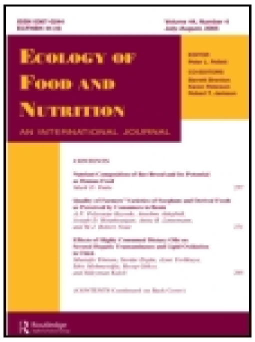

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LEVELS AND CAUSES OF HOUSEHOLD FOOD AND NUTRITION INSECURITY IN DRYLAND KENYA

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Ensuring food and nutrition security in the drylands of sub-Saharan Africa is a critical challenge. Often, information on the level of insecurity is either scanty or unavailable. This paper looks at food and nutrition access at the household level and its determinants in two cases in one of the sub-Saharan African countries: Kenya. Data were collected from a repeat-visit survey of 50 households in two areas of Makueni District, located in the southern part of the country, during 1994–1996, a period that included 'normal' and drought seasons. Even in a season of normal rains, 32 to 42 per cent of households were food insecure, percentages that rose to 40 and 52 during drought. The annual incidence of food poverty was higher (46%) in the drier area than in the wetter area (36%). Food distribution among households, however, showed a reverse trend with the drier area having a Gini coefficient of 0.32 compared to 0.34 in the wetter area. Regressions were used to examine the causes of food and nutrition insecurity. Amongst the main factors improving food and nutrition security was earnings from off the farm. Households headed by women were more food secure than those headed by men, all other things being equal. These findings provide support for prioritising entitlements in terms of earnings and food prices in policy-making, rather than focusing on food production alone. They also indicate that there may be higher social returns to addressing issues of livelihoods associated with women rather than men.

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KEY WORDS: Food security, nutrition, food policy, Kenya's drylands, sub-Saharan Africa

INTRODUCTION

It is estimated that over 700 million people in the Third World today suffer from inadequate food intake, of whom over 100 million are found in Africa (Nyariki and Wiggins, 1997). Three quarters of those affected in this manner live in the rural areas and include those who for the most part depend on drylands for their livelihoods (Pinstrup-Andersen, 1994; Carter, 1997).

In Kenya, a growing problem of food and nutrition insecurity (here also referred to as food and nutrition poverty) is linked to the disappointing growth of agricultural production over the last two decades. Even though agriculture is the mainstay of Kenya's economy, only about 7% of the country's 582,000 km^2 land area has adequate and reliable rainfall, soil, and topography suitable for crop production. A further 5% of the land can sustain crops in years when there is adequate rainfall. The remaining arid and semi-arid lands (ASAL) constitute over 80% of the country's landmass (ROK, 1986). Although Kenya's ASAL contain little more than one fifth of the population, they are disproportionately poor. Moreover, the number of households trying to earn their livelihoods in the drylands is increasing both as local populations grow and as migrants seeking land arrive from the densely settled high potential lands. Therefore poverty is a more convincing factor affecting food and nutrition security; with more than half the population below the poverty line (ROK, 1996), it is no wonder that there is likely to be much under-nourishment.

The incidence of poverty tends to be worse in the drylands than in the higher potential areas. Here poverty is associated with livelihoods based on extensive crop farming and herding. Finding ways to improve the food and nutrition security of households in the drylands has thus become a key policy issue.

Micro-studies of food security are potentially useful both to evaluate food intervention programmes and to understand the strategies households adopt to secure their access to food. Since government policies influence food security and nutritional status of households both directly through changes in real income and indirectly through relative price changes, studies at the local level can be used to assess existing macro-economic policies, thus contributing towards informed policy reforms (Babu and Mthindi, 1994; Kumar, 1993; Jaeger and Humphreys, 1988).

This paper examines the degree of food and nutrition insecurity and the causal variables in Kenya's semi-arid areas, taking two case studies.

CONCEPTUAL AND DEFINITIONAL CONSIDERATIONS

Food security may be defined as access by all people at all times to adequate food for an active life (World Bank, 1991). Although food is the defining concept, it is not all that matters. Food security encompasses food availability through production, storage or imports; and the access that people have to food through their purchasing power in markets (Nyariki and Wiggins, 1997). Access derives from the entitlements a household has to food, either through its own production of foodstuffs or through command over food in markets or other circuits, decisions over the amount and kind of food produced or bought, the internal distribution of household food amongst residents, and the health of individuals which affects the ability to secure nourishment from food (Figure 1). In this paper the concern is with access to and distribution of food at the household level.

