



Household Incomes and Poverty Dynamics in Rural Kenya: A Panel Data Analysis*

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Abstract: This study uses both descriptive and econometric methods to analyze rural household income and poverty incidences over time and the drivers of welfare dynamics in rural Kenya. The analysis uses balanced panel data from 1,299 households in rural Kenya collected by Tegemeo Institute of Agricultural Research and Development, Egerton University. The results reveal considerable variation in regional welfare dynamics over time in rural Kenya, but with overall decreasing poverty levels between 2000 and 2007. Welfare dynamics are associated with demographic factors such as household dependency burden, and the gender and educational attainment of household heads. Households with high dependency ratios and those under single-female headship are more likely to

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transition into poverty. These findings underscore the importance of post-secondary education, access to land, physical infrastructure, markets, and drought shocks for the welfare of rural households.

Keywords: Poverty, Income Dynamics, Poverty Dynamics, Panel Data, Kenya

Over the last two decades, the goal of economic policy in Kenya has been the mobilization and efficient utilization of national resources to achieve high economic growth and reduced poverty levels. These goals have been spelled out in three successive policy documents. The first, the *Poverty Reduction Strategy Paper* (PRSP) (Republic of Kenya 2001), was the product of broad-based and in-depth consultations among key stakeholders and in particular, the poor. It outlined the priorities and measures necessary for poverty reduction. The PRSP was congruent with the long-term vision outlined in the National Poverty Eradication Plan (NPEP) and the United Nations endorsed Millennium Development Goals (MDGs). It is important to note that the PRSP was central to the development of the Medium Term Expenditure Framework (MTEF) budgeting system that started in 2000/01. The MTEF budget was aimed at improving the quality of expenditure by shifting resources towards pro-poor activities and programs. Next, the *Economic Recovery Strategy for Wealth and Employment Creation* (ERS) (Republic of Kenya 2003) initiated some pro-poor programs such as free primary education, the constituency development fund (CDF), and the local authorities transfer fund (LATF). The funds in the CDF and LATF go directly to local levels, thus providing people at the grassroots the opportunity to make expenditure decisions that maximize their welfare (Kimenyi 2005). In 2008, the government then launched a long-term development plan, *Kenya Vision 2030* (Republic of Kenya 2008). This policy document proposes a variety of pro-poor investments especially in the health and

education sectors.

Despite these policy efforts, poverty remains pervasive in the country. According to the 2005/06 Kenya Integrated Household Budget Survey (KIHBS) report, national absolute poverty incidence was 45.9 percent while absolute rural poverty stood at 49.1 percent (Republic of Kenya 2007). According to this report, North Eastern and Central provinces have pockets with the highest and lowest poverty incidences, respectively. The continued high incidence of poverty in Kenya has created the need for empirical studies and the generation of new knowledge to inform poverty reduction strategies.

So far, the failure of poverty reduction efforts has been attributed to a number of problems. Key among these is the lack of implementation of the formulated poverty reduction plans (Kristjanson et al. 2010). While the policy makers have focused on reducing the national aggregate poverty incidences, it is important to note that the poor are not poor all times (Yaqub 2000), and there is movement in and out of poverty. This study is therefore premised on the need for researchers and policy makers to know more about why households move into and out of poverty, and the welfare pathways along which they do so, and why it is that some households remain consistently trapped in poverty.

Consequently, the study uses household panel data collected through surveys in 2000, 2004 and 2007 to understand these poverty dynamics. The study identifies four types of rural households: (1) those that consistently remained poor through the panel period; (2) those that were poor in two spells; (3) those that were poor in one spell; and (4) those that remained consistently non-poor throughout the seven-year panel period. We employ both descriptive and econometric methods to understand the correlates and drivers associated with these four welfare groups.

The results reveal considerable variation in regional welfare dynamics over time in rural Kenya, but with overall decreasing poverty levels between 2000 and 2007. Welfare dynamics are associated with demographic factors such as household dependency burden, and the

gender and educational attainment of household heads. Households with high dependency ratios and those under single-female headship are more likely to transition into poverty. These findings underscore the importance of post-secondary education, access to land, physical infrastructure, markets, and drought shocks for the welfare of rural households.

Poverty Dynamics and Kenya

The majority of earlier studies of poverty in Kenya have been basically static in nature, focusing on poverty indices and the construction of poverty profiles at a point in time (e.g. House & Killick 1981; Hazlewood 1981; Bigsten 1981; Foster et al. 1984; Mwabu et al. 2000; Manda et al. 2001; Geda et al. 2001; Oyugi et al. 2000). Others have examined regional, institutional and spatial determinants of poverty in Kenya (Kabubo-Mariara et al. 2005; Okwi et al. 2006). While such studies provide valuable information on poverty characteristics and distribution, they do not necessarily provide a good indication of household welfare dynamics over time and the determinants of such dynamics.

There are many movements into and out of poverty and within poverty itself, with some households remaining consistently trapped in poverty. These poverty dynamics and inter-temporal household income mobility are less examined, partly due to the lack of reliable panel data sets (Woolard & Klasen 2004). The injection of the time element in data opens up many analytical possibilities. It makes it possible to study the inter-temporal welfare pathways along which households move into and out of poverty, and why (Haddad & Ahmed 2003). It also makes it possible to examine how certain initial conditions and other factors that change over time affect households' welfare pathways.

Common approaches to the subject of income and poverty dynamics have been the use of transition matrices, and binary and multinomial limited dependent models (Okidi & McKay 2003; Woolard & Klasen 2004; Bokosi 2007; Badiani et al. 2007; Quisumbing 2007;

Baulch & Hoddinott 2000). These studies found that poverty is not only location-specific but depends on various initial household characteristics. Generally, the results indicate that education of the household head, per capita acreage cultivated, changes in household size, and household assets significantly increase the probability of being poor. However, transition matrix analysis and multinomial models have limitations. While transition matrices describe the condition of being poor, rather than considering how or why the condition exists, multinomial models impose the property of “independence of irrelevant alternatives” (McFadden 1973). This means that relative probabilities for any two alternatives depend only on the attributes of those alternatives.

In terms of Kenya-specific literature, past research has shown that factors that influence poverty and income dynamics are universally comparable to those of other developing countries. However, the literature lacks poverty and income dynamic studies due to the scantiness of panel data. Most previous studies are based on only two or three waves of short panel data covering fairly short periods of analysis (Place et al. 2003; Kristjanson et al. 2004; Krishna et al. 2004; Burke et al. 2007; Muyanga et al. 2007; Muyanga et al. 2013; Suri et al. 2008). As many households tend to experience temporary movements into and out of poverty, a permanent movement across the poverty line is indistinguishable from temporary movements when only short panels are available. Thus, short panels are unable to detect longer-term asset accumulation processes that occur over a decade or longer.

