Livelihood Choices and Returns among Agro-Pastoralists in southern Kenya[1]

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Summary

This article addresses livelihood choices and income diversification strategies among agro-pastoralists and pastoralists in southern Kenya, and the factors influencing the returns to the diverse livelihood strategies being pursued. We explore how variability in income and wealth levels across households can be explained by household-level versus geographic factors. We find that household livestock asset levels, education level, landholdings, and diversification of household income sources can largely explain how well households are doing. Geographic factors such as distance to the nearest town, permanent water source, and Nairobi National Park, as well as pasture potential also matter in some cases, but relatively little compared to household-level factors. Investments in livestock remain key to how well households are doing and in some cases appear to be driving livelihood diversification strategies that keep them from falling into poverty. While relatively few households are yet receiving wildlife conservation-related income, for those that are, it is a more lucrative option than cropping, from which very few are earning positive returns. This information can contribute to more evidence-based decision making occurring across pastoral areas and inform policy decisions regarding conservation of wildlife and poverty reduction strategies.

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Introduction

This paper is based on a household survey that was conducted across Kitengela, a pastoral/agropastoral and wildlife area located just south of Nairobi in 2004. It builds upon previous household socio-economic studies conducted in the area in 1999, 2000 and 2003 (Mwangi and Warinda, 1999; Kristjanson et al, 2002 and Nkedianye, 2004), covering a larger portion of the broader Kitengela ecosystem than the previous studies. The main questions addressed by this body of research are:

- What livelihood strategies/options are households pursuing?
- What are the returns to land and households from the various land-use alternatives available (i.e. livestock, crops, tourism/wildlife, and off-land options)?
- What helps explain household income and wealth levels, and what is the relative importance of spatial, or community/meso-level factors, versus household-level factors?

While several studies looking at land-use, diversification and livelihood options have been carried out in some agro-pastoral/pastoral systems (e.g. Rutten, 1992, Homewood, 2004, Thompson and Homewood, 2002, Serneels 2001, Campbell et al. 2003, Little et al., 2001), few have been able to derive measures of how well households are doing, in terms of revenues earned from the various activities household members are pursuing, and look closely at what factors significantly influence those returns. This research aims to fill that gap, in an area where rapid and extensive social and economic changes have been occurring. This information can contribute to more evidence-based decision making occurring across pastoral areas and inform policy decisions regarding conservation of wildlife and poverty reduction strategies.

Background

The Kitengela area covers approximately 390 km^2 (GOK, 2001) within Kajiado District and is part of a larger rangeland ecosystem called the Athi-Kaputiei Plains (a 2,456 km^2 ecosystem). Neighboring the city of Nairobi with an estimated population approaching 3 million, the Kaputiei plains, also called the Kitengela dispersal area, are unique in that they support a large and long distance wildlife migration. Nairobi National Park (NNP) sits at the northernmost tip of these plains. NNP is one of the most remarkable protected areas in the world due to the fact that its wide variety of wildlife is separated from the city of Nairobi by just a fence. Livestock and a large number of wild herbivores (e.g. wildebeest, zebra, gazelles, giraffe) dominate the Kitengela ecosystem. This ecosystem forms an important part of the wet season dispersal area for wildlife that lives part of the year within Nairobi National Park.

Population growth and urbanization have been processes occurring alongside the land tenure changes that have taken place in Kitengela (i.e. a shift from community-owned group ranches to privately owned land), resulting in unprecedented changes in land use and livelihood strategies being pursued (Reid et al., 2006, Kristjanson et al., 2002, Gichohi, 2000). The 1999 population census counted 17,347 residents of Kitengela, up from 6,548 in 1989 (GOK, 2001). More than two-thirds of the population is concentrated in the Kitengela shopping centre and other smaller shopping centres (Nkedianye, 2004). This rapid population increase has led to more settlements, which in turn led to more fences being built, blocking the traditional wildlife migration routes (Kimani and Pickard, 1998). This open space, which is key to maintaining healthy pastoral livestock and wildlife herds in the Kitengela ecosystem, is quickly dwindling (Mwangi and Warinda, 1999). Many of the new in-migrants come from different ethnic backgrounds than the Maasai, most with sedentary farming experience (Herrero et al., forthcoming).

There has also been a trend toward diversification of income sources, seen also in other pastoral areas including Amboseli (Burnsilver, 2003) and northern Kenya (McPeak and Little, 2004). Given its proximity to Nairobi and the export processing zone, the range of 'off-land' income-earning opportunities is also relatively large in Kitengela compared to other more remote traditional pastoral areas. Results of a 2000 household survey showed that one-third of households obtained between 10-30% of their total annual income from 'off-land' activities (such as employment in town) (Kristjanson et al., 2002).

In Kenya, approximately more than 70% of wildlife is found outside parks and game reserves on private and communally owned lands within pastoral areas/rangelands (Western and Pearl, 1989). Given the abundance of wildlife in pastoral systems, wildlife utilization in these systems can generate substantial incomes for households, leading to improved welfare. One of the most promising ways of households diversifying their incomes in Kitengela is through the Wildlife Conservation Lease Program, initiated in 2000[2]. The aim of the program is to ensure that wildlife in the Athi-Kaputiei Plains can move freely to their traditional habitats (Reid et al., 2006).