As depicted in Figure 1, the main elements of food and nutrition security, which are now understood to include *adequate food availability, adequate food access*, and *appropriate food use*, are influenced by several household-level attributes. One of the major attributes that determine the ability of a household to acquire adequate food is its ability to produce or purchase food (Babu and Mthindi, 1994; Maxwell, 1996). Implied in this is the ability of the household to use available resources efficiently. In turn, the resources should be sufficiently productive. Other attributes include the nature and extent of endowment of these resources to the household, production processes, income accrued from production, and the level and methods of consumption.

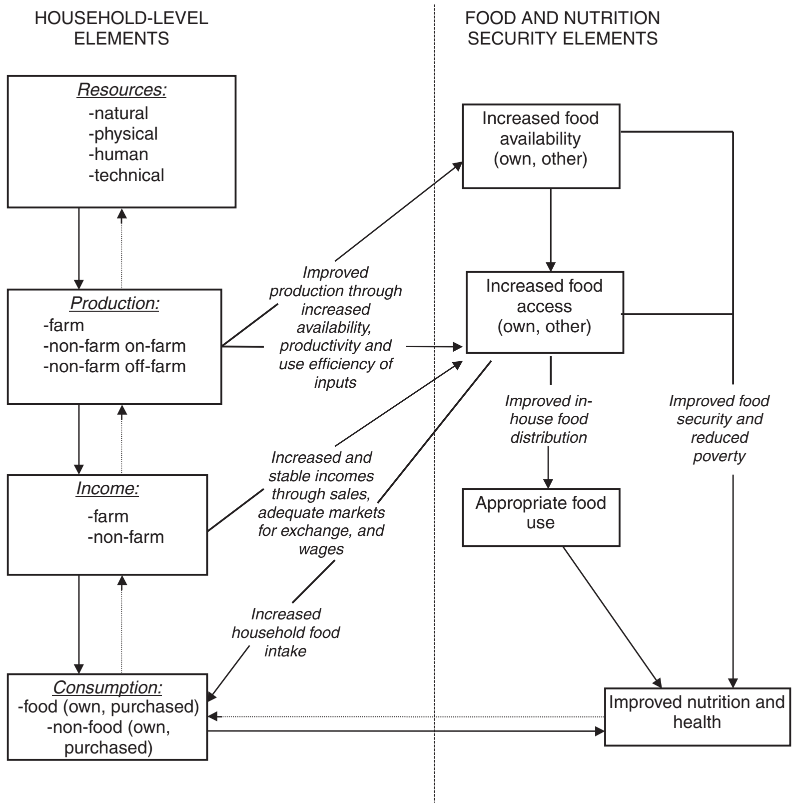

FIGURE 1 Elements of farm household food and nutrition security.

Household food availability is influenced by own production, production by other households (which influences the availability of loans and gifts), and food markets. Production levels are, in turn, influenced by the productivity of the resources (inputs) available. The resources may be natural, physical, human and technical. Natural resources may be in the form of land (both quantity and quality) and weather; physical resources may include tools, machinery and the state of infrastructure; human resources are usually in the form of physical labour, skill and education; while technical resources may include modern input use and traction methods.

Another major component of household-level elements of food security is production of farm and non-farm outputs, using the resources available. The availability of land and labour plays a big role in food production. When land is limited, the labour resource of a household determines the income to be earned from non-farm employment to supplement own-farm production. Households may also be involved in generation of income from farm and or non-farm product sales. With increased and stable incomes (in other words, reduced poverty) through product sales and wages, and with the availability of markets for exchange, improved food access is possible. In addition to improved production, leading to improved availability of food, there should be improved in-house food distribution (resulting in appropriate food use) and intake and, therefore, adequate food consumption. When improved food availability and access is achieved, and assuming food is appropriately used, then improved household nutrition, health, and accumulation, are likely.

METHODOLOGY

Area of Study and Data Collection

This study concerns two areas within Makueni District, Kenya. The district lies east of the Great Rift Valley and covers about 7,263 km^2 (ROK, 1994). In the north the district is hilly with elevations up to 1,900 m, from which there is a downward slope to the south-east where it forms an undulating plateau at about 700 m. As one moves down the slope, so rainfall diminishes—from an annual average of 1,300 mm in the northern hills to as little as 500 mm in the south—whilst temperature and evapo-transpiration rise. This gives a wide range of agro-ecological zones, from the hills where coffee may be grown, to the lower plateau perhaps best suited to grazing livestock but where crops may be planted at the risk of frequent harvest failures. The rainfall regime is bimodal, with 'long' rains falling in March to May and 'short' rains in October to December, giving two cropping seasons.

