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Drought Tolerant Maize for Africa (DTMA) Project

Characterization of Maize Producing Households in Machakos and Makueni Districts in Kenya

Lutta Muhammad, Domisiano Mwabu, Richard Mulwa, Wilfred Mwangi, Augustine Langyintuo, and Roberto La Rovere

CIMMYT
International Maize and Wheat Improvement Center

KARI

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DTMA

The Drought Tolerant Maize for Africa (DTMA) Project is jointly implemented by CIMMYT and the IITA, and is funded by the Bill & Melinda Gates Foundation and the Howard G. Buffett Foundation. The project is part of a broad partnership, involving national agricultural research and extension systems, seed companies, non-governmental organizations (NGOs), community-based organizations (CBOs), and advanced research institutes, known as the Drought Tolerant Maize for Africa (DTMA) Initiative. Its activities build on longer-term support by other donors, including the Swiss Agency for Development and Cooperation (SDC), the German Federal Ministry for Economic Cooperation and Development (BMZ), the International Fund for Agricultural Development (IFAD), the United States Agency for International Development (USAID), and the Eiselen Foundation. The project aims to develop and disseminate drought tolerant, high-yielding, locally-adapted maize varieties and aims to reach 30–40 million people in sub-Saharan Africa with better technologies in 10 years.

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This report is presented without a thorough peer review with the main purpose of making data and information rapidly available to research teams and partners in the Drought Tolerant Maize for Africa (DTMA) project and for use in developing future, peer-reviewed publications. Readers are invited to send comments directly to the corresponding author(s). The views expressed in this report are those of the authors and do not necessarily reflect opinions of CIMMYT, KARI, other partners, or donors.

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Drought Tolerant Maize for Africa (DTMA) Project
Country Report – Household Survey

Characterization of Maize Producing Households in Machakos and Makueni Districts in Kenya

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DTMA Country Report - Kenya

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Acknowledgements

The Drought Tolerant Maize for Africa (DTMA) initiative aims to address the challenge of combating the impacts of drought on people's livelihoods, food security and economic development. It links the efforts of several organizations and projects supporting the development and dissemination of drought tolerant maize in 13 countries in sub-Saharan Africa (SSA). The initiative is supported by the Bill & Melinda Gates Foundation, Howard G. Buffett Foundation, and the United States Agency for International Development (USAID). DTMA also benefits from the long-term, generous support of core donors to CIMMYT. For further information about the initiative, refer to the project website (http://dtma.cimmyt.org).

Developing, distributing and cultivating drought tolerant maize varieties is a highly relevant intervention to improve food security, reduce vulnerability to climate change and dependence on food aid in SSA. However, for this to succeed, it needs to be grounded in the local reality based on good understanding of limiting biophysical and socioeconomic constraints and opportunities for change. Each of the participating countries was therefore supported to conduct a community assessment and household surveys in the target areas. This report presents the findings from initial analysis of household survey data which will serve as a baseline on production and economic conditions of smallholder maize farmers and presents the main characteristics of farm households and production systems in the Machakos and Makueni districts of Kenya.

This country study received financial support from the DTMA project. During the course of the study, the authors benefitted from constructive contributions and comments from Girma Tesfahun Kassie and Olaf Erenstein, among others. We also acknowledge the logistical and technical support of Kenya Agricultural Research Institute (KARI). The authors are responsible for any remaining errors and inferences.

Acronyms and abbreviations

ABC	African Brotherhood Church
AEZ	Agro-ecological zone
AFC	Agricultural Finance Corporation
AGRA	Alliance for a Green Revolution in Africa
BMZ	German Federal Ministry for Economic Cooperation and Development
CBO	Community-based organization
CAN	calcium, ammonium, nitrate (fertilizer)
CIMMYT	International Maize and Wheat Improvement Center
CRS	Catholic Relief Services
DTMA	Drought Tolerant Maize for Africa project
FSA	Farmers' Savings Association
GDP	Gross domestic product
HH	Household head
HYV	High yielding variety
ICRC	International Committee of the Red Cross
IFAD	International Fund for Agricultural Development
IITA	International Institute of Tropical Agriculture
KARI	Kenya Agricultural Research Institute
KFA	Kenya Farmers' Association
KSC	Kenya Seed Company
masl	meters above sea level
MEU	Man equivalent unit
NGO	Non-governmental organization
NPK	nitrogen, phosphorus, potassium (fertilizer)
OPV	Open-pollinated variety
PCA	Principal components analysis
PE	poorly endowed
PFS	Probability of failed season
SDC	Swiss Agency for Development and Cooperation
SSA	sub-Saharan Africa
WE	well endowed
WFP	World Food Program

1 Introduction

Kenya has an estimated population of 33 million persons on a land surface of 0.6 million km^2. The country has five main ecological regions: a narrow, humid to sub-humid coastal strip; bush-covered plains in the interior; high-lying scrublands in the northwest; fertile grasslands and highland forests in the south-west; and the Great Rift Valley in the west, where some of the country's highest mountains, including Mount Kenya (5,199 meters above sea level) are situated, as well as Lake Turkana. Except for the temperate highlands, the climate is hot and dry. Coffee, tea, petroleum products, cereals, fresh vegetables, fruits, and flowers are the chief exports. Large numbers of cattle are pastured in the grasslands. The expanding commercial industry includes oil refining, food processing, and the manufacture of consumer goods, cement, and textiles. Agriculture, dominated by smallholder farming, directly contributes 26–27% of Kenya's gross domestic product (GDP). The range of agricultural commodities includes cereals and pulse crops, horticulture and floriculture, roots and tuber crops, industrial crops, dairy production and ranching. The staple commodities are maize and sorghum (cereals), beans, cowpeas and pigeon peas (pulses), potatoes and cassava, meat, milk and an assortment of fruit and vegetable. The main tenets of the agricultural policy are food security, income generation, employment creation and poverty alleviation. While maize is the most important agricultural commodity, production often falls below requirements due to drought, necessitating massive imports (Muhammad et al. 2009).

This country study is part of the Drought Tolerant Maize for Africa (DTMA) project. It presents the findings of the household survey, which serves as a baseline and characterizes the maize producing households in the Machakos and Makueni districts of Kenya. The two districts are part of the project's medium drought risk zone (20–40% PFS) target area. The study complements an earlier community assessment in the same area (Muhammad et al. 2009).

The survey collected baseline data on farm households to construct indicators for measuring changes in the adoption of improved maize varieties and for assessing impact on adopting households. The main objective of the study was to understand the potential use of the drought tolerant maize (DTM) technology by farmers, provide information for policy makers, and serve as a baseline for measuring impacts of the project.

Specific objectives of the household survey were:

1. To identify farmer perceptions of and preferences for maize variety attributes;
2. To identify factors that influence the adoption of improved maize varieties;
3. To characterize maize production systems and gender mainstreaming; and
4. To assess farmers' perceptions of risks and shocks, and their coping strategies.

2 Materials and methods

2.1 Sampling and data collection

Actual site selection was guided by three main criteria: significance of maize production; prevalence of large numbers of poor people; and a high frequency of drought. The areas selected needed to offer opportunities for drought tolerant varieties to increase returns to farmers' investment, and to present incentives for the seed sector to sell seeds. These were defined as locations where probability of failed seasons falls within the 20–40% range. Two districts (Machakos and Makueni) were first identified, and within them, several locations were selected (Figure 1).

The first phase of the survey entailed familiarization with the study area; construction of the sampling frame; identification and training of five enumerators; and consultation with farmers, extension service personnel, provincial administrators, and other local leaders. These activities were undertaken concurrently with the pre-testing of the questionnaire. The development of the sampling frame involved the researchers, local leaders, farmers, and enumerators. A random sample of 175 rural households was taken in each district, for a total of 350 households.

Administration of the 350 questionnaires in Machakos and Makueni districts began at the end of May 2007 and concluded in mid-August 2007. The questionnaires were then taken to Nairobi and subjected to completeness and consistency checks. The data were subsequently entered into an electronic medium for further cleaning and analysis.

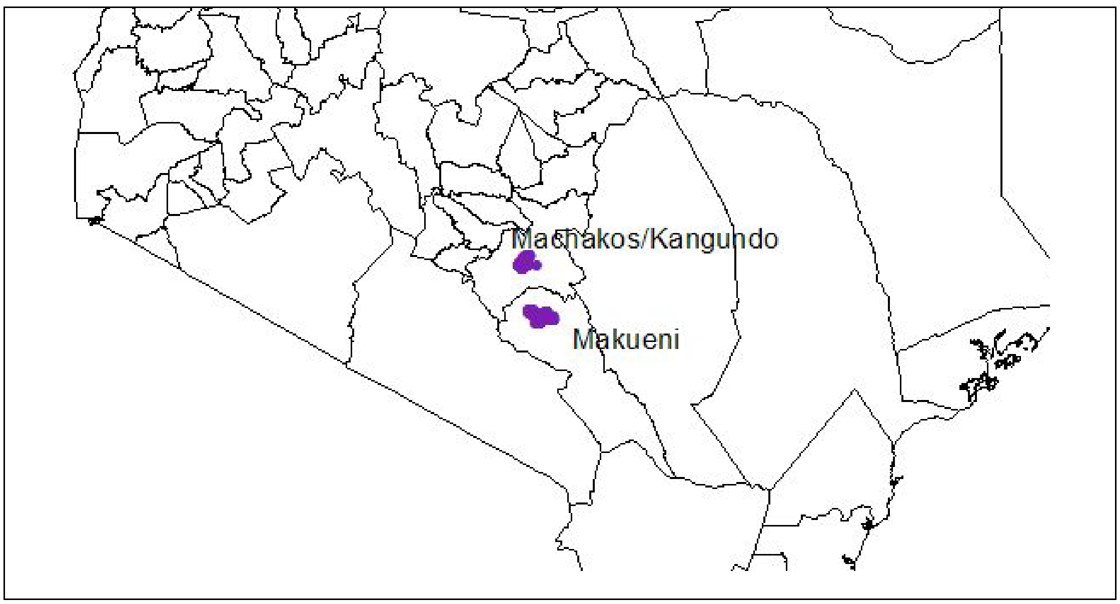


Figure 1. Location of survey districts in Kenya.

2.2 Characterization of survey locations

There are five major agro-ecological zones (AEZs) in which maize accounts for between 5–80% of cropped acreage in Kenya (Hassan 1998, Figure 2). The AEZ targeted by this study is the dry transitional (DT) zone, which is drought prone. The DT zone accounts for 20% and 11% of national maize acreage and average annual production, respectively. The zone is characterized by low yields ranging from 300–1,200kg/ha, well below the national average estimated at 1,600 kg/ha.

Machakos District stretches from latitudes 0º45´S to 1º31´S from north to south and from longitudes 36º45´E and 37º45´E from east to west. It has a total area of 6,281 km^2 and 906,644 persons (GoK 2001). Makueni District stretches from latitude 1º35´S to 3º01´S from north to south and from longitudes 37º10´E and 38º30´E from east to west. It extends over an area of 7,965.8 km^2, and had 771,545 persons according to the population census conducted in 1999 (GoK 2001).

In Kangundo constituency in Machakos District, where the survey locations were selected, 54–64% of the residents were living below the poverty line while in Kaiti constituency in Makueni, 64–74% of the residents were classified as living below the poverty line, according to the Ministry of Planning and National Development (CBS 2005). Out of 210 constituencies in Kenya, Makueni and Kaiti constituencies were ranked 124th and 175th respectively (on a scale of poorest = 210 and the least poor = 1).

The center of Machakos and the north of Makueni mainly consist of hills and small plateaus rising between 1,800–2,100 meters above sea level (masl). The mean elevation is however 1,357 masl in Machakos and 1,047 masl in Makueni. This undulating pene-plain is broken by isolated hill masses like Oldonyo Sabuk in the northwest, the volcanic out-flow of the Yatta Plateau in the east and Chyulu Hills in the southeast. Athi River (and its main tributaries, i.e., Kambu, Kiboko and Mtito Andei) forms the major drainage system for the two districts.

Rainfall distribution in the two districts is bimodal and is received in the short rainy season (October/November–January/February) and the long rainy season (March–August/September). Mean rainfall for each of the two seasons ranges from 200 to 350 mm (half of the annual precipitation), depending on altitude and other factors. The mean monthly temperature varies between 18°C and 25°C; the hottest months being February and October, and the coolest being July (Jaetzold et al. 2006; Jones 1988; Corbett 1998).

The area where the two districts are situated supports a wide range of agricultural activities. Rainfed, integrated crop and livestock production dominate land use and household livelihoods, especially in the small-scale semi-subsistence sector. Table 1 represents a summary of agro-ecological conditions of the area. A more complete account can be found in sources such as Jaetzold et al. (2006) and Hassan (1998).

Table 1. Selected survey districts and agro-ecological characteristics.

Description	Highlands	Mid-Alt moist	Mid-Alt	Dry transitional	Dry	Lowland
Elevation (m)	>1,800	1,400–1,800	1,400–1,800	1,200–1,600	900–1,800	<900
Annual rainfall (mm)	>1,800	1,000–1,800	800–1,200	<800	400–800	400–1,400
Season length (days)	180	170	120	100	90	120
Maize area ('000 ha)	307	461	118	118	118	33
Production (%)	35	20	20	10	10	5
Potential yield (t/ha)	6.7	5.2	5.2	4.5	2.7	3.3
Farmer yield (t/ha)	2.0	0.7	1.1	1.1	0.5	1.0

Source: Jaetzold et al. (2006).

