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The linkages between property rights, migration, and productivity: the case of Kajiado District, Kenya

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ABSTRACT. This study investigates the relationship between property rights, resource degradation, and productivity among herders in semi-arid regions of Kenya using survey data. Binary and conditional logit models are used to explain migration, while ordinary least squares and fixed effects models are used to explain productivity. The main findings of the study are that private property right regimes discourage migration with livestock, while private property right regimes and migration increase productivity. The study recommends that if privatization is not feasible, then the existing common rights system should be strengthened through promotion of collective action and limiting of group sizes.

1. Introduction and problem statement

Land degradation and declining agricultural productivity is often attributed to the traditional tenure systems of managing agricultural land. It is argued that customary tenure systems fail to provide sufficient incentives to conserve and invest in land, which results in general loss of productivity (Hardin, 1968; Mäler, 1997; Barbier, 1997). Pinckney and Kimuyu (1994) cite literature which argue that emerging individual property rights spur growth through increased credit resources, higher security of investment, and an increase in land area controlled by the most efficient farmers. However, Larson and Bromley (1990), argue that incentives for resource degradation can exist in any property regime. A change from one regime to the other does not guarantee an improvement over the status quo. Indeed such a change might accelerate the rate of resource degradation. Similar views have been expressed by Jodha (1985, 1986). Institutional structures, both of government and market origin are also argued to influence degradation.

Land degradation in Kenya, as in most other developing countries, has manifested itself in rapid rates of natural capital depletion, exemplified by

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forest degradation and soil erosion especially in river basins. The situation is worse in the marginal lands (which constitute about 80 per cent of the total agricultural land) where there is serious environmental deterioration, largely due to rapidly increasing human and animal population pressure. The crisis has manifested itself in resource depletion and declining production (Darkoh, 1994). This degradation is often attributed to poverty (Republic of Kenya, 1999). The poorest groups in rural areas are concentrated on low-potential lands where inadequate or unreliable rainfall, adverse soil conditions, fertility, and topography limit agricultural productivity and increase the risk of land degradation. Their endeavours to make a living often lead to over exploitation of land and water resources. Given these facts, resource management by poor rural households is crucial for dealing with the development and poverty problems facing Kenya.

The link between productivity and environmental degradation is a contentious one. Some authors argue that the poor degrade the environment in their endeavours to satisfy their present demands. Others argue that it is poor environmental quality that leads to low productivity. Developing countries are therefore said to have an environmental equivalent of a 'low-level equilibrium trap': poverty leads to increased resource degradation, which leads to low productivity and to more poverty (López, 1997b; Mäler, 1997). Existing literature also argues that market and other institutional failures are the major factors driving poverty and environmental degradation. Such failures manifest themselves through lack of well-developed capital and insurance markets, poor agricultural pricing policies and trade reforms, uncompetitive labour markets, ill-specified property rights and population pressure (Baland and Platteau, 1996; Ensminger, 1996; Dasgupta and Mäler, 1995; Deininger and Minten, 1999, among others).

Studies that investigate the impact of institutional factors such as property rights on productivity and resource degradation are virtually non-existent in Kenya. Our study aims to fill this research gap by investigating the link between property rights, productivity and resource degradation in Kenya, with the aim of offering policy prescriptions for environmental conservation and increased productivity. The study attempts to answer the following questions: Are grazing pastures held in common more degraded than those held under other regimes? What property right regime would be most appropriate for the semi-arid regions of Kenya in order to conserve the environment and increase productivity?

The rest of the paper is organized as follows: section 2 presents a brief on the study area and the prevailing institutional structure. Section 3 presents the methods of analysis, section 4 describes the data, section 5 presents the research findings, and section 6 concludes the study.

2. Study area and institutional structure

Kajiado district is one of the arid and semi-arid districts in Kenya, which lies within the Rift Valley. The district has a bimodal rainfall pattern with the short rains falling between October and December and the long rains between March and May. The rainfall is, however, quite unreliable and is influenced by altitude. Regions with a high elevation have the highest average annual rainfall (1,250 mm), while most of the district (low elevation) records an average annual rainfall of about 500 mm (Republic of Kenya, 1997). In-terms of vegetation, 80 per cent of the district can be classified as low savanna and arid/semi-arid (ranching zones). The soils are of low to moderate fertility and make the ecosystem fragile and easily degradable. In bio-diversity terms any increase in livestock and/or wildlife could lead to acute land degradation and rapid destruction of the fragile fauna and flora habitats. The land spans the agro-ecological zones III (semi-humid climate – mixed agriculture, 1.2 per cent), IV (arable semi-humid/semi-arid climate, 6.5 per cent), V and VI (arid climate – ranching, pastoral land, 92.3 per cent) (Republic of Kenya, 1997). Economic activities are therefore largely dependent on livestock and wildlife.

