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Drought Tolerant Maize for Africa (DTMA) Project

Characterization of Maize Producing Households in Adami Tulu - Jido Kombolcha and Adama Districts in Ethiopia

Getachew Legese, Moti Jaleta, Augustine Langyintuo, Wilfred Mwangi and Roberto La Rovere

CIMMYT MR
International Maize and Wheat Improvement Center

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Ethiopian Institute of Agricultural Research
(EIAR)

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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.

Correct citation: Getachew Legese, M. Jaleta, A. Langyintuo, W. Mwangi and R. La Rovere. 2010. *Characterization of maize producing households in Adami Tulu - Gido Kombolcha and Adama districts in Ethiopia* Country Report – Ethiopia. Nairobi: CIMMYT.

AGROVOC DESCRIPTORS: Agricultural economics, Agricultural products, Maize, *Zea mays,* Home economics, Households

AGRIS CATEGORY CODES: E10, E16, E80, F02, U40

DEWEY DECIMAL CLASSIFICATION: 633.15 63

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Country Report – Household Survey

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DTMA Country Report - Ethiopia

September 2010

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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 and characterizes the maize producing households in the Adami Tulu - Jido Kombolcha (ATJK) and Adama districts of East Shewa zone of the Oromia Regional State in Ethiopia.

This country study received financial support from the DTMA project. The views expressed in this report are those of individual scientists and do not necessarily reflect the views of the donor, the DTMA project, or the author's institutions. During the course of the study the authors of the study benefited from constructive contributions from Girma Tesfahun Kassie and Olaf Erenstein, among others. We are grateful to Judie-Lynn Rabar, CIMMYT Science Writer/Editor, for editing this report. We also acknowledge the support of the Ethiopian Institute of Agricultural Research.

The authors are responsible for any remaining errors and inferences.

Acronyms and abbreviations

ATJK	Adami Tulu - Jido Kombolcha District
B&MGF	Bill & Melinda Gates Foundation
CIMMYT	International Maize and Wheat Improvement Center
DTMA	Drought Tolerant Maize for Africa project
ha	hectares
HH	household head
IDTM	Improved drought tolerant maize
kg	kilograms
km	kilometers
NGO	Non-governmental organization
OPV	Open-pollinated variety
PCA	Principal component analysis
PFS	Probability of failed season
SSA	sub-Saharan Africa
TLU	Total livestock units
USAID	United States Agency for International Development

1 Introduction

Maize is an important cereal crop in Ethiopia as a source of both food and cash and represents a shift in farmers' choice of crops. In terms of area coverage on a national basis, it is next to teff (CSA 2007). Of all food crops covered under the extension program, maize has received special attention owing to its wide cultivation and its great significance among food crops. This can be seen from the fact that at mean annual growth rate of 1.62%, the total area of land under maize cultivation has increased significantly from 75,500 ha in 1961 to about 1.69 million ha in 2006/07. It constituted 12.8 % of the total area under cereal crops in 1961 and 20% in 2008. Annual production is more than 3.8 million tons, accounting for nearly 29% of the total cereal production in the country. The rates of increase in maize production and its share in the total cereal output have been at 3.27% and 1.92 %, respectively. Average yields have also increased from 9.6 q/ha in 1961 to 22.29 q/ha in 2007, growing at an annual rate of 1.62%.

With respect to drought tolerant maize, 40% of the total maize cultivated area is in drought prone regions of the country (Mandefro et al., 2001). Thus, increasing the production of maize under drought conditions has a direct impact on the livelihood of farm households that depend on maize production for their income and consumption. This emphasizes the need for targeted maize breeding research.

Maize research in Ethiopia was first initiated by Jimma College of Agriculture in 1952 and Alemaya College of Agriculture (now Haramaya University) in 1953 (Tesfaye et al. 2001). Since the inception of formal maize research in Ethiopia, about 30 maize varieties have been developed by the national research system. Of these varieties, 18 are OPVs and 12 are hybrids (Annex 1). The OPVs were developed by the public institutions, primarily Ethiopian Institute of Agricultural Research (EIAR), Hawassa College of Agriculture, and Haramaya University. While most of the hybrids were similarly developed by EIAR, three were developed by Pioneer. OPVs released specially for drought stressed areas (where cultivation is rain fed only) include Katumani, Tesfa, Fetene, Melkassa-I, Melkassa-II, Melkassa III, Melkassa IV, and A-511(Dawit et al. 2007). These improved varieties are grown alongside local varieties such as Sheye, Hararghe, Bukuri, Limat, and China (Mandefro et al. 2001).

