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Full Length Research Paper

Drivers of the transition from pastoralism to vegetable farming in Africa's arid and semi arid areas and implications for soil fertility management: The case of Kenyan pastoralists

Beatrice Nyamwamu[1], Julius J. Okello[2]* and Geoffrey Kironchi[1]

[1]Department of Land Management and Agricultural Technology, University of Nairobi, P.O. Box 29053, Nairobi, Kenya.
[2]Department of Agricultural Economics, University of Nairobi, P.O. Box 29053, Nairobi, Kenya.

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The arid and semi arid areas comprise a large percentage of the land area in Africa. Communities in these areas have over the years depended on livestock production for livelihood. Livestock has traditionally served as source of food and a store of wealth in the arid and semi arid areas. However, the challenges posed by the harsh environmental factors, especially climate-change induced shocks are causing significant changes in livelihood strategies in the arid and semi-arid areas. Increasing numbers of households are shifting from pure pastoralist livelihood to crop farming with many growing vegetables commercially. This paper examines the factors driving this transition from pure pastoralist system to vegetable farming. It then assesses the strategies used by these new farmers to manage the fertility of the vegetable fields and the factors driving the use of these strategies. The paper finds that the shift to vegetable farming is driven by, among others, access to other sources of income, hence desire to diversify livelihoods. It also finds that, in general, these vegetable growers use a number of soil fertility management practices. The intensity of adoption of soil fertility management practices is driven by, among others, access to information and prior participation in govern soil conservation programs. The paper highlights the policy implications of these findings.

Key words: Kenya, pastoralists, transition, vegetable farming, fertility management, drylands.

INTRODUCTION

The high population growth rate in many African countries has resulted in increased population pressure on the land as farmers struggle to meet increased household demand for food (Eicher and Staatz, 1998; Nyamwamu, 2009). Farmers in these countries have tended to respond to pressure on land by expanding to the hitherto untilled land. However, as opportunities for expansion diminish, farmers have encroached into fragile ecosystems (that is, marginal areas) largely unsuitable for farming, often without the necessary land and water management and/or investment strategies. In the areas where opportunities for extensive agriculture no longer exist, intensive farming, which involves the use of improved crop varieties and livestock breeds is to increase output per unit of land, is practiced. Opportunities for either intensive or extensive farming in marginal (that is, arid and semi arid) areas is however limited by agro-ecology of these areas (Shiferaw, 2008). Agricultural communities in the arid and semi arid lands comprise a large proportion of the rural farming communities (Bantillan and Shiferaw, 2004). Majority of these households practice low input agriculture characterized by low use of improved technology. Due to harsh environment, most of the households in these areas rely on livestock production. However, frequent weather related shocks (especially droughts and floods) make households that depend on agriculture increasingly vulnerable (Shiferaw and Holden, 2000; Barrett et al., 2002). To smooth the effects of weather related shocks, communities located in the arid and semi arid lands (ASALs) diversity farming into

*Corresponding author. E-mail: jjokello@gmail.com.

crop production with livestock rearing still remain the dominant agricultural activity (Ahuja, 1998). In particular, such communities keep various types of cattle, camels and goats.

Livestock, in marginal areas, act as source of food (especially milk), income (from surplus sales) and stored wealth (Barrett and Swallow, 2006a, b). The low output (due to use of local varieties and breeds) result in low production surpluses and hence low or non-participation in commodity markets. Low participation in the market is a major cause of low household incomes which results in poor or lack of investment in agriculture. Consequently, communities in the ASALs tend to be easily locked in what has come to be known as low-equilibrium poverty trap that is characterized by low use of improved agricultural inputs and breeds, low production, low marketable sales, low income and subsequently low use of inputs (Babier, 2000; Barrett and Swallow, 2006a). In addition to the vulnerable natural conditions communities in ASALs face, these areas have witnessed the fiercest effect of climate change induced shocks in the last one decade. At the same time there have been changes in the strategies being used by households in these areas (Nymwamu, 2008). Increasing number of households that were initially pure pastoralists are incorporating crop cultivation into the hitherto pure livestock production dominated livelihood (Barrett and Swallow, 2006b). While this shift in livelihood strategy was initially mainly for subsistence purpose, some households have switched to commercial growing of crops using intensive farming practices. The crops produced include tomatoes, kales and capsicums. These “new” farmers use seasonal rivers to irrigate crops early in the dry season and excavate river beds to extract water to support production later into the dry season. What is driving this shift to vegetable production and what does this change portend for sustainable soil and water management? Given the fragile nature of the soils in these areas, the shift from pastoral farming to intensive crop farming can have a negative effect on soil fertility and quality. It can increase the salinity of the soils and further reduce the fertility of the already infertile lands (Pender et al., 2004; Pingali, 2008).