Four classes of property rights regimes prevail in Kajiado (Republic of Kenya, 1997). Over 90 per cent of the land in the district is under private ownership with individuals holding title deeds (in the study sample, 69 per cent of the households were found to own land privately). Open access and state land resources include forest reserves, hills, and gorges such as the Amboseli reserve, Ngong, Ngurumani, and Chyulu hills. Lastly, common property is the traditional mode of ownership in the district. For many years the tribe controlled land use although ownership of cattle lay solely with individual families. Fieldwork results indicated that this pattern of land ownership still prevails to date. Where group ranches still exist (Amboseli, Magadi, Loitoktok, Mbirikani, and Konza ranches), land is registered under one (scheme) name but is owned by all married men in the scheme. Although each household is entitled to an *olopoli* (a small area next to each family's gate to a k*raal* for exclusive use by each family's calf population, or for cultivation), all cattle are grazed and watered communally, as dictated by group ranch elders. Field observations indicated that most of the existing group ranches are in the process of subdivision, but this process is very slow due to failure of collective action arising from high transaction costs and misappropriation of funds (see Rutten, 1992; Kituyi, 1990; Jacobs, 1965 for a discussion of institutional structures and changes from transhumance to private ownership among the *Maasai).*

3. Methods of analysis

3.1. Introduction

This section specifies frameworks for predicting migration and also for explaining productivity. We first discuss the theory and hypotheses relating migration and productivity. This is followed by specification of a binary logit model relating migration to a range of determinants, from which we predict the probability that a herder migrates in search of pasture and water. We then proceed to specify the average revenue function following the production function approach and previous studies (López, 1997a, 1998; Stevenson, 1991), incorporating the predicted variable for migration as an explanatory factor, along with other conventional determinants.

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3.2. Analytical framework

Evidence from Kenya indicates that livestock activities have contributed to environmental degradation. The arid and semi-arid lands are characterized by a limited natural resource base and low carrying capacity, such that a relatively small increase in the population can result in the over exploitation of resources (Republic of Kenya, 1999). The increase in livestock population needed to support larger human numbers, is often unsustainable, leading to environmental stress, increased vulnerability to drought, and to food insecurity. Over grazing has therefore resulted from increases in livestock numbers, changes in grazing patterns, and provision of centralized services, such as watering points, encroachment of dry areas by cultivators, and insecurity. Marginal lands must therefore be utilized in a way that minimizes land degradation but still provides economic returns to the users.

Our field observations indicated that over grazing in the study area has led to unpalatable bush encroachment. The bushes suppress the growth of grass, resulting into a downward spiral whereby the range becomes less productive. In addition, invading thorn bushes require more water than the original woody plants, leading to a drop in the ground water level. Another indirect effect of livestock husbandry is felling of trees for firewood. During droughts, the herds shrink and expenditure on food rises. The pastoralists are then forced to turn to other sources of income, such as production of charcoal for the urban market, leading to a reduction in bush and tree stocks. The overall effect of these practices is lower productivity.

Flexibility and mobility of stock grazing and herding is a priority, both in space and time to reduce environmental degradation. Mobility is an effective tool for range improvement as it provides the herder flexibility to modify herds and access alternative pasture areas. Movement with livestock in search of pasture and water is a form of rest-rotation scheme, albeit less strictly organized. The movement allows regeneration of natural vegetation. This increases biomass, biotic diversity of both fauna and flora, and increases the moisture-holding capacity of the soil. If the movements are too short, they lead to insufficient growth of natural vegetation and consequently to low soil fertility and soil instability. The vegetation that grows in the fallow period is a form of capital that accumulates and is eventually used when the pastrolists return home with their livestock. If a herder does not move with his livestock to avoid over grazing, the natural vegetation is reduced. Thus over grazing has a direct short-term output-increasing effect at the cost of reducing the natural capital and thus reducing productivity (López, 1997a, 1998).