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 for characterizing the maize producing households in the Adami Tulu - Jido Kombolcha (ATJK) and Adama Districts of East Shewa zone of the Oromia Regional State districts of Ethiopia—part of the project's medium drought risk zone (20–40% PFS) target area. It complements an earlier community assessment study in the same area (Jaleta et al. 2009).

Apart from characterizing the maize producing households, this study assesses the adoption of improved maize varieties and identifies factors influencing their adoption. The information generated will be used as a feedback for research and development interventions and relevant policy actions.

2 Materials and methods

2.1 Sampling, data collection and study areas

This study was conducted in Adami Tulu Jido Kombolcha (ATJK) and Adama districts of East Shewa zone of the Oromia Regional State in Ethiopia in 2007. A multistage random sampling technique was used to select a sample of 369 farmers from these districts. The sample included 196 and 173 sample households selected from 11 villages in ATJK and 9 villages in Adama districts, respectively, based on the proportion of maize areas in the two districts. Data were collected by eight trained enumerators with close supervision by the researcher in charge of the survey work.

The study areas are located in Eastern Shewa Zone of Oromia Regional State (Figure 1) Oromia is one of the nine regional states that constitute the Federal Democratic Republic of Ethiopia. It extends from 30 40'N to 10 35'N and from 34 05'E to 43 11'E. On the basis of the current border delineation, the land area of the region is estimated at 359,620 km^2. The region occupies more than 30% of the country's total area and can be categorized into three distinct geographical areas: the western highlands and associated lowlands, the eastern highlands and associated lowlands and the Rift Valley.

Adama and Adami Tulu - Gido Kombolcha districts are located in the rift valley area. The total population in the two districts was about 0.63 million (CSA 2007). Adama District has a total area of 1,008 km^2 and a population of 456,637 of which 50.3% is male. On the other hand, Adami Tulu - Jido Kombolcha has a total population of 178,204 of which 50.4% is male. Its total land area is 1,275 km^2. The population densities in the two districts are 453 and 50 persons per km^2, respectively.

The study areas have a mixed crop-livestock farming system. The major crops grown include maize, sorghum, pepper, noug, finger millet, teff, wheat, barley, field peas, faba beans, sweet potatoes. The main types of livestock kept include cattle, sheep, goats, equines, and chickens.

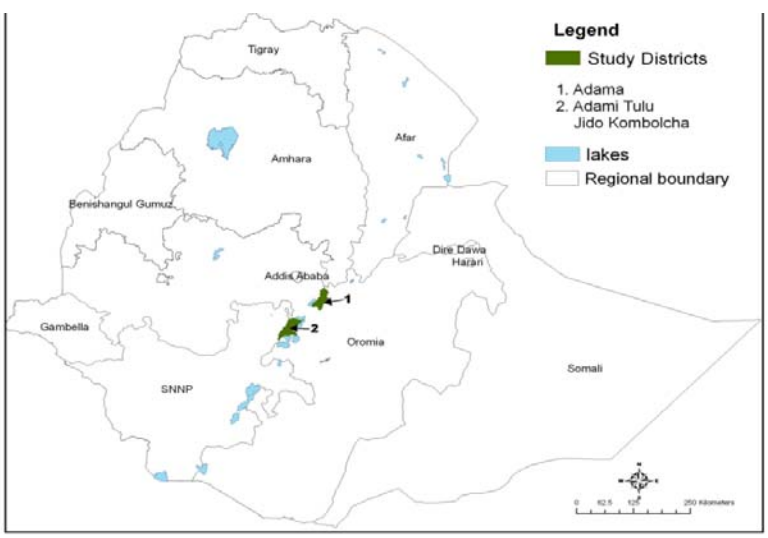


Figure 1. Map of Ethiopia showing selected survey districts.

2.2 Data analysis

In this study, principal component analysis (PCA), double hurdle regression model, and descriptive statistical tools were used to analyze household data. The PCA, as detailed in Filmer and Prichett (2001), Zeller et al. (2005) and Langyintuo and Mungoma (2008), was used to compute wealth indices to categorize households according to their resource endowments. The double hurdle model was used to analyze factors influencing the probability of adoption and intensity of use of maize varieties.

Estimating wealth indices

The productive assets (or asset indicators) owned by households can potentially contribute to their wealth but their ownership varies tremendously between households. This makes it very difficult to rank households based on their economic status without normalizing (or weighting) the assets in a manner that avoids distortions due to different measurement scales. Once normalized, indices can then be constructed and aggregated to facilitate ranking. A challenge here is the identification of the relevant weights to give to each asset indicator. As adapted from Langyintuo and Mungoma (2008) and Filmer and Pritchett (1998) there are four possible options:

1) assigning weights based on qualitative or subjective judgment,
2) constructing a set of weights based on a common factor which can be applied to all the indicators (for example, market or shadow prices),
3) avoiding the need for weights by running a multivariate regression analysis with all the indicators as unconstrained variables, or
4) allowing the weights to be determined mathematically, using PCA method.

