Environment and Development Economics 9: 67–85 © 2005 Cambridge University Press
DOI: 10.1017/S1355770X04001512 Printed in the United Kingdom

Herders response to acute land pressure under changing property rights: some insights from Kajiado District, Kenya

JANE KABUBO-MARIARA
Department of Economics, University of Nairobi, P.O. Box 30197, Nairobi. Tel: 254 2 334244. Fax: 254 2 336885. E-mail: jkmariara@yahoo.com

ABSTRACT. This paper examines the response of herders to increased shortage and degradation of land in an arid and semi-arid land setting in Kenya, under changing property right regimes using both survey and secondary data. We argue that the responses adopted are livelihood strategies to improve herder's welfare. We explore the determinants of three different strategies: crop cultivation, investment in land improvements, and migration with livestock. We employ the probit regression framework to explain each strategy. The main findings of the study are that private property rights, educational attainment, and availability of water are major determinants of the three strategies. We recommend policies that favour privatization of existing common property resources, improve education levels, and increase supply of water in the district.

1. Introduction

Land pressure is most acute in marginal pastoral areas, where livestock husbandry tends to have adverse effects on the environment. Available estimates show that overgrazing causes 35 per cent of all human-induced soil degradation worldwide and 49 per cent in Africa (Haen, 1993; Pinstrup-Anderson and Pandya-Lorch, 1994). Available evidence from Kenya also indicates that livestock activities have contributed to environmental degradation especially in the arid and semi-arid areas, which are characterized by a limited natural resource base and low carrying capacity (Republic of Kenya, 1999). Pressure on land is evident from a

The author wishes to sincerely thank Prof. Jean-Phillipe Platteau for his valuable insights on analytical issues in the preparation of this paper. Special thanks also go to Professors Karl-Göran Mäler, Partha Dasgupta and David Starrett as well as participants of two Beijer Advanced Workshops on Property Rights and Environmental Resource Management, and participants of the Programme on Ecological Economics at the Abdus Salam International Centre for Theoretical Physics (ICTP), Italy for useful insights on an earlier draft of this paper. Thanks are also due to Professor Germano Mwabu of the University of Nairobi. The usual disclaimer applies.

steady decrease in the ratio of cattle to small stock, which is an indicator of falling per capita stock holding (Chopra and Gulati, 2001; Western and Nightingale, 2002; Little *et al.*, 1999) and a steady increase in the ratio of occupied to unoccupied Maasai huts, indicating that the Maasai are becoming more sedentary (Little *et al.*, 1999). The consequence of increased land pressure is not only increased persons/land ratios, reduced fallow periods, land degradation, and changing farming systems, but also pressure on the laws and customs, which have in the past assured farmers of land rights (Atwood, 1990). For instance, Coast (2002) notes that the economic and social conditions of the Maasai have changed throughout their history in response to a myriad of factors operating over a variety of spatial and temporal scales.

Overgrazing and other forms of land pressure are caused by increased animal and human population pressure, changes in grazing patterns due to privatization of land, losses of grazing lands to agriculture, limited mobility due to political insecurity, absence of mechanisms for smoothing number of stocks through the seasons, and crop and livestock raids by wild animals (Rutten, 1992; Western and Nightingale, 2002; Leneman and Reid, 2001; Fratkin, 1991; Ensminger, 1992). Climatic uncertainty and drought as well as environmental changes driven by shifts in land use patterns have also seriously diminished the ability of pastoral communities to cope using traditional strategies, calling for flexible range practices, herding strategies, and strong social networks (Western and Nightingale, 2002; Leneman and Reid, 2001; Kishel *et al.*, 1999). All these forces contribute to increased pressure on the environment and raise the ecological vulnerability of marginalized herders.

The responses adopted by herders under such circumstances are broad and varied ways of diversifying livelihoods and lifestyles in order to minimize environmental risks and uncertainty (Western and Nightingale, 2002). They include crop cultivation, wage employment, subdivision of land, livestock trade, petty trade, home brewing and sale of alcohol, charcoal burning, tourism, and hunting among others (Western and Nightingale, 2002; Nduma *et al.*, 2001; Little *et al.*, 1999; Kishel *et al.*, 1999; Coast, 2002; Leneman and Reid, 2001; Ensminger, 1992; Kituyi, 1990). These studies also concur that the main force driving the choice of various survival strategies is property rights and concomitant markets among other factors. Empirical evidence also argues that secure property rights provide important investment incentives and therefore act as a catalyst for increased productivity growth (Besley, 1995; Platteau, 2000; Brasselle *et al.*, 2002; Jocaby *et al.*, 2002). Furthermore, the manner in which property rights to land are defined is also argued to have far-reaching implications for the social organization of communities and households' ability to cope with shocks (Deininger and Jin, 2002).

This paper examines the response of herders to increased shortage and degradation of land under changing property right regimes in an arid and semi-arid land setting in Kenya. We assume that herders are compelled by environmental and population changes (both human and livestock) to adapt their behaviour and livelihood strategies. Three such strategies are looked at: herders shifting to crop cultivation, investment in land improvements, and transhumance.[1] Crop cultivation and, more so, investment in land improvements require privatization of land rights, which, if Boserup's hypothesis of induced institutional innovation is valid, should take place as an endogenous response to increasing land scarcity. These strategies have important welfare implications for the Maasai as well as implications for environmental conservation for arid and semi-arid areas.

The rest of the paper is organized as follows: The next section presents the methods of analysis. Section 3 presents a description of the study area and the data for analysis, section 4 presents the results, while section 5 concludes.

2. Methods of analysis

2.1. Conceptual framework

To gain insight on how property rights in land affect herder's choice of livelihood strategies, our study adopts the standard theory developed by Boserup (1965). According to Boserup, as population grows, land and other natural resources become scarcer relative to labour and access to markets improve. As a result, agricultural intensification occurs, relative prices change, and food prices increase as demand for food rises. This process induces institutional innovations such as private property rights, which then facilitate adoption of better technologies that help to starve off the operation of diminishing returns in natural resource use.[2] The same premise is held by the evolutionary land rights theory (Platteau, 1996, 2000).[3] Drawing from Boserup's work, Platteau makes a convincing case that population density relative to land abundance is the place to begin to understand evolution of property rights.

