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FACTORS INFLUENCING PASTORAL AND AGROPASTORAL HOUSEHOLD VULNERABILITY TO FOOD INSECURITY IN THE DRYLANDS OF KENYA: A CASE STUDY OF KAJIADO AND MAKUENI COUNTIES

DOROTHY A. AMWATA*, DICKSON M. NYARIKI and NASHON R. K. MUSIMBA
South Eastern Kenya University (SEKU), Kitui, Kenya

Abstract: This study establishes the determinants of household vulnerability to food insecurity in pastoral households of Kajiado and agropastoral households of Makueni Counties of Kenya. A randomly selected sample of 198 households was interviewed. Descriptive analysis showed that pastoral households of Kajiado County were more vulnerable to food insecurity (VFI) with a VFI of 0.59 than agropastoral households in Makueni County, who had a VFI of 0.27. Further, a two stage least squares approach established that vulnerability of households to food insecurity is determined by land size, household size, rainfall and herd size for Makueni County and access to climate information, herd size, off-farm employment and gender of the household head for Kajiado County. The findings imply that Makueni County needs access to and control over land resources, destocking through improved livestock breeds and creation of a microclimate to enhance rainfall levels. For Kajiado County, policies need to promote access to climate information, diversification of livelihoods and female access to production resources. Copyright © 2015 John Wiley & Sons, Ltd.

Keywords: determinants; pastoral; food insecurity; drylands; agropastoral; vulnerability

1 INTRODUCTION

Kenya's long-term goal of food self-sufficiency remains unmet. Frequent droughts precipitate requests for donor-provided food aid to mitigate the ravages of famine, especially in ASALs, populated largely by livestock dependent pastoral tribes (United

*Correspondence to: Dorothy A. Amwata, Department of Range and Wildlife Sciences, South Eastern Kenya University, P.O. Box 170-90200, Kitui, Kenya.
E-mail: damwata@yahoo.com; damwata@seku.ac.ke

States Department of Agriculture, 2009). Kenya, just like other African countries, is faced with hunger and poverty and these problems are getting worse. It is estimated that more than 14.3 million people or 60% of the population live below the poverty line (ROK, 2009). In addition, about 52.9% of the population living in the rural areas and 34.8% of those living in urban areas are poor. Besides, 49% of the rural population is absolutely poor (Kenya National Bureau of Statistics, 2007), and 7.6% of the urban live in extreme poverty, such that they cannot meet their food needs even if their entire resources were devoted to food.

Like many other sub-Saharan African countries, Kenya has faced frequent incidences of food deficit in recent times, so much that hunger is evidently one of the greatest problems facing the country today. Kenya has a population of more than 38 million about 10% of whom are classified as food insecure (WFP, 2009).The prevalent high food and non-food prices, crop failure, livestock diseases, and conflict have compounded the already precarious food insecurity in the ASALs (Joseph, 2004). This clearly shows that people in the Kenyan dry lands represent a sizeable portion of the potentially hungry and vulnerable to food shortages. The frequency and magnitude of hunger in Kenya is a major impediment and is catastrophic to the national development agenda (FAO, 2005). With an annual population growth rate of about 3%, the country remains the largest import market for food and agricultural products in East Africa. In an attempt to mitigate the food crisis during 2009, Kenya imported about $725 million in agricultural products, a figure much higher than the $525 million in 2007 (ROK, 2009). The Government of Kenya has identified droughts and erratic rainfall as the main reason for vulnerability to food insecurity in the ASALs (within which the study area falls). Furthermore, agricultural development is considered the main source of food security but it is also recognised that agriculture alone cannot ensure food security to the masses in the long run (ROK, 2010).

The factors contributing to food insecurity and related survival mechanisms vary with people and region. The causes and possible remedies of hunger in Kenya are still unclear. There is therefore need for research and empirical analysis to provide scientific facts for public policy formulation and action for minimising food insecurity and adapting to impacts of climate variability and change. More evidence on this issue is necessary, particularly at the household level. The current study attempts to fill this gap by providing further guidance on the problem of climate variability and its links to household vulnerability to food insecurity in the ASALs of Makueni and Kajiado Counties.

2 LITERATURE REVIEW

2.1 Dryland agriculture and livelihood challenges

The ASALs of Kenya cover nearly 90% of the country's land mass and are home to nearly 30% of its population. In addition, they hold approximately 70% of the national livestock herd, which is worth US$800 million per year (Odhiambo, 2013), and are home to most of the country's national parks that are the foundation of its thriving wildlife tourism. Yet the ASALs have not received adequate attention commensurate with their status in the country's economic development. Instead, they have historically been marginalized in terms of resource allocation, land transformations, infrastructure development, social service delivery and economic transformation, thus threatening livelihood sustainability in these areas. Dynamic ecological and environmental change models suggest that climate

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change-induced drought events may push dryland systems to cross biophysical thresholds, causing a long-term drop in agricultural productivity (Fraser *et al*., 2011) and consequently recurrent food insecurity. Clearly, the current livelihoods and resource use patterns in the drylands are insecure and cannot maintain, let alone improve, the living standards of the inhabitants (Ngugi and Nyariki, 2005). One of the main strategies to cope with food insecurity in the drylands is livelihood diversification (Amwata, 2004; Kinyua, 2004). The rural households diversify to spread risks and smooth consumption and labour allocation, among others. However, livelihood diversity in complex interactions with poverty, income distribution, farm productivity and environmental conservation is sometimes not straight forward (Ngugi and Nyariki, 2005). Therefore, future rural poverty reduction policies need to be better informed on the nature of these interactions.

2.2 Definitions and Concepts on Food Security

Food security has been variously defined by many authors depending on the context and purpose of the study. According to FAO (2002) and Tasokwa (2011) food security refers to when all the people at all times have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active healthy life. Amwata (2004) and Nyariki and Wiggins (1997) define food security as the availability of adequate diet all year round for an active healthy life (that is, 2250 kcal/AAME/day). Other studies, such as that of Nyariki and Wiggins (1999), state that food security is attained when sufficient growth in food crops and livestock is achieved not only to maintain output per person, but also to reduce food calorie deficits and to lower food imports.