The two study areas selected were Maiani Sub-Location, Kilome Division, on the fringes of the northern hills, and Kibwezi Division in the southern plateau of the district. Kilome has an average population of 115 persons a km^2, most of them smallholders producing maize, beans and bananas for food and some cultivating coffee as a cash crop. The area has been settled for more than a century and there is a moderately well developed road network. Kibwezi is much drier, with an average annual rainfall of 600 mm. It is populated at less than 50 persons a km^2, most households having moved into the area since the early 1970s. The road network is less developed. The majority of the population live in smallholding households growing maize, sorghum, beans, cow peas, pigeon peas, vegetables and raising livestock. A few households have access to small plots irrigated from streams.

In each of the two areas, 50 households were selected through a two-stage simple random sampling procedure. One administrative area was randomly selected in each case, to reduce the area covered because of the expansive nature of the district, and then 50 households were randomly selected from each zone. Households were visited during three successive cropping seasons—in late 1994, mid-1995, and early 1996—and interviewed using a pretested questionnaire. Data were collected on household size and characteristics, crop areas, inputs and yields, use of labour, access to markets, and food consumed in the previous 24 hours according to recall. Households were asked to list and estimate the quantities of the foods prepared (Nyariki, 1997). The long rains season of early 1995 proved to be a drought: the other seasons were times of rainfall closer to the average rainfall.

Household Food Consumption Levels and Distribution

To compute annual food poverty ratios, a food poverty line for both Kibwezi and Kilome was constructed from the list of foods and their calculated proportions as reported in the survey. Total income for each household was then calculated and the non-food expenditures were subtracted. Per capita incomes were then computed and weighted using the rural food and non-food price indexes—so as to obtain 'real' per capita (adult-equivalent) income per day. The incomes so derived were compared with the poverty line, also weighted using the same indexes, to estimate the food poverty incidence using the head-count ratio and food distribution using the Gini coefficient.

The incidence of food poverty and food distribution measures were based on the cost of basic needs (CBN) approach. In this approach, the main ingredients of food poverty measures are the caloric requirements, the food bundle to achieve that requirement, and the allowance for non-food items, which entail a normative judgement (Ravallion and Sen, 1996; Nyariki and Wiggins, 1997).

The food poverty incidence is given by

$$H = q/n$$

where H is the food poverty index, q is the number of households falling below the food poverty line and n is the total number of households in the sample. The Gini coefficient, on the other hand, is given by

$$G = 1 + (1/q) - (2/q^2z)\sum_{i=1}^{q}(q+1-i)y_i$$

where G is the Gini coefficient of food income distribution, q is the number of food poor households (i.e., those falling below the food poverty line), z is the mean food income of the poor households and y_i is the food income of household i.

Determinants of Household Food Consumption

Regression models were used to examine the determinants of food consumption at the household level. The dependent variable was derived from food consumption reported in the surveys. The lists and quantities of different foodstuffs prepared were converted into their kilocalorie energy content, summed for the household, and divided by the number of residents expressed as adult equivalents, with children below the age of 16 weighted at half an adult. (For further information on these assumptions, *see* Bouis *et al.*, 1992). The resulting figure was then compared to the FAO recommended daily intake of 2,250 kcal an adult a day by obtaining ratios, those households with a ratio falling below one being considered food insecure, those on or above one food secure. Table I shows average seasonal and annual calorie availability per adult-equivalent.

Seasonal data (from the three visits) were pooled to create a panel of cross-section and time-series. The calorie consumption

TABLE I
Average per capita nutrient levels (kcal) in the study areas, 1995/96

Season and poverty group	Kibwezi	Kilome
Wet season		
Above poverty line	2,455	2,664
Below poverty line	1,986	2,088
Wet season mean	2,258	2,480
Dry season		
Above poverty line	2,390	2,453
Below poverty line	1,759	1,837
Dry season mean	2,062	2,207
Annual mean	2,160	2,343

variable was based on the 24-hour recall of food intake data collection technique developed by nutritionists (*see*, for example, Bouis *et al*., 1992). The basis for pooling data from the three interviews was that it made it possible for one to assess the effect of changing determinants over seasons.