Following Boserup's hypothesis, we assume that property rights emerge endogenously, all the more so in Kenya as private property right regimes can be sanctioned by legally granted titles. The private property rights then act as incentives for land improvements (including conservation), that is, a way of escaping poverty in conditions of land scarcity. This is confirmed in many instances by empirical evidence, even though Platteau (2000) argues that this relationship is far from automatic as far as the shift from unregulated common property towards private property rights is concerned.

[1] Throughout the paper, migration with livestock is used synonymously with transhumance.

[2] Although Boserup's hypothesis has been found to be consistent with certain empirical evidence from developing countries (Lopez, 1997a; Tiffen *et al.*, 1994 among other studies'), we note that it has also been contradicted by some studies. Instead the latter studies show that population growth is associated with increased environmental degradation and declining productivity (Place and Otsuka, 2000; Mäler, 1997; Pinstrup-Anderson and Pandya-Lorch, 1994; Reardon and Vosti, 1995).

[3] The evolutionary land rights theory contends that as land scarcity increases, people demand more land tenure security. As a result, private property rights in land tend to emerge and once established, to evolve towards greater measures of individualization and formalization.

We distinguish here between division of the commons and individualization of privately held landholdings. Empirical evidence convincingly shows that the latter occur as a response to growing land scarcity. Once land is privatized, in the sense of being divided into individually held plots, individualization of other rights increase as land scarcity increases (Platteau, 2000). The problem with division of the commons is that it is normally taken for granted, yet there are two main problems highlighted by Platteau (2000). The first is the efficiency argument. That is, if governance costs[4] are less than privatization costs plus opportunity costs, such as insurance gains, and scale economies lost, then privatization should not occur. The second is the equity consideration where likely losers may oppose privatization.

The endogeneity of property rights and the issue of equity are well addressed by Besley, 1995; Brasselle *et al.*, 2002; Jacoby *et al.*, 2002. Empirical evidence also show that in some instances, the equity gains may outweigh the efficiency losses and therefore it may not be worth moving towards privatization, even if secure rights increase household's propensity to make investments (Deininger and Jin, 2002; Platteau, 2000). In other instances, policies to reduce tenure security have been shown to produce minimal efficiency gains (Jacoby *et al.*, 2002). However, these arguments are based on studies and cases where common property resources are not titled and where subdivision of land and assignment of private property rights can be influenced by individuals, which is inconsistent with the case at hand.

Our study makes an important contribution to the available literature in that we look at herders and we are not only concerned with the equity issue but also with the efficiency issue because what we still have in some instances are group ranches, some of which have been privatized and others are not. Where they have not been privatized, it is usually due to collective action problems, which are incurred because of group titling in the specific instance of Kenya. An immediate implication is that privatization is beyond the control of a single household. It is decided or blocked at the collective (group ranch) level, as a result of which the endogeneity problem (of property rights) vanishes. For instance, in some of the existing group ranches, members have agitated for subdivision of land for a long period of time, yet this has not been done due to non-cooperation and misappropriation of funds by the management. We can therefore consider the property right regime as exogenous because we deal with individual households and not with collective grazing entities. Still it is interesting to note that in our study area, where land is most productive, there is more privatization, which confirms the prediction of Platteau (2000).

We are then able to test to what extent private property rights, whenever they could be established, have encouraged herders to be involved in

[4] Governance costs include all those costs incurred to reach a collective agreement and to organize a community of users. They are likely to be higher the larger the group and also the more heterogeneous the group (Platteau, 2000; Baland and Platteau, 1996).

agricultural activities.[5] We do this by looking at two dimensions of this involvement: whether they cultivate crops; and whether they invest in land improvements. The assumption is that, since we do not have to worry about the endogeneity problem, private property rights raise the likelihood of crop cultivation and investment in land improvements. When private property rights are not well established, we expect that herders look for an alternative to agriculture and probably a second-best alternative. One alternative which immediately comes to mind is migration with livestock in search of pasture and water. Our study tests this and uses the results to draw policy conclusions for improving the welfare of herders.

We employ probit regression methods to estimate the probability of a herder choosing a particular strategy. We note here that though any herder could choose from a set of strategies, we do not assume exclusivity of these strategies as a herder could choose more than one at a point in time and the strategies are complementary rather than competing. However, since decisions are simultaneous, we need to instrument our equations, yet we could not find any suitable instrument among the available data. We therefore have to fall back on the last resort method, consisting of estimating the reduced-form equations for each dependent variable.

2.2. Theory and hypotheses

To apply the conceptual framework presented above, we first discuss theory and hypotheses that place our study in the context of existing literature. Previous studies indicate that with increased land pressure, non-pastoral diversification has been increasing since the early 1980s. These studies further note that crop cultivation is the most common and important form of pastoral diversification as it allows herders to better manage risks and to respond better to drought-induced shocks than non-farming pastoralists, especially in areas where rain-fed agriculture is possible (Little *et al.*, 1999; Coast, 2002; Nduma *et al.*, 2001). The Maasai cultivate for a wide range of reasons from subsistence cultivation of beans designed to complement a pastoral subsistence strategy to intensive rain-fed irrigation of export crops (Coast, 2002). However, Little *et al.* (1999, p. 3) note that though cultivation may be perceived as an important mechanism to sustain consumption and assets during disasters, cropping could also be seen as a strain on labour for herding, a cause of increased vulnerability to drought and a reason for localized pockets of ecological degradation.