Food security has been studied at both the national and household levels. At the national level, food security implies that adequate supplies of food are available through domestic production or through imports to meet the consumption needs of all people in a country. At the household level, food security depends on a number of factors that are related to various forms of entitlements such as income and food purchasing power, hence its strong relationship with poverty. The current study adopts the definition by Ganapathy *et al*. (2005) and Power *et al*. (1998) that understands food security as a bivariate concept composed of anti-hunger or poverty elimination goals and goals of food system issues. This two dimensional concept essentially relates to food access goals in terms of quantity and quality respectively. An anti-hunger or anti-poverty approach argues that people should have a sufficient quantity of food and/or enough income to access a sufficient quantity. The food system approach expresses a concern with the quality of food that is available, how food is produced and the impact of its production, distribution and consumption on individuals and communities.

2.3 Methodologies Used in Household Food Security Studies

Different methodologies have been used by various scholars to establish the factors influencing household vulnerability to food insecurity using qualitative and quantitative approaches. Some of the studies that have used quantitative approaches are Amwata (2004), Kaluski *et al*. (2001), Nyariki *et al*. (2002), Pankomera *et al*. (2009), Amaza *et al*. (2009) and Tasokwa (2011). On the other hand, qualitative studies have been

DOI: 10.1002/jid

conducted by Wolfe and Frongillo (2001), Oni *et al*. (2010) and Bartfeld and Hong-min (2011). In both qualitative and quantitative studies, the logit, probit and multiple regression models have been widely used in establishing the determinants of household food security. The most commonly reported determinants of household food security in these studies include the education level of the household head, land size owned by a household, household size, household income, access to credit facilities, access to markets and gender, among others.

For instance, Amwata (2004) used a binary logit regression model to estimate the determinants of household food security. She found out that gender and land ownership were the main determinants of household food security in Kajiado District. Nyariki *et al*. (2002) used Ordinary Least Squares (OLS), Weighted Least Squares (WLS) and Feasible Generalized Least Squares (FGLS) models in determining the factors influencing household food security in Makueni County. He found out that WLS produced better results in terms of R^2 and number of significant variables with income being the main determinant of household food security. Other studies from Africa, such as Pankomera *et al*. (2009), used a binary probit regression model and reported household size and education level of the household head as being among the main determinants of household food security. In these studies, food security measure was either binary or continuous. The underlying assumption in the above models was that there is a one-way relationship between food security and its determinants. This assumption is disputed by Tasokwa (2011) who argued that these factors can be categorised into two, namely agricultural and social factors, which are often intertwined in terms of their influence. This implies that they include exogenous, endogenous and instrumental variables that result in a two-way relationship between food security and its explanatory variables. Therefore, similar to Tasokwa (2011), this current study uses a simultaneous equation model (SEM) to estimate the factors influencing household vulnerability to food insecurity.

Kigutha (1994) used child nutrition as a measure of food security. In this approach, the focus was on women and children, the most vulnerable members of the poor households. Approximately 2.3 million children aged 6–24 months die annually in developing countries because of malnutrition (Tangka *et al*., 2000). Such households discriminate among their members in distributing food when food supply is inadequate but this declines with plenty supply. Also parameters such as Weight-for-Age (W/A), Height-for-Age (H/A), Weight-for-Height (W/H), head circumference and mid-arm circumferences for different age groups have been used as a basis for assessing malnutrition and evaluating the effects of dietary treatment in children. Weight, height, head circumference and mid-arm circumference for age are the percentages of adequacy of each of these measurements based on the respective standards for the children's chronological age (Kigutha, 1994; Tangka *et al*., 2000).

Vulnerability to food insecurity (VFI) has also been used to determine household food poverty status (ROK, 2000a; Sunya, 2003; Amwata, 2004; Nyariki and Wiggins, 1997). One of the indexes used to estimate food poverty is the food poverty incidence (FPI). FPI is the ratio of food poor households to all households in a community. The ratio gives the food insecurity vulnerability status of the community under investigation (Nyariki *et al*., 2002; Amwata, 2004). The studies have emphasised on actual household food consumption as a measure of vulnerability to food insecurity. This current study uses a similar measure of food consumption but from the income approach. The argument is that one can only access enough food if one can produce it or if one has adequate income to purchase the food. According to the Government of Kenya (ROK, 2000a), poverty lines

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for Kenyans in rural and urban areas are Kshs 1 239/month/adult equivalent and Kshs 2 648/month/per adult equivalent respectively. Kenyans living below these standards are thus considered to generate inadequate income levels to feed, clothe, educate and pay for basic health care for their families. A similar approach has been used by Kristjanson *et al.* (2002) in valuing alternative land-use options in the Kitengela dispersal area of Kenya.

3 METHODOLOGY

3.1 Area of Study and Data Collection

This study was conducted in Makueni and Kajiado Counties of Kenya. The two counties are located in the southern rangelands of Kenya. Makueni County covers an area of 7 965.8 km^2 and had a human population of 884 527 in 2009 (CBS, 2009) with an annual growth rate of 2.8%. Kajiado County covers approximately 19 600 km^2 and lies between longitudes 36° 5′ and 37° 5′ east and 1° 0′ and 3° 0′ south (CBS, 1981). Both counties are classified by the Kenyan Government as arid and semi-arid, characterised by variable and unpredictable rainfall patterns, dry spells and droughts. The rainfall regime in the two counties is bimodal with long rains falling between March and May and short rains in October to December, resulting in two growing seasons. The main food crops for both counties include maize, beans and pigeon peas, while cereals such as millet and sorghum are also grown. The population in these counties are primarily small-holder subsistence farmers and/or livestock keepers who wholly depend on rainfall for their livelihood.

A multistage sampling technique was used to select 198 households, 98 from Kajiado County and 100 from Makueni County. First, these two counties were purposely sampled based on the main land-use activities, culture, weather conditions and livelihood sources. The locations in each county were listed and eight randomly selected for each county for the study, then 100 and 98 households were randomly selected for the administration of questionnaires for Makueni and Kajiado Counties, respectively. Household interviews were conducted from March to September 2009. The data collected were on land-use, livelihood sources, household size, gender of the household head, household total income, land size, herd size, types of crops grown and their acreage, rainfall, rain days, temperature patterns and access to climate information.

3.2 Determinants of Household Vulnerability to Food Insecurity

The current study uses income per adult equivalent to estimate household vulnerability to food insecurity. This involves collection of data on household total income and the number of individuals present. Total income refers to an aggregate value of livestock, crop and off-farm income in a given time period (Kristjanson *et al.*, 2002). In addition, the number of members present in a household was standardised into adult equivalents (AE). The concept of AE is based on the differences in nutritional requirements according to age and sometimes sex (Kristjanson *et al.*, 2002). This study adopts the consumption weights by age where: 0–4 years is 0.24 AAME; 5–14 years, 0.65 and over 15 years, 1.00 (ROK, 2000b). Depending on the size and ages of the household members, adult equivalent (AAME) is derived.