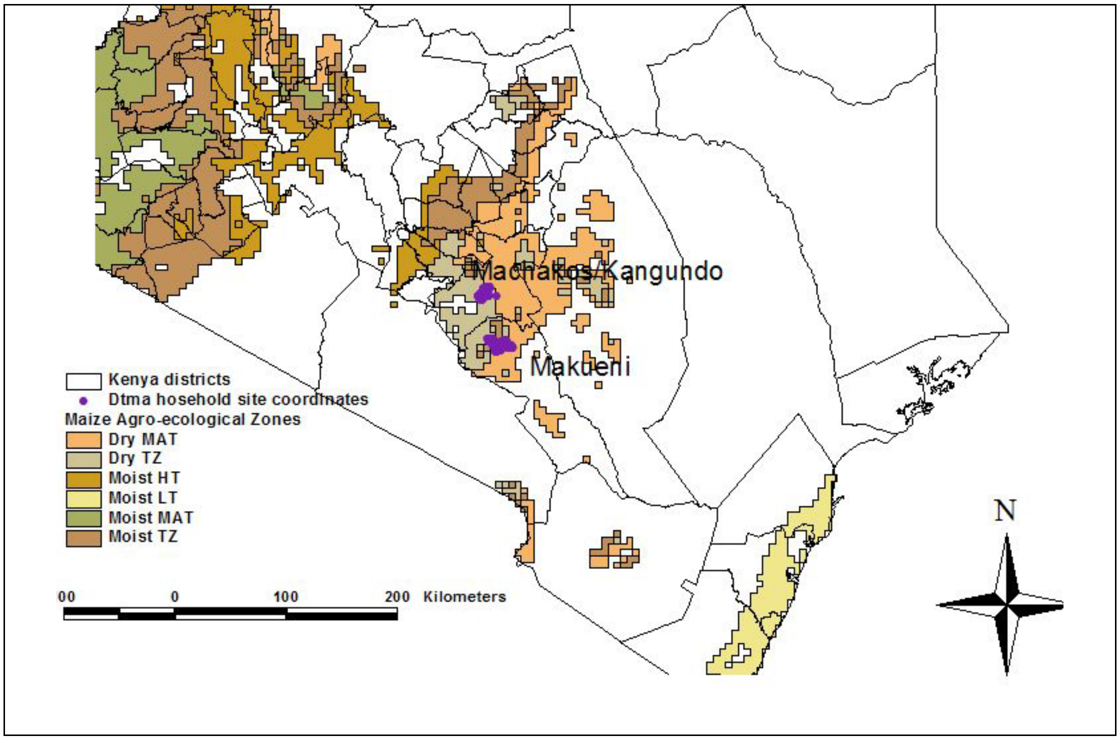


Figure 2. Maize agro-ecological zones in Kenya.

Source: Hassan 1998.

3 Household characteristics

3.1 Categorizing household access to capital assets

To pursue livelihood strategies, households need human, natural, physical, financial, and social capital. Human capital considers only households' access to labor. Natural capital assets consider total household farm land as well as land under cultivation. Various durable assets that households own are discussed under physical assets while credit facilities are discussed under financial assets. Social capital concerns households' access to the social support system (or social networks) (Langyintuo 2005).

Drawing heavily on Langyintuo (2008) and Langyintuo and Mungoma (2008), this section discusses households' access to capital assets after normalizing their resource endowments and computing wealth indices using principal components analysis (PCA). The levels of endowment of these assets vary tremendously between households, making it difficult to compare or rank households when necessary. It is therefore important to find a common denominator that would be used in ranking or comparing households' assets of different types e.g., crop acreage and household labor. Following Filmer and Pritchett (2001), Langyintuo (2008), and Langyintuo and Mungoma (2008), one possible approach in normalizing assets for ease of comparison and ranking households is to use their resources to construct indices scaled from 0 to 1 as follows:

$$\mathbf{i} = \frac{x_{level} - x_{\min}}{x_{\max} - x_{\min}} \qquad (1)$$

where **i** is the index, x_{level} is the value of the asset under consideration, while x_{min} and x_{max} are the minimum and maximum values of the asset, respectively taken from the actual data collected. Once scaled (or normalized), the indicators can be added together. The challenge, however, is in identifying the relevant weights to give to each indicator. The assets considered for analysis are categorized in Table 2. After normalization of the 16 assets, this study used PCA to estimate the weights of the different assets, and thereafter, the overall wealth index.

Table 2. Capital assets available in households.

Capital category	Capital asset
Natural capital	1. Total farm size
	2. Cultivated farm size
Physical capital	3. Total tropical livestock units[1]
	4. Own motor vehicle
	5. Own bicycle
	6. Own ox-plough
	7. Own scotch cart
	8. Own wheelbarrow
	9. Own television
	10. Own radio
	11. Own water tank
	12. Own mobile phone
Human capital	13. Household labor capacity[2]
Social capital	14. Membership to an
association	
Financial capital	15. Benefit from aid projects
	16. Access to credit

Note: [1] Livestock are measured in Tropical Livestock Units (TLU). A TLU is an animal unit that represents an animal of 250 kg live weight, and used to aggregate different species and classes of livestock as follows: Bullock: 1.25; cattle: 1.0; goat, sheep, and pig: 0.1; guinea fowl, chicken, and duck: 0.04; and turkey: 0.05 (Runge-Metzger 1988).

[2] This is estimated using Man Equivalent Units (MEUs) after Runge-Metzger (1988) as follows: household members less than 9 years = 0; 9 to 15 years or above 49 years = 0.7; and 16 to 49 = 1.

Computing wealth index using principal components analysis

PCA aims at extracting from a set of *v* variables a reduced set of *m* components or factors that accounts for most of the variance in the *v* variables. The objective is to reduce a set of *v* variables to a set of *m* underlying superordinate dimensions (Wuensh 2006). Each factor is estimated as a weighted sum of the *v* variables. The *i*-th factor is thus:

$$F_i = w_{i1}x_1 + w_{i2}x_2 +,...,+ w_{iv}x_v \qquad (2)$$

where, *w* are the weights and *x* are the variables. To better understand the concept, consider N households each owning a non-negative vector of assets $\mathbf{a} = (a_1,...,a_K)$. The procedure of PCA begins with a set of K-variables, $(a_i^1,...,a_i^K)$ representing the ownership of K-assets by the *i*-th household. This is represented by binary scale: (1 if true and 0 otherwise). Each variable, a_i^1, is specified by its mean and standard deviation, i.e.,

$$\frac{a_i^1 - a_m^1}{s^1} \qquad (3)$$

where, a_m^1 is the mean of a_i^1 across all N households and s^1 is the standard deviation. The selected variables are linked with latent components (factors) for each of the *i*-th household through the equation:

$$
\begin{aligned}
a_i^1 &= v_{11}A_{1i} + v_{12}A_{2i} +,...,+ v_{1K}A_{ki} \qquad & i = 1,..., N \quad (Households)\\
&... & (4)\\
a_i^N &= v_{N1}A_{1i} + v_{N2}A_{2i} +,...,+ v_{KK}A_{Ki} \qquad & k = 1,..., K \quad (assets)
\end{aligned}
$$

where, the *A*s are the components and the *v*s the coefficients on each component for each variable and these are constant across all households. Note that it is only the left hand-side which is observed, making the solution to the problem indeterminate. The PCA solves this by determining specific linear combinations of the variables with maximum variance accounted for in the first principal component A_{1i} (Lawley and Maxwell 1971). The procedure is repeated for each successive component accounting for the maximum of variance remaining. Technically the procedure solves the equations $(\mathbf{A} - \lambda\mathbf{I})\mathbf{x}_n = 0$ for λ_n and $\mathbf{x}_n$, where **A** is the matrix of correlations between the scaled variables (the *a*'s) and $\mathbf{x}_n$ is an unknown column vector of coefficients on the *n*-th component for each variable. Solving the equation yields the eigenvalues (or characteristic roots) of **A**, λn and their associated eigenvectors, $\mathbf{x}_n$ (Johnston 1984). The final set of estimates is produced by scaling the $\mathbf{x}_n$s so the sum of their squares sums to the total variance.

Reversing equation *(4)* yields factor loading ('scoring factors') from the model that are estimates for each of the K-principal components:

$$
\begin{aligned}
A_{1i} &= f_{11}a_i^1 + f_{12}a_i^2 +,...,+ f_{1K}a_i^K \qquad & i = 1,..., N\\
&... & (5)\\
A_{Ki} &= f_{K1}a_i^1 + f_{k2}a_i^2 +,...,+ f_{KK}a_i^N &
\end{aligned}
$$

where, A_{1i} is the first principal component, a_i^1 is the normalized variable, f_{1i} is the factor score coefficient (weight) by which the normalized variable is multiplied to obtain a factor score in the linear combination. Thus, the asset index for each household is based on the expression:

$$
A_{1i} = f_{11}\frac{a_i^1 - a_m^1}{s^1} +,...,+ f_{1N}\frac{a_i^N - a_m^N}{s^N} \qquad (6)
$$

Estimating household wealth index

The assigned weights are then used to construct an overall 'wealth index,' applying the following formula:

$$
\mathbf{w}_i = \sum_{j=1}^{k}[b_i(a_{ji} - x_i)]/s_i \qquad (7)
$$

where, $\mathbf{w}_i$ is a standardized wealth index for the *i*-th household; $\mathbf{b}_i$ represents the weights (scores) assigned to the (*k*) variables on the first principal component; $\mathbf{a}_{ji}$ is the value of the *k* variables for each household; $\mathbf{x}_i$ is the mean of each of the *k* variables; and $\mathbf{s}_i$ the standard deviations. A negative index (-$\mathbf{w}_i$) means that, relative to the communities' measure of wealth, the household is poorly endowed, while a positive figure (wi) signifies that the household is well-off. A zero value, which is also the sample mean index, implies the household is neither well-off nor worse-off (Langyintuo and Mungoma 2008; Filmer and Pritchett 2001).

Note that the sum of the v eigenvalues will be equal to $\sum v$, the number of variables (Table 3). The proportion of variance accounted for by one component equals its eigenvalue divided by *v*. Each component is a linear combination of the *v* variables. The first component accounts for the largest possible amount of variance (26%). The second component, formed from the variance remaining after that associated with the first component has been extracted, accounts for the second largest amount of variance (10%). The principal components are extracted with the restriction that they are orthogonal. Geometrically they may be viewed as dimensions in *v*-dimensional space where each dimension is perpendicular to each other dimension.

Table 3. Total variance explained using PCA.

Component		Initial eigenvalues*	
	Total	% of variance	Cumulative %
1	4.15636	25.97726	25.97726
2	1.56990	9.81190	35.78916
3	1.24447	7.77794	43.56710
4	1.17847	7.36545	50.93256
5	1.14036	7.12727	58.05983
6	1.08519	6.78241	64.84224
7	0.91198	5.69988	70.54212
8	0.81698	5.10613	75.64825
9	0.78648	4.91553	80.56378
10	0.74436	4.65226	85.21604
11	0.65484	4.09277	89.30881
12	0.57338	3.58363	92.89244
13	0.43487	2.71794	95.61038
14	0.36873	2.30457	97.91495
15	0.27341	1.70883	99.62378
16	0.06020	0.37622	100
Sum	16	100	—

Note: * Each **eigenvalue** represents the amount of variance that has been captured by one component. Each standardized variable contributes at least the variance of 1 to the principal components extraction. The Kaiser criterion states that we retain only components with eigenvalues of one or more. That is, drop any component that accounts for less variance than does a single variable.

Source: Survey data, 2007.

From Table 4, the assets with the largest impact factors are ownership of a scotch cart, an ox-plough, a wheelbarrow, motor vehicle, and a bicycle. After estimating the wealth index for each household (**w**i), the households were sorted based on the wealth scores. These scores ranged from -4.1362 to 8.7273 (mean = -1.6324, sd = 0.8236).

Figure 3 illustrates the ranked distribution of households according to the wealth indices. The households were then grouped into "well endowed" (WE) and "poorly endowed" (PE) if they fell above or below the mean score of zero, respectively. The mean score for WE households was 0.50343 (-0.47155 for PE households). The poorly endowed households in the region constitute 68.3% of the sample. This estimate is close to a study by Mwabu et al. (2002) which estimated poverty in the region at 70.3%.

Table 4. Total variance explained using PCA.

Capital asset	Mean	Standard deviation	Score	Impact factor*
Natural Capital				
Total farm size	1.51	6.2500	0.2030	0.0325
Cultivated farm size	1.12	3.4080	0.1832	0.0537
Physical Capital				
Bicycle	1.2283	0.8925	0.1861	0.2085
Ox-plough	1.0723	0.2989	0.1737	0.5813
Scotch cart	1.0480	0.2155	0.1624	0.7535
Wheelbarrow	1.2610	0.5648	0.1568	0.2777
Motor vehicle	1.3330	0.4924	0.1408	0.2859
Mobile phone	1.5400	0.9472	0.1022	0.1079
Water tank	1.3888	0.9984	0.0855	0.0856
Radio	1.3748	0.7216	0.0747	0.1035
Total TLU	4.6680	8.3198	-0.0135	-0.0016
Television	1.1010	0.3491	0.0218	0.0625
Human Capital				
Household labor capacity	4.1870	2.2411	0.0704	0.0314
Social Capital				
Association membership	0.3324	0.4717	0.0270	0.0573
Financial Capital				
Benefited from project	0.4864	0.0972	-0.0236	-0.2424
Access to credit	0.0141	0.1182	0.0022	0.0185

Note: * Impact factor is given by the ratio of the score to standard deviation.

Source: Survey data, 2007.

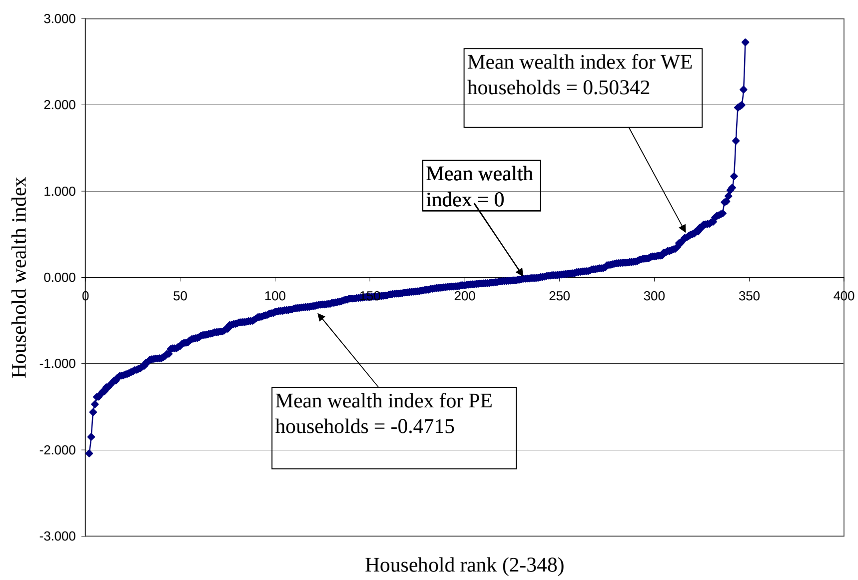


Figure 3. Distribution of households according to wealth groups.