[2] This program was introduced as a pilot effort by the Friends of Nairobi National Park (FoNNaP), a local conservation NGO, with support from the Wildlife Trust (USA). In 2002, the program was transferred to the Wildlife Foundation (a Kenyan NGO), which aims to expand it sufficiently to establish a sustainable trust fund such that the program runs off the interest payments. This program has experienced considerable donor interest (since it is a potential model for other conservation areas such as Amboseli and Mara) and pledges of support from the Kenyan government, but as of yet no substantial additional funds (e.g. a proportion of Nairobi National Park gate receipts).

Participants in this program receive KShs 300/acre/year ($U.S. 3.75 in 2005) and in return agree to allow free movement of wildlife on their land, refrain from poaching, report poaching by others, and avoid fencing or sub-division of their land. In years of poor rainfall, these payments are sufficient to double the annual income of the poorest households in the area (Kristjanson et al., 2002). Currently the program covers 8,545 acres from 117 Kitengela families, disbursing around KShs 3,000,000/year by late 2003 (Nkedianye, 2004). Payments are scheduled three times per year to coincide with school payment time. Nkedianye (2004) reports that participants in the leasing program are sending their children to school, including secondary school, have more positive attitudes towards wildlife, are more willing to share water and pastures with wildlife, and strongly support keeping the range open without fencing. Participants also say that the lease program allows them to choose not to sell land, because of reduced pressure to sell, usually arising from the need for cash for school fees.

So while Kitengela is quite unique in several aspects, such as its proximity to Nairobi, the extent and speed of change, the corresponding adjustments in livelihood strategies and outcomes in terms of incomes and asset levels that we are witnessing in this area may have important lessons for other pastoral and agro-pastoral communities facing similar challenges in the future (e.g. land privatization, wildlife conservation schemes).

Methods and data

A formal household survey was carried out on a random sample of 177 Kitengela households between the months of August and September 2004. Detailed information was sought regarding household demographic characteristics, revenues, production costs, income sources and income levels under various land–use options as well as off–land activities. In addition to this information, spatial variables were generated for each household, including distance to the nearest tarmac road, town, park, permanent water source and primary school. Various other secondary sources of data on crop and livestock prices and other spatial information were also used.

Analytical method

A multiple linear regression model was used to look at the determinants of annual total net income (i.e. adding up net income from livestock, crops and off-land activities). Separate similar regression analyses were also carried out to examine the most important factors influencing the components making up net income (livestock-related and income from other sources), land prices and herd value[3]. The independent variables (household and spatial factors) were tested for multicollinearity before the analysis, and where this was a problem, we tested each individual variable against the dependent variable and chose the variable that had the highest explanatory power amongst the highly correlated ones for inclusion in the analysis. We also checked for normality for explanatory and dependent variables. In cases where the data were not normally distributed, natural log transformation was used.

When dealing with household survey data for which location attributes are an important source of information (i.e. spatial data), spatial autocorrelation may be a concern (where variables in one area are affected by the value of that variable in neighbouring areas). There are two main ways in which spatial autocorrelation can manifest itself, referred to as spatial lag dependence and spatial error dependence.

[3] Households were asked to estimate average local market prices for each type and breed of animal they owned and total herd value was calculated using these prices.

Spatial lag dependence refers to a situation in which the dependent variable in one area is affected by the dependent variable in nearby areas. For example in this study, the spatial dependence could be a result of the income levels (our dependent variable) in a household/area affecting the level of income in neighboring households/areas, through, for example, the level and range of economic activities. If the regression analysis is carried out without adjustments for spatial dependence, the estimated coefficients will be biased and inconsistent.

The second possible type of spatial autocorrelation is called spatial error dependence, where the error term in one household/area is correlated with the error terms in nearby households/areas (Anselin, 1992). This can occur if there are variables that are not included in the regression model but do have an effect on the dependent variable and they are spatially correlated. In this case, using ordinary least squares to estimate the model does not yield biased coefficients, but the estimates of the coefficients are not efficient and the standard t and F tests will produce misleading inference.

Each of the models was tested for the different types of spatial autocorrelation and heteroskedasticity. For models where spatial autocorrelation was a problem, we chose to follow the approach of using either spatial lag or spatial error models, depending on the type of spatial autocorrelation we needed to correct for. Similarly, for models where heteroskedasticity was a problem, heteroskedasticity-robust standard errors were used to construct heteroskedasticity-robust t statistics.

Table 1 presents the list of dependent and explanatory variables and their descriptions. Thirteen independent variables were used in the final models after correcting for multicollinearity.

Results

The range of household characteristics, size of land and livestock holdings, choice of land–use and other activities is wide across Kitengela. Key informants feel that, on average, family sizes have been shrinking, more children are going to school, and land and herd sizes are smaller than before, and data from our survey and two earlier ones support these perceived trends, although they only cover a 5-year period (Table 2).