DOI: 10.1002/jid

Total income per household per month divided by the sum of Active African Man Equivalence (AAME) gives the income per adult equivalent per month. In the descriptive analysis of food security, the figure obtained was compared to the recommended income per adult equivalent per month for the rural area of Kshs 1239 (See, for example, Kristjanson *et al*., 2002).

For the calculation of household vulnerability to food insecurity, the equation below was used:

$$VFI_t = Ya_t / Yr_t$$

Vulnerability to food insecurity (VFI_t) at time t = Actual total income per adult equivalent/month for a household (Ya) divided by the required total income per adult equivalent/month for that household (Yr) at time t.

The households' vulnerability to food insecurity is the proportion of households who fall below the poverty line of Kshs 1239 per adult equivalent per month. The food poor households are those who do not have access to income of Kshs 1239 per adult equivalent per month. Households whose members have access to income of Kshs 1239 and/or above per adult equivalent are considered less vulnerable to food insecurity.

A simultaneous equation model (SEM) was used to assess the determinants of household food security. The dependent variable was the household food security measure, using total income per adult equivalent per month as an indicator. The independent variables hypothesised to influence household food security included farm and household-level factors. Some of the explanatory variables are agriculture related, most of which are expected to have a two-way feedback. Therefore, the problem of simultaneity was expected in the model, hence the choice of a simultaneous equation model. The simultaneity problem was confirmed by Hausman specification test. The assumption was that there were exogenous and endogenous variables in the model that could not be estimated through OLS. Therefore, a 2SLS approach was used to estimate the model.

The model was conceptualised that household food security is a relationship between the amount of income per adult equivalent per month and the household characteristics, farm characteristics, on-farm employment and rainfall levels. Even though similar studies, such as Tasokwa (2011), have suggested that climatic parameters such as rainfall and temperature intensity should not be included in the model because of the assumption that climate is a community factor, this study found otherwise; that households within the community experience different levels of rainfall because of differences in agro-ecological zones and altitude. Land size, herd size and household size were presumed endogenous because they are influenced by other factors such as income, rainfall and household size, which are also explanatory variables. Therefore they are likely to correlate with the error term. Hausman test for exogeneity, as suggested by Gujarati and Sangeetha (2007), was conducted to confirm the endogeneity of the variables. The assumption in the model was that income per adult equivalent is influenced by three main endogenous variables, land size, herd size and household size, and other exogenous variables. However, education and land size also influence each other and are in turn influenced by the availability of income and some exogenous variables, which are not included in the main equation. The model, therefore, contains the dependent variable, predictors, predictors and instrumental variables, and purely instrumental variables (Figure 1). Instrumental variables are exogenous variables that influence the endogenous variables in the model but are not included in the main equation of the model.

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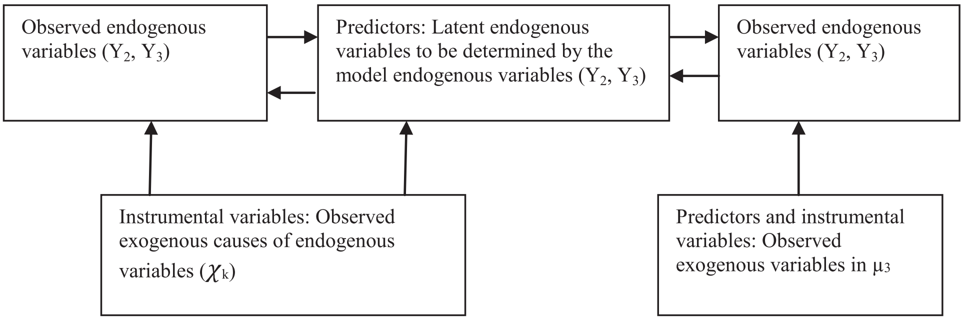

Figure 1. Theoretical framework for SEM

Predictors and instrumental variables are exogenous variables that are included in the main equation of the model. Household characteristics include household size, and gender, education and age of the household head. Farm characteristics include farm size, labour, access to climate information and sources of climate information. Earnings include household income from farm and off-farm employment. Thus, vulnerability of households to food insecurity depends on the factors that influence production and purchase of food. These factors are interrelated in nature as shown in Figure 1.

The model can be expressed as:

$$Y_1 = \beta_{10} + \beta_{11} Y_2 + \beta_{12} Y_3 + \beta_{13} Y_4 + \lambda_1 \chi_{m1} + \lambda_2 \chi_{m2} + \lambda_3 \chi_{m3} + \ldots + \lambda_n \chi_{mn} + \mu_2 \quad (2.1)$$

$$Y_2 = \beta_{20} + \beta_{21} Y_1 + \beta_{22} Y_3 + \varphi_1 \chi_{k1} + \varphi_2 \chi_{k2} + \varphi_3 \chi_{k3} + \ldots + \varphi_n \chi_{kn} + \mu_2 \quad (2.2)$$

$$Y_3 = \beta_{30} + \beta_{31} Y_1 + \beta_{32} Y_2 + \omega_1 \chi_{p1} + \omega_2 \chi_{p2} + \omega_3 \chi_{p3} + \ldots + \omega_n \chi_{pn} + \mu_3 \quad (2.3)$$

$$Y_4 = \beta_{40} + \beta_{41} Y_1 + \alpha_1 \chi_{l1} + \alpha_2 \chi_{l2} + \alpha_3 \chi_{l3} + \ldots + \alpha_n \chi_{ln} + \mu_4 \quad (2.4)$$

where Y_1 is a dependent variable, Y_2, Y_3 and Y_4 are endogenous variables or jointly dependent variable, $\chi_{\text{k's,m's}}$, $\chi_{\text{p's}}$ and $\chi_{\text{i's}}$ are observed exogenous variables or predetermined variables associated with given equations, β_{10}, β_{20}, β_{30} and β_{40} are constants, β's are coefficients for endogenous variables (Y), λ's, ω's, φ's and α's are coefficients for exogenous variables (χ), and μ_1, μ_2, μ_3 and μ_4 are stochastic disturbances.