Crop cultivation is influenced by a number of factors (appendix table A1): first we hypothesize that crop cultivation would be encouraged by more land ownership, while secure land rights will give the herder incentives for crop cultivation (Little *et al.*, 1999, 1992; Coast, 2002; Homewood *et al.*, 2001). Other factors expected to favour crop cultivation include wealth (flow of incomes from transfers and non-farm activities), age, marital status,

[5] Drawing from Boserup's hypothesis, in the course of intensification of land use, the amount of labour used in investment activities to improve the land increase is replaced by pastoralism, then forests, bush and short fallow, and eventually cropping are adopted when population densities become very high (Platteau, 2000).

and level of education (Homewood *et al.*, 2001). However, large herds of livestock, scarcity of water, and availability of biomass (biomass would favour livestock production) are expected to discourage crop cultivation. Agro-ecological conditions are also expected to influence adoption of cultivation as well as the mix between cash and subsistence cultivation (Coast, 2002).

Next we explore adoption of land-improving investments. With increased sedentarization, crop cultivation and movements towards a more market-oriented economy, herders adopt simple land improvements in order to maximize returns from their farms. In our sample, these included blocking soil erosion outlets, land terracing, leaving land fallow, planting of trees and other drought-resistant vegetation. Although a few studies have investigated the impact of property rights in land as determinants of investment in land improvements in Africa (Besley, 1995; Brasselle *et al.*, 2002), there is a dearth of literature on adoption of investment in land improvements by herders. First we hypothesize that investment in land improvements will be encouraged by well-defined property rights (Deininger and Jin, 2002; Alemu, 1999; Roth *et al.*, 1994; Kebede, 2002; Chopra and Gulati, 2001; Shiferaw and Holden, 2001). Other factors hypothesized to influence investments in land improvements include the amount of land owned, availability of labour, wealth (transfers), improved technology, age, education, and agro-ecological zones (Somda *et al.*, 2002; Deininger and Jin, 2002; Li *et al.*, 1998). We use the division in which a household is located to capture the agro-ecological zone under which a household falls. Loitoktok division is used as the reference region. The main populated part of this division enjoys better agro-climatic conditions than other parts of the district due to proximity to Mt. Kilimanjaro, whereby the high elevation gives the division an average rainfall of 1,250 mm, while areas of low elevation report as little as 500 mm. The division also enjoys availability of water, which makes irrigation agriculture possible.

The other strategy that we explore is seasonal migration with livestock (transhumance). Transhumance is a traditional way of life that the Maasai have adopted in order to cope with their environment and to ensure survival and maintenance of their culture (Kishel *et al.*, 1999). Western and Nightingale (2002) also note that East African pastoralists move their livestock in response to erratic rainfall conditions of the savannas in order to maximize herd size, milk yields, and meat production for human consumption. Pastoral mobility is also a key strategy to protect the environment as herbaceous vegetation recovers to a marked degree following rainfall and protection from herbivory. The importance of transhumance pastoralism as a strategy to cope with high degree of variability and land pressure in the Savanna ecosystem has been well documented (Fratkin, 1991; Rutten, 1992; Jacobs, 1965; Jacobs and Coppock, 1999). However, with increased sedentarization caused by individual land tenure, cultivation, and education, migration of the entire household has declined considerably due to the need for family members to remain working on the farm (Coast, 2002; Kabubo-Mariara, 2003).

The decision as to whether to migrate with livestock or not is conditioned by a number of factors. In the first place, we expect that due to deficiency of pasture, herders in more arid areas where land is less productive are more likely to migrate than their counterparts with better-quality land. We also expect that privatization of land and market development will make herders more sedentary and therefore less likely to migrate (Coast, 2002; Kabubo-Mariara, 2003; Homewood *et al.*, 2001; Ensminger, 1992). Leneman and Reid (2001) also argue that privatization restricts mobility, flexibility, and access of pastoralists to crucial key resources, such as swamps and riverine areas. Jacobs and Coppock (1999) argue that factors responsible for reduced mobility of pastoralists include growth in human populations, land annexation, insecurity, and poor distribution of watering facilities.

Transfers/remittances and non-farm incomes received by households also influence mobility with livestock. These variables represent a flow of income, which we use as a proxy for wealth (Ensminger, 1992; Little *et al.*, 1999). Wealth could reduce the propensity to migrate in search of pasture as more wealthy herders may not have to rely on livestock for survival compared with their poorer counterparts (Herren, 1991; Kabubo-Mariara, 2003). Furthermore, a herder family with members engaged in a lucrative non-farm job can help the family maintain a pastoral livelihood through remittances as well as provide capital to rebuild herds after a disaster (Little *et al.*, 1999, p. 9). Further we hypothesize that expenditure on livestock inputs will influence the migration decision as the herder endeavors to mitigate the high cost of maintaining herds by avoiding any losses of livestock to drought. Older herders are expected to be less likely to migrate than their younger counterparts. Migration with livestock is a male affair and so gender is expected to affect the probability of migration. Marital status is also expected to have an important impact on the probability of migration. It is expected that married herders are more likely to migrate than the unmarried, as their wives could be left behind taking care of the home and farm. Education is expected to reduce the probability of migration as it is expected to broaden alternative income-earning opportunities, relative to no education at all (Western and Nightingale, 2002).

Herders with more livestock units are expected to be more mobile than their counterparts with less livestock (Western and Nightingale, 2002; Kishel *et al.*, 1999; Jacobs and Coppock, 1999; Kabubo-Mariara, 2003). Lack of water is expected to be one of the major factors forcing the herder to move. The further the distance to source of water, the higher the likelihood of migration. Field observations indicated that traditional cattle can feed on dry grass, even during droughts, but cannot survive without water, which is one major reason why herders migrate. Availability of biomass at the cluster level is expected to discourage distance migration due to availability of pasture, but is expected to increase the likelihood of open grazing (local migration) within the village (Western and Nightingale, 2002). Agro-climate and ecological constraints determine mobility and diversification in pastoral communities (Little *et al.*, 1999; Fratkin, 1986; Kishel *et al.*, 1999; Jacob and Coppock, 1999; Coast, 2002; Homewood *et al.*, 2001). It is expected that relative to herders in Loitoktok division, all others are more likely to migrate due to adverse agro-ecological zones and therefore increased scarcity of pasture and water.

