who invest in a lot of physical capital are likely to get more output than those who do not invest, as expected.

The coefficient of labour in terms of crop production is positive and statistically significant. This result implies that labour has an impact on crop production and generally total output and that farming households are more likely to gain if they invest in more labour in crop production. This result is consistent with that of Chirwa (2007) who found a statistically significant relationship between labour and production of maize in Malawi. This result is expected since most of crop production in Kenya uses traditional technology that relies heavily on family labour. However, in terms of livestock production, the results change in that it exhibits a negative statistically significant coefficient. In terms of total output, the labour coefficient is positive but it is now not statistically significant.

ISSN: 2053-2199 (Print), ISSN: 2053-2202(Online)

Table 1: Regression of natural log of crops, livestock and total output - OLS regressions

	Dependent variable		
	CROPS	LIVESTOCK	TOTAL OUTPUT
Regressors:			
Labour	0.53***	-0.14*	0.01
(Total work hrs)	(0.06)	(0.08)	(0.04)
Capital	0.14	0.11	0.10
(‘000’kshs)	(0.11)	(0.15)	(0.07)
Land	-0.51***	0.95***	0.45***
(Acres)	(0.10)	(0.14)	(0.07)
Fence	0.53***	0.08	0.26**
(Area)	(0.18)	(0.25)	(0.12)
Dummy	2.04***	-1.72	-0.11
	(0.76)	(1.07)	(0.53)
Number of observation	249	249	249
R-squared	0.38	0.25	0.27

Notes: *(1) Dependent variable is total value of crops, total value of livestock and total output (2)* Significant at 10% ** Significant at 5% and *** significant at 1 %(3) Standard errors in parentheses.*

The coefficients of Land in terms of livestock and total output are positive and statistically significant implying that land has an impact on livestock production and total output. This result may also mean that farmers are likely to keep more livestock given a large area of land a result that appears to be theoretically correct. On the other hand, in terms of crop production, the coefficient of land variable is negative and statistically significant implying that land area has no impact in crop production. This could be explained from the fact that the area under study is semi arid and large area of land does not imply increased crop production.

Fence as a dummy variable

It is also important to mention that Tables 1 shows the results of the specification that treats fence as a standard variable like capital and labour. Fence is also used as a variable that measures the area (Equation 6). It is however imperative to also consider a model that allows for a change in the slopes of associated variables. This is done by using fence as a binary dummy variable. The model is estimated by multiplying the fence dummy by the natural log of all inputs and what this implies is that other variables that take on a multiplicative effect (Equation 7) are introduced into the model.

ISSN: 2053-2199 (Print), ISSN: 2053-2202(Online)

Table 2: Regression of natural log of crops, livestock and total output with multiplicative effect variables - OLS regressions

	Dependent variable		
Regressors:	**CROPS**	**LIVESTOCK**	**TOTAL OUTPUT**
Labour	0.57*** (0.07)	-0.01 (0.10)	0.06 (0.05)
Capital	0.13 (0.14)	0.25 (0.19)	0.12 (0.10)
Land	-0.74*** (0.12)	0.95*** (0.17)	0.39*** (0.08)
Fence	0.27 (0.20)	-0.15 (0.28)	0.20 (0.14)
Dummy*labour	-0.07 (0.11)	-0.30* (0.16)	-0.13* (0.08)
Dummy*capital	0.02 (0.20)	-0.27 (0.28)	-0.01 (0.14)
Dummy*land	0.60*** (0.20)	-0.08 (0.28)	0.18 (0.14)
Dummy*fence	0.09 (0.31)	0.31 (0.43)	0.06 (0.21)
Number of observation	249	249	249
R-squared	0.39	0.26	0.28

Notes : *(1) Dependent variable is total value of crops, total value of livestock and total output (2)* Significant at 10% ** Significant at 5% and *** significant at 1 %(3) Standard errors in parentheses.*

For the fence variable, OLS estimates in terms of livestock production show a negative statistically insignificant coefficient. The negative sign is not a surprising result for the reasons that in real life situations, fence is supposed to keep livestock away. It can also be argued that it may prevent the movement of livestock freely, in some cases animals can be trapped in the fences and can even lead to electrocution if it is an electric fence thus leading to a reduction in quantities. The positive sign in terms of crop production is a sensible result in that as already mentioned, a fence is supposed to keep intruders away and if this objective is attained, it is expected that quantities will increase. Otherwise generally, the variable of interest fence continues to exhibit a positive relationship in terms of total output as expected.
Labour exhibits a negative coefficient and capital consistently maintains a positive coefficient. Land maintains the same negative coefficients as before except that in this setting all the coefficients turn out to be statistically significant.

CONCLUSION AND RECOMMENDATIONS

In the classical regression model, fence was measured in two ways, as a variable which measures area and as a binary dummy variable. Using fence as a variable that measures area allowed for fence to be treated as a standard variable like capital or labour .On the other hand, treating fence as a binary dummy variable allowed for changes in the regression intercept and in slopes of associated variables. The changes in slopes were estimated by multiplying the fence dummy by the natural log of all inputs. In all the models estimated, it was found that the variable of interest fence continued to exhibit a positive coefficient.

ISSN: 2053-2199 (Print), ISSN: 2053-2202(Online)

Furthermore, when fence was measured as a binary dummy variable in the model that allowed for a change in slope of associated variables, fence also continued to exhibit a positive coefficient. However, the OLS estimates presented a negative coefficient on fence in terms of livestock production and it is in fact the only model which presented a negative coefficient a result that implies that fence may not have a positive impact in terms of livestock production. This however makes sense for the reason that practically, fence is supposed to keep livestock away from crop farms. This finding is also consistent with that of Boone *et al.* (2004) who in their study of effect of fencing on large herbivores found out that when 10km^2 of land was fenced, 19 percent fewer cattle could be supported compared to the land being unfenced. It is therefore very evident from this study that fencing can improve agricultural production of farms in semi-arid areas.

However, the multiplicative effect results show a statistically significant coefficient of land implying that fence improves the marginal productivity of land in terms of crop production. This paper thus recommends that for the government to achieve its objective of increasing agricultural production, it should support those farmers who wish to fence their land. The main contribution of this paper to existing body of knowledge is that for the first time, fence is included in the conventional production function to examine its effect on agricultural production alongside traditional inputs such as capital, labour and land.

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