While increasing numbers of pastoralists, especially those living along or near river basins are turning to commercial vegetable production, there is limited information on the causes of the shift and effects of this transition from pastoralism to irrigated vegetable soil fertility management in the hitherto rangelands.

This paper addresses three research questions:

1) What are the conditioners of the switch from pastoral production regime to irrigated commercial vegetable production?
2) What strategies are these “new” commercial vegetable producers are using to manage the soils of this fragile environment to sustain the new farming system?
3) What factors explain the choice of strategies in 2) aforementioned?

The study focuses on the Maasai pastoralists who recently shifted from pure pastoral livelihood to commercial vegetable farming along Olkaria river in Kajiado district of Kenya. Kajiado is home to the Maasai whose source of livelihood has until recently been pure pastoralism. Given the lack of experience in crop farming, and especially in soil and water management, these new farmers are likely to adopt practices that degrade the environment. Kajiado therefore presents an interesting case to study. In addition, the on-going climate change and its ravaging effects especially in the marginal areas is likely to cause more residents of such areas to diversify livelihoods and adopt practices that degrade the environment. Hence, findings of this study can help inform policy and practice on how to educate individuals transitioning into livelihood strategies that can negatively impact the environment.

The rest of this paper is organized as follows: Subsequently, it provides study context, after which it presents the conceptual framework, the empirical methods and the data. Thereafter we discuss the results; lastly, the study concludes.

The study background

Recent studies have documented the livelihood challenges that face pastoralists. The changes in weather patterns have resulted in frequent severe droughts and floods in the semi arid habitats of pastoralists. These shocks have resulted in frequent famines among the pastoral communities forcing many hitherto pure pastoralists to seek alternative strategies of coping with the climate induced shocks. One of the coping strategies taking root among such communities is the transition to crop farming especially along the rivers. Two kinds of farming practices have emerged. First, the pastoralists themselves grow the crops and sell to supplement their food needs and earn income from sale of surpluses. For this group of pastoralists, crop production helps generate income that is used to smooth household consumption during the peak of weather induced shocks. Crops are produced both for home consumption and sale. The major crops grown include kale, tomatoes, spinach and capsicums. The second type of farming practice that has emerged is that of sharecropping. The pastoralists (landlords) in this case, perhaps due to lack of experience, get into an informal sharecropping arrangement with a non-pastoralist farmer or with a pastoralist that has shifted into crop farming (that is, the tenant) who produces vegetables for sale. The landlord provides the land and inputs (mainly fertilizer, seed, and pesticides) while the tenants cultivates, plants and manages the farm and also is responsible for harvesting. Once sold, the proceeds from the crop are shared on pre-negotiated ratio between the landlord and the tenant. In both cases aforementioned, vegetable production occurs along the major rivers since vegetables require good supply of water. These new farming arrangements have implications for water management especially among communities that also depend on the rivers for their livestock.

At the same time however, the cop farming is occurring in areas that are traditionally fragile and most suited for livestock farming. Irrigated agriculture can also degrade the soil by making the soil become saline or acidic (Pingali, 1998; Rhoades et al., 1999). In particular, irrigating crops with waters high in dissolved nutrients affects the soil nutrient balance thus exacerbating problems relating to soil health and accelerating degradation. This has raised concern over sustainability of crop farming in such areas and interest in the way the new farmers are managing land and water. It has also fuelled the long-standing hot debate pastoralism as a livelihood strategy is sustainable and what the transition portends for land degradation. This debate is however not new. Over the years, conservationists and development agents have debated whether or not pastoralism should be encouraged. On the one hand, development agents argue that pastoral households should diversify their livelihoods (into crop farming) to better cope with the impacts of climate change. On the other hand, conservationists argue that such livelihood shifts will strain the already fragile environments in which pastoralists live by degrading soils unless strategies to maintain soil health are implemented alongside the shift to crop farming. The maintenance of good soil physical properties requires adoption of proper land use technologies. The literature outlines a number of practices that are essential for maintaining soil fertility and physical health (Nyamwamu, 2009). These practices include the use of inorganic fertilizers, agroforestry, stone bunding, terracing and the use of trash-lines (Joshi et al., 2005; Nyamwamu, 2009). In particular, agroforestry has recently been strongly promoted around the world. This is because soils that develop under natural woodland or forests tend to be fertile, have good structure and moisture-holding capacity and less prone to erosion.