Migration with livestock is however dependent on several factors. Lack of well-specified property right institutions, policies, and infrastructure favourable to herders may not only slow the evolution of pastoral systems but may lead to environmental degradation. For instance, it is argued that private property rights are necessary to give individuals the long-term incentives to invest in resources and use them efficiently. Common property resources are therefore seen as a constraint to intensification and investment, especially where information costs are low and markets (credit and insurance) are perfect.

Interactions of social and economic factors also influence mobility with livestock and the efficiency of production systems in fragile ecological environments. An increase in total expected income (including transfers and non-farm incomes) reduces the propensity to migrate (Chopra and Gulati, 1998). Markets determine the capacity for growth and efficiency. Improved transport, convenient markets, and provision of feed supplies could encourage pastoral people to increase production from individual animals rather than from large unproductive herds. But in many parts of the region, markets barely exist, or, if they do exist, operate inefficiently, leaving many pastoralists outside or only loosely connected with the marketing system. Also, the pastoral communities continue to be marginalized in terms of access to education and other essential services. Numerous agencies have programmes in the pastoral areas, but these are primarily focused on emergency relief, with inadequate attention to development, and there is little coordination. Increasing human populations, water scarcity, and the expansion of cultivated areas have contributed to the diminishing quantity and quality of productive rangelands. This, combined with poor animal and human health, places enormous stress on traditional pastoral and land management practices. A substantial portion of the pastoral population is consequently food insecure due to low productivity even in normal rainfall years.

Assuming that herders' objective function is to maximize revenue from grazing, our study hypothesizes that migration with livestock would enhance environmental capital (mobility contributes to pasture sustainability and improvements) and lessen production inefficiencies in order to increase production and incomes, which in-turn leads to a reduction in the degradation of the land. We argue that mobile pastoral systems are more economically efficient than sedentary systems, with higher overall returns per hectare but lower productivity per animal.

Constraining revenue by the quality of the environment is well documented by López (1997a, 1998) who focuses on productivity under shifting cultivation and Ahuja (1998) among other studies. Our study takes into account the fact that the basic constraints in an arid land household unit differs from those in the community López focuses on. While farmers under shifting cultivation attempt to maximize revenue subject to the growth rate of village biomass, herders in an arid land setting wish to maximize revenue subject to the prevailing environmental conditions and the technological constraints they face.

From the foregoing discussion, holding the interaction of other social and economic factors constant, three interrelationships between degradation, migration, and productivity can be identified. In the first place, increases in herds and human population exert pressure on available pasture and water. Second, such pressure forces the herders to move out in search of more pasture and water. Third, the movement allows regeneration of vegetation, which increases productivity in subsequent periods. Below we specify these relationships in formal modelling.

3.3. Empirical framework

A herder contemplating whether to migrate in search of pasture has to make two decisions. The first, whether such a venture is worth taking or not, the second how far the herds have to be moved. Underlying these decisions is a random utility function. The herder's decision to migrate is based on a set of parameters or attributes which describe the profitability of the decision taken thus affecting productivity. Environmental conservation (which increases environmental capital) is a dummy variable assigned the value of 1 if the herder migrates in search of pasture and 0 if he does not migrate. If we let X represent a vector of determinants of migration, then the basic form of the multivariate logistic function with Z as the predictor variable can be expressed as

$$Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots \beta_j X_j \tag{1}$$

Analogous to equation (1) and following Chopra and Gulati (1998), the probability that a herder migrates in search of pasture (migr) is predicted as

$$Migr = m(Ppr^j, X^j, K^j, TRF^j, FAMI^j, H^j, NCO^j, RSG^j, \phi^j) \tag{2}$$

where Ppr^j is the property right regime facing herder j; X^j is the total land owned by herder j; K^j is value of capital (equipment) employed by herder j; TRF^j is transfers/remittances received by herder j; $FAMI^j$ is non-farm income received by herder j; H^j is a vector of household characteristics (household size, age, gender, and education – education is measured by two dummy variables, primary and secondary education); NCO^j is the number of cows owned by herder j; RSG^j is the ratio of sheep and goats to the number of cattle owned by herder j; ϕ^j is the perceived impact on the value of migration on productivity by herder j.