The present study is innovative in a number of ways. First, it covers a 10-year period, which makes it possible to detect long-term trends and distinguish them from transitory movements. Second, some of the past studies are limited in scope and analysis. Most focus only on some regions and use relatively small samples. To circumvent data deficiencies, some adopt unusual approaches and methodologies. The existence of such studies notwithstanding, continued analysis is important in the light of rapidly changing economic and market conditions. In this study, we attempt to overcome these limitations by

using a rich data set that is representative of the rural population in Kenya at the agro-ecological zones level.

Data Source and Variables

This study uses balanced panel data of 1200 rural households collected between 1997 and 2007 by Tegemeo Institute (Egerton University) and Michigan State University (MSU) as part of the TAMPA project funded by United States Agency for International Development (USAID). Administratively, the households span 24 counties, 39 divisions and 120 villages. The sampling was done within a framework of incorporating the ecological diversities that are inherent in the country to ensure that the emerging sample was representative. Agro-ecological zoning brought together areas with similar ecological characteristics and thus livelihoods (Appendix A).

Even though the panel consists of four waves (1997, 2000, 2004 and 2007), only data from three waves (2000, 2004 and 2007) was found to be useful in the current study. Whereas the original sample consists of 1500 households, only 1299 households consistently remained in the sample in 2000, 2004 and 2007. The attrition arose mainly as a result of dropping North Eastern region due to security risks and migration. The average attrition rate between any two consecutive rounds is about five percent. Accordingly, Jin and Jayne (2011) found that the observed attrition in these panels is largely random, supporting our presumption about the inexistence of selection bias arising from attrition.

Conceptual Framework

In this study, we attempt to examine the factors that influence household welfare pathways over the seven-year panel period. Similar to Woolard and Klasen (2004), this study follows the standard household utility maximization model with adult equivalent household income as a money metric measure of utility. Even though most previous studies on

poverty have used consumption data based on its appropriateness in measurement of household welfare (or ill-fare) as per the economic theory, data on consumption was not available.¹ The underlying assumption in this model is that household income is a function of household assets (both physical and human) and the economic environment in which these assets can be utilized to generate income (Woolard & Klasen 2004).

Household income is derived as the sum of both on- and off-farm incomes. Since most rural households derive the majority of their income from agriculture, the instrument used in the panel survey included comprehensive crop and livestock modules capturing production input costs and the value of outputs. Off-farm income included proceeds from employment, business, remittances and pensions. The summary statistics of the other variables in the analysis are presented in Appendix B. Household income was deflated by the Consumer Price Index published by Kenya National Bureau of Statistics (KNBS), allowing 2004 and 2007 household income values to be compared with those from 2000. Next, the real household income was adjusted for the number of equivalent adults and the gender of household members using the World Health Organization (WHO) adult equivalent scales.² These scales are derived from detailed studies of the nutritional requirements of males and females of different ages in developing countries. At time t , our measure of income for household i , denoted by y_{it} is:

$$y_{it} = \left[\frac{\sum_{h=1}^{H_i} z_{hit} + \sum_{k=1}^K w_{kit}}{\sum_{k=1}^K q_{kit}} \right], \forall i = 1, 2, \dots, N ; t = 1, 2, \dots, T \quad (1)$$

¹ In some instances both income and consumption have been used, with insignificant difference in the findings (Badiani et al. 2007).

² The well-being of individual household members will depend additionally on the number of people who have to share these assets and the incomes derived from them.

where Z_{hit} is the income accruing at the household level from H_i different sources (for example, crop income) and W_{hit} is the income of each household member (for non-earning members income is zero) summed over the household size K_i , all divided by the sum of equivalent adults q_{jit} in the household.

To determine whether a household was poor in any of the three survey waves, we use the food poverty line. The food poverty line is the cost of consuming the Food and Agriculture Organization (FAO) and World Health Organization's (WHO) recommended 2250 kilocalories per day per adult. In Kenya, the poverty line estimate was computed by making an extrapolation from the Kenya National Bureau of Statistics (KNBS) poverty lines for 1997 and 2006, which were KSh1239/month and KSh1562/month, respectively. The resulting poverty line for 2007 was KSh1598/month (KSh19,176/year). Based on household poverty status in 2000, 2004 and 2007, the household welfare trajectories were identified (Figure 1).

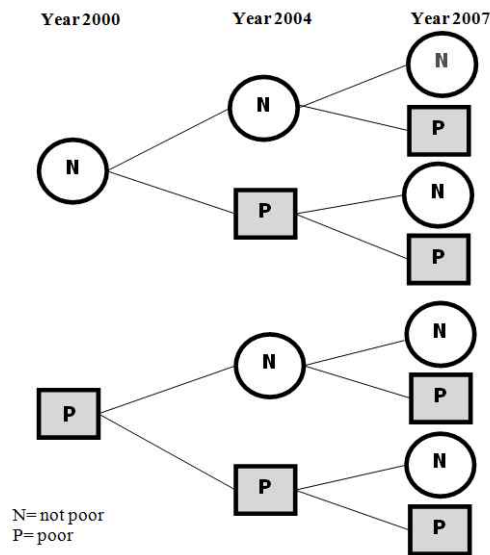


Figure 1. Possible poverty trajectories across three waves of panel data. Source: Scott et al. (2014).

Estimation Strategy and Empirical Model

We use panel data estimation techniques to evaluate the correlates of per adult equivalent household incomes over the panel period. Having data across time for the same cross section units is useful because it allows us to control for unobserved time invariant factors. Following Wooldridge (2010), the unobserved population panel data model for a randomly drawn cross section observation i is specified as follows:

$$y_{it} = x_{it}\beta + c_i + u_{it}, \quad t = 1, 2, \dots, T, \quad i = 1, 2, \dots, N \quad (2)$$

where, the dependant variable y_{it} is the real per adult equivalent income, x_{it} is a vector of both household level and community-level variables, β a vector of the parameters to be estimated, c_i is the unobserved effects while u_{it} is the random disturbance. We assume x_{it} allows for a full set of the time period intercepts, and that u_{it} is uncorrelated with the elements of x_{it} and has a zero mean.

How we estimate Equation 2 depends on the assumption we impose on c_i . There are two major panel data models: fixed and random effects. The fixed effects model allows arbitrary dependence between c_{it} and the explanatory variables. One of the key advantages of panel data is that it allows the fixed effect factor to be removed from Equation 2 through fixed effect estimation. The main drawback of the fixed effects model is that it is not possible to estimate the impact of time-constant variables. If there are sufficient grounds to assume that the unobserved heterogeneity is uncorrelated with any of the explanatory variables in all time periods, then estimation of Equation 2 using fixed effect estimation is not efficient. Instead, an alternative random effects model is used. The equation is rewritten as follows:

$$y_{it} = x_{it}\beta + v_{it}, \quad t = 1, 2, \dots, T, \quad i = 1, 2, \dots, N \quad (3)$$

where $V_{it} = c_i + u_{it}$ is a composite error. Even if in this random effects model we are willing to assume that u_{it} is serially uncorrelated, v_{it} is likely to be serially correlated because of the presence of the c_i component in each period. Generalized least squares (GLS) is used to handle the problem of serial correlation in v_{it} . If we assume the random effects assumption hold, then the pooled OLS estimator is also available. However, the standard errors and hypotheses testing must be made fully robust to arbitrary serial correlation and heteroscedasticity.