3. The setting and the data

The data for this study are based on Kajiado district, which lies to the southern of the Rift Valley province of Kenya. The district covers an area of 21,105 square kilometers. The land spans between 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).[6] Economic activities are therefore largely dependent on livestock and wildlife. The total population of the district was estimated at 406,054 at the onset of the survey (1999), with 52 per cent males and 48 per cent females, but had risen to about 502,861 by the year 2001, given a growth rate of 5.54 per cent. Given the total land area in the district, it is apparent that the main cause of land pressure is aridity, as the average number of persons per square kilometer is less than 25.

This paper is based on both primary and secondary data. The primary data were collected from a cross section of households in all six divisions of the district. The data were collected in three phases. Phase one corresponds to long rains (March–May 1999), phase two to the short rains, (October–December 1999) and phase three to 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. A detailed questionnaire was used to obtain the requisite data. The secondary data were sourced from remote sensing data based on satellite images and vegetation indices collected by the National Oceanic and Atmospheric Administration (NOAA) and translated into biomass in kilograms per acre by the Department of Resource Surveys and Remote Sensing (DRSRS) using Geographical Information Systems (GIS).

Appendix table A2 presents the sample statistics for the main variables used in the analysis. We give a few highlights on the data focusing our attention on the main variables of interest. The main economic activity is livestock production with 93 per cent of all herders engaging in livestock production. The rest 7 per cent constituted mostly immigrants and the landless who concentrate on market-oriented crop production. However, the data indicate that about 71 per cent of all herders in our sample had attempted crop cultivation during the reference season, with maize and beans as the main crops cultivated under rain-fed agriculture and other crops (mainly tomatoes and onions for market) under irrigation farming in Loitoktok division (only 13 per cent of all herders). Crop cultivation is however characterized by low mean acreage planted (average 2.3 acres), with only 28 per cent of all herders cultivating more than 2 acres of land. Furthermore 41 per cent of the crop cultivating herders reported a total crop failure during the reference season. The data also indicate that 77 per cent

[6] The classification of these agro-ecological zones is based on differences in soil quality, rainfall variability, altitude, and vegetation. We created dummies for the administrative divisions to capture agro-ecological zones as our sample clusters were scattered throughout the entire district and thus fell under different agro-ecological zones.

of all herders holding land under private property had adopted crop cultivation, compared with only 55 per cent holding land under common property. The difference in these percentages is significant at the 1 per cent level of significance, irrespective of whether variance is taken into account or not.

In total 39 per cent of all herders have undertaken at least one land-improving investment. Five different types of land-improving investments were reported: planting of drought resistant vegetation (18 per cent of all herders), blocking soil erosion outlets (9 per cent), land terracing (7 per cent), planting trees (6 per cent) and leaving land fallow (only 4 per cent). Planting drought resistant vegetation is the main land-improving investment adopted, which is important as it implies complementarity between cultivation and herding as the main drought-resistant vegetation is used as fodder for cattle. We note that 49 per cent of private property holders have invest in at least one land improvement, compared with only 27 per cent of their common property holding counterparts. The difference is statistically significant at the 5 per cent level of significance. Of all herders cultivating crops, 43 per cent have invested in at least one land improvement, compared with only 8 per cent of those who have not cultivated crops. The latter are engaged in either leaving land fallow, planting trees, or planting drought-resistant vegetation.

The data further indicate that 55 per cent of all herders migrate with livestock in search of water and pasture and that herders holding land under common property are more likely to migrate (66 per cent) than their counterparts holding land under private property (48 per cent). The difference is statistically significant at the 1 per cent level of significance. An analysis of the distance migrated also indicate that on average private property herders migrate for shorter distances (43 kilometers), than common property herders (51 kilometers), with a statistical significance at the 1 per cent level. Further the data show that only 44 per cent of all cropcultivating herders also migrate with livestock compared with 76 per cent of their counterparts not cultivating crops.

Three other variables that are important in the context of the study and therefore warrant attention are property right regimes, land and livestock ownership. Sixty nine per cent of all households in the sample hold land under private property, while the rest hold land under common property (with a statistically significant difference at the 1 per cent level). Furthermore, at the time of the survey, most of the remaining ranches were still in the process of subdivision, while, in others, respondents had been allocated individual parcels for farming, but grazing land was yet to be subdivided. High transaction costs, mismanagement of the common property resources, and inequality in distribution of benefits accruing from these resources are major bottlenecks to subdivision of common property resources in the district.

The district is characterized by a lot of inequality in land ownership as indicated by the high standard deviation in the amount of land owned. The mean amount of land owned is 89 acres with a standard deviation of 140 acres and a maximum of 800 acres, yet 5 per cent of all households are landless. We obtained the total amount of land owned by group ranch members by dividing the total group ranch land by the number of listed members.[7] We note a lot of disparity in the amount of land owned by herders by property right regime. Herders holding land under common property report a mean land ownership of only 51 acres compared with 102 acres for those holding land under private property. This difference in land ownership for the two regimes is statistically significant at the 1 per cent level. A lot of inequality is also evident in livestock ownership, with a mean of 21 and a standard deviation of 58 heads of cattle. Furthermore, about 26 per cent of all herders own no cattle at all, but have small stock (sheep and goats). Given that the maximum number of cattle owned is 902 heads, there is clear evidence of inequality in stock holding. The mean number of cattle owned is much lower for herders holding land under common property (14 per cent) compared with their private property counterparts (24 per cent). The difference is statistically significant at the 5 per cent level.

4. Results

4.1. Introduction

To model choice of livelihood strategies, we employ maximum likelihood methods and estimate probit models to explain choice of the strategies. This section presents the empirical results. We seek to answer two questions: what livelihood strategies herders adopt in response to acute land pressure and shrinking herds and what factors determine the adoption of each of these strategies with the aim of offering policy prescriptions for enhancing the welfare of herders.

4.2. Adoption of crop cultivation

Crop cultivation is a dichotomous variable that takes the value of 1 if herder cultivated crops and 0 otherwise. The probit estimates for the determinants of crop cultivation are presented in table 1 below. The Chow test for the goodness of fit {LR chi2(18) = 239.81} indicate that our model fits the data better than the intercept only model. The results support most of our hypotheses. More land ownership discourages crop production. Increasing the amount of land owned by 1 per cent reduces the probability of cultivating crops by 0.06 per cent. This is probably explained by the fact that it is only in the more arid areas where herders own very large tracks of land, implying lower productivity as acreage increases.