To model the impact of migration on productivity, our study estimates an average revenue function using the production function approach.[1] The innovation is to follow the standard revenue maximization problem but to constrain the maximization problem by degradation of the resource stock (López, 1997a, 1998; Ahuja, 1998). However, Stevenson (1991), introduces a simple model to compare the productivity of private and common property as

$$Y = \gamma_1 R + \beta_1' X_1 + \mu_1 \tag{3}$$

where Y is average milk production (liters/cow/day), R is a dummy variable for property right regimes, which equals to 1 if tenure system is private, and otherwise equal to 0. X_1 is a vector of exogenous variables other than the rights system that might affect productivity; γ_1 and β_1 are unknown coefficients, and μ_1 is a stochastic disturbance term. The author argues that milk production can be used as a proxy of the extent of over grazing, because less degraded pastures will yield more milk per cow per day, controlling for the characteristics of the pasture and other factors. Following this approach, we specify a productivity model as

[1] Average revenue (revenue per acre) is taken as a proxy for productivity as an increase in output with prices and land held constant translates to an increase in average revenue resulting from increased productivity. A Meta production function also allows gross revenue/profit to be used as a proxy for productivity (Evenson and Mwabu, 1998).

$$R^j = f(X^j, TRF^j, FAMI^j, NCO^j, K^j, Ppr^j, H^j, Mg^j) \quad (4)$$

where R^j is revenue per acre, Mg^j is the predicted probability of migration predicted from equation (2). All other variables are as defined above. Ratio of sheep and goats to cattle and the perceived impact of migration on productivity are used as the identifying variables for the migration equation.

The estimable form of equation (4) can be expressed as

$$Y_{jt} = \alpha + X_{jt}\beta + v_{jt} + \epsilon_{jt} \quad (5)$$

where j denotes the jth household (herder), t denotes the time period (t = 1,2,3), Y_{jt} is the revenue per acre (productivity) for herder j at time t, α is a constant term, and β is a vector of coefficients to be estimated. X_{jt} is a vector of determinants of productivity specific to household j at time t. $V_{jt} + \epsilon_{jt}$ is the residual where v_j is the household-specific residual, which differs among households but is constant for any household. ϵ_{jt} is white noise with the usual properties.

In panel data studies, equation (5) can be modified and estimated either as a fixed effects or a random effects model. In the fixed effects model, v_i is assumed to be a fixed parameter to be estimated. The fixed effects model is useful when we are confident that the difference between units can be viewed as parametric shifts of the regression function. However, it suffers from a number of shortcomings. First, it is costly in terms of degrees of freedom lost (non-parsimonious) as $N-1$ extra parameters need to be estimated reducing the precision of the estimates. Also, it has too many dummies that could aggravate the problem of multicollinearity among the regressors (Baltagi, 1995). Lastly, it sweeps out/drops all fixed effects and therefore cannot estimate the effect of any time invariant variable, such as sex, marital status, and schooling. Due to these shortcomings, the random effects model is more attractive than the fixed effects model. However, the fixed effects approach has one advantage over the random effects model in that there is no justification for treating effects as uncorrelated with other regressors. The random effects treatment may therefore suffer from inconsistency due to omitted variables (Greene, 1997).

In this paper, we estimate equations (2) and (4) as pooled sample and as fixed effects. Given the nature of our data, potential problems include specification errors, omitted variables, simultaneity, and heteroscedasticity, which we try to take care of using appropriate econometric procedures.

4. The data

The data used in this study represent a time panel collected from a cross section of households in Kajiado district. The data were collected in three phases. In phase one, data were collected for the long rains (March–May 1999), phase two for the short rains (October–December 1999) and phase three for the long rains (March–May 2000). The data were collected using the National Sample Survey and Evaluation Program (NASSEP III) frame (Republic of Kenya, 1996). A sample of 220 households were visited with a response rate of 202, 192, and 176 households in phases one, two and three respectively, making a total of 570 observations.[2] A detailed questionnaire was used to collect the required information. To obtain information on the role of institutional changes in resource degradation, focus group discussions were held in some of the clusters that fall under group ranches.

The main variables used in the analysis are summarized in appendix table A1. The data show that 69 per cent of the observed households held land under private property, as compared to 31 who held land under common property. The data further indicate that out of the 570 observations, 54 per cent migrated in search of pasture and water. Of those who migrated, 71 per cent were engaged in long distance migration while the remaining 21 per cent commuted with livestock. These households further reported that the migrants were mainly children (34 per cent), household heads (25 per cent), workers (19 per cent), and other relatives (12 per cent). One important qualification to make is that although the mean household size was found to be 7 with a standard deviation of 4, some households were very large. 84 per cent of all households reported household sizes of less than ten members, and only 4 per cent reported more than 25 members. Most of the families that reported more than ten members were polygamous households. For instance, the household with 38 members comprised of one head (aged 71 years), who had five wives, implying that the average number of children per wife was only 6.4. Such a family is considered as one household since the members live together in a single *manyatta*.