The random effects model imposes a particular variance-covariance structure, which is overcome using Mundlak's (1978) and Chamberlain's (1984) Correlated Random Effects (CRE) or the Mundlak-Chamberlain device. This approach allows the modeling of c_i in the following way:

$$c_i = \bar{x}_i\psi + \omega_i, \quad \omega_i | x_i \sim N(0, \sigma_\omega^2), \quad i = 1, 2, \dots, N \quad (4)$$

where $\bar{x}_i$ represents the time-averaged x_{it} over the various panel periods. The CRE estimator, however, requires the model to have a standard normal distribution, and strict exogeneity conditional on c_i . While the parameter estimates (β) are interpreted as the short run effects, the estimates (ψ) are interpreted as the long run effects of the explanatory variables on the dependent variable. The main benefits of the CRE estimator are that: (1) it controls for unobserved time-constant heterogeneity as with fixed effects; and (2), by including time-average terms we can measure the effects of time-constant independent variables.

Since the primary motivation for panel data applications is to solve the omitted variables problem associated with the existence of unobserved individual or household effects, it makes sense first to test for the presence of the unobserved effects. Wooldridge (2010) proposes a simple AR(1) serial correlation test. Since it is assumed that the variance of v_{it} in Equation 3 is $\sigma_v^2 = \sigma_u^2 + \sigma_c^2$, then the null hypothesis of the absence of unobserved effects is, $H_0 : \sigma_u^2 = 0$. To implement the test, we

first estimate Equation 3 using the random effects estimator and save the residuals, $\hat{v}_{it}$. In the second step, we estimate the auxiliary regression.

$$y_{it} = x_{it}\tilde{\beta} + \rho\hat{v}_{i,t-1} + \varepsilon_{it}, \quad t = 2, \dots, T, \quad i = 1, 2, \dots, N \quad (5)$$

where $\tilde{\beta}$ and ρ are the coefficients to be estimated, $\hat{v}_{i,t-1}$ is the lagged residuals from the first step, and ε_{it} is the error term. The variables are as earlier defined. A standard t test, robust to arbitrary heteroscedasticity, on coefficient ρ is sufficient and valid under the null $H_0 : \rho = 0$. If the null holds then by implication $H_0 : \sigma_u^2 = 0$ also holds. If the null is not rejected, the pooled OLS is efficient and the pooled OLS statistics are asymptotically valid. If the null is rejected, then we appeal to the Mundlak-Chamberlain CRE estimator model (4).

The dependent variable y_{it} is the household income per adult equivalent in Kenyan shillings (KSh). The choice of the explanatory variables is informed by previous studies and conditioned on data availability. The covariates in the econometric model relate to demographics, household asset ownership, distances to nearest infrastructural facilities and market access, biophysical factors such as expected rainfall amount and expected drought shock,³ and dummies that capture seasonal events.

To examine the factors behind sustained poverty escapes we apply a *sequential logit* model to the three-wave panel data (Baulch & Vu 2011). This model imposes structure on poverty dynamics. In this case, the model consists of seven logit models, which are estimated in the order in which households make poverty transitions (Figure 1). While the dependent variable is the household welfare trajectory (as indicated in

³ Expected rainfall is defined as a six-year moving average of rainfall prior to the main growing season in the survey year, while expected drought shock is a six-year moving average of the percentage of 20-day periods during the main growing season with less than 40 mm of rainfall. The variables were computed by David Mather, Michigan State University.

Figure 1), the vector of explanatory variables (x) remains as explained in the previous paragraph but this time measured at baseline.

Results and Discussion

Poverty transitions and profiles

The mobility of households' incomes between quintiles using the transition matrix is presented in Tables 1-2. The rows show household income distribution in quintiles in the initial period, t_1 . The columns show household income distribution the current period, t_2 . The results reveal rural household incomes to be quite dynamic. Out of the 259 households classified as the poorest 20 percent in 2000, only 40 percent remained in that category in 2004 (Table 1). Other households experienced increases in incomes with some nine households being categorized among the wealthiest 20 percent of households in 2004. Similarly, out of the 260 households classified as the wealthiest 20 percent of households in 2000, only 51 percent remained in this category

Table 1.

Transition Matrix for Real Income Quintiles (2000-2004)

		Income quintiles in 2004					Total
		1 (Lowest)	2	3	4	5 (Highest)	
Income quintiles in 2000	1 (Lowest)	104 (40%)	76 (29%)	44 (17%)	26 (10%)	9 (4%)	259 (100%)
	2	78 (30%)	77 (30%)	54 (21%)	32 (12%)	19 (7%)	260 (100%)
	3	38 (15%)	52 (20%)	70 (27%)	64 (25%)	36 (14%)	260 (100%)
	4	25 (10%)	37 (14%)	57 (22%)	77 (30%)	64 (25%)	260 (100%)
	5 (Highest)	14 (5%)	18 (7%)	35 (14%)	61 (24%)	132 (51%)	260 (100%)
	Total	259 (20%)	260 (20%)	260 (20%)	260 (20%)	260 (20%)	1299 (100%)

Note. Data are from the Tegemeo Institute Rural Household Surveys.

in 2004. Other households experienced a considerable decline in incomes with about five percent ending up among the poorest 20 percent group in 2004.

Between 2004 and 2007 (Table 2), out of the households in the lowest (poorest) income quintile in 2004, only 46 percent remained in that category in 2007. Likewise, out of the households in the highest (wealthiest) income quintile in 2004, only 57 percent remained under that category in 2007. The rest experienced a decline in incomes with nine households entering the poorest 20 percent category in 2007.

Table 2.

Transition Matrix for Real Income Quintiles (2004-2007)

		Income quintiles in 2007					Total
		1 (Lowest)	2	3	4	5 (Highest)	
Income quintiles in 2004	1(Lowest)	120 (46%)	66 (26%)	46 (18%)	24 (9%)	3 (1%)	259 (100%)
	2	74 (29%)	78 (30%)	57 (22%)	38 (15%)	13 (5%)	260 (100%)
	3	37 (14%)	62 (24%)	73 (28%)	65 (25%)	23 (9%)	260 (100%)
	4	19 (7%)	40 (15%)	56 (22%)	73 (28%)	72 (28%)	260 (100%)
	5 (Highest)	9 (4%)	14 (5%)	28 (11%)	60 (23%)	149 (57%)	260 (100%)
	Total	259 (20%)	260 (20%)	260 (20%)	260 (20%)	260 (20%)	1299 (100%)

Note. Data are from the Tegemeo Institute Rural Household Surveys.