As expected a *priori*, herders holding land under private property are more likely to cultivate crops than their counterparts holding land under common property (Little *et al.*, 1999; Coast, 2002). Transfers and non-farm income have positive but insignificant impacts. We observe a concave relationship between crop cultivation and age. Gender and marital status do not seem to be important determinants of crop cultivation.

[7] The average so obtained could be misleading as the group size changes over time while the land is fixed. Any newly married man has to be automatically listed as a member so long as the land is not subdivided. However, the average will be representative at a given point in time.

https://doi.org/10.1017/S1355770X04001512 Published online by Cambridge University Press

Table 1. *Probit crop cultivation model: maximum likelihood result (Dependent variable, Y = 1 if herder cultivated crops, Y = 0 otherwise)*

Variable	*Coefficient*	*Std. error*	*Marginal effects*
Log total land owned (acres)	−0.200***	0.043	−0.059
Property right dummy (1 = private, 0 = common)	0.532***	0.185	0.167
Log of transfers (Kshs)	0.017	0.021	0.005
Log non-farm incom (Kshs)	0.008	0.017	0.002
Log age of household head	27.431**	13.403	8.061
Log age squared	−7.947**	4.062	−2.335
Gender (1 = male, 0 = female)	−0.058	0.307	−0.017
Marital status (1 = married, 0 = not married)	0.278	0.303	0.088
Primary school dummy (1 = yes, 0 = no)	0.442***	0.186	0.121
Secondary school dummy (1 = yes, 0 = no)	0.508**	0.275	0.126
Post-sec school dummy (1 = yes, 0 = no)	0.433	0.340	0.107
Log distance to source of water (kms)	−0.274***	0.088	−0.080
Log biomass (Kgs/acre)	−0.115***	0.030	−0.034
Division in which household is located (Reference is Loitoktok)			
Mashuru (1 = yes, 0 = no)	−1.010***	0.280	−0.359
Magadi (1 = yes, 0 = no)	−2.731***	0.340	−0.806
Ngong (1 = yes, 0 = no)	−1.789	0.237	−0.587
Central (1 = yes, 0 = no)	−0.615	0.292	−0.211
Namanga (1 = yes, 0 = no)	−0.730	0.300	−0.254
Constant	−21.661	10.990	−0.059
Number of observations		570	
LR chi2(18)		239.81***	
Log likelihood		−225.71	

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

The level of education positively influences the probability of crop cultivation. Increasing any level of education by 1 per cent increases this probability by about 0.12 per cent. Secondary schooling seems to be the most important level of education influencing crop cultivation. The fact that the coefficient for post secondary education is lower than that for secondary education could be explained by the fact that post secondary education may diversify the alternative income-earning opportunities for herders, such as wage employment. Lack of water discourages crop cultivation. An increase in the distance traveled to the source of water by 1 per cent reduces the probability of crop cultivation by 0.08 per cent. This can be explained by the time lost in search of water, which requires the household to reduce time available for productive activities (Mwabu *et al.*, 2000). The amount of biomass available at the village level exerts a negative impact on crop cultivation. Increasing biomass by 1 per cent would reduce crop cultivation by 0.03 per cent. This result conforms to a *priori* expectations, as availability of biomass would give the herder more incentives to increase his herd and

https://doi.org/10.1017/S1355770X04001512 Published online by Cambridge University Press

Table 2. *Probit land improvements model: maximum likelihood result (Dependent variable, Y = 1 if herder invested in land improvements, Y = 0 otherwise)*

Variable	*Coefficient*	*Std. error*	*Marginal effects*
Property right dummy (1 = private, 0 = common)	0.564***	0.158	0.184
Log total land owned (acres)	−0.070**	0.034	−0.024
Log total labour input (number)	0.056***	0.017	0.020
Log of transfers (Kshs)	0.010	0.018	0.003
Log value of farm tools (Kshs)	0.116***	0.043	0.041
Log age of household head	5.884	11.745	2.054
Log age squared	−1.427	3.550	−0.498
Gender (1 = male, 0 = female)	−0.064	0.250	−0.023
Marital status (1 = married, 0 = not married)	0.027	0.245	0.010
Primary school dummy (1 = yes, 0 = no)	0.303*	0.159	0.109
Secondary school dummy (1 = yes, 0 = no)	0.345*	0.209	0.127
Post-sec school dummy (1 = yes, 0 = no)	0.391	0.274	0.146
Division in which household is located (Reference is Loitoktok)			
Mashuru (1 = yes, 0 = no)	−0.292	0.223	−0.096
Magadi (1 = yes, 0 = no)	−0.334**	0.160	−0.112
Ngong (1 = yes, 0 = no)	0.003	0.229	0.001
Central (1 = yes, 0 = no)	0.142	0.279	0.051
Namanga (1 = yes, 0 = no)	−0.396*	0.241	−0.125
Constant	−7.564	9.645	
Number of observations		570	
LR chi2(17)		86.47***	
Log likelihood		−316.74	

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

therefore concentrate on livestock production instead of crop cultivation. The results for the divisional dummies indicate that the location of the household is an important determinant of adoption of crop cultivation.

4.3. Adoption of investment in land improvements

Investment in land improvements is defined as equal to 1 if herder adopted any land improving investment and 0 otherwise. The maximum likelihood results for this strategy are presented in table 2. As for crop cultivation, the Chow test for the goodness of fit {LR chi2(17) = 86.47} indicates that our model fits the data better than the intercept only model. The results indicate that the coefficient for the land tenure system dummy (1 = private, otherwise = 0) is positive and significant. The results therefore imply that private ownership acts as an incentive for herders to engage in land improvements, relative to common property ownership (Alemu, 1999; Kebede, 2002; Shiferaw and Holden, 2001). This is consistent with our a *priori* expectation that private landowners are more likely to make such investments as they are assured of retaining the long-term gains from

https://doi.org/10.1017/S1355770X04001512 Published online by Cambridge University Press

investments in land improvements. This result is also partly consistent with Besley (1995) who found land rights (with approval) to increase the probability of investing in land improvements. However, Brasselle *et al.* (2002) found that no category of land rights had a significant impact on investments in Burkina Faso. The variable for the total land owned exerts a negative significant impact on investment in land improvements. A 1 per cent increase in the amount of land owned would lower the probability of investing in land improvements by 0.02 per cent.