The sample of 350 households comprised 14% female-headed and 86% male-headed households. The mean wealth indices for female and male headed households in the PE category were -0.468 and -0.472, respectively. The corresponding WE mean wealth indices for female and male headed households were 0.97 and 0.425, respectively. Figure 4 shows the cumulative probability distribution of the household wealth index.

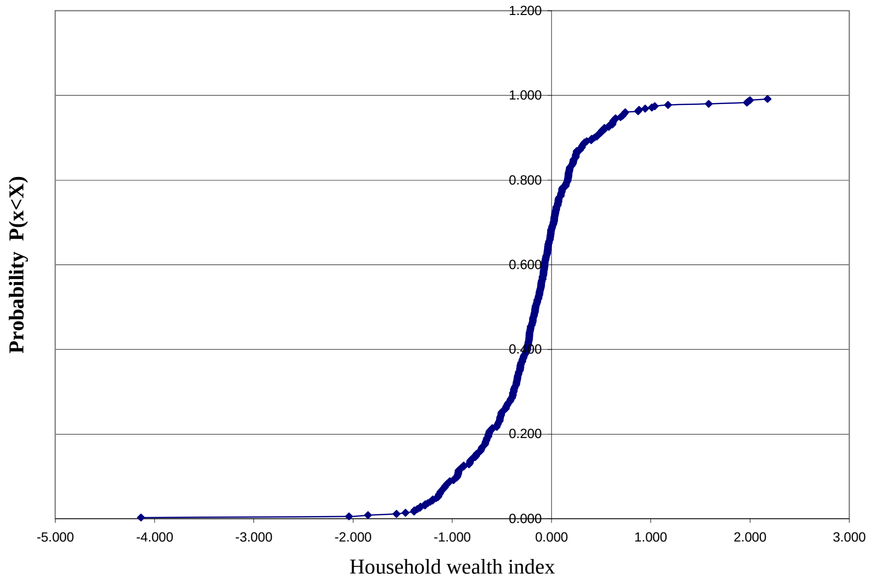


Figure 4. Cumulative probability distribution of households within wealth categories.

3.2 Human capital

Out of the 350 households, mean household size was 6.3 persons (minimum 2 and maximum 25 persons) with a standard deviation of 2.9. The average household was composed of one or more sub-categories of members as shown in Table 5. The composition of the household was dominated by the children/grandchildren category (mean: 3.7 children/grandchildren per household).

Table 5. Descriptive statistics of sample households: Composition and age of household head.

Wealth group	**Poorly endowed**		**Well endowed**		**Whole sample**
Gender household head	**Female**	**Male**	**Female**	**Male**	
Household heads/household (no)	1.00	1.00	1.00	1.00	1.00
Spouses/household (no)	0.09	1.07	0.13	1.08	0.94
Parents/household (no)	0.03	0.11	0.00	0.22	0.13
Children/household (no)	3.53	3.64	3.81	3.75	3.67
Nephews/household (no)	0.19	0.11	0.06	0.23	0.15
In-laws/household (no)	0.47	0.09	0.06	0.12	0.13
Siblings/household (no)	0.09	0.07	0.00	0.17	0.09
Other relatives/household (no)	0.06	0.15	0.06	0.19	0.15
Workers/household (no)	0.03	0.09	0.00	0.08	0.08
Household size (no)	5.50	6.32	5.13	6.84	6.33
Man Eq. Units/household (no)	3.57	4.25	4.03	4.47	4.24
Males/household (no)	2.31	3.34	1.94	3.54	3.24
Females/household (no)	3.13	2.91	2.94	3.31	3.04
Age of household	27.01	27.88	33.59	29.21	28.43

Source: Survey data, 2007.

The mean age of 28 years may convey a deceptive impression of relatively youthful households. In fact, the age of members ranged between 3 and 83 years (Table 5). A household had on average 3.5 and 1.3 persons with primary and secondary school education, respectively. There were on average 0.6 illiterate persons per household. Members of households spent between 4 and 12 months at home (mean = 11 months). The most commonly reported non-farm occupation was 'farm laborer.' This was mainly an occupation for male heads of household, especially those in the poorly endowed category (Table 6).

Table 6. Household educational attainment and types of non-farm occupation.

Wealth group	**Poorly endowed**		**Well endowed**		**Whole sample**
Gender household head	**Female**	**Male**	**Female**	**Male**	
Educational attainment[*]					
Illiteracy	0.66	0.54	0.81	0.72	0.61
Scant literacy	0.44	0.48	0.13	0.54	0.47
Primary education	3.19	3.62	2.00	3.66	3.52
Secondary education	0.91	1.33	1.56	1.49	1.35
Post sec. education	0.31	0.32	0.56	0.24	0.31
Adult education	0.00	0.02	0.06	0.11	0.05
Non-farm occupation					
Artisans	0.25	0.34	0.13	0.34	0.32
Teachers	0.13	0.08	0.44	0.09	0.10
Farm labor	1.81	2.14	1.75	2.29	2.13
Nursing	0.00	0.00	0.00	0.03	0.01
Other	0.34	0.19	0.44	0.25	0.23

*Mean number of household members attained education level or engaged in occupation.
Source: Survey data, 2007.

Human capital includes availability of household labor, level of education, attendance at agricultural training events, etc. However, here we focus on the potential availability of household labor expressed in man equivalent units (MEUs) as explained earlier. The concept of MEU takes into account the ages of the different household members and their potential contribution toward the household labor pool. For instance, a 9 year old child is not expected to contribute an equal amount of labor as a 30 year old person. Therefore, individuals in different age brackets are assigned different weights between 0 and 1. The MEU in the overall sample ranged from 1 to 16.5 with a mean of 4.1. The dependency ratio[1] is an indicator of the number of household members to be looked after. The mean dependency ratio in the sample was 1.26.

Table 7 illustrates the different categories of MEUs in our Machakos and Makueni samples. The mean MEUs in Makueni for male- and female-headed households were not statistically different at a 95% confidence interval.

1 Dependency ratio is the ratio of (household members under 16 years plus household members above 60 years) to (household members between 16 and 60 years).

Table 7. Household labor availability by gender of household head.

Labor category	Machakos		Makueni		Overall sample	
	Male (n=154)	Female (n=21)	Male (n=150)	Female (n=25)	Male (n=304)	Female (n=46)
2 or less	35	4	22	5	57	9
2.1-4	57	10	48	9	105	19
4.1-6	40	5	46	7	86	12
6.1-8	16	2	22	3	38	5
8.1-10	3	-	8	1	11	1
>10	3	-	4	-	7	-
Mean MEU	3.92	3.66	4.52	3.98	4.22	3.83

Source: Survey data, 2007.

3.3 Natural capital

In Machakos and Makueni districts, land was owned either by a family, by the farmer, or was rented. In the sample, 94.4% had personal land, 3.4% had family land 2.3% had rented land. Acreage per households ranged from 0.1 ha to 31 ha. On average, 1 ha of land supported up to 7.5 people in the two districts. The main types of land use were field crops, trees, and natural pasture. There was also land allocated for homesteads and other non-farm purposes. The field crops portion was dominated by maize. The distribution of farm acreage among land use types by gender and by wealth group is shown in Table 8 and Table 9, respectively.

Table 10 shows farm size distribution by district and gender of household head. Farmers with less than 1.22 ha constituted over 63% of the whole sample. However, the proportion of female-headed households is higher for farmers in this category.

Determinants of cultivated farm size

As indicated earlier, farmers have slightly over 85% of their farms under crops—with Machakos having 88% and Makueni 83%. Apart from crops, the farmers plant trees, pasture and fodder, and in some cases, abandon the plots or put land under fallow. Farmers consider an array of factors before committing their land to an enterprise. The farmers were therefore requested to rank three most important factors they would consider before putting their land under crops. Thirty-one percent of the farmers consider their food needs before they put their land under crops, 22% consider the seed availability, while 15% consider the availability of family labor and cash (Table 11).

Table 8. Land use by households (mean ha/household).

Wealth group	Poorly endowed		Well endowed	
Gender HH head	Female	Male	Female	Male
Field crops	0.96	1.30	1.10	1.21
Trees	0.10	0.34	0.17	0.15
Natural pasture	0.00	0.06	0.06	0.04
Total farm acreage	1.06	1.70	1.33	1.41

Source: Survey data, 2007.

Table 9. Land and maize area by wealth group and gender.

Indicator	Whole sample	Wealth group Well endowed	 Poorly endowed	Gender Male HH	 Female HH
Cultivated land area (ha)	1.01	1.05	1.01	1.05	0.85
Cultivated maize area (ha)	0.49	0.61	0.45	0.53	0.32

Source: Survey data, 2007.

Table 10. Access to farm land by districts and gender (%).

Farm size range (ha)	Machakos Male (n=154)	 Female (n=21)	Makueni Male (n=150)	 Female (n=25)
0.4 or less	27	19	17	24
0.4 0.8	23	38	23	32
0.8-1.2	17	29	19	16
1.2-1.6	14	5	12	4
1.6-2.02	5	5	9	0
> 2.02	15	5	19	24

Source: Survey data, 2007.

Table 11. Determinants of cultivated farm size.

Category	Responses (%)
Food needs	30.8
Availability of seed	21.6
Expected family labor availability	15.4
Cash availability to purchase other inputs	15.2
Expected grain price after harvest	7.9
Cash availability to hire labor	6.9
Other	2.2
Total	100.0

Source: Survey data, 2007.

Dynamics of cultivated farm size

Information on changes in crop acreage and reasons for this change over time is important for the design of interventions. Over 58% of the respondents in the overall sample indicated that their farm sizes were unchanged, 18% had increased the share of their farm sizes, while 23% had reduced farm sizes (Figure 5). The respondents were asked to indicate factors that determine how large farm size should be. Their answers included seed quantity, changes in land size, labor availability, and rainfall among others.

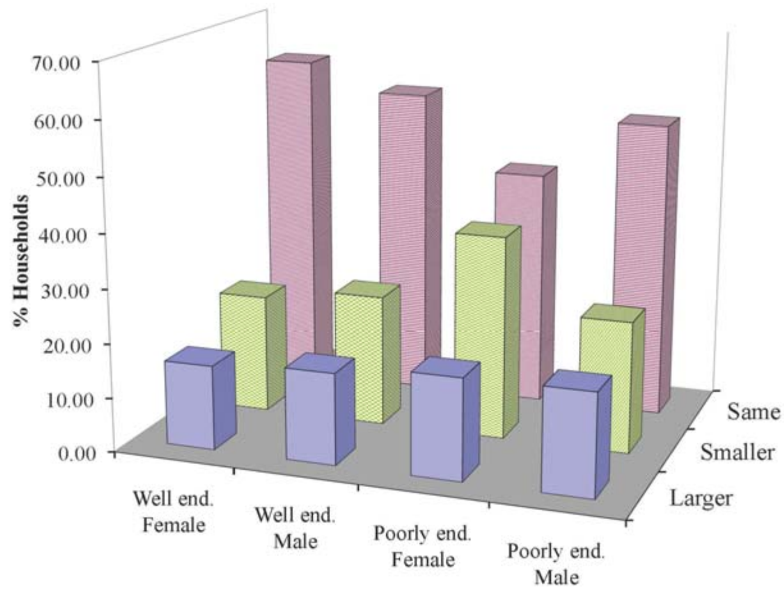


Figure 5. Dynamics of farm size.

Source: Survey data, 2007.

3.4 Physical capital

In the study area, the most prevalent type of dwelling was block houses with asbestos or iron roofing, as found in 88% of households (Table 12). This type of dwelling indicates a fairly high standard of housing.

Table 12. Type of dwelling used by households.

Dwelling type	Machakos	Makueni	Whole sample
Block house with asbestos/iron	97	79	88
Mud hut with asbestos/iron	1	9	5
Mud hut with grass thatch	1	7	4
Brick house with grass thatch	1	3	2
Mud hut with iron roof		1	1
Total	100	100	100

Note: Figures given refer to % households owning, n=350.

Source: Survey data, 2007.

In any given community, each household may own a variety of assets. Such assets often facilitate farming activities and crop production. Adoption of improved farming technology tends to be correlated with household asset endowment. Thus, some studies (e.g., Meinzen-Dick et al. 2004), suggest that where households are poorly endowed with assets, technologies with low investment requirements should be recommended. Table 13 presents the distribution of ownership of assets and inventory changes through purchases by households during 2005–06 in the study area. No significant level of sale of assets itemized in Table 13 took place. The most common assets owned were a radio, wheelbarrow, bicycle, and mobile phone. A few households sold assets such as a motorcycle, bicycle, draft animal, wheelbarrow, radio and water pump (Table 13).

Table 13. Distribution of assets by households in 2005–06.

Asset	% households owning assets during 2005–06			% households who bought assets during 2005–06		
	Poorly endowed	Well endowed	Whole sample	Poorly endowed	Well endowed	Whole sample
Radio	85	80	83	17	12	15
Wheelbarrow	44	50	45	7	2	5
Mobile phone	39	39	39	14	16	15
Bicycle	38	33	36	4	5	4
Animal plough	25	32	27	2	3	2
Draft animals	21	18	20	2	1	2
Television	18	23	20	2	3	2
Water tanks	16	14	15	1	3	1
Animal scotch cart	13	10	12	2	1	2
Private well	9	13	10	1	1	1
Other assets	14	20	16	6	5	5

Source: Survey data, 2007.

3.5 Financial capital

The majority of households (78%) reported that they experience difficulties due to shortages of cash needed for various purposes. This shortage is felt most acutely during the planting and weeding months of the first and second cropping seasons—in the October–December (38%) and January–March (24%) periods. These are also the months during which households need to purchase farm inputs such as seed and fertilizer. Household access to agricultural credit would help ease this cash constraint and stimulate adoption of improved seed. Only five (1%) of the 350 farmers received "in cash" or "in kind" credit in 2005–06 (Table 14). Among the five farmers who received credit, four were adopters of improved maize varieties. This finding is consistent with results of similar studies which suggest that adopters have more access to credit than non-adopters (e.g., Ouma et al. 2002). Out of the five households, two received "in cash" credit for production amounting to Kshs 17,500, at an interest rate of 6%, while one household received credit amounting to Kshs 1,500 at 34% interest, for consumption. The "in cash credit" was extended by financial institutions. One household received "in kind" credit in form of basal fertilizer worth Kshs 2,800 from a co-operative society.