Biamah and Rockstrom (2000) for instance argue that trees enhance nutrient cycling through conversion of soil organic matter into available nutrients.

CONCEPTUAL FRAMEWORK

We assume that a farmer makes decisions regarding the use of land and water in planning the production of vegetables or rearing of livestock. One problem facing the household is how to maintain the quality of its land and water and hence high production. Thus we assume that the household production function comprises of the conventional inputs as well as a vector of land and water management practices variables that affect output. Farmers' production decisions are therefore affected by shocks that can be internal or external to the farming systems. External shocks include drought and floods as well as input and output prices while internal shocks include such event that reduce the capacity of the household to farm such as sickness. Consider a household that seeks to minimize the costs of producing vegetables for sale. Such costs include the costs of conventional inputs (such as labour, land, fertilizer, seeds, and pesticides) as well as the costs of undertaking soil and water conservation (necessary to keep the land productive). The household minimizes these costs subject to a given level of output. Following the non-separable household production models, we assume that the household makes production and consumption decisions jointly. Optimizing the farmer's objective (that is, cost minimization) function, subject to a given output and labour availability, yields the conventional input demand functions including the demand for conservation practices. These input demand functions are essentially the adoption functions. They represent the farmers demand and hence use of conventional inputs and the conservation practices in the production process. In our case, the variables of interest are the conservation practices.

Empirical methods

Conditioners of the shift to commercial vegetable production

The dependent variable used in the model estimated to assess the factors affecting the transition from pastoralism to commercial vegetable production is dichotomous variables defined as '1' if the respondent recently shifted to vegetable production and 0 otherwise. The most commonly used econometric approaches to estimate such discrete dependent variable regression models are the logit, and the probit regression models (Wooldridge, 2002; Gujarati, 2004). These models generate predicted probabilities that are almost identical but have different probability distribution functions (Liao, 1994; Gujarati, 2004). The Probit has a normal distribution while logit has a logistic (slightly fatter tails) distribution. The choice between probit and logit regression model depends, therefore, largely on the distribution assumption that the researcher makes. Following Maddala (2001), the probability, *p*, that a farmer shifts from pastoralism to commercial vegetable production is given by:

$$P = e^{z}/1 + e^{Y} \quad (1)$$

Which after transformation yields:

$$Y = \ln (p/1 - p) \quad (2)$$

Where;

$$Y = Y (F, R, Z) + \varepsilon \quad (3)$$

Where Y is a latent variable that takes the value of 1 if the household recently shifted to commercial vegetable production and 0 otherwise, *F* is a vector of farmer characteristics, *R* is a vector of farm structural variables, *Z* is a vector of institutional (and quasi-fixed capital) variables and ε is the stochastic term assumed to have a normal distribution. Based on Equation 3, the estimated implicit functional form of the probit model can be specified as:

Transition to vegetable growing = f (farmer characteristics, farm structural characteristics, institutional and quasifixed capital factors) + e (4)

The explanatory variables used in the estimation of this model (Equation 4) are presented in Table 1. The variables were selected based on theory and a priori expectations. However, variables that were included on this basis but contributed little to the variability in the transition to vegetable growing were dropped. The coefficients are estimated using maximum likelihood estimation procedures.

Table 1. Variables used in econometric estimations.