5. Results of the empirical analysis

5.1. Introduction

This section presents the empirical results. The section starts with a presentation of binary logit and fixed effects results for environmental conservation through migration of livestock to areas with better pasture. In this case, we seek to answer the question of what factors explain environmental conservation. From the regression results, we obtain the predicted probability that the herder migrates with livestock. The final part presents the empirical results for productivity analysis. We seek to answer the question whether environmental conservation and well-specified property rights increase productivity. The predicted probability from the migration model is used to capture the impact of environmental capital on productivity.

5.2. Participation in environmental conservation

Herders conserve the environment through movement (migration) with livestock in search of pasture and water. We estimate both a binary logit and a panel data model for the determinants of the decision to migrate. In panel data modelling, we choose the fixed effects estimator rather than the random effects estimator since the Hausman specification test rejected the

[2] Since the variations in the sample are not systematic, we assumed that sample attrition does not bias our results. The software used (Stata) also takes care of unbalanced panels automatically.

random effects model, implying that important individual effects which are correlated with the right-hand side variables, may be present in our data (Baltagi, 1995). For the binary logit model, we correct for possible heteroscedasticity using White's Method (Greene, 1997). The estimated results are presented in table 1. We also try to take care of omitted variables and to find out whether migration and productivity are jointly determined by estimating equations (2) and (4) simultaneously. The results are presented in appendix table A2.

We base the discussion on the binary logit results as this model seems to fit the data better than the fixed effects model. For the latter, we also note the huge loss of degrees of freedom compared to the binary logit specification. The log likelihood ratio statistics $\{X^2(13) = 157\}$ for the binary logit model implies that the model fits the data significantly better than the model with the intercept only. The results indicate that the property right regimes dummy negatively and significantly influence the decision to migrate in search of pasture and water. This implies that those who hold land under private property arrangements face less odds of migrating than those who hold land under common property ownership. This could be explained by the fact that most private landholders are more sedentary and are also likely to engage in other non-herding activities, which reduce their propensity to migrate.

Increasing the proportion of total land owned exerts a strong positive impact on migration relative to not migrating. Holding all factors constant, a 1 per cent increase in total land owned increases the probability of

Table 1. *Determinants of the decision to migrate in search of pasture (Y=1 if herder migrated, otherwise Y=0)*

Variable	*Pooled logit*			*Fixed effects*	
	Parameter estimates		*Marginal effects*	*Parameter estimates*	
Property right regimes	−1.158*	(0.256)	−0.262	−0.948***	(0.605)
Total land owned	0.280*	(0.070)	0.068	−0.132	(0.184)
Transfers	−0.058***	(0.035)	−0.014	0.027	(0.066)
Non-farm income	−0.076*	(0.028)	−0.019	0.067	(0.060)
Value of tools (equipment)	−0.138	(0.102)	−0.033	0.114	(0.159)
Household size	0.559	(0.606)	0.136	4.694***	(2.966)
Age of household head	−3.926*	(1.318)	−0.954	−9.135**	(5.020)
Sex of household head	0.568***	(0.332)	0.140	−1.369	(1.348)
Primary school education	−0.992*	(0.328)	−0.242	0.983	(1.245)
Secondary school education	−1.024*	(0.435)	−0.251	0.346	(1.508)
Number of cattle owned	2.138*	(0.267)	0.519	1.056**	(0.522)
Ratio of sheep/goats to cattle	0.026	(0.020)	0.006	−0.013	(0.035)
Perceived impact of migration	0.219	(0.253)	0.053	1.003**	(0.572)
Constant	6.125	(2.281)			
Number of observations	570			167	
Log likelihood	−215.615			−47.968	
Wald/LR Chi-square (13)	156.81*			25.83*	

Notes: Standard errors in parenthesis. *, **, *** Significant at 1%, 5%, and 10% respectively.

migrating by 0.28 per cent. A possible explanation is that it is only in the more arid zones that individuals own large tracts of land. Such herders are therefore more likely to have deficiencies of pasture as compared to their counterparts with less but more productive land.