The average amount of land currently owned for the households surveyed was 137 acres and ranged from as low as 2 acres to as high as 870 acres. Our findings indicate that 45% of respondents obtained their current land through the original group ranch subdivision (in the 1980s), 44% through inheritance and 6% percent through land purchases. The average land size for households who acquired land through subdivision was much higher (179 acres) than the land sizes for those who acquired land through inheritance (118 acres) or purchases (28 acres). Average landholdings have been decreasing since the land was subdivided in the 1980s (Nkedianye, 2004). This can be attributed in part to further land subdivision among household members through inheritance (e.g. to the sons and between/among co-wives) but probably also reflects continuing land sales.

Average herd size in 2004 was 7.1 TLU/adult equivalent, slightly higher than the 5 to 6 per capita TLUs considered to be the threshold below which the household can no longer survive purely on livestock (Talle, 1999). One-half of the cattle are owned by 20% of households that are found in the top income quintile, earning more than US$4,842/year/household, or US$13/day/household (Figure 1). The lowest two income quintiles (i.e. gross income earnings of less than US$1,917/year/household, or US$5/day/household), on the other hand, own only 11% of all cattle. Despite this skewness in livestock holdings, livestock-related earnings (including consumption) still account for over 50% of gross incomes across all income categories, and for over 65% for the second two income quintiles (Figure 2).

With respect to income diversification, poorer households (i.e. in the lowest income quintile) actually have more income sources than the wealthier ones, although off-land earnings are much lower and from less reliable sources (e.g. petty trade). Figure 2 shows that households in the higher income quintiles have a larger proportion of their incomes coming from wages and business, for example, while those in the lower ones depend more on petty trading and other informal sector activities to help them diversify their incomes.

Returns to livestock

Measuring returns to livestock activities where animals still move considerable distances (i.e. they do not remain limited to grazing and water from their owners' land), particularly during drought years, is fraught with challenges (Kristjanson et al., 2002, Burnsilver 2006, Norton-Griffiths and Butt, 2006). While the Masaai can give you detailed histories of each animal they own and their livelihood strategies (see Cochrane et al. 2005), Kitengela community members expressed a strong interest in the survey results regarding returns to different livelihood activities as they admitted they could not give an estimate of their annual revenues from crops, livestock and other activities.

Gross annual livestock income/output was calculated as an aggregate value of:

- Livestock and all the livestock by-products sold by the household, including live animals (cattle, sheep and goats), milk, manure, hides and skin.
- Livestock and livestock by-products consumed within the household including livestock slaughtered and milk consumed.
- Livestock gifts received by the household in the form of live animals.
- Revenues received from traction and any other livestock or their products

Actual prices as reported by the households and average market prices were used to value sales and consumption. Gross livestock annual revenues for 2004 (which was a relatively good year in this area in terms of rainfall), input costs and net income are summarized in Table 3.

Average annual gross livestock returns per acre for our surveyed households in 2004 was $US 36. Per capita livestock returns averaged $US 346 in 2004. Sales from milk and live animals accounted for 60% of the total gross livestock income (roughly 30% each). On a per acre basis (which should be treated cautiously, as the herds remain mobile, grazing beyond their owners' land), net annual returns in 2004 were $17/acre (or less than $10/ha., consistent with the findings of Norton-Griffiths and Butt, 2003, for pastoral areas with less than 500 mm annual rainfall; in contrast, annual returns to large-scale ranching at rainfall levels of 1000 mm are in the $125/ha range).

Livestock input costs included costs of spraying (acaricides), deworming, supplementary feeds and minerals, veterinary care (vaccines and curative drugs), hired labor, livestock purchases and the livestock gifts given out. Annual livestock-related production costs averaged $US 28 per TLU. Across all households, livestock purchases, hired labor, livestock gifts given out and spraying were the main costs incurred and accounted for over 80 percent of total livestock production costs.

Direct livestock production costs were deducted from the annual gross output value to derive net livestock income. Average annual livestock net income per household was $US 974, with 12% of the households earning negative net livestock incomes in 2004.

Other earnings

Cropping returns

Over the years, there has been increased cultivation witnessed across Kitengela. While crop farming is not a major economic activity in Kitengela, 68% of the households engaged in some cultivation. Land under crops was relatively small. Among the households cultivating, the average amount of land under cultivation was 2.1 acres, ranging from 0.25 to 5 acres per household. Crops grown in the area include maize, beans, potatoes, onions and vegetables, mainly for subsistence. Twenty-four percent of the households cultivating had no harvest due to crop failure (again, this in a year of relatively good rainfall, according to respondents). The average annual income per household from cropping in 2004 was $US 202[4].

Returns to off-land activities

Respondents were asked to indicate if they had someone in their household involved in some kind of off-land[5] activities that brought income to their household. Over 85%

[4] This only includes households who were cultivating, and it includes the value of crops consumed within the household plus income from crop sales.
[5] This is typically referred to as 'off-farm' income, but as many of these households are not involved in cropping activities, it seems more appropriate to refer to them as 'off-land' activities. They include

of the households interviewed had someone in their household involved in off-land activities. Off-land income levels were estimated from respondent's description of the type of activity and the monthly income range (which were provided), so these figures are not exact, but do give a good idea of the relative importance of these sources. Off-land income activities were grouped into three main categories, including wages, business and petty trade, and income from wildlife. 57% received income from petty trade and business, 38% received wage income, and 14% had some income from wildlife.