Tables 3-5 respectively present index values for poverty incidence (headcount), poverty gaps and poverty severity over the panel period.⁴ The poverty gap is interpreted as the amount of money required to raise

⁴ The Foster-Greer-Thorbecke (FGT) indices are used to measure poverty because of their additive decomposability property. The FGT indices are expressed as follows:

those below the poverty line out of poverty. Poverty severity is the poverty gap squared. The results indicate that poverty levels have declined considerably. In 2000, about 75 percent of households were below the absolute poverty line (Table 3). This reduced to 57 percent in

Table 3.

Rural Household Poverty Headcount (Percentage) by Agro-Ecological Zone

Agro-ecological zone	2000		2004		2007	
	$P_{\alpha=0}$	Relative contribution	$P_{\alpha=0}$	Relative contribution	$P_{\alpha=0}$	Relative contribution
Coastal lowlands	82 (0.06)	31 (0.03)	74 (0.07)	41 (0.03)	50 (0.07)	32 (0.04)
Eastern lowlands	78 (0.06)	21 (0.03)	43 (0.07)	14 (0.03)	63 (0.07)	26 (0.04)
Western lowlands	94 (0.02)	12 (0.01)	75 (0.05)	12 (0.01)	60 (0.05)	11 (0.01)
Western transitional	69 (0.05)	11 (0.01)	49 (0.06)	10 (0.01)	53 (0.06)	14 (0.02)
High potential maize	72 (0.03)	12 (0.01)	50 (0.04)	11 (0.01)	34 (0.04)	09 (0.01)
Western highlands	86 (0.04)	05 (0.00)	70 (0.05)	05 (0.01)	53 (0.05)	05 (0.01)
Central highlands	43 (0.04)	07 (0.01)	27 (0.03)	06 (0.01)	08 (0.02)	02 (0.00)
Marginal rain shadow	78 (0.07)	01 (0.00)	42 (0.09)	01 (0.00)	28 (0.09)	01 (0.00)
Overall	75 (0.02)	100 (0.00)	57 (0.03)	100 (0.00)	47 (0.03)	100 (0.00)

Note. Data are from the Tegemeo Institute Rural Household Surveys. Standard errors in parentheses.

$$p(\alpha) = \frac{1}{N} \sum_{i=1}^N \left[\frac{(z - y_i)}{z} \right]^\alpha I(y_i) < z$$

where z is the poverty line, y_i is the household adult equivalent income while α is a measure of “poverty aversion” to inequality and variability (Foster et al. 1984). Thus, $p(\alpha = 0)$ is the head count (Table 3), $p(\alpha = 1)$ is the poverty gap (Table 4) index while $p(\alpha = 2)$ is the squared poverty gap or poverty severity index (Table 5). Alpha (α) is also an elasticity of poverty with respect to the poverty gap.

2004 and 47 percent in 2007. Negative (-0.3 percent) economic growth experienced in Kenya at the time support this high poverty figure indicated for 2000. The overall poverty gap and severity indices mimic the poverty head count ratios.

The overall (national) poverty gap index declined from 0.44 in 2000 to 0.29 in 2004, and to 0.19 in 2007 (Table 4). The western highlands, western lowlands and coastal lowlands agro-ecological zones had the highest poverty gaps in all the panel surveys. The central agro-ecological zone had the lowest poverty gap value.

Table 4.

Rural Household Poverty Gaps by Agro-Ecological Zones

Agro-ecological zone	2000		2004		2007	
	$P_{\alpha=1}$	Relative contribution	$P_{\alpha=1}$	Relative contribution	$P_{\alpha=1}$	Relative contribution
Coastal lowlands	0.50 (0.05)	0.32 (0.03)	0.41 (0.05)	0.45 (0.04)	0.22 (0.04)	0.34 (0.06)
Eastern lowlands	0.48 (0.05)	0.21 (0.03)	0.19 (0.04)	0.13 (0.03)	0.24 (0.05)	0.24 (0.05)
Western lowlands	0.69 (0.03)	0.14 (0.01)	0.41 (0.04)	0.13 (0.02)	0.26 (0.03)	0.12 (0.02)
Western transitional	0.34 (0.04)	0.09 (0.01)	0.23 (0.03)	0.09 (0.01)	0.20 (0.03)	0.13 (0.02)
High potential maize	0.39 (0.02)	0.11 (0.01)	0.25 (0.02)	0.10 (0.01)	0.15 (0.02)	0.10 (0.02)
Western highlands	0.50 (0.03)	0.05 (0.01)	0.38 (0.03)	0.06 (0.01)	0.23 (0.03)	0.05 (0.01)
Central highlands	0.17 (0.02)	0.05 (0.01)	0.10 (0.01)	0.04 (0.01)	0.02 (0.01)	0.01 (0.00)
Marginal rain shadow	0.45 (0.05)	0.01 (0.00)	0.14 (0.04)	0.00 (0.00)	0.08 (0.03)	0.00 (0.00)
Overall	0.44 (0.02)	1.00 (0.00)	0.29 (0.02)	1.00 (0.00)	0.19 (0.02)	1.00 (0.00)

Note. Data are from the Tegemeo Institute Rural Household Surveys. Standard errors in parentheses.

The results further show that the severity index also declined significantly from 0.31 in 2000 to 0.18 in 2004, and to 0.11 in 2007 (Table 5). Poverty remains more severe in the same regions with the highest headcount and poverty gaps such as the western highlands, western lowlands and the coastal lowlands. It is important to mention that even though poverty gaps and severity have remained high in some regions, the incidences have come down considerably between 2000 and 2007.

Table 5.

Rural Household Poverty Severity (Squared Gaps) by Agro-Ecological Zones

Agro-ecological zone	2000		2004		2007	
	$P_{\alpha=2}$	Relative contribution	$P_{\alpha=2}$	Relative contribution	$P_{\alpha=2}$	Relative contribution
Coastal lowlands	0.37 (0.05)	0.34 (0.04)	0.26 (0.04)	0.46 (0.04)	0.12 (0.04)	0.34 (0.08)
Eastern lowlands	0.33 (0.04)	0.21 (0.04)	0.11 (0.03)	0.11 (0.03)	0.14 (0.04)	0.25 (0.07)
Western lowlands	0.55 (0.03)	0.16 (0.02)	0.29 (0.03)	0.15 (0.02)	0.14 (0.02)	0.12 (0.02)
Western transitional	0.22 (0.03)	0.09 (0.01)	0.14 (0.02)	0.09 (0.01)	0.11 (0.02)	0.13 (0.03)
High potential maize	0.26 (0.02)	0.10 (0.01)	0.16 (0.02)	0.10 (0.01)	0.08 (0.01)	0.10 (0.02)
Western highlands	0.34 (0.03)	0.05 (0.01)	0.24 (0.02)	0.06 (0.01)	0.13 (0.02)	0.05 (0.01)
Central highlands	0.09 (0.01)	0.04 (0.01)	0.05 (0.01)	0.03 (0.01)	0.01 (0.00)	0.01 (0.00)
Marginal rain shadow	0.29 (0.05)	0.01 (0.00)	0.06 (0.02)	0.00 (0.00)	0.03 (0.02)	0.00 (0.00)
Overall	0.31 (0.02)	1.00 (0.00)	0.18 (0.01)	1.00 (0.00)	0.11 (0.01)	1.00 (0.00)

Note. Data are from the Tegemeo Institute Rural Household Surveys. Standard errors in parentheses.