Two approaches were used for pooling data: OLS technique which combines all cross-section and time-series data and an OLS regression performed on the entire data set; and time-series autocorrelation technique which considers the fact that the error-term may be correlated over time and cross-section units (Maddala, 1989; Thomas, 1993). The two estimation techniques give unbiased and consistent parameter estimates, and the main criterion for discrimination is normally that of efficiency. Estimating using a form of GLS regression is usually one of the most efficient methods (Pindyck and Rubinfeld, 1991). A method of maximum likelihood estimation (MLE) was adopted to derive parameters in the autoregressive models.

The general food security model can be expressed as

$$FS = f_1(AV) + f_2(AC) \tag{1}$$

where FS represents an index of food security, AV are factors influencing food availability and AC are factors influencing food access.

The general model in (1) is in keeping with the concept of food security presented in the framework in Figure 1, as it indicates that a household can achieve food security with or without having to produce any of the food itself. It thus implies that food production by the household or nation may be important but it is not a necessary condition for achieving food security. Therefore three scenarios are possible: a household achieves food security solely by producing food from its own fields; a household secures enough food entirely through purchases; and a household secures enough food through both production and purchases.

The explanatory variables, which were hypothesised to have an influence, included a number of household, community, and natural factors, for which data were collected. These variables appear in Table II. Because of their nature of influence, the variables are either exogenous or endogenous and if both are included in a single equation, they will introduce simultaneity bias. To avoid this, two equations—(2) and (3)—were used to test the variables:

$$Y_{it} = \alpha + \sum_{j=1}^{J} \beta_j X_{ijt} + \mu_{it} \tag{2}$$

$$I_{it} = \lambda + \sum_{k=1}^{K} \gamma_k Z_{kit} + \varepsilon_{it} \tag{3}$$

$$i = 1, 2, \ldots, N; \quad j = 1, 2, \ldots, J; \quad k = 1, 2, \ldots, K; \quad t = 1, 2, \ldots, T$$

where Y_{it} is the calorie consumption per adult-equivalent for household i at time t and X_{ijt} is the level of jth exogenous variable, including income (I) as a major variable influencing food security, associated with household i at time t. I_{it} is income and Z_{kit} is the kth variable influencing income levels associated with household i at time t. α and λ are the intercepts, β_j and γ_k are the estimated parameters, and μ_{it} and ε_{it} are the error-terms associated with farm i at time t for equations (2) and (3), respectively. t stands for season.

For the present analysis, household food security is conceptualised as a relationship between household food consumption (which depends on availability and access) on the one hand and household structure (attributes), community-level factors, and farm

TABLE II
Summary of explanatory variables affecting household food security

Variable	Unit, definition	Average recorded	
		Kibwezi	Kilome
Farming			
Land size	ha	7.7 ha	3.6 ha
Modern input use	Binary: use of hybrid seeds, fertiliser, pesticide	19 households	34 households
Irrigation	Binary: access to irrigation	7 households	None
Number of crops/household	Number	6	4
Livestock units	250 kg tropical unit/household	3.9	3.1
Area cultivated/adult-equivalent	ha/adult-equiv.	0.49	0.23
Crop yield/ha	kg/ha	1,094 kg maize-equiv.	1,739 kg maize-equiv.
Extension visits at farm	Binary: 1 for yes, 0 for no	18 households visited	26 households visited
Season	Binary: 1 for wet, 0 for dry	Dry	Wet–dry

Household characteristics			
Household size	Residents present	7.5	7.3
Gender of household head	Binary: 1 for male, 0 for female	28 male-headed	33 male-headed
Education of household head	Scaled 1–4: the larger the higher	Upper pri. (mode = 2)	Upper pri. (mode = 2)
Age of household head	Scaled 1–5: the larger the older	41–50 yrs (mode = 3)	41–50 yrs (mode = 3)
Off-farm earnings			
Earnings from non-farm self-employment	Binary: 1 for yes, 0 for no	29 hhs self-employed	20 hhs self-employed
Earnings from wage employment	Binary: 1 for yes, 0 for no	18 hhs wage-employed	29 hhs wage-employed
Remittances	Binary: 1 for yes, 0 for no	13 hhs received remit	7 hhs received remit
Other factors			
Purchase price of staple crop, maize	Ksh/kg	Ksh 10/kg	Ksh 8/kg
Distance to nearest market	km	2.5 km	1.5 km

and non-farm linkages on the other. The hypothesis is that household food consumption is influenced by two main proximate factors: availability and access. These factors are in turn influenced by farm production and non-farm factors. The latter are further affected by household and community characteristics. The farm factors include farm resources (inputs) such as land and capital assets, research, and extension, while non-farm factors include infrastructural development, wage employment, and so forth. So, given that the processes by which households achieve their food security depend on how food is acquired, some inputs are necessarily public goods. These include infrastructure (such as roads), research, extension, and development of food markets. The latter particularly influence food access.