Farmer characteristics (F)	Farm structural characteristics (R)	Institutional characteristics (Z)
Natural log of age in years	Farmer lives on the farm (1 = yes, 0 = no)	Access to information (1 = yes, 0 = otherwise)
Education in years of schooling	Access to hired labour (1 = if farmer got hired labor when needed, 0 otherwise)	Natural log of distance to extension agent in walking minutes
Membership to organizations (1 = yes, 0 = no)	Natural log of value of livestock in Kenyan shillings	Natural log of distance to the nearest market in walking minutes
Irrigation experience in years	Amount from other sources of income in Kenyan shillings	Natural log of distance to nearest weather road in walking minutes
Perceived soil fertility (1 = high, 0 = low)	Type of tenure (1 = individual, 0 = rented)	Access to market information (1 = yes and 0 = no)
Family size (count of family members)	Access to hired labour (1 = yes, 0 = otherwise)	

Assessment of factors affecting the use of soil fertility management techniques

Drivers of use of soil fertility management practices are assessed using a double hurdle model. The first hurdle captures the factors affecting the decision by a respondent to use soil conservation practices or not. It is given by a dichotomous choice model that takes the value of 1 if a farmer uses any of the practices for managing the fertility of land used in growing vegetables and 0 if the respondent does not. The strategies considered include fallowing, use of crop residues and stone banding, crop rotation and agroforestry. The second hurdle, on the other hand, assesses the factors affecting the number of conservation strategies used by a farmer to manage the fertility of the vegetable fields. The dependent variable in this second model is therefore the number of soil fertility management techniques used, a count variable. Hence, we use the Poisson regression technique to estimate this model. The density function of the Poisson regression model is given by Greene (2007):

$$f(y_i|x_i)=\frac{e^{-\lambda(x)}\lambda_i(x)^{y}}{\Gamma(1+y_i)} \quad f(y_i|x_i)=\frac{e^{-\lambda(x)}\lambda_i(x)^{y}}{\Gamma(1+y_i)} \tag{5}$$

Where $\lambda_i=\exp(\alpha+X'\beta)$ and y_i (for i = 0, 1, 2, ...) is the number/count of soil conservation strategies used, X is a vector of explanatory variables and β is a vector of coefficient estimates. The explanatory variables for first and second hurdles are similar to those used in first model mentioned.

Data and study area

This study uses primary data collected from 70 farmers through personal interviews using a pre-designed and pre-tested questionnaire. This study was part of a larger study that evaluated the effect of land use change on soil and water management and biophysical and chemical properties of soils and water in areas that have recently seen transition of pure pastoralists to vegetable farming (Nyamwamu, 2009). The respondents were farmers and pastoralists in Mashuru division of Kajiado district, Kenya (Figure 1). The study was conducted along the Olkaria River which passes through Mashuru division of Kajiado district. The district was chosen because of the prevalence of crop farming among former pure pastoralists. Mashuru division has recorded the largest increase in number of pastoralists transitioning to commercial vegetable production because it has a large river that acts as source of irrigation water. The respondents were obtained using stratified random sampling. First, a list of all the households who live near the river was compiled.

The households were then stratified by transition to commercial vegetable production, giving rise to 35 vegetable farmers and 35 livestock farmers. The farmers were interviewed between March and October 2006 and data on farmer, farm, institutional and quasi-fixed capital as well as conservation practices factors collected. Additional data on soil physical and chemical properties were also collected and are presented in Nyamwamu (2009). Table 2 presents the mean and standard deviation for some of the key variables used in the estimation of the econometric models. It shows that commercial vegetable growers are, on average, younger, located nearer the market and agricultural extension office and have experience in irrigating crops.

Vegetable growers belong to more farmer organizations than the pastoralists. As expected, vegetable growers have, on average, fewer livestock as reflected by the lower value of livestock owned. Table 2 also shows that vegetable growers earned more income from non-livestock sources than the pastoralists. The average income earned by vegetable growers from other sources is kshs 99,376 while their counterparts earned Kshs 33,137 from other sources.