3.3 Test for Identification, Simultaneity and Exogeneity

Tests for identification, simultaneity and exogeneity were formally carried out. The order and rank condition of identification as described by Gujarati and Sangeetha (2007) and Tasokwa (2011) were used to find out if the equations were exactly identified or overidentified. The order condition demands that the number of exogenous variables excluded from an equation must not be less than the number of endogenous variables in that equation less 1. That is to say, if K-k = m-1, the equation is exactly identified but if K-k > m-1, it is overidentified.

K is the number of exogenous variables in the model including the intercept, k is the number of exogenous variables in the given equation and m is the number of endogenous variables in a given equation. Therefore, the order condition is a necessary but not sufficient condition for identification. Hence, a rank condition of identification was used

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because it is both a necessary and sufficient condition of identification. It states that, ‘in a model containing M equations, an equation is identified if and only if at least one nonzero determinant of order (M-1) (M-1) can be constructed from the coefficients of the variables (both endogenous and exogenous) excluded from that particular equation but included in the other equations of the model’ (Tasokwa, 2011; Gujarati and Sangeetha, 2007). The advantage of using both conditions is that the rank condition tells whether the equation is identified or not while order condition tells whether the equation is exactly identified or overidentified. The 2SLS approach provides satisfactory estimates of parameters and is suitable for estimation of overidentified equations (Tasokwa, 2011; Vogel and Adams, 1999).

The methods of 2SLS and instrumental variables (IV) give consistent and efficient estimates if there is simultaneity in the model. Therefore, the test of simultaneity was essential to find out if a regressor was correlated with the error term. Hausman specification error test was used for this purpose. The steps were undertaken as follows:

(1) Regress each endogenous variable (Y_2, Y_3 and Y_4) on all the exogenous variables (X_k, Z_k) (reduced form equations) to obtain estimated μ_2, μ_3 and μ_4.
(2) Regress the dependent variable (Y_1) on all endogenous variables and the estimated residuals and perform a t-test on the coefficient of the estimated residuals. If the coefficient is statistically zero, then there is no simultaneity in the model.

Further, it was not obvious to determine the variables which were endogenous in the model. Hausman test was used to test if the endogenous variables were truly endogenous. The test was carried out as follows:

(1) Regress each of the endogenous variables on all the exogenous variables in the model to obtain estimated endogenous variables (Y_2*, Y_3* and Y_4*).
(2) Regress the dependent variable on the endogenous variables (Y_2, Y_3 and Y_4), fitted endogenous variables (Y_2*, Y_3* and Y_4*) and exogenous variables (X_k) and use the F-test to test the hypothesis that the coefficients of the estimated endogenous variables are equal to zero. If the hypothesis is rejected, then endogenous variables are truly endogenous.

4 RESULTS AND DISCUSSION

4.1 Results of Descriptive Analysis

Table 1 presents the results of descriptive analysis associated with the dependent and explanatory variables used in the model. The analysis is on the basis of land-use systems. Using a computed food security measure, the results showed that 59% of Kajiado households were more vulnerable to food insecurity than 27% in Makueni households. In addition, rainfall levels had influence on household vulnerability to food insecurity. For Kajiado County, about 84.5% of the food insecure households inhabited areas receiving <450 mm of rainfall while in Makueni County, approximately 76% of the food secure lived in areas receiving >450 mm of rainfall.

The mean total income was also found to vary with rainfall levels. The mean household income per adult equivalent/month was Kshs 1 138.5 and Kshs 1 386.0 for Kajiado and Makueni Counties, respectively. In Kajiado County, those who received less than 450 mm of rainfall had a mean income/adult equivalent/month of Kshs 808 and those in

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Table 1. Summary of the sample characteristics based on rainfall and land-use

Variables	Unit, definition	Kajiado (Pastoralists)		Makueni (Agropastoralists)	
		≤ 450 mm	≥ 450 mm	≤ 450 mm	≥ 450 mm
		Mean	Mean	Mean	Mean
Dependent variable					
Total income per adult equivalent/month	Kshs/Year	808.00	1345.00	1198.00	1422.00
Explanatory variables					
a. Household characteristics					
Gender of the household head	Binary, 1 for male and 2 for female	1.05	1.23	1.56	1.48
Education levels of household head	Scaled 0–3, 0; no education, 1; primary, 2; secondary; 3; tertiary	0.76	0.75	1.68	1.69
Household size	Individuals present	4.84	4.66	4.6052	4.03
Age of the household head	Age in years	49.98	46.18	44.10	42.39
Years lived by household head in an area	Experience in years	46.71	43.43	27.44	31.01
Income per adult equivalent/month	Kshs/Year	808	1345.0	1198.0	1422.00
On-farm income	Kshs/Year	75 879.31	59 552.50	32 402.40	35 191.80
Off-farm income	Kshs/Year	26 839.48	22 461.88	41 770.00	22 696.92
Expenditure on food items	Kshs/Year	64 780.41	52 395.15	55 597.96	20 620.50
Expenditure on non-food items	Kshs/Year	16 188.22	11 748.10	14 416.04	6450.96
Herd size	Tropical livestock unit	26.42	46.09	0.81	0.74
b. Farm characteristics					
Land size	Acres	187.84	228.03	24.20	15.44
Access to climate information	Access binary: 1; yes 0; no	0.00	0.00	0.76	0.89
Climate information sources	Category, 1–3	1.14	1.18	1.96	2.01

more than 450 mm of rainfall had income per adult equivalent per month of Kshs 1345. Similarly for Makueni County, those living in areas of <450 mm of rainfall and those in >450 mm of rainfall had income/adult equivalent/month of Kshs 1198 and Kshs 1422 respectively. Thus those living in areas with <450 mm of rainfall had lower total income per adult equivalent in both Kajiado and Makueni Counties.

The education levels were categorised into three: those with no formal education, those with at least primary education (1 to 8 years of formal schooling), those with secondary education (9–12 years of formal schooling) and those with tertiary education (12–20 years of formal schooling). The results showed that household heads from Kajiado

County had low levels of education with about 63.3% having no formal education as compared to 3% in Makueni County. In Kajiado County, approximately 62.9% who had no formal education were found in areas receiving less than 450 mm of rainfall. However, the situation was different in Makueni County, where all those who had no formal education were found in areas receiving more than 450 mm of rainfall and were immigrants who had been employed to take care of the farms for the absentee landlords who were either in Nairobi or Mombasa. This result concurs with that of Amwata (2004), who noted that agropastoral households in Kajiado District had more formal years of schooling than their transhumant households. The likely explanation is that pastoral households tend to concentrate more in the remote areas that have limited social facilities including schools and hospitals. Hence schools are few and long distances have influenced the households' school enrolment.