Many households did not devote efforts into seeking credit (Table 15). Given the potential value of credit outlined in the foregoing paragraph, this may seem curious. However, high levels of production risk may explain a fair proportion of this. Lack of credit facilities within the vicinity and lack of collateral were the other factors accounting for the low proportion of farmers who accessed credit.

Table 14. Credit and association membership by wealth group and gender.

	Wealth group			Gender	
	Whole sample	Well endowed	Poorly endowed	Male HH	Female HH
Access to credit (%)	1.5	2.8	0.8	1.5	0
Membership to farmers' association (%)	33.3	31.2	33.8	33	31

Note: HH = household head

Source: Survey data, 2007.

Table 15. Barriers to access credit by households in 2005–06*

Why credit was not accessed	%
Did not look for credit	36
Lack of collateral	29
No source of credit in vicinity	27
High interest rate	4
Other	4

Note: * These figures are a percentage of the 334 households who recorded responses.

Source: Survey data, 2007.

3.6 Institutional and social capital

Institutions and social networks play important roles in the adoption of crop technologies, mainly through facilitation of financial transfers and information flows. Institutions and social networks often facilitate cooperation and this can help overcome externalities (Katungi 2006). Respondents were asked if the household belonged to an association (Table 14). Out of the 347 households who gave responses, 43% belonged to farmers' associations or cooperative societies. Among the households belonging to associations, 37% were adopters of improved maize varieties. There were no significant differences between belonging to farmers' associations and gender of household head (p=0.95%).

In the last two years, a number of households in the study area have benefited from governmental and non-governmental organizations' support programs. The main institutions were the Government Starter Pack, World Food Program (WFP), Save the Children (UK), Government Safety Net, and Chiefs' Office. On average, households benefited about twice from each institution (Table 16). The main support benefit was food relief.

Farmers' access to field days and demonstrations were limited in 2005–06. The number of times they attended agricultural demonstrations and field days held by various organizations were less than one for each service or organization. Maize production was rarely discussed in these fora, and where they were discussed, it was less than once for each service or organization. As Table 16 shows, agricultural extension featured as the most accessed service by farmers. In sub-Saharan Africa, structural adjustment programs reduced access to agricultural extension educators (Katungi 2006). In semi-arid eastern Kenya, farmers pay a facilitation fee to access the service (Bett et al. 2006). This makes the service even more inaccessible, especially to the poor farmers who need it most. Agricultural extension services in Kenya are mainly provided by the government and development agencies (Ouma et al. 2002).

Table 16. Main sources of institutional support to households (various kinds of assistance).

Institution	Food	Seed	Livestock breeding stock	Fertilizer	Other	% households receiving aid from institution
WFP	14.0					14.0
Government Starter Pack	9.4	0.3				9.7
Save Children International (UK)	6.6					6.6
Chief's Office	4.9					4.9
Others*	4.1		0.3	0.3	1.4	6.1
% households receiving aid	38.9	0.3	0.3	0.3	1.4	41.4
% households NOT receiving aid	61.1	99.7	99.7	99.7	98.6	58.6
Total	100	100	100	100	100	100

*Others include Catholic Relief Services (CRS), Action Aid, Self Help International, ICRC (Red Cross), Government Safety Net, African Brotherhood Church (ABC), World Vision, Heifer International and Care International.

Source: Survey data, 2007.

Field days and demonstrations are crucial to improving farmers' knowledge on technology that may be offered for adoption. Information is generally assumed to reduce the risk premium part of adoption costs (e.g., Zhao 2005). Visits by farmers to the extension officer and vice-versa exposes farmers to the new technologies. The interaction stimulates communication which leads to reduction in information imbalance associated with new technologies (Langyituo and Mungoma 2008). Table 17 shows four major sources of information for farming. The most frequently cited sources were other farmers, the radio, and extension services.

Table 17. Main sources of extension information.

Sources of extension messages	% households naming source
Other farmers	34.3
Radio	21.8
Agricultural extension staff (Ministry of Agriculture)	15.5
*Baraza** and posters	11.6
Others sources	16.7
Total	100

Note: * Public meetings organized by government officials at the community level.

Source: Survey data, 2007

Survey results showing participation in agricultural events such as field demonstrations and farmer field days by members of households are presented in Table 18. One-fifth of the households discussed maize production with the extension service, mainly, the Ministry of Agriculture. One-quarter of the households attended farmer field days while only 14% attended field demonstrations. The extension service of the Ministry of Agriculture (MoA) was the main organizer of the field days and demonstrations. It is important to note, however, that although the reported contribution of the 'other institutions' and 'Agricultural Development Agency' (Table 18) is low, this may be an understatement. The extension service of the Ministry of Agriculture in Kenya has the mandate to provide extension services. To support this mandate, it has an extensive network, qualified personnel, infrastructure as well as ready access to inter-departmental resources from other government departments. Due to challenges arising from inadequate resources to meet recurrent expenditure, however, the extension service tends to organize field days and demonstrations in co-operation, collaboration and, often, with the active participation of other institutions and agricultural development agencies.

Table 18. Participation in field days and demonstrations

Extension method	Institution	% households
Discussed maize crop production	% discussed with extension service	20.3
	- Agricultural Extension Agency (MoA)	11.4
	- Agricultural Development Agency	5.4
	- Other institutions	2.0
Demonstrations attended	% attended demonstrations	14.9
	- Agricultural Extension (MoA)	10.3
	- Other institutions	2.3
Field days	% attended field days	24.3
	- Agricultural Extension (MoA)	15.7
	- Other Agricultural Development Agency	6.6
	- Other institutions	2.0

Source: Survey data, 2007.

4 Household livelihood strategies

There are many dimensions to rural livelihoods. These may involve pursuit of recreation, provision of adequate shelter, transportation, water and sanitation, health care, maintenance of the productive capacity of the environment, and status in society. Typically, survival strategies for peasant households are characterized by diversity in the portfolio of livelihood options that sustain them. In areas of marginal agricultural potential where production risk is high, diversity and complexity in the household activity set are pronounced. A variety of crop, livestock and non-farm activities are undertaken in pursuit of various food and income goals. Farm activities are always supplemented by non-farm employment and trading. Understanding this complexity is key to designing and implementing interventions such as drought tolerant varieties aimed at improving the welfare of rural people.

The results of this survey indicate that crop and livestock production dominate the livelihoods of the households in the two districts. Crop production was the most important activity, providing employment, food, and catering to the financial needs of the household. Some cattle, sheep, goats, and chickens were kept but these were second in importance to crops. However, farm land was, as already noted, quite limiting. The mean farm size is only 1.46 ha, of which 85% is crop land. Other natural resource extraction based land uses such as grazing, wood fuel harvesting, charcoal and brick making, and quarrying are common. The farms' natural pasture areas also form the basis for the herbal medicine and ethno-veterinary industry in the area. The cropped portion of farm land supports production of maize, beans, cowpeas and pigeon peas (chiefly for subsistence), and napier grass, vegetables, trees, and in Machakos, coffee.

In addition to farming activities, the majority of households in the sample had at least one member engaged in non-farm cash earning activities. Popular non-farm occupations were petty trading, casual employment, and working as artisans, teachers and nurses. The major sources of income were crop and livestock sales, and remittances.

4.1 Crop production and marketing

The survey identified field crops, natural pasture, and tree crops as the main types of farm land use in the two districts. Overall, the acreage planted to field crops plus that occupied by other crops accounted for 61% of the total farm land in Machakos and 58% in Makueni. The survey identified 15 distinct crops in Machakos and 13 in Makueni with minor differences in the distribution of crops between the two districts. Maize was grown by virtually every household followed by beans, fruits and vegetables. There were also coffee, pigeon peas, and napier grass. Minor crops were cassava, cowpeas, sweet potatoes, sesame, and finger millet (Figure 6).

The land tenure system was predominantly personally-owned land (95% in Machakos and 92% in Makueni). Other land tenure categories were rented land (2%) and family land (5%). The majority of plots were within 15 to 22 minutes walking distance from the house in both districts. Only seven households rented land, paying between KShs 1,000 and 3,000 per year. Two households rented out land and rent paid annually was KShs 2,000 and 4,000.

Crop marketing decisions

There was significant buying and selling of maize and other farm produce during both seasons of 2005–06. Mean quantities produced, consumed, sold, donated or retained for seed as well as post-harvest losses are presented in Table 19. In Machakos, approximately one-third of the maize produced was sold. Note that proportionate amounts of grain legumes, namely, beans, cowpeas, and pigeon peas, which are traditionally jointly consumed with maize, were allocated for consumption. The situation in Makueni was broadly similar. Note also the position of cash vis-à-vis subsistence crops. Virtually all the coffee in Machakos, and bananas and vegetables in Makueni were sold. The figures reported for crop losses were low, compared to those established by previous studies (e.g., De Groote et al. 2002). Evidently, farmers did not suffer severe attacks by storage pests during 2005–06 seasons. High losses of stored produce to pests (up to 15–45%) have been reported (De Groote et al. 2002).

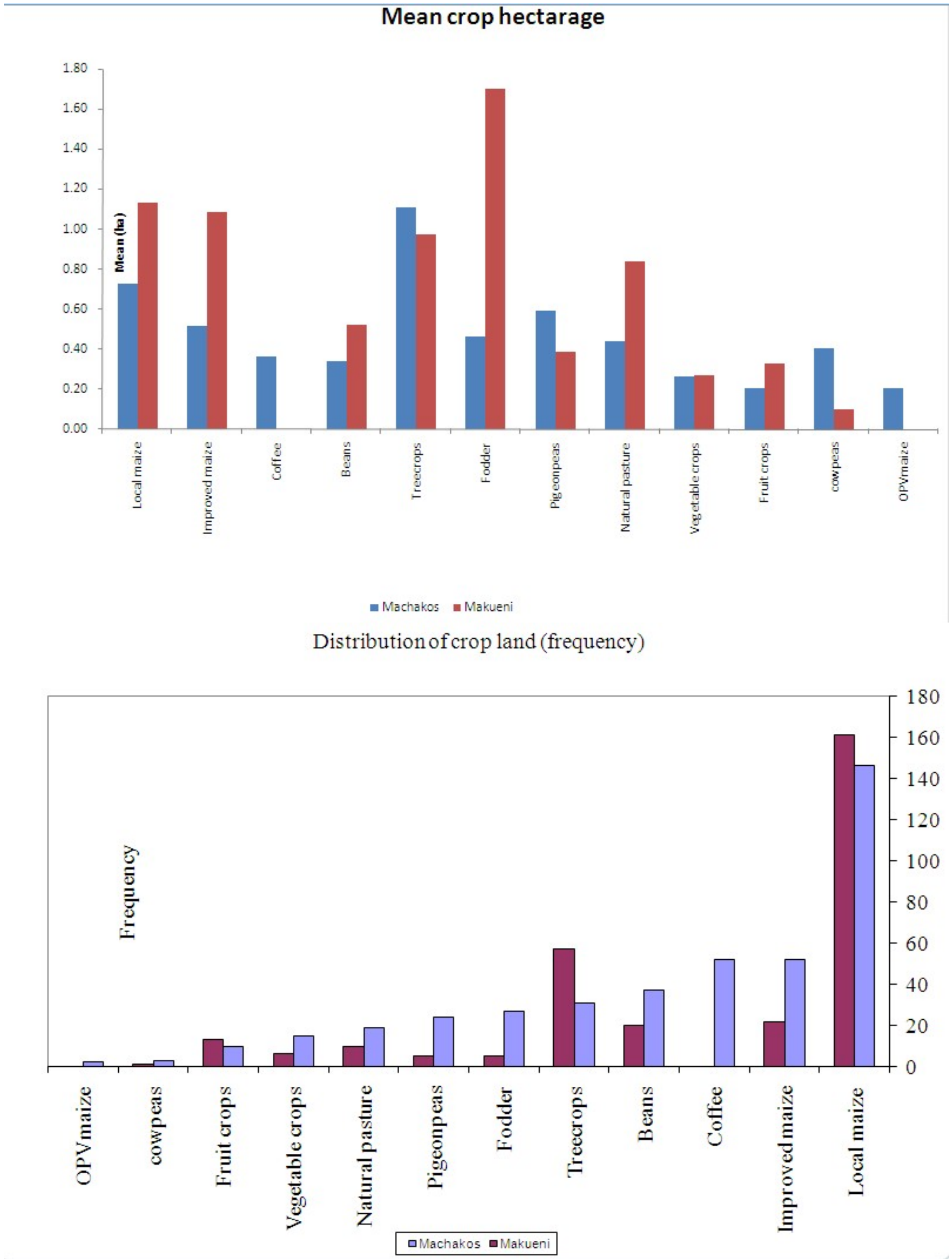


Figure 6. Distribution of land area in Machakos and Makueni districts.

Source: Survey data, 2007.

Table 19. Disposal of crop harvested during 2005–06 (kg).

	Harvested	Consumed	Sold	Given away	Saved seed	Loss	N
Machakos							
Maize	979	397	964	80	21	11	152
Pigeon peas	668	308	764	62	10	11	182
Beans	321	100	343	39	27	5	67
Coffee	290		290				2
Cassava	198	156	172	73			12
Sweet potato	78	68	137	45			4
Cowpeas	65	31	163	14	5	1	33
Vegetables	27	4	19	2		6	2
Sorghum	18	9	5		4		1
Makueni							
Banana	10,017	4	10,015				2
Maize	1,501	602	1,397	99	41	27	165
Vegetables	1,377	40	1,545	46		1	7
Cassava	1,277	103	1,261	27		10	15
Sweet potato	873	393	1,147				3
Pigeon peas	509	213	680	43	14	10	111
Beans	257	106	262	19	25	19	102
Cowpeas	66	58	47	9	4	3	57

Source: Survey data, 2007.

For households selling some maize, average quantities and prices were 1,470 kg and KShs 13/kg for Makueni. Average quantity of maize sold in Machakos was lower (1,222 kg) but the price was slightly higher (KShs 15/kg, see Table 20).

Table 20. Quantities and prices of produce 2005–06.

		Mean	Std. Dev
Makueni	Quantity of maize sold (kg)	1469	498
	Quantity of cereal (kg)	467	152
	Price of cereal in KShs/kg	1.3	30
	Price of maize in KShs/kg	12.9	0.5
Machakos	Quantity of maize sold (kg)	1222	157
	Quantity of cereal (kg)	484	100
	Price of cereal in KShs/kg	22.5	1.6
	Price of maize in KShs/kg	14.7	0.4

Source: Survey data, 2007.