RESULTS AND DISCUSSION

Factors affecting the shift from pure pastoralist to vegetable production

Table 3 presents the results of the probit regression

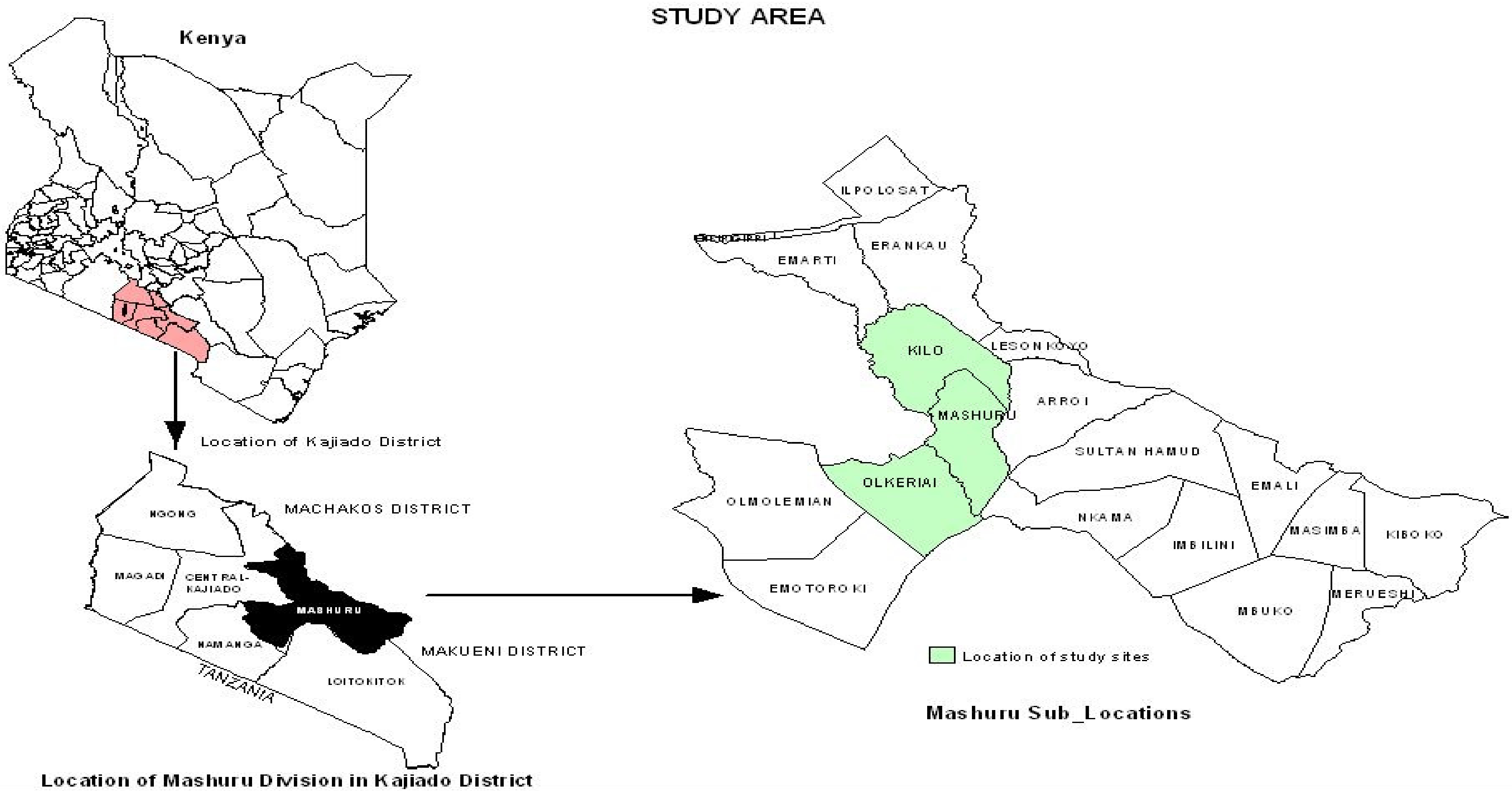

Figure 1. Map of Kenya showing the location of the study area.

model estimated to assess the factors affecting the decision to transition from pure pastoralism into vegetable production. It shows that 7 out of the 12 variables included in the model are statistically significant in explaining the likelihood of the decision to shift from pure pastoralism to vegetable growing. Results show that age and education affect the likelihood of decision to shift into vegetable production. Other things constant, the older the respondents the less likely they will decide to shift to vegetable production. This is probably because farmers in the study area are traditionally pastoralists and hence the older ones are deeply rooted in pastoralism as a lifestyle and are unlikely to abandon traditional way of life for vegetable production. Results further show that respondents with more education are more likely to transition to vegetable production, other things constant. This finding corroborates those of Jha et al. (1991) in a study conducted in Eastern Zambia. The other farmer specific variable that

Table 2. Summary statistics of the key variables used in the analysis.