FGT curves⁵ (Figures 2-4) for the combined agro-ecological zones

⁵ Analyses were done using the Distributive Analysis STATA Package (DASP) routines developed by Jean-Yves Duclos and Abdelkrim Araar

provide a robust check supporting the result that poverty levels generally declined in rural Kenya over the panel period. Poverty dominance curves at the agro-ecological level (not presented here) show that the western lowlands dominate other regions while the central highlands agro-ecological zone clearly maintains low poverty levels across the entire range of poverty lines.

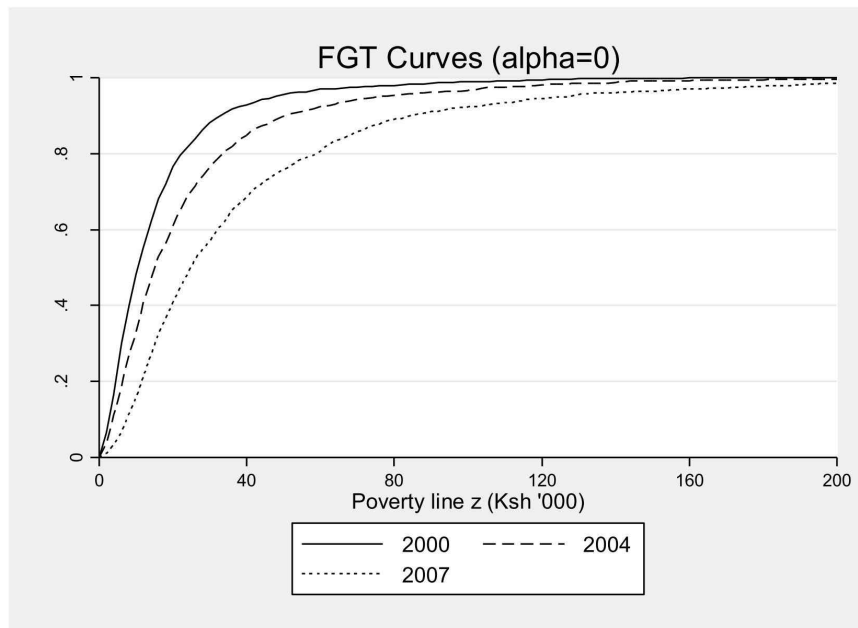


Figure 2. Poverty headcount index by year (2000, 2004 and 2007).

Source: Tegemeo Institute/Michigan State University 2000, 2004 and 2007 panel data.

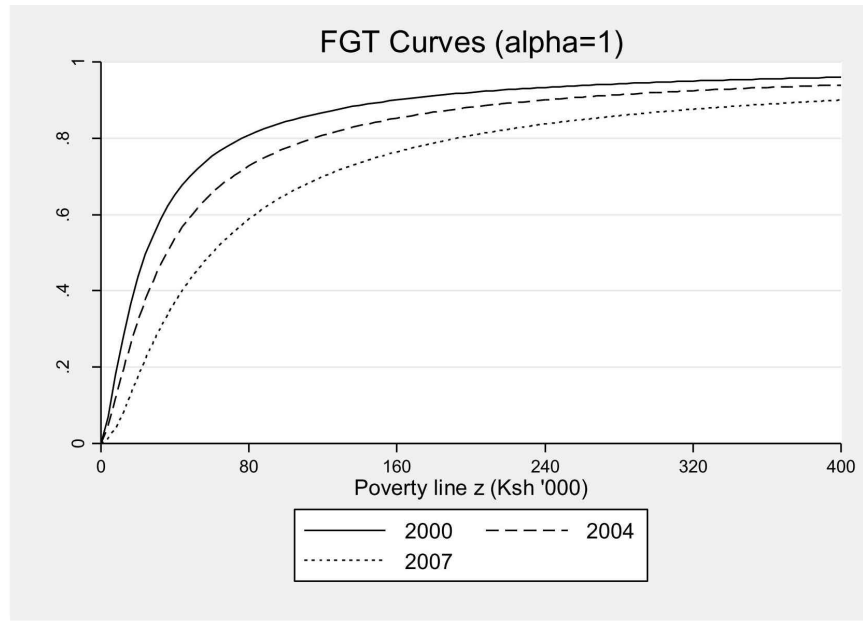


Figure 3. Poverty gaps by year (2000, 2004 and 2007). Source: Tegemeo Institute/Michigan State University 2000, 2004 and 2007 panel data.

No clear dominance is exhibited when we look at the other regions' distribution curves. This means that whether a region is considered poor or non-poor compared to the others depends to a large extent on the choice of the poverty line. The curves become flatter, implying poverty incidences generally declined from year 2000 to 2007. Similarly, comparable trends emerge when we consider poverty gaps and severity dominance curves across regions (not presented here).

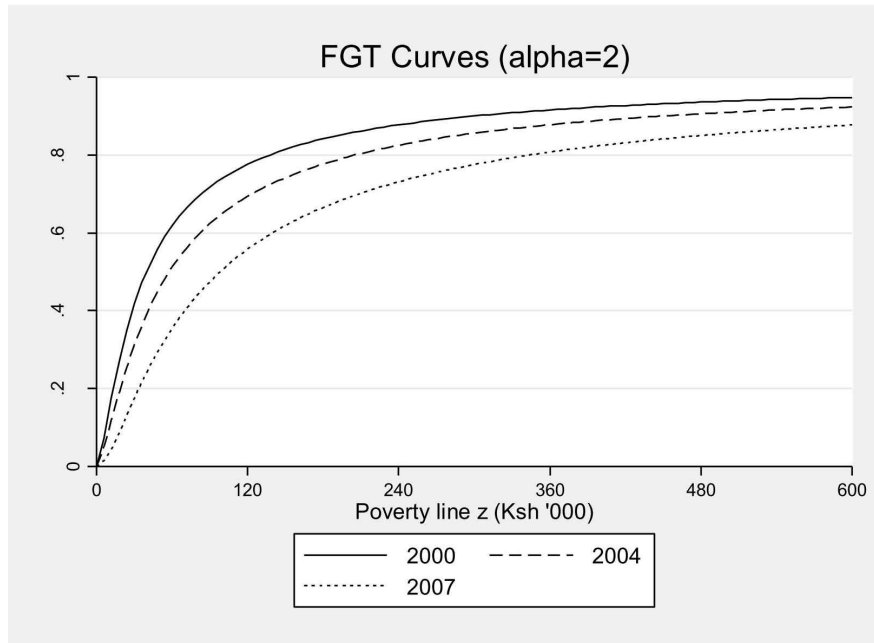


Figure 4. Poverty severity by year (2000, 2004 and 2007). Source: Tegemeo Institute/Michigan State University 2000, 2004 and 2007 panel data.