Of the households receiving income from wildlife (14%), average annual income from this source was $US 248, ranging from $US 46 to 571. All households receiving some income from wildlife are participants in the lease program (described in the background section). We found no difference in the size of landholdings and per capita TLU between these households and the non-lease households, suggesting it is not just the wealthier households that are benefiting from the program.

In summary, on average across all Kitengela households, livestock accounts for 60% of total household income, off-farm income for 35%, and agriculture/cropping activities for less than five percent. Overall gross income levels averaged $US 1,934 for these households in 2004, although with a huge range. This is slightly higher than the range of $1,250 - $1,750 found across five (higher rainfall) Mara sites in the same year (Thompson, 2006), but of course one year 'snapshots' have to be treated cautiously.

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wage employment, livestock trade, retail shops, remittances from relatives and wildlife income among others.

Determinants of income

Turning to the analysis of the factors influencing overall income levels, Table 4 shows the results of the best performing OLS model with natural log of annual net income as the dependent variable. The model was tested for spatial dependence, with the results, shown in Table 6, indicating no evidence of spatial lag or spatial autocorrelation in the error terms. The Moran's I and the Robust Lagrange multiplier tests are not significant, supporting the null hypothesis of no spatial dependence. The explanatory power of the OLS model was relatively high, with an R-squared of 0.51.

Not surprisingly, herd size (TLU) was the principal factor explaining variation in levels of annual net income. Log of TLU was highly significant and positive and alone explained 36 percent of the variation in overall net income levels. The parameter estimate for TLU suggests that an increase of TLU by 10% (e.g. an additional 4 TLUs from an average TLU per household of 42) would increase annual net income by 4 percent.

Education of the household head was also significant with the expected sign. Together with TLU, 41 percent of the observed variation in net income across Kitengela households can be explained. An additional year of education of the household head increases net income by 4 percent. Diversification of household income sources, measured as the number of income earning activities pursued (other than livestock or crops), was another significant household variable influencing how well households in this area are doing. Increasing the total number of off-land activities by one, from a mean of 1.4 per household, would increase annual net income by 16 percent.

Only two spatial factors (distance to the nearest livestock market town and NDVI) showed up as significant in terms of explaining variation in net incomes across households, increasing the explanatory power of the model to 51 percent. However, both had the opposite sign to that expected. NDVI was negatively correlated with net income. Non-intuitively, this suggests that households living in areas with higher NDVI (a greenness, or pasture potential indicator) are associated with lower net incomes. Distance to the nearest livestock market town was significant and positively correlated with annual net income, thus households farther away from markets (in more remote areas) are associated with higher net incomes. This may suggest unsuccessful intensification is occurring closer to towns, but may also reflect that larger herd sizes tend to be located further from towns (possibly due to lower prevalence of East Coast Fever (ECF), the relatively large amount of time spent involved solely with animal husbandry, and that higher TLUs are correlated with higher incomes.

These results suggest that almost half of the variation in net income levels (45%) across these Kitengela households can be explained by household level factors alone, including livestock assets (TLUs), education level of the household head, and extent of diversification (i.e. number of off-land activities being pursued).

We ran similar regressions on livestock incomes to see if the driving factors differed significantly[6]. Not surprisingly, the results show that herd size (in TLU) alone is able to explain over half (52%) of the variation in livestock income. Households with

[6] Gross returns from animal, milk and other animal product sales; these results are not shown here, but are available on request from the authors.

larger herds still earn significantly more than households with smaller herds of livestock. The results suggest that a 10% increase in TLU per household (e.g. of 4 TLUs from the average TLU per household of 42) would increase livestock returns by 7.5 percent. Of the spatial variables, distance to the nearest permanent water source was marginally significant ($p<0.1$) and negatively correlated with livestock returns, implying households located closer to water points earn more from livestock than those living farther from permanent water sources.

Other spatial variables, such as distance to the nearest livestock market town and pasture potential (NDVI), did not significantly influence livestock returns in this area. However, compared to vaster, more remote pastoral areas such as those found in northern Kenya, no households in Kitengela are located more than a day's walk to a livestock market, rainfall and soil variability does not vary hugely across the area studied, and the livestock are still being grazed in areas other than their own land, so perhaps it is not surprising that these factors are not significant at the household-level. Kristjanson et al. (2005) did find that pasture potential, livestock density, distance to a livestock market town, road density, access to education, access to security, soil fertility and agricultural potential were important spatial factors at the meso-level, influencing poverty rates throughout Kajiado district when measured as the proportion of the population falling below the rural poverty line within each Location (the fourth level administrative boundary in Kenya).