Transfers and non-farm incomes have negative impacts on the probability of migrating in search of pasture, implying that as such incomes rise herders are less likely to migrate with livestock, probably because they may not have to rely on livestock production for survival. A 1 per cent increase in each of these incomes reduces the probability of migrating by about 0.06 per cent. Field observations indicated that households that reported high non-farm incomes (mostly from quarrying and housing rents) also reported having smaller herd sizes and thus may not need to migrate in search of pasture.

Value of equipment also has a negative but insignificant coefficient. This implies that households who invest in a lot of physical capital face less odds of migrating with cattle than those who do not invest. An increase in value of investment in equipment by Kshs.1,000 would reduce the probability of migrating by 0.14 per cent. This may be because those who make such investments are the more sedentary herders who also keep mostly mixed and grade cattle, for which they at times purchase fodder and thus may have a lower propensity to migrate.

Household size exerts a positive impact on the probability of migrating in search of pasture and water. An increase in household size by one more member will increase the probability of migrating with livestock by 0.56 per cent. Since household size could be seen as a proxy to family labour this result implies that herding households are more likely to migrate with livestock if family labour is available compared to their counterparts with less labour.

Age has a negative and significant impact on migration, implying that, as expected, elderly herders are less likely to migrate than their younger counterparts, probably due to the fact that elderly herders may not have enough strength to migrate and may prefer to sell their livestock in the face of drought or give out their livestock to their sons. Men are more likely to migrate than women, which is in line with reality, as migration is a male affair whereby the men migrate in search of pasture and water while the females are left behind to take care of the children. Women only migrate if they have to accompany their spouses.

Education dummies have negative coefficients, implying that those who have some level of education face less odds of migrating than those without any education, probably because they are more aware of the benefits of own farm development, the dangers of migration (mostly spread of livestock diseases), or because they may be engaged in other non-herding activities (non-farm income etc.)

The results further indicate that livestock ownership variables have positive coefficients, implying that the more livestock held, the higher the probability that the household will migrate in search of pasture and water – greater numbers of livestock depletes pastures faster, forcing the herders to migrate in search of more. Households with smaller herds are also better placed to temporarily send cattle to relatives/friends during the dry season, so that the household does not have to migrate.

Perceptions of the benefits of environmental conservation was captured by asking herders what they felt was the impact of migration on productivity (the responses were coded as 0 = decreases productivity, 1 = increases productivity). Responses to these questions indicated that most herders who were against migration felt that migration/open grazing increases the spread of animal-related diseases and so the further the cattle were moved, the higher the likelihood of contracting various diseases. However, the results indicate that favourable perceptions exert a positive impact on the probability of migrating. Increasing the proportion of herders with positive perceptions by 1 per cent would increase this probability by 0.22 per cent. If productivity growth is to be achieved, it is therefore vital to educate herders in the district on the benefits of environmental conservation, in order to bring about a change in attitude. We note that this variable turns out to be a good instrument for identifying the migration equation, as it is significantly different from 0 in the fixed effects specification.

The marginal effects of each of the predictor variables are presented in the third column. The results indicate that the highest marginal effects are from number of cattle owned, whereby owning an extra cow increases the probability of migrating by 52 per cent. The results further show that the probability of migrating is 26 per cent lower if a herder holds land under private property than if he holds land under common property. All the other marginal effects can be interpreted in the same way.

5.3. Impact of property rights and migration on productivity

This section presents the regression results for the impact of property right regimes and migration on productivity. We hypothesize that environmental conservation leads to higher productivity and hence whether land is degraded or not can be inferred from the productivity level (Stevenson, 1991). We estimate both an ordinary least squares (OLS) and a fixed effects model to explain productivity. As for migration, results of Hausman's specification tests lead us to present the fixed rather than random effects results. For the OLS model, we correct for possible heteroscedasticity using White's method (Greene, 1997).

We present results for fixed effects and OLS regression specification, with the latter reporting standard errors corrected for heteroscedasticity. The results are presented in table 2. The regression specifications use predicted values of migration from section 5.2. Except for the total land owned and age variables, the results report the same signs in both the OLS and fixed effects models. The Chow tests (F statistics) for both specifications confirm the goodness of fit of the model and also confirm the stability of the coefficients to changes in specifications. We base our discussion on the OLS results as the model fits the data better than the fixed effects model.