Three models were adopted using equations (2) and (3): the ordinary least squares (OLS), the weighted least squares (WLS), and the feasible generalised least squares (FGLS). The exact regression procedure for each model is as follows:

1. OLS: This involves direct application of the base equation. All the classical assumptions on the error term hold.
2. WLS: Because of the low R^2 in the OLS and the suspicion of existence of heteroscedasticity (which was confirmed by the Goldfeld-Quandt test), a form of weighting was applied before running an OLS regression to derive WLS parameters.
3. FGLS: This is one of the so called feasible or estimated GLS models (FGLS). Assuming one independent variable, the model can be expressed as

$$Y_{it} = \alpha + \beta X_{it} + \mu_{it}\,; \quad \mu_{it} = \rho_i \mu_{i,t-1} + \nu_{it} \tag{4}$$

where

$$\nu_{it} \sim N(0, \delta_\nu^2); \quad E(\mu_{it}^2) = \delta^2; \quad E(\mu_{it}\mu_{jt}) = 0; \quad E(\mu_{i,t-1}\nu_{jt}) = 0 \quad i \neq j$$

The model in (4) can be rewritten as in (5). Each error structure is fixed to involve first-order serial correlation but ρ is allowed to vary from individual to individual unit. So, in structure, the model is first-order autoregressive in the error term. With this model, efficient parameter estimates can be obtained by using a GLS process. First, OLS regression is carried out using the entire pooled sample after which the generalised difference of the original model is derived as shown in (6):

$$Y_{it}^{\theta} = \alpha(1-\rho_i) + \beta X_{it}^{\theta} + \nu_{it}^{\theta} \tag{5}$$

and

$$Y_{it}^{\theta} = Y_{it} - \rho_i Y_{i,t-1}, \quad X_{it}^{\theta} = X_{it} - \rho X_{i,t-1}, \quad \nu_{it}^{\theta} = \mu_{it} - \rho \mu_{i,t-1} \tag{6}$$

The model makes use of the assumption that the time-series disturbances are autocorrelated.

RESULTS

Table III gives per capita per day food balance sheet for the two study areas, which was used to derive food poverty incidence and food distribution measures among households. The results indicate that the incidence of food poverty in 1995/96 was worse in Kibwezi than in Kilome (Table IV). Therefore, in respect of command over food consumption needs, Kilome farmers were more secure—Kilome households suffered less incidence of food poverty. This is an indication that rural food poverty increases with reducing agricultural potential. The annual head-count ratio showed a difference of 10 per cent between the two areas. However, numerically, the head-count ratio moved in the same direction as the Gini coefficient, implying that the two were conversely related; i.e., the poorer households had better food distribution.

The Lorenz curves shown in Figure 2 provide a clear picture of annual food poverty distribution. For Kibwezi, the piece of the Lorenz curve below 50% of the population's income was closer to the line of equal division of income equivalent of food, supporting the values derived using the equation for Gini coefficient. About 70% had less than 50% of the population's share of income in Kibwezi, while in Kilome this proportion was about

TABLE III
Per capita per day food balance sheet for the study areas

Food Item	Nutrient content per 100 gm (edible portion)		Per capita normative daily threshold			Dry season rural values of food (Ksh/kg)		Wet season rural values of food (Ksh/kg)		Food expenditure Ksh/capita/day	
	Calorie	Protein (gm)	Food	Calorie (gm)	Protein	Current	'Real'	Current	'Real'	Dry	Wet
Maize	345	9.4	259.9	734.0	19.3	12.00	5.26	10.00	4.38	1.37	1.14
Pulses (peas and beans)	347	23.0	80.8	274.0	17.8	25.50	11.17	22.50	9.86	0.90	0.79
Sorghum/millet	327	9.7	17.5	54.0	1.5	20.00	8.76	18.69	8.19	0.15	0.14
Cassava	138	1.2	25.6	28.0	0.2	14.00	6.13	10.00	4.38	0.16	0.11
Sweet potatoes	109	1.6	37.0	37.0	0.6	16.00	7.02	14.00	6.14	0.26	0.23
English potatoes	75	1.7	20.3	15.0	0.3	18.00	7.89	14.00	6.14	0.16	0.12
Wheat	333	10.0	24.9	68.0	2.0	35.00	15.34	30.00	13.15	0.37	0.33
Banana	85	1.5	15.1	9.0	0.3	15.00	6.57	10.00	4.38	0.10	0.07
Other fruit	—	—	12.3	7.0	—	30.00	13.14	20.00	8.76	0.16	0.11
Vegetables (greens)	22	1.3	44.8	10.0	0.6	35.00	15.34	31.00	13.59	0.69	0.61