Parameter	Pastoralist		Vegetable growers	
	Mean	Std dev.	Mean	Std Dev
Value of livestock (Kshs).	232,000.00	167,502.00	75,000.00	68,765.00
Age (years).	51.00	18.43	44.00	13.60
Household size (persons).	10.00	5.39	9.00	5.00
Distance to the nearest market (walking minutes).	47.00	30.67	39.10	35.80
Distance to the nearest weather road (walking minutes).	28.00	36.48	40.20	28.00
Distance to the nearest agricultural extension agent (walking minutes).	119.00	52.82	77.00	68.70
Other sources of income (Ksh.).	33,137.00	32,994.50	99,376.00	139,878.00
Irrigation experience (years).	0.00	0.00	5.00	3.00
Number of organizations farmer belongs.	1.00	0.50	2.00	1.00

Kshs = Kenya shillings; the exchange rate at the time of survey was Ksh 70.00 = 1 US Dollar.

Table 3. Probit estimates of factors influencing farmers' decision to shift to vegetable production. Dependent variable: Decision to shift to vegetable production.

Variable	Coefficient	p-value
Log of age	-0.16	0.036
Education	0.314	0.001
Household size	0.029	0.043
Distance to market	-0.149	0.046
Distance to road	-0.052	0.073
Distance to agricultural extension agent	-0.152	0.047
Access to market information	0.531	0.026
Other sources income	-0.074	0.059
Belongs to farmer organization	0.232	0.065
Irrigation experience	0.054	0.160
Log of value of livestock	-0.122	0.107
Access to hired labour	0.152	0.048
Intercept	1.882	0.001

N = 70; Log Pseudo likelihood = -623.10; Chi squared = 54.7012; p-value = 0.001.

affects decision to shift to vegetable production is household size. The more the number of household members the more likely the household will decide to shift to vegetable production, other things constant. This is perhaps because larger households seek to diversify income sources by growing vegetables (Godquin and Quisumbing, 2005). At the same time large families provide labour for the more labour-demanding vegetable production. Among the farm structural and institutional variables, access to hired labour, distance to market, distance to extension agent and access to market affect the likelihood of deciding to shift to vegetable production.

Other things constant, farmers closer to markets are more likely to shift to vegetable production than their counterparts. This finding is expected because individuals located closer to markets face lower transaction costs of participating in the market (Barrett, 2008). Results also further show that the nearer the farmer to an extension agent/office the more likely the farmer will decide to shift to vegetable production, other things constant. Indeed, majority of the vegetable farmers interviewed acknowledged having been visited by extension agents before. As expected, results show that respondents with greater access to income from other sources are less likely to shift to vegetable production, other things constant. This finding supports the argument that households shift to vegetable production to diversity sources of income hence livelihood. Thus, households that already have income from other sources are less likely to shift into vegetable production because they have more secure livelihood. Results further show that households who belong to farmer organizations are more likely to shift to vegetable production, other things constant.

In the following study, we discuss what this shift to vegetable growing by pastoralists portends for physical