The results indicate that total land owned has a negative but insignificant coefficient, implying that herders owning large tracks of land are likely to have lower productivity than their counterparts with less land. A possible explanation is that those with large tracks of land are in the more arid zones of the district and their land is therefore less productive than

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that of their counterparts in less arid zones. For instance the data indicate that in Loitoktok division, which is a major farming zone, the mean total land owned was only 27 acres, while in the more arid divisions of Namanga and Mashuru, the mean total land owned was 253 and 174 acres respectively.

Non-farm income exerts a strong positive impact on productivity. The implication is that herders invest this income into production, such as buying more livestock, or livestock inputs, which increases returns per acre. This result is supported by the coefficients for number of cattle owned and livestock inputs, which report strong positive coefficients.

Value of livestock inputs exert a strong positive impact on productivity, implying the need to raise investment in drugs and other animal inputs, such as salt lick and feeds to boost livestock productivity. Increasing this investment by 1 per cent increases average revenue by 0.4 per cent. Although increased investment in inputs could reduce profits due to expenditure incurred, it has a positive impact on productivity through increased output, if all other factors are held constant. This result supports findings by López (1998), Ahuja (1998), and Evenson and Mwabu (1998).

The coefficient for property right regimes has a significant positive effect, which implies that those who hold land under private property record higher productivity than those under common property. This is consistent with our earlier findings on conservation practices, which indicated that well-specified property rights encourage investment in land (and discourage migration) and would therefore translate to higher productivity per head of cattle other factors held constant. This also supports the literature that argues that well-specified property rights will act as incentives for increased productivity (Barbier and López, 1998; Norton,

Table 2. *Regression results for productivity (dependent variable is revenue per acre)*

Variable	*OLS regression*		*Fixed effects*	
	Parameter estimates		*Parameter estimates*	
Total land owned	−0.147	(0.093)	0.358*	(0.084)
Transfers	−0.032	(0.031)	−0.047	(0.038)
Non-farm income	0.054**	(0.026)	0.028	(0.036)
Number of cattle owned	3.040**	(1.406)	4.58***	(2.867)
Value of livestock inputs	0.399*	(0.043)	0.248*	(0.061)
Property right regime	1.174*	(0.265)	0.737**	(0.353)
House hold size	1.648*	(0.510)	2.612*	(1.015)
Age	1.311	(1.067)	−0.773	(2.677)
Primary school education	0.762*	(0.286)	1.682**	(0.832)
Secondary school education	1.042*	(0.414)	2.949*	(1.063)
Post sec. school education	1.071**	(0.489)	2.995*	(1.163)
Predicted prob. of migration	0.012	(0.272)	0.911*	(0.371)
Constant	0.236	(1.944)	1.721	(4.577)
Number of observations		570		570
F(12, 557)		19.24*		F(12,339) = 6.74*
R-squared		0.2713		0.1638

Notes: Standard errors in parenthesis. *, **, *** Significant at 1%, 5%, and 10% respectively.

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1998; Gavian and Fafchamps, 1996 and Stevenson, 1991). This calls for the need to encourage privatization of common property resources in order to boost productivity.

Household size has a positive impact on productivity, and implies that increasing household size by one more member increases productivity by 1.6 per cent, if other factors are held constant. This result implies that the larger the household, the more the labor (population) available, for productivity growth (Ahuja, 1998; Boserup, 1965). All education dummies have positive and significant coefficients, indicating that more educated herders report higher productivity than their less educated counterparts. Further, the magnitudes of the coefficients imply that productivity increases with the level of education (Evenson and Mwabu, 1998). For instance, increasing the proportion of herders with primary education by 1 per cent would increase productivity by 0.76 per cent, while a similar change in post secondary education would increase productivity by 1.07 per cent.

The coefficient for the predicted probability of migration is positive, implying that herders who migrate are likely to report higher productivity than those who do not since they are in a better position to acquire more pasture/water for their livestock. This result is consistent with findings on the importance of biomass in determining productivity (López, 1998 and Ahuja, 1998). Our results could also be interpreted as supporting Evenson and Mwabu (1998) concerning the positive effect of fallow land on productivity.