Milk	79	3.8	90.0	57.0	2.9	25.00	10.76	20.00	8.76	0.97	0.79
Meat (beef, mutton)	171	15.0	20.7	35.5	3.1	82.00	35.93	100.00	43.82	0.74	0.91
Chicken	73	20.1	16.4	11.9	3.3	25.00	47.48	30.00	56.97	0.78	0.93
Eggs	140	12.0	2.9	8.0	0.3	76.00	33.28	60.00	26.29	0.10	0.08
Fats/oils	700	0.0	12.3	96.0	—	122.10	53.51	122.10	53.51	0.66	0.66
Beverages	51	0.6	31.1	16.0	0.2	121.10	53.07	121.10	53.07	1.65	1.65
Sugar/honey	375	0.0	50.4	194.0	—	48.00	21.04	40.00	17.53	1.06	0.88
Nuts/oil seeds	572	23.0	9.9	20.0	0.5	56.00	24.54	50.00	21.91	0.24	0.22
Total (gm, calories, proteins)			772.0	1,674.0	53.0						
Poverty line expenditure on food (Ksh per capita/day)										11.21	9.77
Rural CPI for food*										228.2	228.2
Rural CPI for nonfood*										296.9	296.9

*Derived from estimates by the CBS for Eastern Province using 1991 prices as base (100%) (ROK, 1996).

TABLE IV
Incidence of food poverty and distribution in Kibwezi and Kilome, 1995/96

Measure	Kibwezi			Kilome		
	Wet season	Dry season	Annual	Wet season	Dry season	Annual
Incidence: head-count ratio (%)	42.0	52.0	46.0	32.0	40.0	36.0
Distribution: Gini coefficient	0.28	0.34	0.32	0.33	0.35	0.34

75%. Seasonal distribution was also better, as implied by the lower Gini coefficients. However, as shown by the head-count poverty measure, overall poverty was higher in Kibwezi.

Table V reports the OLS, WLS and FGLS results for Kibwezi and Kilome for equations (2) and (3) respectively, which represent the best outcomes, by considering the number of significant variables, adjusted (Adj) R^2, F, chi-square, log likelihood, and d values. In most of the regressions, the signs of the variables seem to be consistent. After weighting the variables using land area, the resultant WLS seems to represent the data better, as the Adj

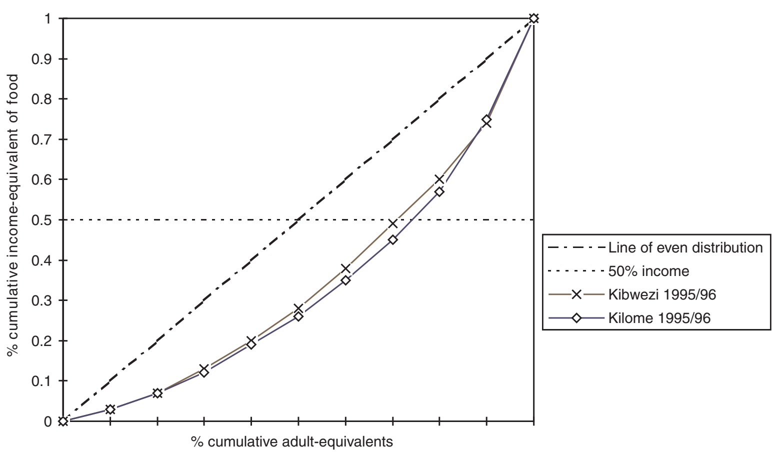

FIGURE 2 Lorenz curves representing food distribution over household populations—Kibwezi and Kilome, 1995/96.

R^2 and the F statistics improve. On the other hand, the FGLS has fewer significant explanatory variables.