Amount of total labour used encourages investment in land improvements. The coefficient for this variable is positive and highly significant, implying that herders with greater access to labour are more likely to engage in land improvements, presumably due to lower costs of production. However, availability of labour will enable a herder to allocate his labour between competing alternatives. Availability of transfers exerts a positive but insignificant impact on investment. This is consistent with findings by Somda *et al.* (2002) and Li *et al.* (1998). As expected *a priori*, higher investment in physical capital (fixed technology) favour investment in land improvements. This is portrayed by the significant positive impact of the value of farm tools. A 1 per cent increase in physical capital would increase the probability of investing in land improvements by 0.04 per cent. Household characteristics are represented by household size, sex, marital status, and the highest educational grade attained by family members. Age, gender, and marital status are not important determinants of investment. Education encourages investment in land improvements. The coefficients for the educational dummies imply that the probability of investing in land improvements will increase with the level of education. Divisional dummies indicate that households located in Magadi and Namanga are less likely to invest in land improvements relative to those located in Loitoktok division. This finding supports findings by Somda *et al.* (2002) who argue that farmers in better agro-ecological and climatic zones are more likely to invest in land improvements than their counterparts in unfavourable zones.

4.4. Migration with livestock (transhumance)

The maximum likelihood results for the migration equation are presented in table 3. The results indicate that the property right regimes dummy negatively and significantly influences 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 be engaged in other non-herding activities, which reduces their propensity to migrate (Coast, 2002; Kabubo-Mariara, 2003).

Amount of total land owned exerts a strong positive impact on migration relative to non-migration. The explanation for this result is that as mentioned earlier, since it is only in the more arid zones where herders own large tracts of land, there is a higher likelihood of deficiencies of pasture as compared with where land is more productive (Coast, 2002). Transfers exert a significant negative impact on the probability of migrating in search of pasture implying that herders receiving more transfers are less likely to

Table 3. *Probit migration model: maximum likelihood results (Dependent variable, Y = 1 if herder migrated with livestock, Y = 0 otherwise)*

Variable	*Coefficient*	*Std. error*	*Marginal effects*
Log total land owned (acres)	0.169***	0.049	0.067
Property right dummy (1 = private, 0 = common)	−1.067***	0.311	−0.385
Log of transfers (Kshs)	−0.043**	0.022	−0.017
Log non-farm income (Kshs)	−0.023	0.018	−0.009
Log livestock inputs (Kshs)	0.092***	0.029	0.036
Log age of household head	−2.284***	0.669	−0.902
Marital status (1 = married, 0 = not married)	0.450*	0.282	0.177
Primary school dummy (1 = yes, 0 = no)	−0.607***	0.190	−0.238
Secondary school dummy (1 = yes, 0 = no)	−0.720*	0.270	−0.279
Post-sec school dummy (1 = yes, 0 = no)	−0.934*	0.333	−0.347
Log total livestock owned	0.770*	0.158	0.304
Log distance to source of water (kms)	0.135***	0.085	0.053
Log biomass (Kgs/acre)	0.005	0.035	0.002
Division in which household is located (Reference is Loitoktok)			
Mashuru (1 = yes, 0 = no)	0.323	0.275	0.124
Magadi (1 = yes, 0 = no)	0.692**	0.332	0.248
Ngong (1 = yes, 0 = no)	0.166	0.211	0.065
Central (1 = yes, 0 = no)	0.044	0.280	0.017
Namanga (1 = yes, 0 = no)	−0.041	0.279	−0.016
Constant	3.023	1.186	
Number of observations		570	
LR chi2(18)		383.11***	
Log likelihood		−201.84	

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

migrate with livestock than their counterparts (Herren, 1991; Little *et al.*). The impact of non-farm incomes is negative but insignificant. Expenditure on livestock inputs has a strong positive impact on the probability of migration. The explanation for this is that herders who migrate in search of pasture and water are more likely to incur higher expenses on livestock inputs, especially for drugs and medicine than those that do not migrate.

Age has a negative and significant impact on migration implying a concave relationship between age and migration. Marital status exerts a positive significant impact on the probability of migration. This implies that married herders are more likely to migrate than their unmarried counterparts as their wives could be left taking charge of their farms as they migrate. Education dummies exert strong negative impacts on the likelihood of migration, implying that herders with some level of education face less odds of migrating than those without any education. This is probably because such herders are more aware of the benefits of own farm development, the dangers of migration (mostly spread of livestock diseases), or because of alternative income earning opportunities outside herding (Western and Nightingale, 2002). The probability of migrating with livestock is about 0.3 per cent higher if the herder has some level of education, relative to if he has none.

The results further indicate that the amount of livestock owned exerts a strong positive impact on the probability of migration. Larger numbers of livestock depletes pastures faster, forcing the herders to migrate in search of more (Kishel *et al.*, 1999; Jacobs and Coppock, 1999). 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. This finding also supports Chopra and Gulati (2001), who argue that ownership of cattle motivates persons to participate in common property resources such as pasture lands because of the expectation of greater accessibility to fodder. Distance traveled to source of water also exerts a positive significant coefficient on migration. Increasing this distance by 1 per cent increases the probability of migration by 0.06 per cent. The impact of biomass is positive but insignificant. Contrary to expectations, the location of the household does not seem to be an important determinant of the likelihood of migration. Our results therefore do not support the literature that argues that agro-ecological constraints are important determinants of mobility with livestock (Little *et al.*, 1999; Fratkin, 1986; Jacobs and Coppock, 1999). The last column indicates that the highest marginal effects on the probability of migrating in search of water and pasture are from property right regimes, livestock ownership, and educational attainment.