6. Summary and conclusions

This study investigates the relationship between property rights, resource degradation and productivity in a semi-arid region of Kenya. The results indicate that the amount of land owned, household size, gender, number of cattle owned, and favourable perceptions concerning the value of environmental conservation favour the migration decision. On the contrary, property right regimes, transfers, non-farm incomes, age, and education attainment negatively influence this decision. However, we note that these results are based on the assumption that migration is a means of conserving the environment. Previous studies suggest that leaving land fallow, which is synonymous to migration, will allow soil and vegetation to recover and therefore lead to higher productivity in subsequent periods (López, 1998; Ahuja, 1998). On the other hand, migration could also be a result of environmental degradation. For instance, Chopra and Gulati (1998: 37) argue that the increased capacity of resources to sustain populations work as disincentives to migrate, which can only hold if resources are not degraded. In this light, therefore, the causal relationship between migration and environmental degradation is not clear. Further research in this direction is recommended.

The results for productivity indicate that non-farm incomes, number of cattle owned, value of livestock inputs, property rights regimes, household size, education attainment, and the predicted probability of migration increase productivity. On the contrary, total land owned and transfer incomes reduce productivity. The results for the property rights dummy imply that privatization of common property land would lead to an increase in productivity in semi-arid regions. This suggests the need to speed up privatization of the remaining schemes so that the community can enjoy the benefits of private property. However, privatization of common property resources could lead to a fall in the probability of migration. Such a policy may adversely affect herders with large herds and should therefore to be considered in the light of its benefits and costs. As a policy option, we would recommend that if schemes cannot be privatized, then it is important to strengthen the existing common rights system through promotion of the role of the group (collective action) and also by limiting the group sizes because very large groups result in failure of collective action.

In line with this, although privatization would be expected to minimize the amount of common land, and therefore reduce the potential for herders to migrate, the immediate consequence would be pressure on trust land and conflict with wildlife and farmers. This argument is based on the fact that the community in question is very aggressive. For instance, in the recent past, the *Maasai* have been seen grazing in the city center and also invading private farms in search of pasture, due to severe drought. The implication here is that, even in the light of privatization, migration may still be possible. This then raises the issue of livestock, human, and wildlife conflicts resulting from privatization of common property resources. We recommend further research in this direction.

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Appendix

Table A1. *Sample statistics*

Variable	*Mean*	*Std. deviation*	*Minimum*	*Maximum*
Age (years)	35.12	13.18	22	70
House hold size (number)	6.83	4.17	1	38
Number of years in school	4.02	4.75	0	19
Total value of livestock production (Kshs* '000)	356.97	830.68	0	10317
Transfers (Kshs. '000)	1.58	7.51	0	100
Income from non-farm sources (Kshs. '000)	10.57	32.68	0	420
Value of equipment (Kshs. '000)	5.10	9.54	0	97.65
Value of livestock inputs (Kshs. '000)	2.49	6.28	0	91.8
Total land owned (acres)	89.32	140.11	0	800
If herder migrates (1 = yes, 0 = no)	0.54	0.50	0	1
Number of cows	20.84	58.44	0	902
Ratio of sheep/goats to cows	3.00	6.53	0	93
Property rights regimes (1 = private, 0 =common)	0.69	0.46	0	1
Perceptions on value of migration (1 = increase, 0 = decrease productivity)	1.43	0.90	0	3

Note: * Kshs: Kenyan shillings.

Table A2. *3SLS estimates of structural parameters for migration and productivity*

Variable	*Migration*		*Productivity*	
	Coefficient	*Std. error*	*Coefficient*	*Std. error*
Property right regimes	−0.193*	0.034	1.089*	0.324
Total land owned	0.052*	0.009	−0.119	0.086
Transfers	−0.008**	0.005	−0.038	0.036
Non-farm income	−0.010*	0.004	0.049***	0.028
Value of tools (equipment)	−0.018**	0.010		
Household size	0.028	0.070	1.689*	0.508
Age of household head	−0.522*	0.139	1.069	1.198
Sex of household head	0.080***	0.047		
Primary school education	−0.140*	0.040	0.695**	0.356
Secondary school education	−0.164*	0.053	0.963**	0.467
Number of cattle owned	0.305*	0.029	3.648***	2.178
Ratio of sheep/goats to cattle	0.002	0.002		
Perceived impact of migration	0.003	0.033		
Value of livestock inputs			0.408*	0.056
Post secondary education			1.063***	0.609
If herder migrates			−0.374	0.964
Constant	1.326	0.242	0.791	2.261
Number of observations		570		570
R-Squared		0.499		0.269
Chi-square (13)/(12)		568.0*		208.6*

Notes: *, **, *** Significant at 1%, 5%, and 10% respectively.

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