Determinants of other income

We next explored what factors are driving returns to activities other than livestock, including crops and off-land activities (Table 4). A spatial error model was estimated, due to the evidence of the existence of this type of spatial autocorrelation (as seen in the significance of the Moran's I statistic in Table 6). The results are very similar to the net income analysis, showing positive and significant relationship between years of education, herd size (TLU), and number of off-land activities. The fact that larger herds also mean higher off-land income suggests that livestock and milk sales help households pursue other opportunities (e.g. purchasing rental properties in town); this is confirmed by observations by Nkedianye (2004).

Once again, the spatial variables are largely insignificant or the opposite sign to that expected (e.g. distance to the nearest livestock market town is positive, and one might expect less remote households to have better access to off-land opportunities and thus more income from other sources, but our analysis does not support this).

What we do know from observations and key informants, however, is that land prices in Kitengela differ quite significantly by location, so we next explored the relationship between household land prices per acre and our spatial variables.

Determinants of land prices

Each household was asked to estimate the current value of their landholdings. They gave a low-high range, and we used the average of this to predict the determinants of land prices per acre in this area. Using a spatial lag model in this case (due to the significance of the Lagrange multiplier seen in Table 6), we regressed land price per acre on spatial variables that included average NDVI, population density, distance to NNP, distance to permanent water, distance to town, and distance to school. The results show that all of these variables as significant determinants of land price, able to explain 70% of the variation in land prices observed (Table 5).

An examination of land versus herd values for each household highlights the huge trade-off in herd-related versus land-related wealth. Households with larger herds and more livestock wealth tend to be living on less valuable land (farther from Nairobi), versus landowners living on extremely valuable land, that are more likely to be located nearer NNP and good roads, but with smaller herds and generally lower livestock assets.

The implications of being able to predict land prices quite accurately, based on spatial, rather than household-level information, are large in this area where these households have had no access to such information. This can empower community-based organizations such as KILA (Kitengela Landowners Association) to pursue more transparent negotiations with district and national officials and others, such as the administrators of the lease program. For example, lease payments in the future may need to be adjusted to account for the varying value of land assets across the Kitengela landscape in order to be sustainable. This model will also allow predictions of land prices into the future, e.g. given different population growth or infrastructural development scenarios.

Determinants of livestock wealth

Looking at the explanatory factors behind household livestock asset wealth (Table 5), we see that both our household and spatial factors are unable to explain much of the variation across households (and as with incomes, we see huge variation). Household labor now shows up as positive and significant, along with years of education of the household head. So larger and more educated households appear to have an advantage when it comes to accumulating livestock assets.

With respect to spatial determinants of livestock wealth, our results show that households living closer to livestock market towns tend to be wealthier, along with those that are living further away from NNP. NDVI has the anticipated positive sign in this model, unlike the income ones, but is not significant.

Conclusions

While unique in its proximity to Nairobi, a major metropolitan area (e.g. over 85% of these rural households have access to income coming from sources unrelated to livestock and crops), nevertheless Kitengela is an area where lessons can be learned, as the trends in system intensification, diversification and increases in population pressure seen here may be echoed in future years in other pastoral areas. This information can contribute to more evidence-based decision making occurring across pastoral areas and inform policy decisions regarding land use policies in drylands, conservation of wildlife and poverty reduction strategies.

People are earning a very wide range of incomes across Kitengela. Of course, incomes are not the only, or necessarily the best, indicator of household well-being in an area where so many still regard livestock holdings as the only significant indicator of relative household status. But it is increasingly important, our interviewees have repeatedly told us, especially to cover their household education and health-related costs (for both people and animals).

Given that income is measured as a flow and wealth as a stock, examining factors driving well-being in predominantly pastoral areas is challenging. We found that a relatively few household characteristics help explain almost half of the variation in income levels across Kitengela (livestock asset levels, education level, landholdings, and diversification of income sources), and location largely determines land prices (70% of the variation in land prices can be explained by four spatial variables – distance to the nearest livestock market town, permanent water source, Nairobi National Park and pasture potential, or NDVI). While NDVI cannot be influenced by policy, investments in infrastructure and services can influence the other factors, so these findings and their policy implications are important for several reasons.

First, our unique dataset (very little data on price of landholdings in ex-group ranch areas exists) has allowed us to look at the determinants of land prices in this area, and as with real estate prices elsewhere, location matters. Unlike elsewhere, however, this is new information that has not been readily available or remotely transparent, putting landowners in this area at a distinct disadvantage when dealing with potential buyers, or when trying to influence land and other policies affecting them.

Second, despite the rapid economic and social changes the Maasai in Kitengela have been experiencing in recent years, policymakers need to know that earnings from livestock are still key in terms of overall household earnings. One-half of the cattle are owned by the 20% of households with the highest overall incomes. Households with larger herds not only have more overall net income, but also more livestock and off-land income, suggesting that livestock/herd size may be driving diversification strategies in some cases (this is a complex relationship, working both ways, since income from off-land is also used to purchase animals). These higher income households also tend to be the ones educating their children past primary school, so they have improved employment opportunities (Nkedianye, 2004, Cochrane et al., 2005). This is in fact is counter-intuitive to conventional wisdom about pastoral families, i.e. a picture of large, uneducated households with huge herds but not much income, and points to the difference that education is already starting to make in this area relatively close to the city. It suggests that investments in education beyond primary school have potentially high payoffs in this and other pastoral areas (and doesn't automatically signal the end of pastoralism).