We also applied a spells approach. We classified households into four categories: those who remained consistently above the absolute poverty line for the three survey periods, those that had one spell below the poverty line, households that experienced two spells, and those that remained consistently below the absolute poverty line. Households that consistently stayed non-poor and those that remained consistently poor represent 36 percent and about 19 percent of the sample, respectively. About 21 percent of the households had two spells below the absolute poverty line, while 24 percent had only one spell. From the agro-ecological perspective, patterns similar to those obtained in the poverty incidence analysis emerge (Table 6). About 73 percent of the households located in the central highlands agro-ecological zone stayed

consistently non-poor. The high potential maize zone followed with the highest consistently non-poor households (42%). At the end of the spectrum, western lowlands (37%), western highlands (32%) and the coastal lowlands (30%) agro-ecological zones had the highest percentage of households that stayed consistently poor over the entire panel period.

Table 6.
Poverty Spells (2000-2007) by Agro-Ecological Zones

Agro-ecological zones	Consistently non-poor		Poor- one spell		Poor two spells		Consistently poor		Sample	
	N	%	N	%	N	%	N	%	N	%
Coastal lowlands	9	13	17	24	23	33	21	30	70	100
Eastern lowlands	48	34	42	29	35	25	18	13	143	100
Western lowlands	12	8	35	24	47	32	54	37	148	100
Western transitional	33	22	50	34	40	27	25	17	148	100
High potential maize zone	143	42	84	25	53	16	60	18	340	100
Western highlands	24	19	31	24	32	25	41	32	128	100
Central highlands	174	73	33	14	23	10	9	4	239	100
Marginal rain shadow	14	38	14	38	5	14	4	11	37	100
Total	457	36	306	24	258	21	232	19	1299	100

Note. Data are from the Tegemeo Institute Rural Household Surveys.

Our results are comparable with poverty estimates from studies carried out during the same period of time. Even though our sample size is smaller than the 2005/06 Kenya Integrated Household Budget Survey (KIHBS) (Appendix C), the poverty incidence estimates are generally comparable. The KIHBS rural poverty estimate for 2006 was 49 percent while the estimate from the current study for 2007 puts it at 47 percent. These results reveal that there are significant differences in regional poverty incidence and considerable dynamics in household income over time. These dynamics are the important policy insight that only panel data analysis can reveal.

Econometric analysis results

A simple AR(1) serial correlation test was implemented and we obtained a $\hat{\rho} = 0.34$ and $t_{\hat{\rho}} = 4.31$, consequently the null, $H_0 : \sigma_c^2 = 0$ is rejected. This implies that the use of pooled OLS or OLS survey-by-survey and random effects models are inappropriate. Consequently, we estimate the model described at Equation 2 using the CRE estimator. The results from the CRE are presented in Table 7. Further, we estimated the sequential logit model to evaluate the correlates of the poverty trajectory. The results are presented in Table 8. Both models show a fairly good statistical fit.

We first discuss the results of the CRE and then those of the sequential logit. The dependant variable is the log of real per adult equivalent income in thousands of Kenyan Shillings ('000KSh). Both the CRE short-run and long-run elasticities are presented. The results indicate that the signs and significance of several variables conform to the theoretical expectations. Among the most important demographic correlates of household incomes are the dependency ratio, gender and education attainment of the household head. Household incomes are a decreasing function of the households' dependency burdens in the long-run. A switch in the dependency ratio from zero to one decreases the household mean income by about 21 percent in the long-run. The results also indicate that a move from monogamous family to single-female headship decreases household mean income by about 10 percent in the short-run and about 13 percent in the long-run. However, the short-run single female headship coefficient is only significant at the ten percent level. Single female-headed households are more disadvantaged in terms of human resource availability compared to their single male-headed counterparts.

As expected, a switch from a household headed by a person without formal education to a person with post-secondary education increases household income by about 28 percent in the long-run. The results also show that an increase in per capita land holding by one acre increases

household incomes by about seven percent in the short-run and about 11 percent in the long run, underscoring the increasing importance of farm plot size in rural areas. With increasing population densities and the high prices of productivity enhancing agricultural inputs, return on additional land is going to remain high and perhaps on the upward trend in the foreseeable future.

Further, results indicate that proximity to electricity supply increases households' incomes both in the short-run and in the long-run. This finding may be attributable to two possible effects. First, access to usable electric power is important in stimulating rural economic growth. It opens up new income opportunities especially in value adding to agricultural primary products. Secondly, the variable could be capturing the effect of other income earning opportunities that come along with the electricity supply. Other important services, significant at the ten percent level, are proximity to motorable roads and a water source. While proximity to motorable roads eases access to both input and output markets by reducing transportations costs, shortened distances to water sources release the labor tied up in water searching activities for other economic uses.

Table 7.

Correlated Random Effects Regression Results of Household Incomes

Dependent variable: log income ('000Ksh)	Short-run elasticities		Long-run elasticities	
	Coef.	Robust SE	Coef.	Robust SE
Dependency ratio	-0.035	0.06	-0.212***	0.07
Age of the household head (years)	0.020	0.09	-0.001	0.12
<i>Gender and marital status of the head (monogamously married as base)</i>				
Single female	-0.101*	0.06	-0.132**	0.06
Single male	-0.016	0.04	-0.009	0.04
Polygamous married	0.010	0.03	-0.054	0.05
<i>Level of education of the head (no formal education as base)</i>				

Primary	-0.001	0.03	0.012	0.03
Secondary	0.022	0.04	0.065	0.04
Post-secondary	0.033	0.04	0.278***	0.05
Per capita land holding (acres)	0.075***	0.02	0.109***	0.02
<i>Distance to infrastructural facilities, services and markets (km)</i>				
Nearest fertilizer seller	0.150	0.15	0.179	0.22
Nearest motorable road	-0.088	0.30	-1.361*	0.80
Nearest water source	-0.050	0.09	-0.371*	0.21
Nearest healthcare facility	0.224	0.19	-0.180	0.34
Nearest electricity	-0.531***	0.15	-0.846***	0.31
Nearest public telephone	-0.046	0.14	-0.220	0.22
Expected rainfall (10mm)	0.017***	0.01	0.115***	0.02
Expected drought shock	-0.327***	0.09	-1.411***	0.20
<i>Region dummies (Central highlands as base)</i>				
Western highlands	0.061	0.04	--	--
High potential maize zone	0.013	0.03	--	--
Western transitional	0.012	0.04	--	--
Western lowlands	-0.082*	0.05	--	--
Eastern lowlands	-0.088***	0.03	--	--
Coastal lowlands	-0.094**	0.05	--	--
Marginal rain shadow	0.154***	0.04	--	--
<i>Survey year dummies (year 2000 as base)</i>				
y2004	0.111***	0.01	--	--
y2007	0.294***	0.01	--	--
Constant	3.451***	0.16	--	--
Observations	3897			
Households	1299			
R-squared				
Within	0.212			
Between	0.468			
Overall	0.345			

Note. Data are from the Tegemeo Institute Rural Household Surveys.