In both districts, the main maize buyers in the market were traders (69%). Middlemen accounted for 20% in Machakos and 27% in Makueni. Other buyers were agents, millers, neighbors, and schools (Table 21). Maize price was mainly set following the sellers' general awareness of what buyers are willing to pay in the neighboring markets. About 10% of the respondents sold maize soon after harvest but the majority sold six months after harvesting. The farmers may have heeded the advice of the Provincial Administration, leading to delayed selling of maize. The administrators always advise farmers not to sell any of their produce before the potential of the following season has been assessed as average to good. This advice is intended to help households ensure that there will be some grain in store if the following season fails.

Table 21. Maize marketing characteristics 2005–06 (% of households).

	Machakos	Makueni
Buyer of maize	n=95	n=95
Established agent	1	2
Middlemen	20	27
Millers	1	1
Neighbors	2	n/a
Other trader	69	69
School	6	
How price was determined	n=155	n=168
Prices in neighboring market	18	19
Used cost of production	3	2
Prices announced on the radio	1	n/a
When maize is sold		
Six months after harvest	56	68
Soon after harvest	11	n/a

Source: Survey data, 2007.

The buying of other cereals was also dominated by traders (over 80% of all transactions) in both districts (Table 22). Almost one-third of the transactions took place at the farm gate. Middlemen accounted for 21% and 16% of all transactions in Machakos and Makueni, respectively. Most of the transactions involving selling of cereals other than maize took place six months after harvest (41% in Machakos and 50% in Makueni). One-quarter of the respondents sold soon after harvest, perhaps, to alleviate cash needs and avoid post-harvest losses. The remainder (34% for Machakos and 27% for Makueni) sold just before planting, probably aiming to take advantage of the high prices that are obtained at that time.

Table 22. Characteristics of the marketing of farm produce other than maize during 2005–06 (% of households).

	Machakos	Makueni
Buyer of other cereal grain	n=28	n=42
Middlemen	21	16
Other trader	79	84
Determinant of grain prices sold in 2005–06	n=101	n=85
Used cost of production	47.5	32.9
At home	50.5	64.7
Government	2.0	2.4
When cereal grain is sold	n=29	n=44
Just before planting	34	27
Six months after harvest	41	50
Soon after harvest	24	23
Where cereal is sold	n=29	n=45
At home	55	47
Market	45	53

Source: Survey data, 2007.

4.2 Livestock production and marketing

Livestock has always played an important role in the livelihoods of rural communities in the two districts. Livestock are fed with residues from the crop enterprises and they in turn produce organic fertilizer and draft power for use in crop production. In many communities, ownership of livestock is a recognized indicator of wealth. In areas of marginal agricultural potential, livestock plays additional functions of providing investment, employment, and risk reduction opportunities. These roles are likely to influence and be influenced by the rate and pattern of wealth accumulation for any given household. The patterns of mean livestock ownership by gender and by wealth category are reported in Figure 7. In terms of average numbers kept per household, the most important livestock were poultry, goats, local cattle, grade cattle, sheep, and donkeys.

Both male- and female-headed households from the well endowed group had more cattle per household than their poorly endowed counterparts. Female-headed households tended to have more goats than their male counterparts. Ownership of grade cattle was male dominated, and within the male-headed group, the well endowed households had twice as many grade cattle as their poorly endowed counterparts. Poorly endowed female-headed households had the highest average numbers of poultry per household. Female-headed households had the highest average number of sheep per household, followed by poorly endowed male-headed households.

There were no clear differences of gender or wealth group in the ownership of donkeys. The entire donkey population was in Makueni where, due to poor transport infrastructure, these animals are used for fetching water for both livestock and domestic use, and carrying farm produce and general trade goods.

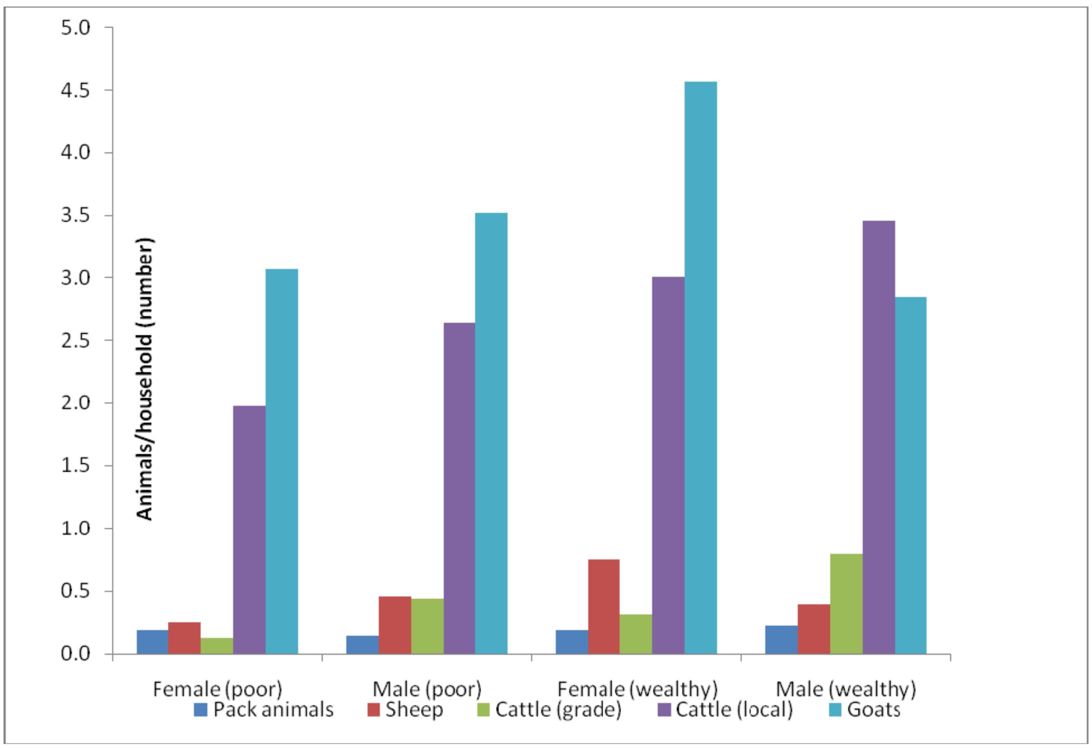


Figure 7. Distribution of mean livestock ownership by wealth group and by gender.
Source: Survey data, 2007.

4.3 Income and expenditure profiles of households

Besides agriculture, households engage in formal and informal income-generating activities such as formal sector employment, self-help group activities (e.g., merry-go-rounds), small-scale business ventures, etc. The combined incomes from these activities were more in Machakos District (average KShs 107,105 versus KShs 90,892 in Makueni).

Table 23 shows the income shares from various farm and off-farm activities. On average, income from agricultural activities (crop sales, livestock sales, and fruit sales) contributed 50% in both districts. Over 80% of the farm household heads had some non-farm occupation. Figure 8 shows that both men and women within the two wealth groups had non-farm occupations. The most frequently cited non-farm occupations were farm laborer, artisan, and petty trader. Other sources of off-farm incomes in both districts include remittances, formal employment, and self employment.

Figure 9 illustrates the relative importance of different income sources and expenditure by wealth category and gender. The well endowed had more income from employment, livestock, and crop than their poorly endowed counterparts while the reverse was true for income from petty trade. The poorly endowed spent more on food than the well endowed, and the reverse was true for expenditure on farm inputs and other non-food items. Within each district, male-headed households had higher income than female-headed households and they spent more on most items.

Table 23. Sources of household incomes (%).

Sources of income	Machakos	Makueni	Overall
Crop sales	18.7	18.5	18.6
Fruit sales	11.7	14.7	13.2
Coffee sales	6.4	0.2	3.1
Trees income	0.7	0.2	0.4
Land rates	0.3	0.0	0.2
Livestock sales	12.2	14.4	13.3
Milk sales	1.8	1.4	1.6
Petty trading	8.9	12.3	10.6
Formal employment	8.4	9.3	8.8
Self employment	7.4	5.2	6.3
Casual labor	2.1	3.9	3.1
Pension income	0.7	0.2	0.4
Merry-go-round	1.3	2.5	2.0
Remittances	18.1	14.8	16.4
Income from relatives	0.2	0.0	0.1
Rent income	0.3	0.2	0.2
Other income	1.0	2.5	1.8

Source: Survey data, 2007.

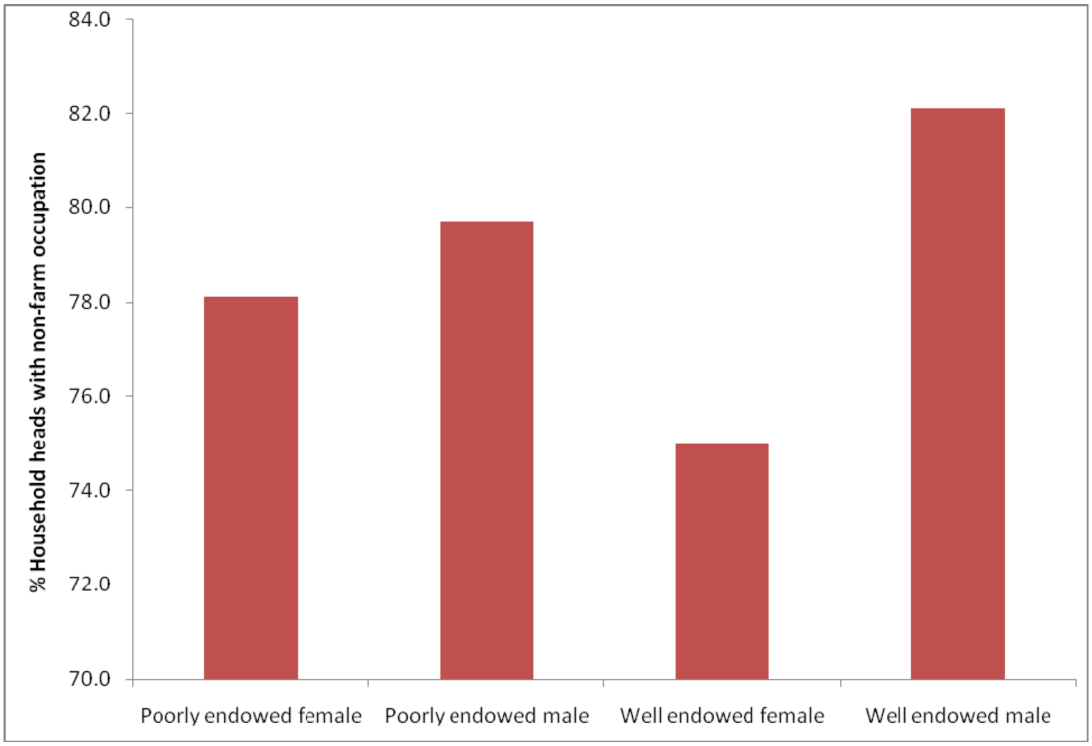
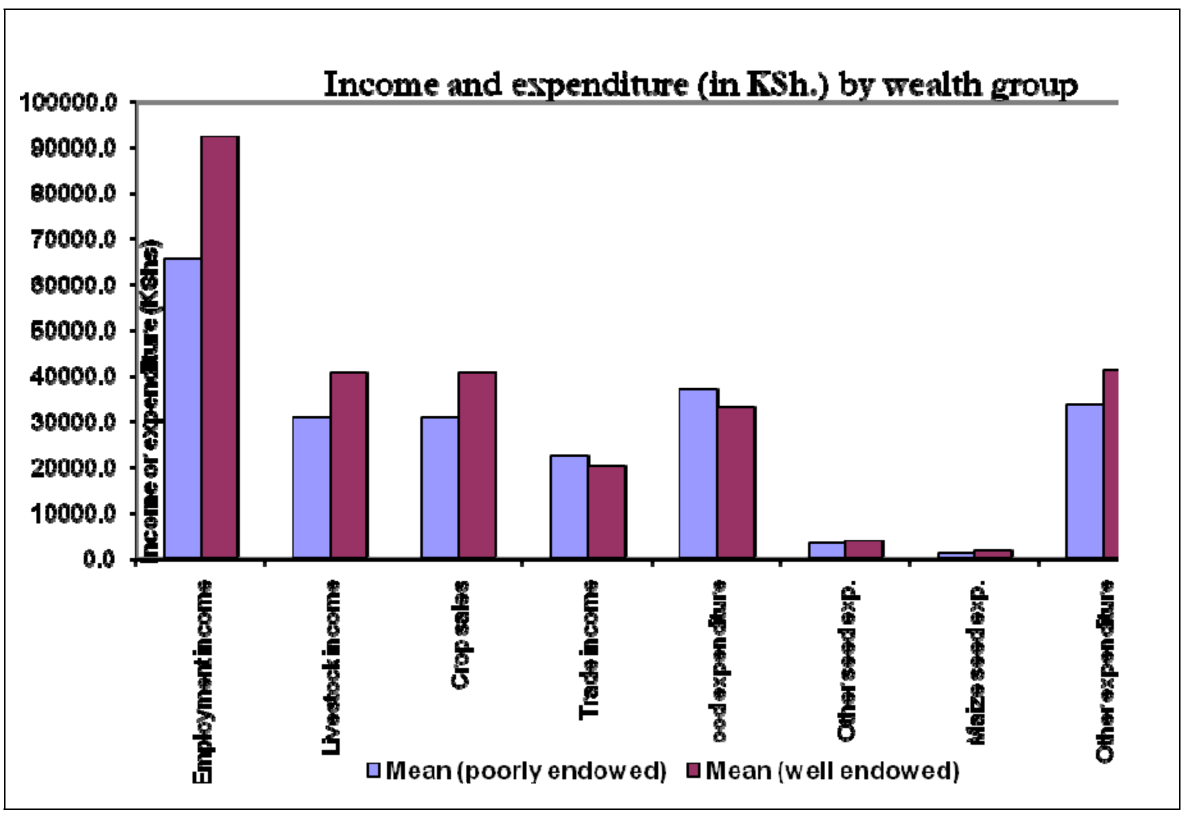


Figure 8. Proportions of households engaged in non-farm occupations.
Source: Survey data, 2007.