Sales from milk provide roughly a third of household income in a good rainfall year. Income from milk is solely in the hands of women. Most of it is spent at the household level, presenting a window of financial flexibility for Maasai women. This simple fact has a huge policy implication. Interventions and policies that assist women in improving their earnings from milk have potentially large poverty impacts at the household level. For example, marketing of milk is currently very disorganized, so training and technical assistance in milk handling, marketing and management skills, for example, through women's groups could be very beneficial.

Diversification through cropping still appears a quite tenuous option, with many households not getting a harvest even in a year considered to be a 'good rainfall year' (Kristjanson et al., 2002). While relatively few households are yet receiving wildlife conservation-related income, for those that are, it is a more lucrative option than cropping, from which very few are earning positive returns. This kind of information has, and will continue to be, shared with community members and local and national policymakers, as it can contribute to a better understanding of the huge trade-offs that these households are facing, and the information they require as they struggle to adjust their livelihood strategies to cope with widespread and rapid socioeconomic changes. A recent study of information needs of local to national policy makers in Maasai areas shows that a wide range of desired information on agriculture, natural resource management, wildlife and livestock issues is simply not reaching them (Herrero et al., 2003), so making the kind of information generated in this study accessible and available to these policymakers will be important.

Ideally, we would have had time series data to examine drivers of household income and well-being instead of a few cross-sectional studies over a relatively short time period. During this short period, however, these communities have been, and continue to be, faced with huge and rapid socioeconomic and political changes, and more and better information regarding livelihood options and trade-offs will assist them in dealing with these changes. When we started out, we weren't really sure what the incorporation of spatial variables would add to the traditional analysis that focuses on household-level factors (and concludes, for example, that education is important), so this has been a learning process, and one upon which we can continue to build so future analyses will have access to such time series data.

Pastoral communities such as those found in Kitengela are rapidly adjusting their livelihood strategies to cope with vast changes in their environment. Providing information to help them understand, adapt and cope is something important that researchers and others can do, as it is the communities themselves that must negotiate the new and more evidence-based land, agricultural and other policies that will improve their levels of well-being sustainably over the long run.

Table 1. Description of the variables used in the regression analysis

Variable	Variable description	Mean	SD
Dependent variables			
Annual gross crop income	Aggregate annual value of crops consumed within the household and crops sold by the household ($/yr); primarily maize, beans, onions and tomatoes.	140	252
Annual gross livestock income	Aggregate annual value of livestock and all the livestock by-products (milk, manure, hides and skin) sold and consumed by the household as well as the value of livestock gifts received by the household and revenues from traction and any other livestock or their products.	1934	2140
Annual off-farm income	Aggregate value of annual household income from wage, business and petty trade, and income from wildlife.	1131	1218
Wildlife-related income (n=24)	Annual revenues related to wildlife conservation via the leasing program	248	135
Annual net income	An aggregate value annual income from livestock, crops and off-farm less costs of livestock and crop production.	2192	2101
TLU per adult unit	Derived as the total of TLU divided by the total number of adult unit (AU). The definition of AU is based on human nutritional requirements for different age/sex classes as described by Little (1980) as adult male = 1, adult female = 0.86, children 0-5 = 0.52, children 6-10 = 0.85, male child 11-15 = =0.96, female child 11-15 = 0.86	7.1	8.9
Independent variables			
Household factors			
Age	The age of the household head in years.		
Years of education	Number of years of formal schooling up to the highest level of education attained by the household head.	6.1	5.2
Leadership	Leadership in terms of influencing decision making or access to resources by the respondent, within the community, where 0-no influence and 1-influence)		
Years of residence	The number of years the household has been living within the Kitengela study area.	24	14
Acres under crop cultivation	Land under crop agriculture/cultivation in acres.	1.4	1.4
No. of workers	Calculated as the total no. of adults and children over 5 years of age living within the household.	6.9	3.7

No. of off-land activities	Total number of off-land income-earning activities the household is pursuing, e.g. trading in livestock, wage employment, retail shops etc.	1.4	0.9
Total livestock TLU	The tropical livestock units were arrived at using the herd and flock characteristics described by Bekure et al (1991) for Maasai livestock in Kajiado District. These were derived by multiplying total cattle numbers per household by 0.72 and total small stock numbers by 0.17 (Grandin et al, 1988).	42	51
Land size	Total amount of land (within the Kitengela wildlife dispersal) area owned by the household in acres.	137	137
Spatial factors			
NDVI average	The Normalized Difference Vegetation Index (NDVI) provides a measure of the amount and vigour of vegetation on the land surface. Higher values of NDVI indicate greater vigour and amounts of vegetation. The calculation of the average NDVI for each household was derived using the spatial analysis facilities in WinDisp, using the GPS coordinates for each household. We used the average NDVI data from 1984-2004.	0.4	0.0
Distance to nearest road in km	The distance to the nearest all-weather road in km. The major roads used for Kitengela were Nairobi-Namanga road, Isinya-Kiserian-Ngong road, and Magadi-Ngong road. Using the GPS coordinates, the distance of each household to the nearest road was calculated using ArcGIS software.	9.4	6.1
Distance to nearest primary school in km	The distance to the nearest primary school was based on data collected by ILRI –SNV project in 2002. ArcGIS [7]was used to calculate these distances.	3.6	2.0
Distance to nearest permanent waterpoint in km	Distance to the nearest permanent water source in km	2.4	1.9
Distance to park in km	Distance to the Nairobi National park and the NEAR function was used to calculate the nearest distance of a household to the Nairobi National park.	19.7	11.6
Distance in km to nearest livestock market town	The distance to the closest major towns (also with livestock markets), includeing; Ngong, Kiserian, Ongata Rongai, Kitengela, Isinya, and Kajiado.	12.6	6.4