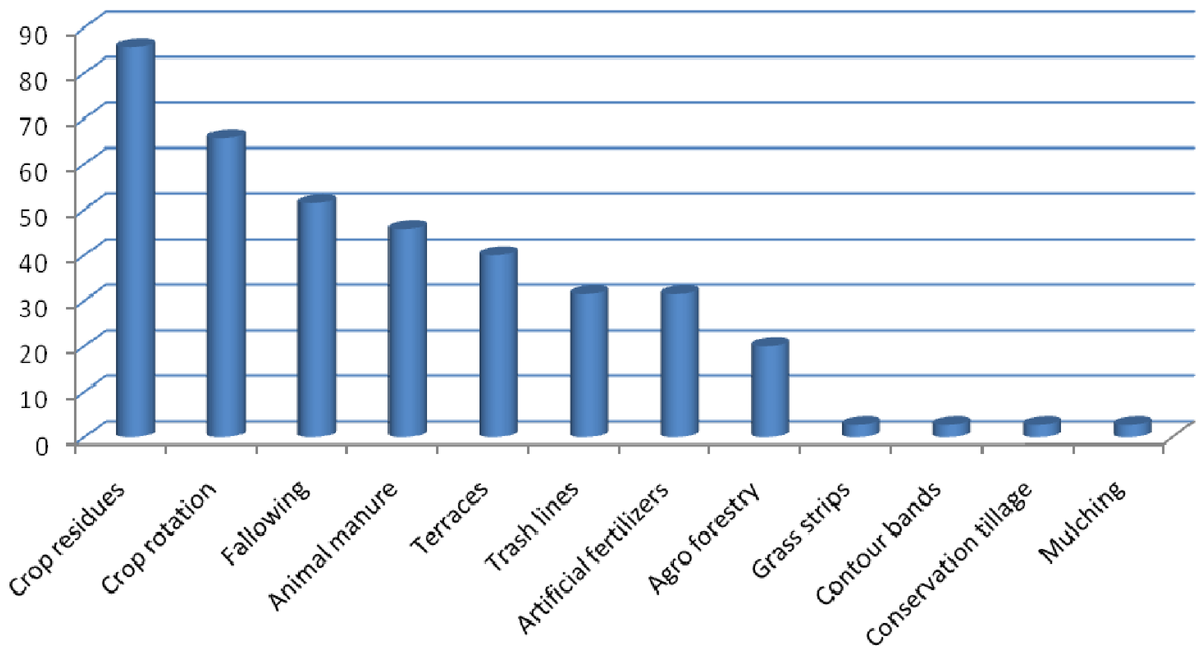

Figure 2. Soil fertility management practices used by vegetable farmers (%).

soil health. We especially examine the drivers of decision to adopt sustainable soil fertility management strategies and the intensity with which they do so.

Soil fertility management practices

The new vegetable, farmers use various soil management practices as shown in Figure 2. The most frequently used fertility management practices include application of crop residues (85.5%), crop rotation (65.7%), fallowing (51.4%) and animal manure application (45.7%). Other soil management practices used (although less frequently) include contour bands, conservation tillage and mulching. In general, the results show that vegetable growers are using the relatively less expensive strategies for maintaining the fertility of vegetable fields. Terracing and the use of artificial/ inorganic fertilizers and agroforestry are less used, probably because they are more expensive financially and also more demanding in terms of labour requirements. Trashlines which involve the application of grass mixed with crop residues and is less applied compared to the pure crop residues probably because they too require heavy use of labour to move and apply the trash on designated lines. Nonetheless, the widespread use of soil fertility management practices by the respondents has benefits for sustainable vegetable production. This finding led us to investigate the factors that explain the decision to use of such practices by farmers and the degree to which soil fertility management strategies are used. Next, we present the results of these analyses.

Factors affecting the use of soil fertility management practices

Table 4 presents the results of the model estimated to assess the drivers of the decision to adopt soil fertility management strategies. Results show that among the farmer specific variables, age, education and household size increase the likelihood of using soil fertility management practices. An increase in the age of the farmer increases the probability of using soil fertility management practices, other things constant. This suggests that older farmers are more likely to have better access to information or technologies through rural development projects that exist in the area or through their social networks than their counterparts (Adesina and Zinnah, 1993; Godquin and Quisumbing, 2005). At the same time, an increase in the size of household increases the likelihood of using soil fertility management practices, other things being constant. This finding can be attributed to the fact that the size of the family determines the available labour and reduces the labour constraints faced on the farm. Among the farm structural and institutional variables, years of experience in irrigation, other sources of income, access to market information, access to hired labour and prior participation in soil conservation activities affect the likelihood of using soil fertility management. Results show that having other sources of income reduces the likelihood of deciding to use soil fertility management practices, other things constant. Results also show that access to labour increases the likelihood of adopting soil conservation practices. This finding is not unexpected since such practices are usually

Table 4. Probit estimates of factors affecting the decision to use soil fertility management practices. Dependent variable: Farmer uses soil fertility management practices.

Variable	Coefficient	p-value
Age in years	0.140	0.050
Irrigation experience	0.029	0.035
Household size	0.144	0.047
Farmer lives on the farm	-0.316	0.971
Other sources of income	-0.117	0.099
Perceived status of fertility	0.536	0.657
Education in years	0.148	0.035
Land tenure	0.481	0.592
Access to market information	0.026	0.032
Access to hired labour	0.613	0.033
Participates in soil conservation activities	0.831	0.004
Belongs to farmer organizations	-1.490	0.670
Intercept	1.456	0.037

N = 35; Pseudo Likelihood ratio = -62.4718; Chi squared = 40.608; p-value = 0.002 013.

Table 5. Poisson regression estimates of factors influencing intensity of use of soil fertility management practices. Dependent variable: Number of soil fertility management practices adopted.