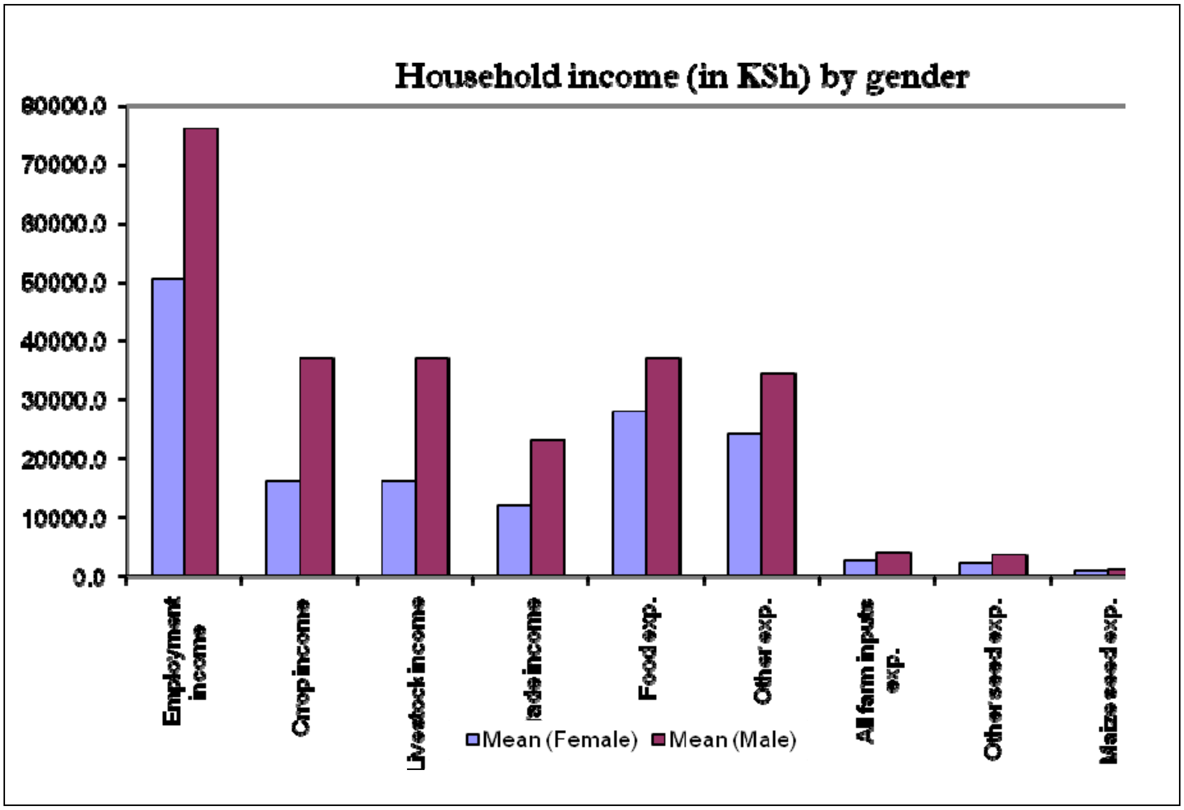


Figure 9. Income and expenditure by wealth groups and gender.

Source: Survey data, 2007.

Households spent their income on food, education, medicine, and clothing, among others. The mean expenditure for the households in both districts was KShs 68,469. Expenditure on food accounted for 53% of the total households' expenditure (51% in Machakos and 54% in Makueni). Education was the second biggest budget expenditure item followed by health care and medicine, clothes, and fuel (Table 24).

Table 24. Household expenditure profiles (%).

Expenditure item	Machakos	Makueni	Overall
Staple foods	51.0	54.4	52.7
Education	16.1	13.2	14.7
Medical	9.4	8.1	8.7
Clothes	7.1	7.5	7.3
Fuel	7.3	7.0	7.1
Miscellaneous	2.5	2.6	2.6
Remittances	2.5	3.7	3.1
Social contributions	4.2	3.5	3.9

Source: Survey data, 2007.

4.4 Outlook of livelihoods

Farmers were asked to enumerate the actions that they could undertake in order to improve livelihoods. The actions ranged from increasing agricultural production to getting out of agriculture. The farmers were asked to rank such actions in order of importance. Increasing agricultural production was ranked highest by 22% of the farmers, while getting out of agriculture was ranked as important by only 2% (Table 25).

Table 25. Possible farmer activities to improve livelihoods.

Action to improve livelihoods	% of households
Increase agricultural production	22.3
Reduce agricultural production risk	20.8
Reduce marketing risk	18.5
Increase food security	12.2
Improve health status of members	6.4
Increase volume of household assets	3.9
Increase education level of household members	3.4
Increase land ownership	2.8
Improve its social status	2.6
Increase income / reduce income risk	2.6
Increase job opportunities / earn wages	2.5
Get out of agriculture	2.0
Total	100.0

Source: Survey data, 2007.

To increase agricultural production, 25.4% of the farmers said they would plant profitable crops, 22.6% said they would use recommended agronomic practices and 12.6% said they would adopt improved varieties. To reduce agricultural production risk, 10.3% of the farmers said they would plant more profitable crops.

To increase food security, 36.6% of the farmers reported that they would improve the storage facilities they are using, whilst on the improvement of health status in the family, 31.4% of the farmers indicated that they would improve on nutrition and eat balanced diets. To reduce household asset risk, 13.7% and 7.1% said they would diversify into livestock and accumulate assets, respectively.

To reduce farm level risk, 40.9% of the households indicated that they would invest in education, while to reduce land ownership risk, 35.4% of the farmers said they would increase on acreage. To reduce the social status risk, 11.4% of the farmers said they would join social groups.

Farmers were also asked to rank the three most important threats to their livelihoods. For the first most serious threat to livelihoods, farmers ranked drought (38.6%), food insecurity (20.6%), and sickness (11.4%). On the second most serious threat, farmers ranked food insecurity (30.3%) and drought (21.7%). On the third serious threat, farmers ranked drought (16%) and food insecurity (13.4 %). Overall, drought and food insecurity can be said to be the most serious threats to livelihoods in Machakos and Makueni districts.

Additionally, farmers were asked to name the three most serious constraints to improvement of livelihoods. Table 26 shows the responses of some of the most important constraints.

Table 26. Farmers' response to constraints on improving livelihoods (%).

Constraint	First	Second	Third
Input markets	25	16	9
Low production	15	11	-
Output markets	12	12	9
Poor soils	7	19	-
Poverty	8	-	-
Production risk	-	-	12
Sickness	13	-	9
Transportation	-	7	13

Note: Blank cells are less than 6%.

Source: Survey data, 2007.

When asked whether the households had enough and adequate food in the last one year, 59% gave a positive response while the rest said no. Then farmers were asked to indicate the months that they had enough food and as shown in Table 27a, households have adequate food between the months of February and May, while the worst month is December.

Farmers were also asked to rank the most important coping mechanisms against drought in their households. Reducing on other expenditures and food intake frequency came out as the first most important coping mechanism (Table 27b). Selling small animals and reducing expenditures were ranked as the second most important mechanism, while working more off-farm was ranked as the third most important.

Table 27a. Months during which households had adequate food.

Month	% of households
January	4.6
February	21.2
March	19.7
April	16.7
May	11.4
June	7.6
July	6.8
August	6.1
September	2.3
October	1.5
November	1.5
December	0.8

Source: Survey data, 2007.

Table 27b. Most important food shortage coping mechanism (%).

Coping mechanism	First	Second	Third
Reduced frequency of food intake	19	-	-
Reducing other expenditure	69	26	-
Selling small animals	-	27	12
Selling other assets	-	7	9
Working more off-farm	-	32	42
Working for 'food-for-work'	-	-	16

Note: Blank cells are less than 6%.

Table 28 shows the most significant shocks affecting households and whether they had a direct effect on maize. The most important shocks are drought, flood, and plant pests and diseases with significant effects on maize production.

Table 28. Significant shocks affecting households in the last 10 years.

Specific shocks	Number of respondents	Mean rank	Direct effect on maize (%)
Death of breadwinner/spouse	43	1.30	37
Illness/disability of breadwinner/spouse	48	1.62	62
Drought	245	1.68	98
Erratic rainfall	83	2.04	99
Flood	166	2.36	80
Death or loss of livestock	83	2.61	20
Livestock diseases	29	2.79	22
Plant pests and diseases	124	2.80	93
Destruction of crops by animals	37	3.08	89
Increased input prices	82	3.10	95
Drop in maize prices	65	3.6	92

Source: Survey data, 2007.

Risks and coping mechanisms

The extent of utilization of land for agricultural purpose is influenced by constraints such as drought, low soil fertility, high soil acidity, soil erosion, lack of early maturing germplasm, lack of improved germplasm, and biotic stresses such as pests like Striga and diseases, among others (see Pingali 2001). These factors contribute to production risk as well as the way it is perceived by smallholders.

The majority of farmers (88–89%) would keep the area under various crops the same if price and yield were less than normal (Table 30; Table 32). When fertilizer is less available and unaffordable, 84% of farmers would prefer that the area under various crops remain the same.

There was not much inclination to change when price and yield were higher than normal: 51–52% of farmers said they would prefer if the area under various crops remained the same (Table 31; Table 33). However, there was a shift in perception regarding fertilizer when it is readily available and affordable, as mentioned by 47% of farmers who would prefer an increase in crop area. The same sentiment was echoed when credit is readily available and affordable, in which 56% of farmers said they would prefer an increase in crop area.

Table 29. Intended adjustment in crop areas when yield is less than normal.

Crop	Decrease	Same	Increase	N
Local landrace maize	7	87	6	330
Improved OPV maize	14	61	25	28
Hybrid maize	9	82	9	153
Millet	0	100	0	6
Beans	3	89	8	319
Groundnuts	0	100	0	4
Cassava	4	95	1	81
Pigeon peas	9	84	7	167
Vegetables	0	100	0	9
Average	5.1	88.6	6.3	122

Source: Survey data, 2007.

Table 30. Intended adjustment in crop areas when yield is higher than normal.

Crop	Decrease	Same	Increase	N
Local landrace maize	1	53	46	330
Improved OPV maize	4	64	32	28
Hybrid maize	1	56	43	152
Millet	0	50	50	6
Beans	2	56	41	339
Groundnuts	0	25	75	4
Cassava	10	77	13	83
Pigeon peas	4	54	42	168
Vegetables	0	25	75	8
Average	2.2	51.2	46.4	124

Source: Survey data, 2007.

Table 31. Intended adjustment in crop areas when price is less than normal.

	Decrease	Same	Increase	N
Local landrace maize	7	87	6	330
Improved OPV maize	14	61	25	28
Hybrid maize	9	82	9	153
Millet	0	100	0	6
Beans	5	89	7	330
Groundnuts	0	100	0	4
Cassava	4	95	1	81
Pigeon peas	5	89	6	167
Vegetables	0	89	11	9
Average	4.9	87.8	7.3	123

Source: Survey data, 2007.

Table 32. Intended adjustment in crop areas when price is higher than normal.

Crop	Decrease	Same	Increase	N
Local landrace maize	5	54	42	331
Improved OPV maize	25	39	36	28
Hybrid maize	8	54	39	153
Millet	17	67	17	6
Beans	4	57	39	338
Groundnuts	0	25	75	4
Cassava	2	88	10	82
Pigeon peas	3	61	37	167
Vegetables	0	22	78	9
Average	7.1	51.8	41.1	124

Source: Survey data, 2007.

The most risky crop in selling price fluctuations is the local landrace maize as mentioned by 46%, while the least risky is cassava (54%; see Table 34). Cassava had the lowest price fluctuation as it is not a common crop. It therefore does not have a national demand like maize. The price of maize depends on demand and supply, and it is also vulnerable to politics of the day. On average, there was no clear ranking in riskiness of crop price fluctuations. In fact, the rank was almost the same for all the crops; the range was 16–20%.

Historically, crop production has been increasing by expanding the crop area or intensifying production in area under cultivation (Achieng et al. 2001), as has been the case in eastern Kenya. Results indicate that an increase in crop area did not seem to be influenced by higher crop yield and price. In fact, increasing crop area without an increase in yield or price is counterproductive. In Ethiopia, high yield is one of three characteristics that influenced the area allocated to improved maize (Gemeda 2001). However, stable yields may be more important than higher yields, as they make people less vulnerable economically (Meinzen-Dick et al. 2004). Studies done in Kenya show there is a decline in yield of various crops in semi-arid lands, despite the introduction of high yielding varieties (HYVs). Bett et al. (2006) show that in spite of the high number of improved maize varieties released in eastern Kenya, their adoption rate is low, leading to poor yields.

Table 33. Ranking of crop in terms of perceived price risk.

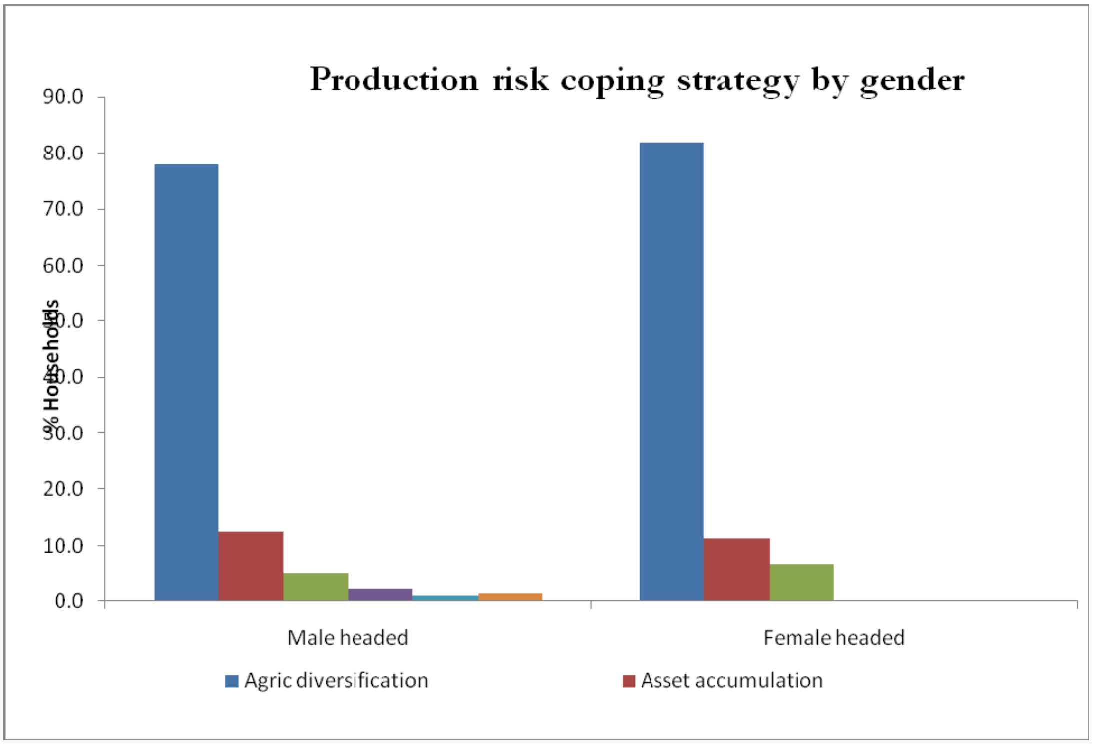
Crop	Most risky	More risky	Risky	Less risky	Least risky	N
Local maize	46	24	15	5	10	311
Improved OPV maize	17	22	33	28	0	18
Hybrid maize	32	31	15	9	13	140
Millet	0	17	17	33	33	6
Beans	28	37	15	8	13	326
Groundnuts	31	8	28	26	8	120
Cassava	4	6	12	25	54	84
Pigeon peas	2	14	42	30	13	192
Vegetables	8	39	8	15	31	13
Average	16.7	19.6	18.4	17.9	17.4	121

Source: Survey data, 2007.