[7] Using the household GPS coordinates, the NEAR function in ArcGIS with option points was used to calculate the distances.

Table 2. Trends in herd sizes, landholdings, household size and education in Kitengela (1999, 2003 and 2004)

	1999[1] (n=171)		2003[2] (n=100)		2004[3] (n=177)	
Household Livestock Holdings:	Mean	Range	Mean	Range	Mean	Range
No. of cattle	48	0-340	34	0-34	40	1-388
No. of shoats	92	0-450			86	2-741
Total livestock units	49	0-299			41	0-310
TLU/Adult Equivalent					7.1	0.3-51.7
Cattle TLU/person	4.9	0-72	2.9	0-18	4.5	0.1-40
Land size (in acres)	152	2-1316	151	4-1216	137	2-870
Households size (no. of dependants)	8	0-30	7	0-23	7	1-35
% of school-age children attending primary school					76	0-100

Source: 1. Derived from a survey by ACC of 171 household in 1999 in the same area (Mwangi and Warinda, 1999).
2. Derived from a survey by David Nkedianye of 100 households in 2003 in the same area (Nkedianye, 2004).
3. Authors' 2004 survey of 177 households.

Table 3. Summary of 2004 annual livestock returns in $US (n=177)

	Per Adult Equivalent		Per TLU		Per Acre	
	Mean	SD	Mean	St. Dev	Mean	St. Dev
Gross livestock income*	346	346	73	62	36	92
Livestock production-related input costs	183	407	28	30	20	44
Net livestock income	167	370	45	63	17	62

* includes value of home consumption

Table 4. Determinants of income – overall and other

Dependent variable	Other income (gross annual crop and off-farm income) **Spatial error model**			Ln net annual overall income **OLS model**		
	Coeff.	s.e.	p>|t|	Coeff.	s.e.	p>|t|
Intercept	-280.60	1830.70	0.878	8.51	1.05	0.000
Household factors						
Age	0.92	6.39	0.885	0.00	0.00	0.987
Years of education	77.21	18.50	0.000	0.04	0.01	0.001
Leadership	-12.87	237.81	0.957	-0.18	0.15	0.224
No. of workers	31.25	23.35	0.181	0.02	0.01	0.264
Log of land size	-26.41	80.77	0.744	0.07	0.05	0.177
Log of TLU	339.44	81.77	0.000	0.41	0.05	0.000
No. of off-land activities	495.21	88.84	0.000	0.16	0.05	0.004
Acres under crop cultivation	61.17	56.99	0.283	0.02	0.03	0.580
Spatial factors						
Distance to primary school	-61.62	52.28	0.239	-0.01	0.03	0.658
Distance to livestock market	34.26	17.42	0.049	0.03	0.01	0.002
Distance to road						
Distance to water	48.50	51.27	0.344	-0.02	0.03	0.401
Distance to park	-7.32	10.26	0.476	0.00	0.01	0.989
NDVI average	-3174.78	4808.22	0.509	-9.90	2.71	0.000
Observations	174			168		
Adj R-square (OLS)				0.51		
Variance ratio (spatial error/lag)	0.41					
Lamba (spatial error)	0.15	0.11	0.189			

Table 5. Determinants of livestock wealth and land prices

Dependent variable	Ln value of livestock assets **Spatial lag model**			Ln average land prices per acre **Spatial lag model**		
	Coef	s.e	p>|t|	Coef	s.e	p>|t|
Intercept	4.05	2.16	0.060	6.51	1.48	0.000
Household factors						
Age	0.00	0.01	0.529			
Years of education	0.06	0.02	0.005			
Leadership	-0.12	0.28	0.681			
No. of workers	0.07	0.03	0.010			
Log of land size	0.24	0.09	0.011			
Log of TLU						
No. of off-land activities	0.13	0.10	0.208			
Acres under crop cultivation	-0.01	0.07	0.829			
Spatial factors						
Distance to primary school	0.00	0.06	0.978	0.03	0.03	0.232
Distance to livestock market	-0.03	0.02	0.056			
Distance to road				-0.03	0.01	0.004
Distance to water	0.01	0.05	0.813	-0.07	0.03	0.010
Distance to park	0.02	0.01	0.038	-0.03	0.01	0.000
NDVI average	1.69	5.18	0.744	5.39	2.55	0.034
Population density				0.00	0.00	0.338
Observations	174			153		
Adj R-square (OLS)						
Variance ratio (spatial error/lag)	0.21			0.63		
Lamba (spatial error)						
Rho (spatial lag)	0.19	0.10	0.042	0.31	0.12	0.004