In terms of age, household heads were grouped into three, namely, those aged less than 30 years (young), those aged more than 30 to 50 years and those aged above 50 years (old). The young household heads aged 18–30 years were not found in areas receiving less than 450 mm of rainfall for both Kajiado and Makueni Counties. For Kajiado County, about 60.4% of those aged more than 50 years were found in areas receiving less than 450 mm of rainfall. In contrast, about 72.5% of those aged more than 50 years were found in areas receiving more than 450 mm of rainfall in Makueni County. The likely explanation is that most of the young, aged 18–30 are educated and dynamic and hence maximise opportunities by diversifying to other income generating activities. Similarly, the old household heads in Makueni County have accumulated many years of wisdom in farming and have developed coping strategies, which have made them survive in these areas, despite rainfall variability. In contrast, the old household heads in Kajiado County still have cultural ties to their livestock; thus they prefer to stay in remote and dry areas where there are large tracts of land for grazing.

Access to climate information is critical for climate variability and change adaptation. In this study, access to climate information was categorised into two: those with access to climate information and those without. The finding of this study shows that more households (86%) in Makueni County compared to Kajiado County (42.9%) had access to climate information. Nevertheless, about 67.9% of the households who had no access to climate information were found in areas of less than 450 mm of rainfall. The reverse was noted in Makueni where 77.9% of those who had access to climate information were found in areas with more than 450 mm of rainfall. Conversely, a great disparity was noted in the source of climate information for the households in Kajiado and Makueni Counties. In Kajiado County, 82.7% relied on traditional sources while in Makueni County 92% relied on conventional sources of climate information. The traditional sources of climate information included observations by local weather men, signs associated to animals, birds and physiological development of plants. The conventional sources included meteorological stations, radio, television and audio visuals. The most common reason cited by those who did not access climate information was unavailability of a radio in their household or in the neighbourhood coupled with their households' locations.

4.2 Simultaneous Equation Model Analysis

4.2.1 Test for identification

Table 2 presents the results of the analysis of order condition of identifiability of the SEM. The results show that the equations were either exactly identified or overidentified. Therefore,

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Table 2. Order condition of identifiability

Equation	No. of exogenous variables excluded (K-k)	No. of endogenous variables included less 1 (m-1)	Decision on identification
2.5	2	2	Exactly identified
2.6	2	1	Overidentified
2.7	3	2	Overidentified
2.8	5	1	Overidentified
2.9	2	2	Exactly identified
2.10	2	1	Overidentified
2.11	2	1	Overidentified
2.12	5	1	Overidentified

it was appropriate to use 2SLS to estimate parameters in the model. However, as pointed out earlier, the order condition is not a sufficient condition for identification.

The equations used in the model are:

$$FS_{kj} = \alpha_0 + \alpha_{11}Sh + \alpha_{12}Ls + \alpha_{13}Hs + \lambda_1 Ge + \lambda_2 Rl + \lambda_3 Ci + \lambda_4 Ag + \mu_1 \tag{2.5}$$

$$Ls_{kj} = \alpha_1 + \alpha_{21}FS + \alpha_{22}Hs + \lambda_{11}Ge + \lambda_{12}Rl + \lambda_{13}Ed + \lambda_{14}Ag + \mu_2 \tag{2.6}$$

$$Sh_{kj} = \alpha_2 + \alpha_{31}FS + \alpha_{32}Ls + \lambda_{21}Ge + \lambda_{22}Rl + \lambda_{23}Ed + \mu_3 \tag{2.7}$$

$$Hs_{kj} = \alpha_3 + \alpha_{41}FS + \alpha_{12}Ls + \alpha_{13}Ed + \mu_4 \tag{2.8}$$

$$FS_{mk} = \beta_0 + \beta_{11}Sh + \beta_{12}Ls + \beta_{13}Hs + \varphi_1 Ge + \varphi_2 Rl + \varphi_3 Ed + \varphi_4 Ci + \mu_1 \tag{2.9}$$

$$Ls_{mk} = \beta_1 + \beta_{21}Fs + \beta_{22}Hs + \varphi_{11}Ge + \varphi_{12}Rl + \varphi_{13}Ed + \varphi_{14}Ag + \mu_2 \tag{2.10}$$

$$Sh_{mk} = \beta_2 + \beta_{31}Fs + \beta_{32}Ls + \varphi_{21}Ge + \varphi_{22}Rl + \varphi_{23}Ed + \varphi_{24}Ex + \mu_3 \tag{2.11}$$

$$Hs_{mk} = \beta_3 + \beta_4 Fs + \varphi_{41}Ls + \varphi_{42}Ed + \mu_4 \tag{2.12}$$

where FS_{kj} and FS_{mk} stand for vulnerability to food insecurity in Kajiado and Makueni Counties, respectively. Sh is the size of the herd, Ls is land size, Ed is education of head of the household, Ci is access to climate information, Cs is source of climate information, Hs is household size, Ge is gender of head of household, Ex is years of experience in an area and Rl is rainfall levels. α_0, α_1, α_2, β_0, β_1, β_2 and β_3 are constants, αs and βs are coefficients of endogenous variables, λ's and φ's are coefficients of predictors and instrumental variables, ∞ and φ are coefficients of instrumental variables and μs are error terms.

It is not obvious to determine the variables, which were endogenous in the model. Therefore a Hausman test was conducted to test if the endogenous variables (size of the herd (Sh), land size (Ls) and household size (Hs)) were truly endogenous. In Makueni County, the results showed that at 5% level of significance, the coefficients for land size and household size were statistically significant, indicating the presence of simultaneity problem. This implies that the hypothesis that they are equal to zero is rejected; therefore, the coefficients for these residuals are not statistically equal to zero. Similarly, the simultaneity test for Kajiado County showed that at 5% level of significance, the coefficient of the residual for household size was statistically significant, indicating the presence of simultaneity problem. In addition, endogeneity test showed that a hypothesis that coefficients of the estimated endogenous variables were equal to zero was rejected; thus the variables were truly endogenous.