5. Summary and conclusions

This paper has examined the response of herders to increased shortage and degradation of land in an arid and semi-arid land setting under changing property right regimes. We argue that the responses adopted by the herders are livelihood strategies, which help them to cope with uncertain environments and increasing land pressure. We explore the determinants of three complementary options, crop cultivation, investment in land improvements, and migration with livestock in search of pasture and water, using probit regression methods.

The results indicate that property right regimes, age of household head, educational attainment, total land owned, distance to source of water, availability of biomass, and agro-ecological zones are important variables that explain adoption of crop cultivation. Property right regimes, labour, technology, educational attainment, and total land owned influence investment in land improvements. Migration with livestock is explained by total land owned, expenditure on livestock inputs, marital status, livestock ownership, distance to source of water, property right regimes, transfers, age of household head, and education attainment.

Important policy options include privatization of common property resources. However we note that with privatization of land, the well connected and the elite are likely to benefit at the expense of the poor *Maasai* as they end up purchasing land as soon as land transfers are facilitated by privatization. Although this issue is not addressed in the paper, there is evidence that political interference has played a big role in sensitizing the local community on the need for privatization, more so with the intention of buying land at uncompetitive prices from the unsuspecting *Maasai*.

Another policy option is the need to improve the level of education in the district. Both formal and informal education would encourage farmers to adopt strategies to mitigate the effects of acute land pressure. For instance, herders could be trained informally through extension services on better crop husbandry which would encourage crop cultivation and raise the probability of investing in land improvements. Our analysis also implies the need to explore ways of increasing the availability of water in the district as the results show that scarcity of water discourages crop cultivation and forces herders to migrate. For instance, with government assistance, local communities could sink boreholes in the dry areas, both for domestic and productive purposes.

References

Alemu, T. (1999), 'Insecure land tenure regimes and soil conservation', *Studies in Environmental Economics and Development Working Paper Series* 1, Göteborg University.

Atwood, D.A. (1990), 'Land registration in Africa: the impact of agricultural production,' *World Development* **18**: 659–671.

Baland, J.-M. and J.-P. Platteau (1996), *Halting Degradation of Natural Resources: Is There A Role for Rural Communities*, Rome: FAO.

Besley, T. (1995), 'Property rights and investment incentives: theory and evidence from Ghana', *Journal of Political Economics* **103**: 903–937.

Boserup, E. (1965), *The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure*, New York: Aldine.

Brasselle, A.S., F. Gaspart, and J.-P. Platteau (2002), 'Land tenure security and investment incentives: puzzling evidence from Burkina Faso', *Journal of Development Economics* **67**: 373–418.

Chopra, K. and S.C. Gulati (2001), *Migration, Common Property Resources and Environmental Degradation: Interlinkages in India's Arid and Semi-arid Regions*, New Delhi: Sage Publications.

Coast, E. (2002), 'Maasai socioeconomic conditions: a cross-border comparison', *Human Ecology* **30**: 79–105.

Deininger, K. and S. Jin (2002), 'The impact of property rights on households' investment, risk coping and policy preferences: evidence from China', *World Bank Policy Research Working Paper 2931*, Washington, DC: The World Bank.

Ensminger, J. (1992), *Making a Market: The Institutional Transformation of an African Society*, Cambridge: Cambridge University Press.

Fratkin, E. (1991), *Surviving Drought and Development: Ariaal Pastoralists of Northern Kenya*, Boulder, Co: Westview Press.

Haen, H. de. (1993), 'Livestock and the environment: interactions and policy implications', *Quarterly Journal of International Agriculture* (Germany) **32**: 122–130.

Herren, U.J. (1991), 'Droughts have different tails: responses to crisis in Mukogodo Division, North Central Kenya, 1950s–1980s', *Disasters* **15**: 93–107.

Homewood, K., E. Lambin, E. Coast, A. Kariuki, I. Kikula, J. Kivelia, M. Said, S. Serneels, and M. Thompson (2001), 'Long-term changes in Serengeti-Mara Wildbeest and land cover: pastoralism, population or policies?', *Proceedings of the National Academy of Sciences of the United States of America* **98**: 12544–12549.

Jacobs, A.H. (1965), 'The traditional political organization of the pastoral Maasai', D.Phil Thesis, Nuffield college, University of Oxford.

Jacobs, M. and D.L. Coppock (1999), 'A review of changes in rangeland vegetation and livestock populations for Northern Kenya', GL-CRSP Pastoral Risk Management Project Technical Report 06/99, Utah State University, Logan.

Jacoby, H.G., G. Li, and S. Rozelle (2002), 'Hazards of expropriation: tenure insecurity and investment in rural China', *American Economic Review* **92**: 1420–1477.

Kabubo-Mariara, J. (2003), 'The linkages between property rights, migration and productivity: the case of Kajiado district, Kenya', *Environment and Development Economics* **8**: 621–636.

Kebede, B. (2002), 'Land tenure and common pool resources in rural Ethiopia: a study based on fifteen sites', *African Development Review* **14**: 113–149.

Kishel S., E. Mcalpin, and A. Molloy (1999), 'The Maasai culture and ecological adaptations', Mimeo, Environment Studies Program, Denison University, USA.

Kituyi, M. (1990), 'Becoming Kenyans: social-economic transformation of the pastoral Maasai', African Center for Technology Studies, Nairobi Kenya.

Leneman, M. and R.S. Reid (2001), 'Pastoralism beyond the past', *Development* **44**: 85–89.

Li, G., S. Rozelle, and L. Brandt (1998), 'Tenure, land rights, and farmer investment incentives in China', *Agricultural Economics* **19**: 63–71.

Little, P.D., B. Cellarius, C. Barret, and D.L. Coppock (1999), 'Economic diversification and risk management among East African herders: a preliminary assessment and literature review, GL-CRSP Pastoral Risk Management Project Technical Report 02/99, Utah State University, Logan.