*** p < .01. ** p < .05. * p < .1.

Table 8.

Sequential Logit Regression of Results of Poverty Trajectories

	Household welfare trajectories													
	2000		2004				2007							
	[1]		[2]		[3]		[4]		[5]		[6]		[7]	
	N v. P		NN vs. NP		PN vs. PP		NPN vs. NPP		NNN vs. NNP		PPN vs. PPP		PNN vs. PNP	
	OR	P>z	OR	P>z	OR	P>z	OR	P>z	OR	P>z	OR	P>z	OR	P>z
Dependency ratio	0.99	0.01	0.99	0.13	0.98	0.00	0.99	0.19	0.99	0.29	0.99	0.09	0.98	0.03
Age HH head	1.00	0.94	0.99	0.48	0.99	0.29	0.98	0.29	1.01	0.38	1.01	0.25	1.02	0.37
<i>Status of HH head</i>														
Single fem.	0.60	0.02	1.33	0.44	0.96	0.88	0.15	0.02	1.40	0.60	1.07	0.84	0.57	0.29
Single male	0.77	0.44	1.31	0.71	1.77	0.37	1.87	0.56	0.11	0.02	1.47	0.63	0.80	0.81
Polygamous married	1.31	0.45	1.13	0.79	0.40	0.12	0.92	0.91	0.92	0.92	0.77	0.64	0.42	0.26
<i>Education HH head</i>														
Primary	1.40	0.05	1.46	0.17	0.96	0.86	0.68	0.39	1.18	0.69	1.56	0.14	1.17	0.72
Secondary & post-secondary	4.27	0.00	2.36	0.01	2.23	0.01	1.84	0.31	3.25	0.05	2.57	0.03	1.79	0.27
Per capita land holding (acres)	4.55	0.00	2.24	0.00	2.47	0.00	1.78	0.25	1.33	0.19	2.01	0.04	1.43	0.42
<i>Distance to nearest (km)</i>														
Fertilizer seller	0.97	0.04	0.95	0.04	0.99	0.65	1.00	0.90	1.05	0.33	1.01	0.92	0.97	0.46
Hybrid seed seller	1.01	0.47	1.05	0.12	1.00	0.86	1.00	0.93	1.01	0.80	0.98	0.63	0.98	0.60
Motorable road	1.02	0.19	1.00	0.85	0.98	0.24	1.02	0.57	0.96	0.03	1.01	0.51	0.98	0.10
Water source	1.01	0.62	0.99	0.59	0.99	0.53	0.96	0.27	1.09	0.14	1.02	0.51	1.00	0.89
Healthcare Facility	1.00	0.88	1.01	0.73	0.93	0.09	0.93	0.35	0.95	0.25	1.04	0.29	1.06	0.76
Electricity	0.95	0.00	0.95	0.04	1.03	0.14	0.89	0.03	0.92	0.06	0.94	0.07	0.92	0.06
Public telephone	0.97	0.11	1.01	0.48	0.99	0.67	1.06	0.26	1.06	0.13	0.99	0.68	0.97	0.33
Expected rainfall (10mm)	1.00	0.00	1.00	0.00	1.00	0.48	1.00	0.44	1.00	0.12	1.01	0.03	1.01	0.10
Expected drought shock	0.01	0.00	0.01	0.04	0.03	0.04	0.06	0.55	0.08	0.53	0.01	0.12	0.01	0.12
<i>Zone</i>														
Western highlands	0.80	0.62	0.37	0.20	0.75	0.64	1.78	0.72	0.20	0.27	0.37	0.23	0.53	0.56
High potential maize	0.81	0.44	0.81	0.63	1.05	0.91	0.76	0.81	0.39	0.28	0.38	0.12	0.54	0.42

Western transitional	1.51	0.36	0.34	0.16	1.26	0.71	2.09	0.64	0.09	0.09	0.58	0.55	0.45	0.46
Western lowlands	0.21	0.00	0.51	0.41	0.90	0.85	0.32	0.47	0.15	0.22	0.41	0.26	0.79	0.82
Eastern lowlands	0.27	0.00	0.28	0.01	0.96	0.93	0.12	0.02	0.13	0.02	0.61	0.42	0.11	0.03
Coastal lowlands	0.23	0.00	0.44	0.31	0.65	0.48	0.01	0.01	0.06	0.03	0.96	0.96	1.13	0.92
Constant	6.94	0.02	17.3	0.03	18.8	0.01	38.8	0.02	14.2	0.25	0.38	0.54	15.5	0.27
Households	1299													
R Squared	0.38													
Log pseudo-likelihood	1907													
Wald chi2(26)	243													
Prob > chi2	0.00													

Note. Data are from the Tegemeo Institute Rural Household Surveys. Monogamously married is the base for status of the head. No formal education is the base for level of education of the head. Central highlands is the base for agro-ecological zones.

As expected, the results show that rural household incomes in rural Kenya are also driven by expected rainfall and drought shocks. A decrease in rainfall by 10 mm below average reduces incomes by about 2 percent in the short-run and by about 12 percent in the long-run. In terms of drought shocks, a move from 0 to 100 in the percentage of 20-day periods during the main growing season with less than 40 mm of rainfall reduces household income by about 33 percent in the short-run and by over hundred percent in the long-run. This is perhaps an indicator of the effects of global warming and increased weather variability on the livelihoods of agriculturally reliant rural households in sub-Saharan Africa.

Household income levels are also found to be associated with the agro-ecological and administrative region where the households are located. The results indicate that households residing in the other regions, and especially the lowlands, are associated with relatively lower household incomes but at varying degrees. The survey year dummies emerged statistically significant. This shows there was a general improvement in household incomes over the panel period, which coincided with a period of increased general economic growth. One can

only speculate about the causes of a generalized improvement in incomes over this period, but clues can be obtained by considering other trends and development initiatives at work during this period that might have broadly influenced households' incomes.

Odds ratios and the corresponding p values for the sequential logit results are presented in Table 8. In terms of conclusions on the drivers of poverty dynamics, the results are conclusively comparable to those of the CRE. When the odds ratio is greater than one, it means that the variable increases the probability of a household escaping poverty in that transition period. Conversely, when the odds ratio is less than one, the variable decreases the probability of a household escaping poverty in that transition period. The factors associated with living out of poverty vary according to the transition as presented under panels 1 to 7.