DOI: 10.1002/jid

4.2.2 SEM results for Makueni and Kajiado Counties

Before regressing the independent variables in the SEM model, a correlation analysis was conducted to help choose among the variables that were highly correlated. Thus, only uncorrelated variables were included in the model. The results are based on the objective addressing the determining factors of household vulnerability to food insecurity (Table 3).

Household size had a positive and significant influence in Makueni ($p \leq 0.05$). This result indicates that large households are likely to be food secure in an agropastoral system such as Makueni County mainly because of their large labour force required in the farms. Makueni County is predominantly an agricultural community where large households provide more labour to ensure timely management of crop production, thus increasing farm productivity, and consequently food security. By contrast, Kajiado County is more oriented to pastoralism with extensive livestock production being practised, and is thus less labour intensive. One person can therefore herd a large number of livestock; hence large households have a high number of individuals who contribute to consumption rather than resource production. This finding is consistent with findings from other studies (Reardon and Vosti, 1995), which show that large households lower the risks of poverty because of the availability of labour. In support, Amwata (2004) noted that an increase in household size leads to increased food security for both agropastoral and transhumant households. Further, Kigutha *et al*. (1994) and Kavishe and Mushi (1993) noted that large households with low dependency ratio favour resource contribution to the household because there is more food available for household consumption. However, other studies have reported the reverse, that smaller household sizes lead to higher household food security because the households have less people to feed (Nyariki *et al*., 2002; Tasokwa, 2011). The current findings imply that larger households are less vulnerable to food insecurity. However, this argument only holds if those particular households have a dependency ratio of less than 70.8 per cent.

In this study, household dependency ratio was computed by dividing the total number of individuals in the *de facto* population (total number of individuals aged less than 15 and above 64 years) divided by the number of individuals in the productive age (those between

Table 3. SEM regression results for Makueni and Kajiado Counties

	Makueni County		Kajiado County	
Variables	Coefficient	t-value	Coefficient	t-value
Constant	—	−2.512**	—	−1.753*
Land size	0.339	2.605**	0.071	0.797
Household size	0.426	3.235**	0.234	1.180
Gender of the household head	−0.078	−0.625	0.225	2.492**
Rainfall levels	0.320	2.487**	—	—
TLU per adult equivalent	−0.241	−1.809*	−0.152	−1.756*
Education of the household head	−0.049	−0.361	0.050	0.489
Age of the household head	0.204	1.630	—	—
Household access to climate information	−0.084	−0.691	0.348	2.993**
Experience in the area	0.183	1.363	0.030	0.174
Source of climate information	—	—	−0.015	−0.139
Off-farm income	—	—	0.522	5.871**

**Significant at $p \leq 0.05$.
*Significant at $p \leq 0.10$; adjusted $R_{MC}^2 = 0.336$, $F_{MC} = 3.702$ ($p \leq 0.05$); Adjusted $R_{KC}^2 = 0.354$, $F_{KC} = 6.908$ ($p \leq 0.05$).

DOI: 10.1002/jid

15 and 64 years of age) expressed in adult equivalents. However, for Makueni County, the average dependency ratio was 78.5 per cent, a figure lower than the national dependency ratio of 81 per cent as per World Bank Report (2001). For Kajiado County, the dependency ratio was 82.6 per cent, a figure higher than the national value. Households that had a dependency ratio of over 85 per cent were food insecure irrespective of their household sizes in both counties.

Land size had a positive and significant ($p \leq 0.05$) influence on household food security in Makueni County. This implies that households with larger land holdings were more likely to be food secure because of more farm production assuming all other factors remain constant. The direct relationship between land size and food security is consistent with previous studies (Amwata, 2004; Pankomera *et al*., 2009; Tasokwa, 2011). However, a study by Matchaya (2007) has reported an inverse relationship between farm size and agricultural production in Malawi. He noted his finding to be unusual but argued that the outcome may have been caused by use of total farm output than crop yield. Tasokwa (2011) further explains that there is more to land than size. From her study in Malawi, there are sub-factors that influence the size of land owned by a household, which include gender, age of the household head, social networks, marital status and culture and traditions.

Herd size presented in tropical livestock units (TLU) per adult equivalent had a negative and significant ($p \leq 0.05$) influence on household food security status of both Makueni and Kajiado Counties. This implies that households with larger herds of livestock are more likely to be food insecure. The likely explanation was that in both agropastoral and pastoral areas, grazing resources have diminished because of rapid expansion of both human population and agricultural land, thus resulting in losses in livestock.

Rainfall had a positive and significant ($p \leq 0.05$) influence on household food security in Makueni County. Areas receiving more rainfall tend to have high crop and forage production. According to Hesselberg and Yaro (2006), Assan *et al*. (2009) and Tasokwa (2011), climatic variability, especially rainfall fluctuations, is a major constraint to agricultural livelihoods.

Household access to climate information had a positive and significant ($p \leq 0.05$) influence on household vulnerability to food insecurity in Kajiado County. Access to climate information enables rural households to plan their land-use activities, especially when to move with their livestock depending on the weather conditions for each year. Thus, households with access to climate information are likely to plan their land-use activities such as where to graze livestock, when to plant and type of crops to plant. In support, Ziervogel (2004) and Tasokwa (2011) reported a similar finding among small-holder farmers in Lesotho and Malawi, respectively.

Gender of the household head had a positive and significant ($p \leq 0.05$) influence on household vulnerability to food insecurity in Kajiado County, where female headed households were more food secure than their male counterparts. This finding supports previous studies such as Kennedy and Haddad (1994), Carter (1997) and Nyariki *et al*. (2002) in which women were found to be more food secure because they prioritise their income on food for their families than men. In contrast, Tasokwa (2011) reported that female-headed households were more food insecure in Malawi because of cultural beliefs that limit female access to food production resources such as land and inputs.

Off-farm income had a positive and significant ($p \leq 0.05$) influence on household vulnerability to food insecurity in Kajiado County. Therefore, households without off-farm income were more likely to be food insecure. Off-farm employment is a source of income that can be used to purchase food, although the money raised from it may have other

DOI: 10.1002/jid

priorities. Similar findings have also been reported by Reardon (1997), Ellis (2000) and Bryceson (2004). Moreover, Barrett *et al*. (2001) underscore the positive relationship among off-farm diversification, income and wealth in rural Africa. They state that these three interactions offer an opportunity out of poverty in the continent. Further, they expound that livelihood diversification, involving off-farm activities, has over the years become an important poverty reduction and income generating strategy for peasants and rural small farm households especially in vulnerable and marginal environments throughout the developing world.