Table 6**.** Diagnostics for spatial dependence

Dependent variables	Net income		Other income		Livestock wealth		Land prices	
	Stat-istic	p-value	Stat-istic	p-value	Stat-istic	p-value	Statis tic	p-value
Spatial error								
Moran's I	0.295	0.768	2.030	0.042	2.201	0.028	3.639	0.000
Lagrange multiplier	0.146	0.702	1.589	0.207	2.086	0.149	7.013	0.008
Robust Lagrange multiplier	0.049	0.825	0.365	0.546	5.606	0.018	0.146	
Spatial lag								0.702
Lagrange multiplier	0.455	0.500	1.231	0.267	4.625	0.032	8.146	0.004
Robust Lagrange multiplier	0.357	0.550	0.007	0.934	8.145	0.004	1.279	0.258

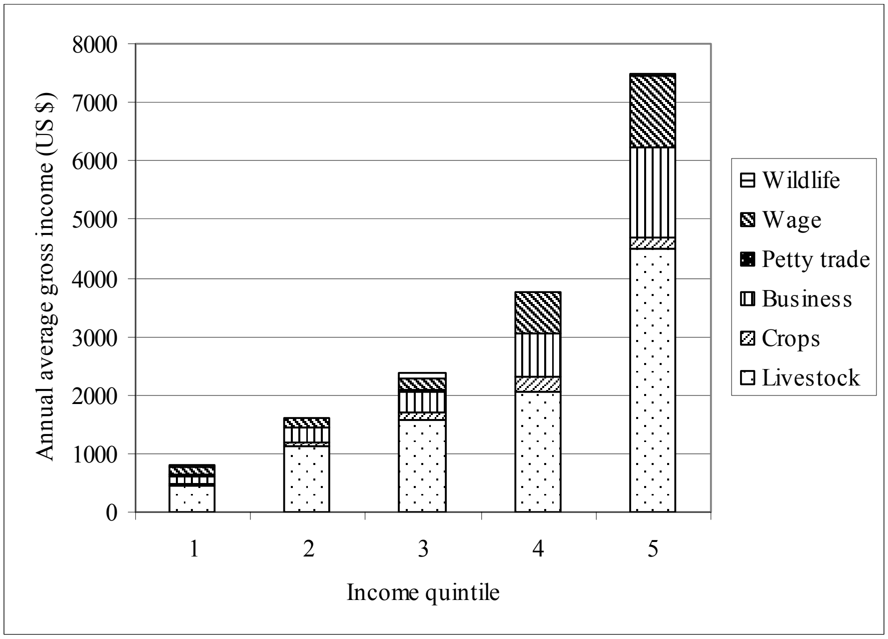

Figure 1. Contribution of different sources of income to annual gross income per household, with households grouped into income quintiles, from lowest 20% (1) to highest 20% (5).

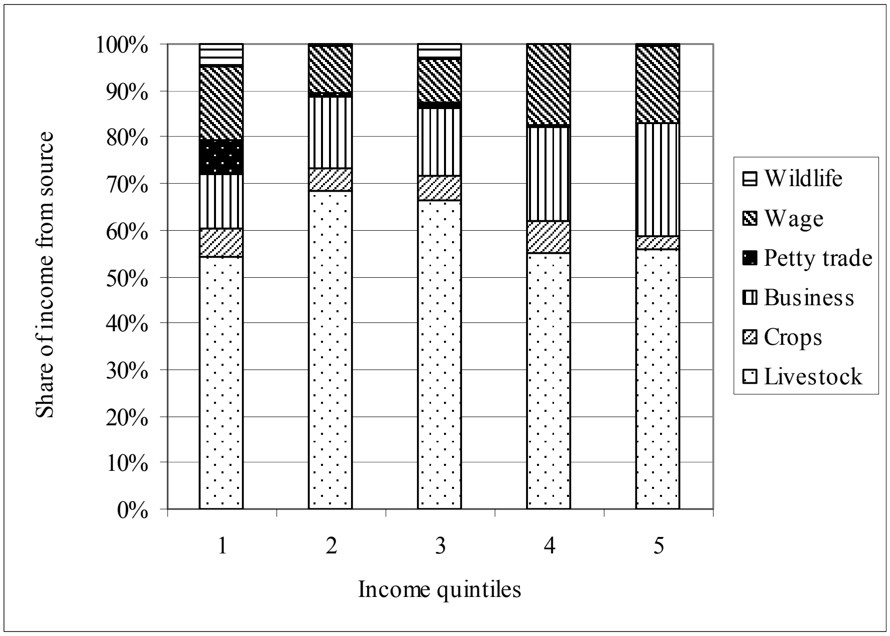

Figure 2. Income sources in shares by quintiles

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