Variable	Coefficient	SE	p- value
Age in years	-2.708	1.033	0.109
Irrigation experience	0.414	0.314	0.187
Household size	2.526	1.020	0.013
Does farmer live on the farm?	0.119	0.180	0.509
Other sources of income	1.012	0.584	0.083
Perceived status of fertility	0.693	1.414	0.624
Education in years	2.226	1.020	0.012
Land tenure	-1.705	1.045	0.103
Access to information	2.741	1.016	0.007
Access to hired labour	0.405	1.155	0.725
Involved in soil conservation activities by MOA	1.749	0.120	0.000
Membership to farmer organizations	1.170	0.186	0.107
Intercept	7.524	3.484	1.013

N = 35; Pseudo Likelihood ratio = -76.734; Chi-squared = 36.41; p-value = 0.004.

labour intensive. Results further show that access to information increases the likelihood of use of soil fertility management practices other things constant.

At the same time, prior involvement in conservation activities increases the probability of using such practices. Indeed, most of the respondents who used these practices indicated that they had previously been involved in soil conservation activities such as field days and farmers' tours organized by Ministry of Agriculture. This finding suggests that exposure of farmers to conservation practices positively affects their likelihood of using soil fertility management strategies. The factors affecting the intensity of adoption of soil fertility management practices (that is, the second hurdle) are shown in Table 5. As shown, the extent to which vegetable growers use soil fertility management practices depends on household size, education, access to information and prior participation in soil conservation practices. Results show that an increase in household size by one member increases the expected number of soil fertility management practices by 2.5, other things constant. At the same time, an increase in years of education increases the expected number of practices by 2.2, other things constant. Results also show that farmers who have been involved in soil conservation campaigns organized by Ministry of Agriculture undertake more soil fertility management practices than their counterparts. These results indicate that education and experience in soil conservation affect the extent of adoption of soil conservation practices.

SUMMARY, CONCLUSIONS AND POLICY IMPLICATIONS

This paper assesses the drivers of decision to transition from pure pastoralism to commercial vegetable production. It also examines the soil fertility management practices these "new" farmers are using to conserve the fertility of their fields and the factors that affect the use of such practices. The study find that a number of farmer specific, farm structural and institutional variables affect the decision to shift to vegetable production. Among other things, size of the household, age, education, income from other sources, access to information from extension advice, and membership to farmer organizations affect the likelihood of shifting to vegetable production. The study also finds that these new farmers use a number of soil fertility management practices, with the most frequently used practices being the application of crop residues, crop rotation, fallowing and use of manure. The study further finds that wide range of farmer specific, farm structural and institutional variables affect the decision to use soil fertility management practices. However, the extent to which such practices are used is affected by household size, access to information, other income sources, and prior participation in soil conservation activities. Based on these findings, the study concludes that the decision by pastoralists to transition to crop farming and their use and intensity of use of soil fertility management strategies are affected by different types of farmer specific characteristics, farm structural characteristics, institutional and quasi fixed capital factors.

The finding that larger households and those with limited alternative income sources are more likely to shift to vegetable production implies that the transition to vegetable production by pastoralists is driven by the desire to diversity livelihood. This finding therefore implies the need for the government and other development agencies to support the transition by pastoralists to crop farming given the frequent and usually ravaging effects of climate change (especially floods and droughts). However, this must be done in tandem with strategies to encourage adoption of soil fertility management strategies in order to maintain sustainable physical soil health in the usually ecologically fragile pastoralist ecosystem. The finding that access to agricultural information and experience in soil conservation enhances the use of fertility management strategies implies that the government can use its network of extension officers and outreach programs to educate pastoralists that are shifting to crop farming about the need to maintain soil physical health. These findings imply that sustainable use of riverside farming by the transitioning pastoralists farmers will require concerted efforts that include farmer education on the benefits of soil fertility management. The experience from conservation success stories such as the "Machakos miracle" can further apply in this case. In the Machakos case, farmer education was coupled with provision of good physical infrastructure (especially roads) that make market access less costly thus increasing the incomes from farming. Increased income in turn acted as an incentive to conserve the soils in order to maintain high yields (Shiferaw et al., 2009).

This therefore means that the government has a role to improve physical infrastructure thereby reducing the transaction costs of market access and hence increasing profits from vegetable farming which in turn will create incentive to manage soils better.

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