Mwabu, G., T. Kiriti, G. Ndenge, J. Kirimi, J. Kabubo-Mariara, R. Gesami, W. Masai, M. Chemingich, and F. Munene (2000), 'Poverty in Kenya: profiles and determinants', Mimeo, Nairobi.

Nduma, I., P. Kristjanson, and J. Mcpeak (2001), 'Diversity in income-generating activities for sedentarized pastoral women in Northern Kenya', *Human Organization* **60**: 4.

Pinstrup-Andersen, P. and R. Pandya-Lorch (1994), 'Poverty, agricultural intensification, and the environment', *The Pakistan Development Review* **33**: 463–496.

Platteau, J.P. (1996), 'The evolutionary theory of land rights as applied to Sub-Saharan Africa: a critical assessment', *Development and Change* **27**: 29–86.

Platteau, J.P. (2000), *Institutions, Social Norms, and Economic Development*, Harwood Academic Publishers.

Republic of Kenya (1999), 'National Poverty Eradication Plan', Ministry of Planning and National Development, Nairobi.

Republic of Kenya (1996), 'Welfare Monitoring Survey II Basic Report', Central Bureau of Statistics. Ministry of Planning and National Development, Naiorbi.

Roth, M., J. Cochrane, and W. Kisamba-Mugerwa (1994), 'Tenure security, credit use, and farm investment in the Rujumbura Pilot Land Registration Scheme, Uganda', in J.W. Bruce and S. Migot-Adholla (eds), *Searching for Land Tenure Security in Africa*, Dubuque, Iowa: Kendall/Hunt Publishing, pp. 169–198.

Rutten, M.M.E.M. (1992), *Selling Wealth to Buy Poverty: The Process of the Individualization of Land Ownership among the Maasai Pastoralists of Kajiado District, Kenya 1890–1990*, Nicoles Verlag Breitenbach Publishers, United States.

Shiferaw, B. and S. Holden (2001), 'Farm-level Benefits to investment for mitigating land degradation empirical evidence from Ethiopia', *Environment and Development Economics* **6**: 335–358.

Somda, J., A.J. Nianogo, S. Nassa, and S. Sanou (2002), 'Soil fertility and socio-economic factors in crop-livestock systems in Burkina Faso: a case study of composting technology', *Ecological Economics* **43**: 175–183.

Western, D. and D.L.M. Nightingale (2002), 'Environmental change and the vulnerability of pastoralists to drought: a case study of the Maasai in Amboseli, Kenya', *UNEP.Net, Africa*. United Nations Environmental Program.

Appendix

Table A1. *Variable definition and expected impacts on choice variable*

	Expected impact on[±]		
Variable definition	*Crop cultivation*	*Land improvements*	*Migration*
Property right regime (1 = private, 0 = otherwise)	Positive	Positive	Negative
Total land owned by household j (acres)	Positive	Negative	Negative
Transfers from other households (Kshs)	Positive	Positive	Negative
Non-farm incomes (Kshs)	Positive	–	Negative
Total value of farm tools (Ksh)	Positive	Positive	–
Value of livestock inputs	–	–	Indeterminate
Total labour units hired by household *j*	Positive	Positive	–
Household characteristics			
(i) Age	Positive	Positive	Positive
– age squared	Negative	Negative	Negative
(ii) Education–three dummies			
– primary (1 = yes, 0 = otherwise)	Positive	Positive	Negative
– secondary (1 = yes, 0 = otherwise)	Positive	Positive	Negative
– post-secondary (1 = yes, 0 = otherwise)	Positive	Positive	Negative
(iii) Gender (1 = male, 0 = female)	Indeterminate	Indeterminate	Indeterminate
(iv) Marital status (1 = married, 0 = not married)	Indeterminate	Indeterminate	Indeterminate
Distance to source of water (Km)	Negative	–	Positive
Total livestock owned by household *j*	–	–	Positive
Amount of biomass available at village level (kg per acre)	Negative	–	Negative
Division household is located (reference is Loitoktok)	Negative	Negative	Positive

Note: [±] A – implies that the independent variable in question has no direct impact on the corresponding dependent variable.

Table A2. *Sample statistics for variables used in the analysis*

Variable	*Mean*	*Std. dev.*	*Min.*	*Max.*
Herder cultivates crops (1 = yes, 0 = no)	0.71	0.46	0	1
Herder invests in land improvements (1 = yes, 0 = no)	0.39	0.47	0	1
Household migrates (1 = yes, 0 = no)	0.55	0.50	0	1
Total land owned (acres)	89.32	140.11	0	800
Total labour inputs (number)	3.76	4.02	1	11.43
Property right regime (1 = private, 0 = common)	0.69	0.46	0	1
Transfers (Kshs. '000)	1.58	7.51	0	100
Non-farm income (Kshs. '000)	10.57	32.68	0	420
Value of inputs (Kshs. '000)	2.49	6.28	0	91.8
Value of equipment (Kshs. '000)	5.10	9.54	0	97.7
Age of household head (years)	35.12	13.18	22	70
Sex of household head (1 = male, 0 = female)	0.86	0.35	0	1
Household size (number)	6.83	4.17	1	38
Marital status of household head (1 = married, 0 = otherwise)	0.86	0.35	0	1
Primary school education (1 = yes, 0 = no)	0.31	0.46	0	1
Secondary school education (1 = yes, 0 = no)	0.13	0.33	0	1
Post sec. school education (1 = yes, 0 = no)	0.05	0.23	0	1
Number of cattle owned (number)	20.84	58.44	0	902
Distance to source of water (kms)	3.22	4.37	0	20
Biomass ('000 Kg per acre)	2.22	0.81	1	3.6
Loitoktok (1 = yes, 0 = no)	0.29	0.46	0	1
Mashuru (1 = yes, 0 = no)	0.12	0.32	0	1
Magadi (1 = yes, 0 = no)	0.10	0.30	0	1
Ngong (1 = yes, 0 = no)	0.30	0.46	0	1
Central (1 = yes, 0 = no)	0.09	0.29	0	1
Namanga (1 = yes, 0 = no)	0.10	0.30	0	1

Notes: * Kshs = Kenyan shillings.
** Kms = Kilometers.