The selling prices of various crops by the farmers have been low mainly due to factors such as inaccessible and/or lack of markets, high cost of production, transportation costs, and interference by middlemen, among others. This has not improved the farmers' financial position but rather entrenched them further into poverty.

As an important input for improving soil fertility, fertilizer is indispensable in the farming systems of the area. Its availability and affordability was seen to contribute to an increase in crop area. However, Meinzen-Dick (2004) cautions that investment in inputs can make farmers more vulnerable as their precious cash resources and food security are at risk if crops fail due to unexpected drought or floods.

As indicated earlier, credit for agricultural purposes in the study area was not easily available or affordable. Lack of credit facilities is a major impediment to agricultural development. Lack of collateral, distance to sources of credit, lack of knowledge on sources of credit, and high interest rates all contribute to farmers' lack of access to credit. However, farmers will only borrow when it is profitable to do so—where profitability depends on the price of credit and the potential returns to investment (Doss 2005). In Kenya, the major sources of credit have traditionally been the Agricultural Finance Corporation (AFC) and Kenya Farmers' Association (KFA). Being public enterprises, the terms and conditions of credit to the farmers were regulated. However, this is not the case in recent times, in which a number of private financial institutions have sprung up. These institutions claim to be friendly but their terms and conditions of lending are not favorable to majority of farmers. K-REP Bank through its Farmers' Savings Association (FSA) service is probably the only financial institution that has penetrated the study area, and which has gained credibility with the farmers.



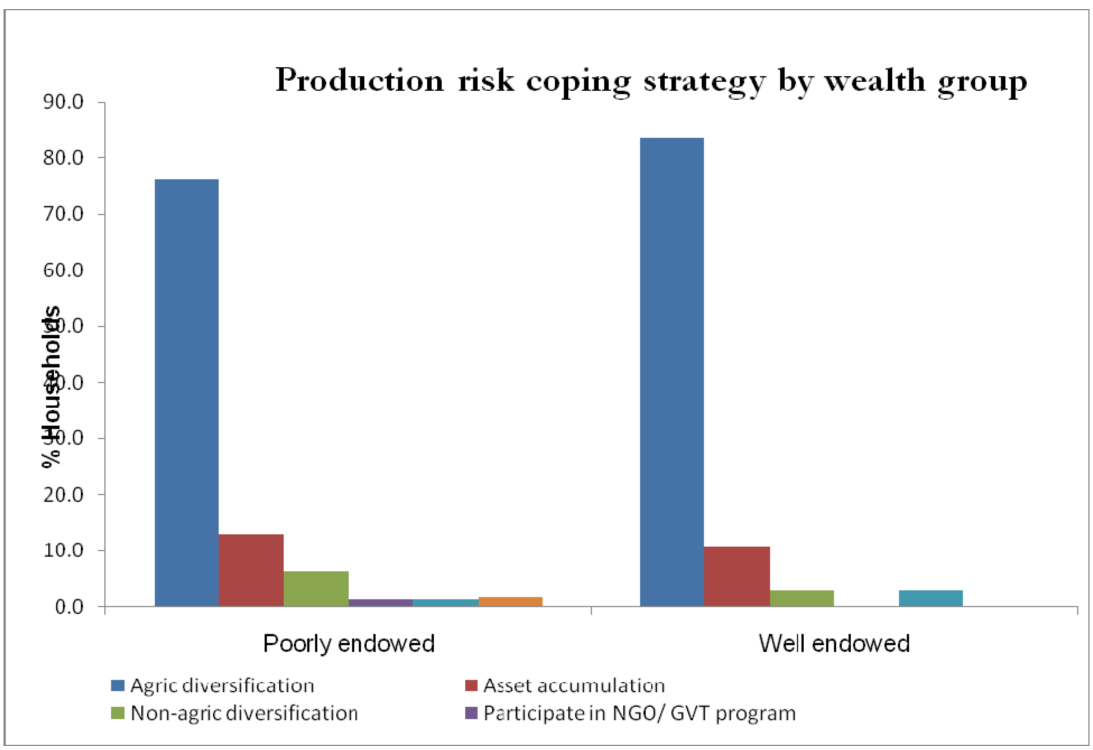


Figure 10. Production risk coping strategies.

Source: Survey data, 2007.

The main strategy adopted for reducing or eliminating production risks is agriculture diversification (Figure 10). About half the farmers (48%) improve profitability of their crops by increasing production. Increasing production through agriculture intensification is common in areas where small farm sizes are common such as in the study areas. However, farmers do not interfere with assets such as livestock when crops fail as they regard them as insurance for the future. In a traditional herding community such as the Kamba (the inhabitants of the study areas), assets such as livestock are highly treasured and only disposed of as the last resort. This is reflected in farmers' reaction when crop yield increase, as almost half (50%) of the households are quick to replace or increase their assets.

Even if price is not an important factor for increasing crop area, it determines how much of the crop is sold. This was mentioned by 56% of the households. Were it not for pressing cash needs, most farmers would prefer to wait for better prices on the sale of their crops, to get good value on their investment. Attractive selling price of produce can however be tricky as it might tempt the farmer to sell all the produce, thus exposing the household to food insecurity. In regard to maize, about half of the respondents (50%) said they would not change how they sold their maize even if the price of other crops were higher than normal. This can be interpreted to mean that maize is independent of other crops and would not influence their selling price.

The attractiveness in selling prices of various crops would not influence input, such as the use of fertilizer (64% of farmers). This means that inputs are lowest among the farmers' priorities, even if those crops fetch better prices in the market. Attractive prices of crops would also not influence the farmer to acquire more credit. Farmers may have found some factors of production unpredictable (e.g. unreliable rainfall). Therefore, relying on price as a motivation for credit without improvement in yield is both unsustainable and counterproductive.

Assets such as livestock would remain unaffected at all times, irrespective of whether the price of crops decreased or increased as mentioned by 72% and 53% of respondents, respectively. As mentioned earlier, the community in the study areas places high value on certain assets, which they will only sell when in dire need.

On reducing or eliminating price risks, the most important strategy is the asset accumulation (Figure 11). As seen earlier, farmers in the area acquire more assets whenever the financial situation allows. The information on price risks is accessed by farmers mainly from other farmers as mentioned by 69% of the respondents. Studies have shown that farmers are the main source of agricultural information on a wide range of agricultural services.

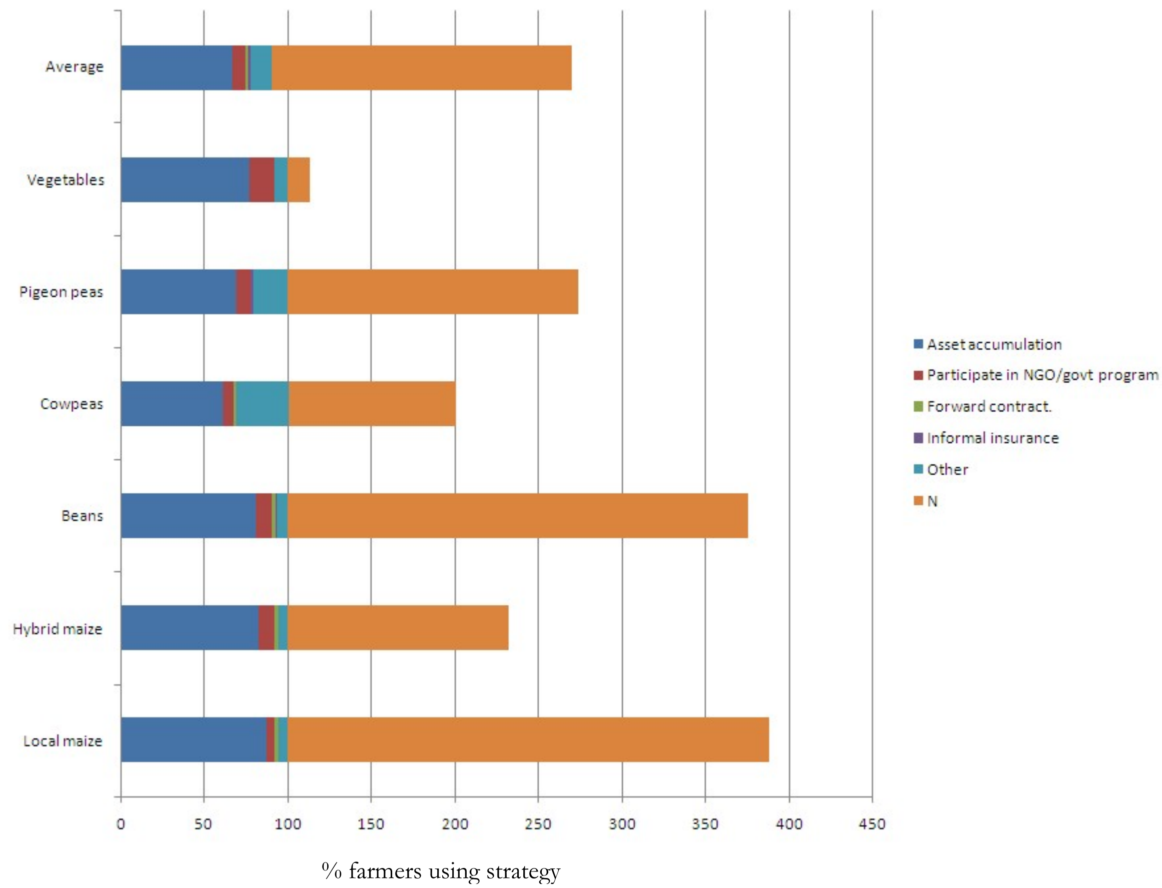


Figure 11. Price risk coping strategies.
Source: Survey data, 2007.

5 Technology use in crop production

5.1 Input use by farm households

The major agricultural inputs used during the 2005–06 farming year were local or improved seeds, organic and inorganic fertilizers, and pesticides. Less than 0.5% of households in Machakos (none in Makueni) used herbicides. The findings of this study regarding average quantities used and financial outlay per household on non-seed inputs are summarized (by gender and by wealth status) in Table 35.

In both districts, only insecticides and NPK (nitrogen, phosphorus, potassium) fertilizers were used by significant numbers of households. Few households used top-dressing fertilizer. Machakos farmers seem to have favored CAN (calcium, ammonium, nitrate) fertilizer while those in Makueni preferred urea, perhaps due to either district specific extension messages emphasizing use of CAN or urea, or the stocking preferences of farm inputs vendors within the respective districts.

Table 34. Non-seed input use by households in Machakos and Makueni districts.

Average quantity of farm inputs (kg or lt/household)	Female	Male	Poorly endowed	Well endowed	Whole sample
Organic fertilizer (manure)	877	1177	1404	558	1136
NPK	22	42	37	42	39
Urea	16	26	21	33	25
Insecticide	0.1	0.1	0.1	0.1	0.1
Herbicide	0.0	0.0	0.0	0.0	0.0
Average amount spent on farm inputs (KSh/household)					
NPK	869	1421	1308	1424	1345
Urea	543	770	641	949	739
Organic fertilizer	58	108	118	65	102
Insecticide	83	80	81	78	80
Herbicide	7	16	17	10	14

Source: Survey data, 2007.

Results showed high costs of transporting various farm inputs, especially in Machakos District. These high transport costs may be explained by differences in the quality of the road network and distribution of retail outlets. The main sources of farm inputs are reported in Figure 12.

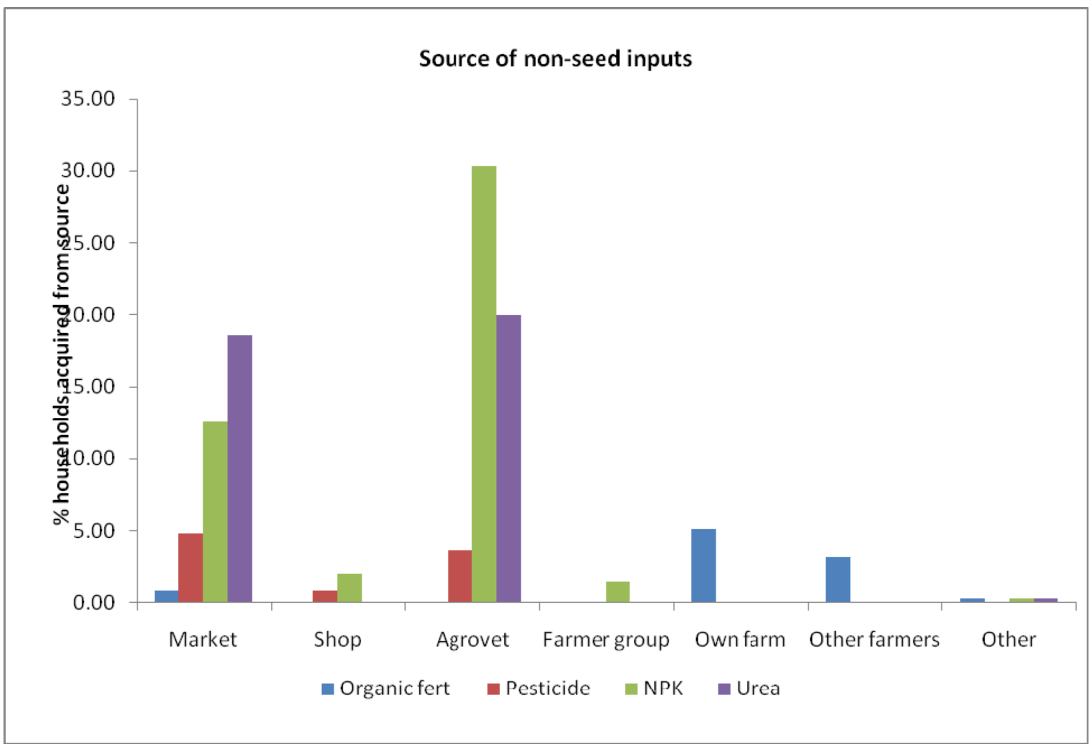


Figure 12. Sources of farm inputs.