5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In the drylands of Kenya, both farm and household factors jointly influence household food security. For both counties, households that had small herd sizes were likely to be more food secure. The probable explanation is that reduced land sizes can only productively support small herd sizes, as more of the grazing land has been converted to non-grazing uses. For Makueni County, determinants of household vulnerability to food insecurity were land size, household size and rainfall levels. Thus, households in high rainfall areas with large tracks of land and large household sizes were less vulnerable to food insecurity. On the other hand, gender of the household head, access to climate information and off-farm employment determined household vulnerability to food insecurity in Kajiado County. This implies that households with access to climate information, more off-farm income, and female as heads were more food secure.

Policy interventions in the ASALs need to emphasise holistic and a ‘systems’ development interventions in the drylands. For instance, in Makueni County, a predominantly agropastoral area, initiatives on food security should focus on promoting access to land resources and diversification of livelihoods as a means of destocking large livestock herds. Similarly, innovative programmes that have potential to improve the micro-climate such as agroforestry, especially multipurpose trees and shrubs, should be promoted so as to attract more rains as well as provide ecosystem services. Even though household size has shown a positive influence on food security, studies have shown that this is applicable if the dependency ratio is below 70.5 per cent, where members of the household contribute to resource generation. According to Kigutha *et al*. (1994) and Kavishe and Mushi (1993), a large household size favours resource contribution to the household. As such, there is more food available for household consumption and, consequently, an improvement in the nutritional status of the household members. They further argued that in cases where the dependency ratio is high, the number of consumers of the available resources in the household is more than the number of contributors; hence, less is available to share among them, negatively affecting their nutritional well-being.

Although these results are specific and relevant for Makueni and Kajiado Counties, these findings can be used as a case study for other areas with similar conditions and culture. In conclusion, diversification into off-farm sources, improved breeding programmes, strengthening of extension services, agroforestry and re-afforestation programmes, education and awareness on minimising dependency and women empowerment are key to minimising household vulnerability to food insecurity in the drylands of Kenya.

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5.2 Recommendations

From this study, interventions to reduce household vulnerability to food insecurity in the study area are categorised into three: general recommendations and those specific to Kajiado and Makueni Counties. For both counties, strengthening extension services is critical to enable households acquire skills on better livestock management practices, enhancing their access to climate information for land-use planning and promoting breed improvement programmes to upgrade the local breeds for drought tolerance and increased production and partnerships and collaboration among actors to generate demand driven agro-climate advisories. In Kajiado County, central focus should be on women empowerment in order to increase their access to and control over production resources through formation of women groups that provide a forum for sharing ideas, teamwork, and strengthening micro-finance trusts. Second, is the establishment of alternative livelihood sources that are compatible with transhumance such as creation of micro-industries for hides and skins, milk processing plants to provide ready market to avoid exploitation by middlemen. These industries will create job opportunities, thereby minimising rural–urban migration in the county. In Makueni County, focus should be on agroforestry and tree planting programmes to help conserve soil and water while providing multiple benefits such as creation of micro-climate and attracting rains. Further, there is need to promote family planning programmes for the households to ensure low household dependency ratio and to facilitate access to land resources and inputs for improved land production.

REFERENCES

Amaza P, Abdoulaye T, Kwaghe P, Tegbaru A. 2009. *Changes in Household Food Security and Poverty Status in PROSAB Area of Southern Borno State, Nigeria*. International Institute of Tropical Agriculture (IITA): Ibadan, Nigeria.

Amwata DA. 2004. Effects of Communal and Individual Land Tenure Systems on Land-use and Food Security in Kajiado District, Kenya. MSc Thesis, University of Nairobi, Kenya.

Assan J, Caminade C, Obeng F. 2009. Environmental Variability and Vulnerable Livelihoods: Minimising Risks and Optimising Opportunities for Poverty Alleviation. *Journal of International Development* **21**(3): 403–418.

Barrett CB, Reardon T, Webb, P. 2001. Non-Farm Income Diversification and Household Livelihood Strategies in Rural Africa: Concepts, Dynamics, and Policy Implications. *Food Policy* **26**(4): 315–331.

Bartfeld JS, Hong-Min A. 2011. The School Breakfast Programme Strengthens Household Food Security Among low Income Households With Elementary School Children. *Journal of Nutrition* **141**(3): 470–475.

Bryceson DF. 2004. Agrarian Vista or Vortex: African Rural Livelihood Policies. *Review of African Political Economy* **102**: 617–629.

Carter I. 1997. Rural Women and Food Insecurity. *Footsteps* 32.

Central Bureau of Statistics (CBS). 1981. *The 1979 Population Census. Ministry of Finance and Planning*. Government Printer: Nairobi, Kenya.

CBS. 2009. *The 2009 Population Census*. Government Printer: Nairobi, Kenya.

Ellis F. 2000. *Rural Livelihoods and Diversity in Developing Countries*. Oxford University Press: Oxford, UK.

DOI: 10.1002/jid

Food and Agriculture Organization (FAO). 2005. *Committee on World Food Security: Conflict and Food Security*. Food and Agricultural Organisation: Nairobi.

FAO. 2002. *The State of Food Insecurity in the World 2001*. FAO: Rome, Italy.

Fraser, EDG, Dougill AJ, Hubacek K, Quinn CH, Sendzimir J, Termansen M. 2011. Assessing Vulnerability to Climate Change in Dryland Livelihood Systems: Conceptual Challenges and Interdisciplinary Solutions. *Ecology and Society* **16**(3): 3.

Ganapathy S, Duffy SB, Getz C. 2005. *A Framework for Understanding Food Insecurity: An Anti-Hunger Approach, a Food Systems Approach*. The Centre for Weight, Health, College of Natural Resources, University of California: USA.

Gujarati DN, Sangeetha S. 2007. *Basic Econometrics*, *4th edition*. McGraw-Hill: New York, USA.

Hesselberg J, Yaro JA. 2006. An Assessment of the Extent and Causes of Food Insecurity in Northern Ghana Using a Livelihood Vulnerability Framework. *Springer Geojournal* **67**: 41–55.

Joseph K. 2004. *Towards Achieving Food Security in Kenya*. Ministry of Agriculture: Nairobi, Kenya.

Kaluski DN, Ophir E, Amede T. 2001. Food Security: The Ethiopia Case for Action. *Public Health Nutrtion* **5**(3): 373–381.