Focusing on the WLS models for both food security index and income, in Kibwezi, income level, education of the household head, irrigation, and season show a positive and significant influence on calorie consumption per adult-equivalent. The number of adult-equivalents in the household, gender of household head, and price of maize (staple crop) exert a significant and negative effect. Households tend to consume fewer calories as price goes up. Since a fairly large proportion of foods consumed is purchased, this result is consistent with a negative price elasticity of demand for most goods. This implies that people in Kibwezi are likely to be more food and nutrition insecure when prices of staples increase, unless there is a commensurate increase in household incomes.

For Kilome households, the results exhibit a few similarities and differences compared to those for Kibwezi. Similarities are observed in the effect of household size, infrastructural proximity and maize price on calorie intake. Similarities are also seen in the effect of non-agricultural wage earnings on income, through which food security is influenced. Differences are observed in the effect of modern inputs (fertilisers, pesticides and hybrid seeds) on income, which is significant in Kilome but not in Kibwezi. The number of crops grown seems not to be important in both Kilome and Kibwezi. Gender of household head affects food security significantly in both Kibwezi and Kilome. There were 22 and 17 female-headed households in the former and the latter respectively.

DISCUSSION AND CONCLUSIONS

The study results indicate that, in both areas, no matter the quantity of rain, off-farm earnings play a major role in ensuring food access through increased incomes. This is important when considering agricultural policy. If households can buy food using off-farm earnings, it matters much less that harvest failures are avoided. Kibwezi was, in this respect, remarkable; smallholders located in an agro-ecological zone officially considered suitable

TABLE V
Factors influencing household calorie consumption in Kibwezi and Kilome

Variable[†]	Coefficients for Kibwezi			Coefficients for Kilome		
	OLS	WLS	FGLS	OLS	WLS	FGLS
Equation 2: dependent variable, food security index						
Income/adult-equivalent	2.37	5.09	1.03	3.18	2.07	0.96
	(2.69)**	(4.71)**	(2.47)**	(3.28)**	(3.55)**	(1.80)*
Household size	−1.45	−2.08	−0.45	−1.30	−2.31	−0.48
	(−1.98)**	(−3.83)**	(−0.92)	(−2.41)**	(−3.21)**	(−1.29)
Irrigation	1.06	2.61	0.96	—	—	—
	(1.35)*	(2.24)**	(1.02)	—	—	—
Gender of household head	−2.66	−4.71	−1.60	−2.03	−6.75	−0.64
	(−2.28)**	(−3.50)**	(−1.56)*	(−2.11)**	(−3.98)**	(−1.36)
Education of household head	0.90	2.46	1.26	0.59	0.33	0.91
	(1.13)	(1.93)**	(2.74)**	(1.45)	(1.10)	(0.82)
Season	2.44	10.62	8.21	1.30	1.87	0.48
	(1.94)**	(3.77)**	(3.46)**	(2.10)**	(2.16)**	(0.99)
Purchase price of staple crop	−0.61	−1.65	−0.59	−2.34	−1.71	−1.84
	(−1.06)	(−2.48)**	(−1.29)	(−1.98)**	(−2.13)**	(−1.40)
Distance to nearest market	−0.46	−1.26	−0.75	−0.54	−0.92	−1.44
	(−0.89)	(−0.74)	(−1.15)	(−1.39)	(−1.63)*	(−1.99)**

Equation 3: dependent variable, income/adult-equivalent						
Number of crops	0.74	0.09	1.03	0.08	0.17	1.98
	(1.30)	(1.17)	(1.47)	(0.68)	(1.01)	(1.16)
Area cultivated/adult-equivalent	1.51	1.26	0.59	2.34	1.94	1.82
	(1.89)*	(1.54)*	(1.85)*	(1.60)*	(1.81)*	(1.97)**
Livestock units	0.461	3.65	0.09	–0.47	–2.21	–1.87
	(1.56)*	(2.78)**	(1.33)	(–1.29)	(– 2.63)**	(–1.49)
Earnings from wage employment	4.27	2.62	0.31	4.00	6.14	0.87
	(3.00)**	(2.69)**	(1.11)	(3.24)**	(4.16)**	(1.09)
Modern inputs	0.43	1.26	0.79	2.22	3.51	1.83
	(1.16)	(1.48)	(0.85)	(1.95)**	(2.68)**	(1.74)*
Crop yields/ha	0.23	1.48	0.50	1.34	2.19	1.44
	(0.48)	(1.59)*	(1.22)	(1.69)*	(2.13)**	(1.00)