Source: Survey data, 2007.

In Kenya, the "agrovet" business concept describes small retail outlets widely distributed through the main towns and market centers dedicated to stocking seed, fertilizers, pesticides, and veterinary products for sale to farmers. While the agrovet store was the main source of fertilizers and insecticides, other farm inputs were obtained from ordinary shops and also from fellow farmers. There was evidence of farmer-to-farmer exchange of farm inputs, other than seed.

Standard extension advice for farmers is that they should plant cultivars that are likely to optimize not only the local soil and climatic conditions but also the level of management applied. Thus, farmers using farm inputs as described in this section should plant cultivars which are likely to maximize returns to money used to purchase the fertilizers and pesticides.

Figure 13 shows that there were seven main sources of maize seed. In both districts, the highest percentage of households obtained seeds from local agrovet stores, followed by the market. In Makueni District, the Kenya Farmers' Association (KFA) was an important source of seed. Some of the farmers obtained seeds from the Kenya Seed Company (KSC) directly. Other sources were shops, own farm, other farmers, and the local shop.

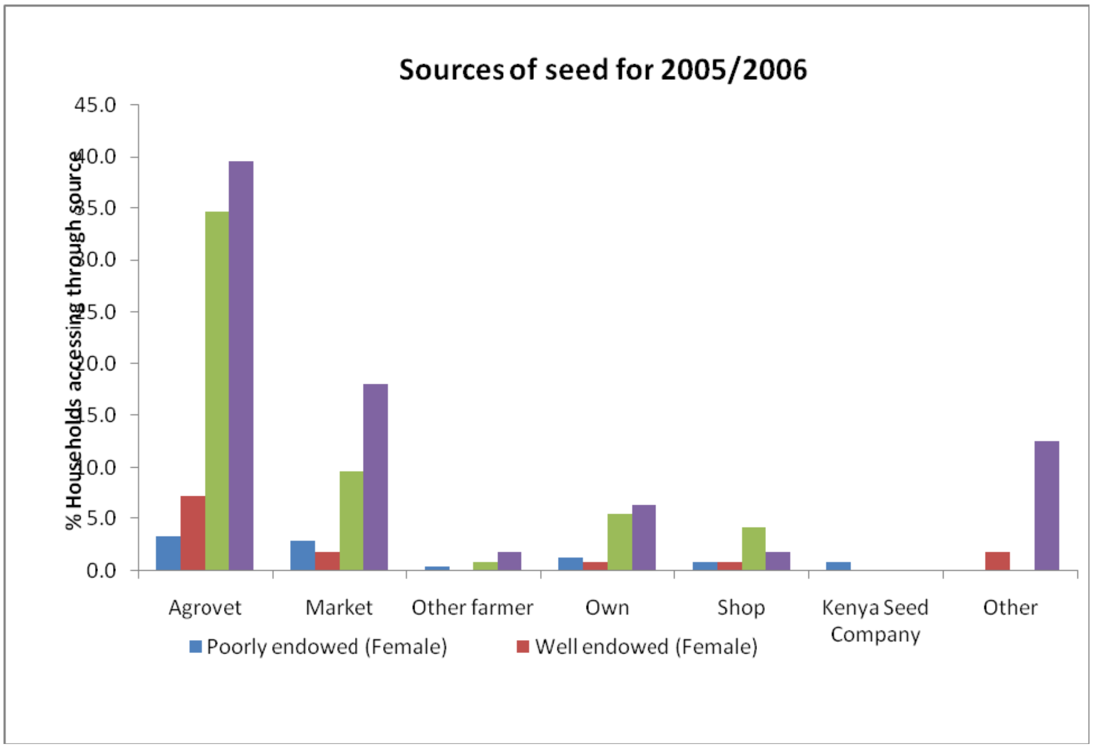


Figure 13. Sources of seed.
Source: Survey data, 2007.

A striking feature of maize production in the area is the diversity among varieties planted. Overall, the number of varieties per household ranged from 1 to 4 with a mean of 1.5. Some 32%, 8%, and 3% planted 2, 3, and 4 different varieties, respectively. Households in the sample grew 22 sub-categories of varieties (5 local, 2 improved OPVs, and 15 hybrids) during the 2005–06 farming year. However, for the sake of clarity of presentation, nine major categories are shown in Table 35. The share of the two (Katumani and DLC1) improved OPVs is insignificant. Only poorly endowed male farmers grew some DLC1 seed (average 0.01 ha). By contrast, local varieties represented between 66% (well endowed male farmers) and 86% (poorly endowed female farmers) of total maize seed sown during the 2005–06 season. The most popular improved varieties were hybrids distributed by local agents of Pioneer, Seedco (Duma), and Pannar International companies in Kenya. Male farmers planted more improved seed and had access to a wider range of varieties than their female counterparts. Among male and female farmers, well endowed farmers planted higher proportions of improved seed.

Perhaps prompted by scarcity of land in the area, adoption of improved maize varieties has been slow but discernible so that by 2005–06, adoption reached 32% (Makueni) and 44% (Machakos). The acreage of improved varieties has not grown at the same rate as the number of plots with improved maize varieties. However, the share of hybrid maize has been increasing while local types have been declining.

Table 36 summarizes the main maize production indicators.

Table 35. Maize cultivars planted by households in Machakos and Makueni districts by gender and wealth category.

Wealth group	Poorly endowed		Well endowed	
Gender of household head	**Female**	**Male**	**Female**	**Male**
Maize area planted (ha/hh)				
– Local	0.728	0.845	0.884	0.800
– Pioneer	0.105	0.156	0.158	0.213
– Duma41-4	0.059	0.071	0.064	0.169
– Pannar	0.016	0.025	0	0.107
– DLC1	0	0.010	0	0
– DH01-04	0	0.006	0	0.004
– H511-513	0.0125	0.004	0	0.02
– Katumani	0	0.002	0	0.001
– CG4141-5051	0	0.001	0	0.004
Total maize	0.920	1.118	1.107	1.320
N	32	207	16	95
Seed purchases (kg)				
– Local seed	8.641	14.708	13.188	11.089
– Pioneer seed	0.719	1.709	1.625	1.895
– Duma41-43 seed	0.438	0.570	0.5	0.611
– Pannar seed	0.031	0.164	0	2.947
– DH01-04 seed	0	0.082	0	0.063
– Katumani seed	0	0.024	0	0
– DLC1 seed	0	0.019	0	0
– CG4141-5051 seed	0	0.002	0	0.053
– H511-513 seed	0.1875	0	0	0.063
Total maize	1.375	2.571	2.125	5.632
N	32	207	16	95

Source: Survey data, 2007.

Table 36. Summary indicators to characterize maize production.

Indicator	Whole sample	Wealth group: Well endowed	Wealth group: Poorly endowed	Gender: Male HH	Gender: Female HH
Improved maize adoption rate					
- % of cropped area	33	32	39	34	35
- % of farmers	44.5	45.3	42.7	55.0	41.7
Improved maize seed purchased (kg)	9.2	10.1	8.8	9.4	7.7
Quantity of NPK used (kg)	90.2	109.7	82.6	95.6	57.3
Maize yield (t./ha)	1.13	1.07	0.79	1.11	1.26

Source: Survey data, 2007.

5.2 Determinants of adoption of improved maize seed

As noted in the preceding section, farmers in the sample named some 22 varieties which they were growing during 2005–06. Five out of these 22 were local types (*Kangundo*, *Kikamba*, *Kinyanya*, *Mulava* and *Mukunga*). Out of the 17 improved varieties, two were well-known open-pollinated varieties, namely, Katumani (Katumani Composite B or KCB) and Makueni (Dryland Composite 1 or DLC1). Adoption of all improved varieties stood at only 46%, despite the effort dedicated to their promotion over the last four decades. One objective of this study was to understand the factors affecting adoption of improved maize seed in the area.

Farmers who have not adopted improved maize seed cited lack of money for seed purchase (33%); satisfactory local varieties (20%); unawareness of availability of the new varieties (10%); disinterest in experimenting with unknown varieties (5%); lack of demonstrations (5%); and inaccessibility of seed (2%) as reasons for not adopting improved varieties. Twenty-eight percent of farmers did not respond to the questions.

A large number of factors which may determine adoption of improved technology have been discussed in the literature (e.g., Feder et al. 1985). Such factors tend to cluster around availability or farmer access to information, technology, and the required economic means. Subject to factors within the three clusters, the adoption process is assumed to follow five stages: the farmer develops awareness of both his problem and solution promised by the technology, acquires more information, evaluates the technology, accepts, and finally adopts.

An analytical framework for investigating adoption should involve a farmer's decision-making model on the choice, and intensity or extent of use of the technology. Farmer decisions may be assumed to be derived from maximization of expected utility subject to land, capital, information, institutional, and other constraints. Thus, maximization of utility depends on the farmer's discrete choice of technology from bundles which may include new and traditional technologies.

The goal in this section is to investigate the determinants of adoption of improved maize seed by farmers in the dry transitional zone of Kenya. This requires that the analytical framework chosen should allow the modeling of factors that influence farmers' decisions to adopt as well as determinants of intensity of use. Economic factors may be significant in both decisions, while factors related to information may be relevant in informing the decision to adopt and not intensity of use.

A qualitative dependent variables model (Probit) was evaluated for use and was not adopted on the grounds that quantitative observations on the dependent variable are available. A limited dependent variables model (Tobit) too was found unsuitable on the grounds that it could not accommodate the 2-step decision envisaged for the current problem. The Heckman (1979; Greene 2003) regression model was found suitable and was adopted for use in the analysis reported in this section.

The Heckman 2-step estimator is an alternative consistent estimator for the Tobit model parameters. The model assumption is that there is an underlying regression equation:

$$y_j = x_j \beta + u_{1j}$$

The dependent variable is not always observed. Rather, the dependent variable for the j[th] observation is observed for the selection equation:

$$z_{j\gamma} + u_{2j} \succ 0$$

where

$$u_1 \approx N(0, \sigma)$$

$$u_2 \approx N(0, \sigma)$$

Corr(u1, u2) = ϱ

When ϱ ≠ 0, standard regression techniques applied to the regression equation yield biased results. The Heckman procedure provides consistent, asymptotically efficient estimates of the model parameters. In this application, the dependent variable is adoption of improved maize seed, represented as the acreage of improved maize as a proportion of total maize acreage. Households choose whether to grow improved maize or not, and, thus, whether the acreage of improved maize is observed. If farmers made this decision randomly, ordinary regression would be used. However, due to many possible causes referred to earlier, this may not be true in many instances, and the sample of observed acreages may be biased. The motivation here is that a solution can be found if there are some variables that affect the chances of observation (adoption) but not the outcome (acreage).

The dependent variables and independent variables are the dependent variable and regressors for the underlying regression model to be fitted ($y = x\beta$), and the variables (z) thought to influence whether the dependent variable is selected. The model for this study was implemented using the Heckman command of STATA software. The estimates of model parameters are presented in Table 37.

The model results suggest that eight factors (the selection or z variables) have some influence on the initial decision to adopt improved maize seed. Literacy, non-farm income, perception of drought tolerance, district, wealth status, and awareness influence the initial adoption decisions positively. Food insecurity (household does not have enough food for the year) and gender (if female) were shown to have negative influences on adoption decisions. Food insecurity, the district dummy (for Machakos), gender, and awareness coefficients were statistically significant.

Nine variables were shown to influence the intensity of use of improved maize seed (proportion of maize acreage sown to improved varieties). Seed price, expenditure on food, perception of variety riskiness, non-farm income, and literacy were shown to influence intensity of use of improved varieties negatively. Grain price, gender, farm expenditure, and the wealth grouping, on the other hand, were shown to have positive influences on the intensity of use of improved maize. The coefficients of the food expenditure, literacy, gender, and farm expenditure were statistically significant.

Table 37. Factors influencing the adoption of improved maize cultivars.

	Coef.	Z	P>z
Adoption equation			
Seed price	-0.001	-1.470	0.141
Food expenditure**	0.000	-2.270	0.023
Grain price	0.007	0.670	0.501
Gender*	0.283	1.990	0.047
Risk perception	-0.038	-1.350	0.178
Farm expenditure*	0.000	1.880	0.059
Wealth group	0.011	0.150	0.883
Non-farm income	-0.048	-0.340	0.735
Literacy*	-0.120	-1.900	0.057
Constant**	1.022	3.090	0.002
Adoption intensity equation			
Literacy	0.273	1.500	0.134
Non-farm income	0.289	0.640	0.521
Food insecure**	-0.790	-3.060	0.002
Perception of drought tolerance	0.095	1.340	0.179
District**	0.844	3.580	0.000
Gender*	-0.804	-1.830	0.067
Wealth group	0.152	0.610	0.541
Awareness*	0.667	2.420	0.015
Constant	-1.721	-2.290	0.022
Mills Lambda	-0.0743	-0.720	0.471
Rho	-0.318		
Sigma	0.234		
Lambda	-0.074		

Note: * = significance at 5% level of confidence; ** = significance at 1%.

Source: Survey data, 2007.

6 Conclusion

Maize production and livelihood strategies are challenging in the poor and drought-prone study areas of Kenya. Drought risk was identified as the most serious threat to local livelihoods. Drought tolerant maize thus seems to offer significant opportunities. Preferred attributes for maize varieties include yield, drought tolerance, and earliness. Although maize is a major livelihood source, overall input use in maize production is low, attributable to limited purchasing power of farmers. The initial decision to adopt improved maize seed is influenced positively by literacy, non-farm income, perception of drought tolerance, district, wealth status, and awareness of the adopter. On the other hand, the intensity of use is influenced positively by grain price, gender, farm expenditure, and the wealth grouping.

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