Kavishe FP, Mushi SS. 1993. *Nutrition-Relevant Actions in Tanzania. UN ACC/SCN Country Case Study for the XV Congress of International Union of the Nutritional Sciences*. UNICEF: Tanzania.

Kennedy E, Haddad L. 1994. Are Pre-Schoolers from Female Headed Households Less Malnourished? A Comparative Analysis of Results from Ghana and Kenya. *Journal of Development Studies* **30**(3): 680–695.

Kenya National Bureau of Statistics. 2007. *Basic Report on Well-being Based on the Kenya Integrated Household Budget Survey-2005/06*. Government Printer: Nairobi, Kenya.

Kigutha HN. 1994. *Household Food Security and Nutrition Status of Vulnerable Groups in Kenya: A Seasonal Study Among Low Income Small-Holder Rural Households*. PhD Thesis, Wageningen University: The Netherlands.

Kigutha HN, Van Stareven WA, Veerman W, Haustvast J. 1994. *Child Malnutrition in Poor Small-Holder Household in Rural Kenya: An In-Depth Situation Analysis: In Household Food Security and Nutritional Status of Vulnerable Groups of Kenya*. PhD Thesis, University of Wageningen: The Netherlands.

Kinyua J. 2004. *Towards Achieving Food Security in Kenya*. Ministry of Agriculture: Nairobi, Kenya.

Kristjanson P, Radeny M, Nkedianye D, Kruska R, Reid R, Gichohi H, Atieno F, Sanford R. 2002. Valuing Alternative Land-use Options in the Kitengela Wildlife Dispersal Area of Kenya. *ILRI Impact Assessment Series* 10. A joint International Livestock Research Institute/African Conservation Centre Report. ILRI, Nairobi, Kenya.61 pp.

Matchaya G. 2007. Does Size of Operated Area Matter? Evidence from Malawi's Agricultural Production. *International Journal of Agriculture and Rural Development* **10**(2): 114–125.

Ngugi KN, Nyariki DM. 2005. Rural Livelihoods in the Arid and Semi-Arid Environments of Kenya. *Agriculture and Human Values* **22**: 65–71.

Nyariki DM, Wiggins S. 1997. Household Food Insecurity in sub-Saharan Africa: Lessons from Kenya. *British Food Journal* **99**(7): 249–262.

Nyariki DM, Wiggins S. 1999. Livestock as Capital and a Tool for *Ex-Ante* and *Ex-Post* Management of Food Insecurity in Semi-Traditional Agropastoral Societies: An Example from Southeast Kenya. *Social Sciences* **3**(3): 117–126.

Nyariki DM, Wiggins SL, Imungi JK. 2002. Levels and Causes of Household Food and Nutrition Insecurity in Dryland Kenya. *Ecology of Food and Nutrition* **41**(2): 155–167.

Odhiambo MO. 2013. Releasing our Full Potential: The ASAL Policy, its Promise and Challenges. A briefing note for members of County Assemblies, Community Representatives, Leaders, CSO and ASAL stakeholders. http://www.disasterriskreduction.net/fileadmin/user (accessed 2 April 2015).

DOI: 10.1002/jid

Oni SA, Maliwichi LL, Obadire OS. 2010. Socio-Economic Factors Affecting Small-Holder Farming and Household Food Security: Case of Thulemela Local Municipality of Vhembe County of Limpopo Province, South Africa.

Pankomera P, Houssou N, Zeller M. 2009. Household Food Security in Malawi: Measurements, Determinants and Policy Review. Conference on international research on food security, natural resource management and rural development, University of Hamburg, Tropentag, October 6–8, 2009, Hamburg.

Power E, Sheeshka JD, Hero AL. 1998. Canadian Dieticians Understanding of Food Security. *Journal of Nutrition Education* **30**(1): 45–49.

Reardon T. 1997. Using Evidence of Household Income Diversification to Inform Study of the Rural Non-Farm Labour Market in Africa. *World Development* **25**(5): 735–748.

Reardon T, Vosti SA. 1995.Links Between Rural Poverty and Environment in Developing Countries. Asset Categories and Investment Poverty. *World Development* **23**(9): 1495–1506.

Republic of Kenya (ROK). 2000a. *Second Report on Poverty in Kenya. Welfare Indicator. A Report Prepared by Central Bureau of Statistics and Human Resources and Social Services Department*. Government Printer: Nairobi, Kenya.

ROK. 2000b. *The 1999 Population and Housing Census. Central Bureau of Statistics*. Government Printer: Nairobi, Kenya.

ROK. 2009. *Food Security in Kenya*. Ministry of Agriculture: Nairobi, Kenya.

ROK. 2010. *The Republic of Kenya Agricultural Sector Development Strategy 2010–2020*. Ministry of Agriculture: Nairobi, Kenya.

Sunya O. 2003. *Marketing of Sheep and Goats and its Role in Food Security Among Pastoral Communities in Marsabit District*. MSc Thesis, University of Nairobi: Kenya.

Tangka F, Jabbar MA, Shapiro BI. 2000. *Gender Roles and Child Nutrition in Livestock Production Systems in Developing Countries: Critical Review Paper Series 27*. ILRI: Nairobi, Kenya.

Tasokwa VMK. 2011. *The Impacts of Climate Variability and Extreme Weather Events on Gender and Household Vulnerability to Food Insecurity*. PhD Thesis, University of Nairobi: Kenya.

United States Department of Agriculture. 2009. *Food Security Analysis: Kenya*. Foreign Agricultural Services, Office of Global Analysis: Nairobi, Kenya.

Vogel RC, Adams DW. 1999. Old and new Paradigms in Development Finance Should Direct Credit be Resuscitated? Briefing Notes for Consulting Assistance on Economic Reform II. *Discussion Paper* No. 2.

WFP. 2009. *Food Security Network: Kenya Food Security Updates Network*. World Food Programme: Nairobi, Kenya.

Wolfe WS, Frongillo EA. 2001. Building Household Food Security Measurement Tools from the Ground up. *Food and Nutrition Bulletin*, 22(1), 2001. The United Nations University.

World Bank Report. 2001. The World Factbook. www.cia.gov (accessed 1 April 2015).

Ziervogel G. 2004. Targeting Seasonal Climate Forecasts for Integration into Household Level Decisions: The Case of Small-Holder Farmers in Lesotho. *The Geographical Journal* **170**: 6–21.

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