** Significant at 5%; * Significant at 10%; *t*-values/ratios in brackets; †Variables shown without the time subscript.

Equation 2

Kibwezi

OLS: Adj $R^2 = 0.24$, $F = 8.99$**, $d = 1.70$; WLS: Adj $R^2 = 0.41$, $F = 14.32$**, $d = 2.09$; FGLS: Log likelihood = –78.11; Ramsey RESET test on OLS: $F_{(1,131)} = 2.67$; Goldfeld-Quandt test on OLS: $F_{(60,60)} = 4.55$**; Goldfeld-Quandt test on WLS: $F_{(60,60)} = 1.79$.

Kilome

OLS: Adj $R^2 = 0.28$, $F = 6.21$**, $d = 1.99$; WLS: Adj $R^2 = 0.54$, $F = 19.00$**, $d = 1.97$; FGLS: Log likelihood = –242.32; Ramsey RESET test on OLS: $F_{(1,131)} = 2.75$; Goldfeld-Quandt test on OLS: $F_{(60,60)} = 4.23$**; Goldfeld-Quandt test on WLS: $F_{(60,60)} = 0.92$.

Equation 3

Kibwezi

OLS: Adj $R^2 = 0.41$, $F = 13.44$**, $d = 2.13$; WLS: Adj $R^2 = 0.55$, $F = 18.02$**, $d = 2.11$; FGLS: Log likelihood = –92.45 Ramsey RESET test on OLS: $F_{(1,133)} = 3.01$; Goldfeld-Quandt test on OLS: $F_{(60,60)} = 5.77$**; Goldfeld-Quandt test on WLS: $F_{(60,60)} = 0.82$.

Kilome

OLS: Adj $R^2 = 0.52$, $F = 9.78$**, $d = 1.98$; WLS: Adj $R^2 = 0.62$, $F = 35.67$**, $d = 1.92$; FGLS: Log likelihood = –294.66; Ramsey RESET test on OLS: $F_{(1,133)} = 2.58$; Goldfeld-Quandt test on OLS: $F_{(60,60)} = 4.52$**; Goldfeld-Quandt test on WLS: $F_{(60,60)} = 1.06$.

for sorghum, millet or livestock grazing sowed much of their land to maize. This crop failed two or more times out of every five harvests, but this did not seem to worry the farmers. Presumably they were prepared to take the risk of losing the maize harvest because the yields expected from a maize plot when the rains are good far exceed those of sorghum and millet. This suggests that in this particular part of the Kenyan drylands, policy and public resources should give priority to issues of the off-farm economy and should invest in agricultural research and extension centred on drought-resistant crops, including maize.

It was established that in the two study areas, purchase price of staples was important. This was to be expected because under the prevailing conditions harvests fail and households have to buy more staples than would be the case in higher potential areas. This suggests that policies that hold down the price of cereals in drylands when drought strikes are socially valuable, and may well justify public subsidies.

Female-headed households were more likely to be food and nutrition secure than those headed by men. This may have a cultural implication that women place a higher priority on providing food for the family than men (Carter, 1997). This finding is similar to that obtained by Kennedy and Haddad (1994). The policy implication would then be that interventions that enable women to gain better control over cash and to adopt technologies of producing food staples which are more predictable and reliable are likely to have higher social returns than similar schemes that concentrate on men. This implies not merely correcting the usual tradition of supporting activities undertaken by men, but enhancing the priorities of those activities that are concerned with food procurement and are traditionally dominated by women.

Finally, the inverse relation between household size and food or calorie consumption is not obviously explicable. Indeed, it runs counter to what is often found in Africa's drylands: that larger households make good use of their labour and thus have higher food production per head than smaller ones (*see*, for example, Becker, 1990; Kremer and Lock, 1993). It may be that poorer households have larger numbers of children. But equally possible is that since household size was taken as the number of residents, those with migrants would appear smaller, and such households would have more off-farm earnings than their neighbours without migrants. Whatever, there is no clear policy implication.

Even though the sample sizes in this study were small and the results should therefore be regarded as tentative, and should not be extrapolated beyond semi-arid areas in Kenya, in sum, the study confirms ideas about food and nutrition security which stress entitlements through earnings and the price of staple foods; in contrast to views which stress food production by vulnerable households. It also provides support for those concerned at biases that limit the ability of women to earn livelihoods.

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