The results indicate that a high dependency ratio, female headship, long distances to agricultural input markets (fertilizer) and electricity, and drought shocks increased the probability of a household being poor in the initial period (panel 1). Conversely, higher education attainment by household head, larger land endowment and higher expected rainfalls decreased the probability of households being poor in the initial period. Households headed by persons with high education attainment, those with relatively large land endowment, and those that received comparably more rainfall in 2004 were more likely to stay out of poverty in 2004 after having been non-poor in 2000 (panel 2). Additionally, households at close proximity to infrastructural facilities (agricultural input markets and electricity supply), and those that expected less drought shocks in 2004 were more likely to remain non-poor in 2004 after having been non-poor in 2000. Households with a low dependency burden, those headed by persons with higher education attainment, those that expected less drought shocks in 2004, and those that had a relatively large land holding had a higher probability of staying out of poverty in 2004 after having been poor in 2000 (panel 3).

Households headed by single females and those located far away from infrastructural facilities were more likely to be poor in 2007 after

having been non-poor in 2000 and 2004 (panel 4). The results also show that households headed by single males and persons with low education attainment, and those located relatively far away from infrastructural facilities were more likely to be poor in 2007 after having been non-poor in 2000 and 2004 (panel 5). Households with high dependency ratios, headed by persons with no post-secondary education (using no education as the base), relatively small landholdings, located far away from infrastructural facilities, and those expecting relatively low rainfalls had a higher probability of being poor in 2007 after having been poor in 2000 and 2004 (panel 6). Lastly, the results show that high dependency ratios, long distances to infrastructural facilities, and low rainfalls received in 2007 increased the chance for households to fall into poverty after having been poor in 2000 and non-poor in 2004 (panel 7).

Conclusions

This study sought to analyze household welfare dynamics in rural Kenya using both descriptive statistics and econometric methods. The results reveal that rural households' incomes do not remain stable across space and over time. There are significant regional welfare differences as well as welfare differences over time. The econometric results indicate that a high dependency ratio and gender and education attainment of the household heads, influence household incomes and transitions into and out of poverty. The other very important correlates of household welfare transitions are proximity to infrastructural facilities, household landholding size, and the quantities of expected rainfall and expected drought shock. While proximity to motorable roads improves access to markets for both inputs and outputs, as well as cuts down transportation costs, reduced distances to electricity supply appear to be triggering new income generating opportunities in rural communities. The results also highlight the increasing importance of land in rural areas. The marginal return on land is likely to remain high. However, shrinking land holding sizes due to increased population pressure means access to more land is

not a feasible option. Sustainable agricultural intensification and transitions to off-farm income earning opportunities are crucial as land increasingly becomes a binding constraint on rural development. Perhaps the most interesting finding is the effect of expected rainfall quantity and expected drought shocks on household incomes and poverty. As mentioned above, this is likely an indicator of the harm that global warming and increased weather variability is having on agriculturally dependent households in sub-Saharan Africa.

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Appendix A

Sample size

Agro-ecological zone	Sample period			Attrition (%)		
	2000	2004	2007	2000_04	2004_07	2000_07
Coastal lowlands	79	78	75	1.27	3.85	5.06
Eastern lowlands	161	155	147	3.73	5.16	8.70
Western lowlands	177	163	153	7.91	6.13	13.56
Western transitional	166	156	149	6.02	4.49	10.24
High potential maize zone	399	375	353	6.02	5.87	11.53
Western highlands	151	142	139	5.96	2.11	7.95
Central highlands	259	246	240	5.02	2.44	7.34
Marginal rain shadow	54	45	43	16.67	4.44	20.37
Total	1446	1360	1299	5.95	4.49	10.17

Appendix B

Sample characteristics

Variables	2000 survey		2004 survey		2007 survey	
	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.
Income per adult equivalent '000KSh	18.19	0.61	28.71	1.00	50.31	2.09
Dependency ratio	0.43	0.67	0.41	0.68	0.40	0.79
Age of the household head (years)	53.57	0.38	56.36	0.37	58.65	0.37
<i>Household head marital status and gender (proportion)</i>						
Single female headed	0.12	0.01	0.16	0.01	0.19	0.01
Single male headed	0.02	0.00	0.03	0.00	0.05	0.01
Monogamously married	0.81	0.01	0.72	0.01	0.69	0.01
Polygamously married	0.04	0.01	0.10	0.01	0.07	0.01
<i>Household head education attainment (proportions)</i>						
No formal education	0.47	0.01	0.46	0.01	0.44	0.01
Primary education	0.33	0.01	0.33	0.01	0.35	0.01
Secondary education	0.15	0.01	0.13	0.01	0.14	0.01
Post secondary education	0.06	0.01	0.07	0.01	0.07	0.01
Per capita land holding (acres)	4.44	0.15	4.30	0.12	4.02	0.13
<i>Distances to nearest markets, services and infrastructure facilities (Kms)</i>						
Fertilizer seller	5.72	0.22	4.10	0.21	3.34	0.13
Motorable road	1.28	0.06	1.06	0.04	0.53	0.02

Water source	5.31	0.25	6.86	0.27	3.96	0.17
Healthcare facility	3.40	0.10	2.79	0.08	3.05	0.09
Usable electricity	5.03	0.21	4.29	0.19	4.04	0.20
Public telephone	4.50	0.13	4.11	0.13	2.81	0.07
Expected rainfall (mm)	556.21	4.35	489.73	5.07	535.22	5.75
Expected drought shock	0.24	0.00	0.34	0.01	0.33	0.01
<i>Agro region zone (proportion)</i>						
Central highlands	0.18	0.01				
Western highlands	0.11	0.01				
High potential maize zone	0.27	0.01				
Western transitional	0.11	0.01				
Western lowlands	0.12	0.01				
Eastern lowlands	0.11	0.01				
Coastal lowlands	0.06	0.01				
Marginal rain shadow	0.03	0.00				
<i>Province (administrative)(proportion)</i>						
Central	0.12	0.01				
Coast	0.06	0.01				
Eastern	0.17	0.01				
Nyanza	0.18	0.01				
Western	0.20	0.01				
Rift valley	0.26	0.01				

Appendix C

Rural Absolute Poverty in Kenya by Region According to the 2005/06 KIHBS

Province	Headcount ($P_{\alpha=0}$) (adult equivalent)	Poverty Gap ($P_{\alpha=1}$)	Poverty Severity ($P_{\alpha=2}$)	Contribution – head count (%)
Central	30.4	9.5	4.5	9.0
Coast	69.7	26.6	13.2	10.1
Eastern	50.9	17.8	8.7	20.3
North eastern	73.9	32.9	17.8	4.6
Nyanza	47.6	16.8	8.0	14.7
Rift Valley	49.0	17.5	9.4	26.7
Western	52.2	18.3	8.6	14.7
Total-rural	49.1	17.5	8.8	100

Source: Republic of Kenya (2007).