Option one is inappropriate in this analysis because households own assets ranging from human capital (e.g. household labor) to physical assets (e.g. radio sets) that makes it impossible to find a common factor which could meaningfully be applied to all the assets (Filmer and Pritchett 2001). Option two is not suitable either given the highly imperfect markets for most commodities and services in the study area (as in most parts of the developing world) to allow the use of shadow pricing (Sadoulet and de Janvry 1995). The third option, multivariate regression, is statistically unsatisfactory because the variables to be included are not independent of each other suggesting that the resulting multi-collinearity would produce misleading regression coefficients. The fourth option, PCA, a technique for extracting from a set of variables those few orthogonal linear combinations of the variables that capture the common information most successfully, was used to construct an overall index of household wealth (Filmer and Pritchett, 2001; Zeller *et al.*, 2005). In PCA, the first principal component of a set of variables is the linear index of all the variables that captures the largest amount of information that is common to all of the variables (Filmer and Pritchett, 2001).

Suppose we have a set of *K* variables, a^*1j to a^*Kj, representing the ownership of *K* assets by each household *j*. Principal components starts by specifying each variable normalized by its mean and standard deviation. For example, $a_{1j} = (a_{1j}^* - a_1^*) / s_1^*$, where a_1^* is the mean of a_{1j}^* across households and s_1^* is its standard deviation. These selected variables are expressed as linear combinations of a set of underlying components for each household *j*:

$$a_{1j} = v_{11}A_{1j} + v_{12}A_{2j} + \ldots + v_{1K}A_{Kj}$$
$$\ldots \qquad \forall j = 1, \ldots, j \qquad (1)$$
$$a_{K1j} = v_{K1}A_{1j} + v_{K2}A_{2j} + \ldots + v_{KK}A_{Kj}$$

where, the *A*'s are the components and the *v*'s the coefficients on each component for each variable (and do not vary across households). The solution for the problem is indeterminate because only the left-hand side of each line is observed. To overcome this indeterminacy, PCA finds the linear combination of the variables with maximum variance, usually the first principal component A_{1j}, and then a second linear combination of the variables, orthogonal to the first, with maximal remaining variance, and so on. Technically the procedure solves the equations $(\mathbf{R} - \lambda\mathbf{I})\mathbf{v}_n = 0$ for λ_n and $\mathbf{v}_n$, where **R** is the matrix of correlations between the scaled variables (the *a*s) and $\mathbf{v}_n$ is the vector of coefficients on the *n*th component for each variable. Solving the equation yields the eigenvalues (or characteristic roots) of **R**, λn and their associated eigenvectors, $\mathbf{v}_n$. The final set of estimates is produced by scaling the $\mathbf{v}_n$s so the sum of their squares sums to the total variance.

The "scoring factors" from the model are recovered by inverting the system implied by Equation (1), to yield a set of estimates for each of the *K* principal components:

$$A_{1j} = f_{11}a_{1j} + f_{12}a_{2j} + \ldots + f_{1K}a_{Kj}$$
$$\ldots \qquad \forall j = 1, \ldots, j \qquad (2)$$
$$A_{K1j} = f_{K1}a_{1j} + f_{K2}a_{2j} + \ldots + f_{KK}a_{Kj}$$

The first principal component, expressed in terms of the original (un-normalized) variables, is therefore an index for each household based on the expression:

$$A_{1j} = f_{11}(a_{1j}^* - a_1^*)/(s_1^*) + \ldots + f_{1K}(a_{Kj}^* - a_K^*)/(s_K^*) \qquad (3)$$

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

$$W_j = \sum_{i=1}^{k} [b_i(a_{ji} - x_i)]/s_i \qquad (4)$$

where, $\boldsymbol{W_j}$ is a standardized wealth index for each 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 each household on each of the *k* variables; $\mathbf{x}_i$ is the mean of each of the *k* variables; and $\mathbf{s}_i$ the standard deviations.

A negative index ($-W_j$) means that, relative to the communities' measure of wealth, the household is poorly endowed and hence worse-off while a positive figure (W_j) 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.

According to Filmer and Pritchett (2001) the critical assumption of PCA is that the undefined 'common information' is determined by the underlying phenomenon that the index is trying to measure (in this case, wealth), which unfortunately cannot be statistically verified since it depends on the correct identification of the relevant variables or indicators, and is therefore largely a matter of judgment. One of the advantages of PCA apart from the objectivity of the weights is that it estimates the contribution of each variable to the underlying common phenomenon, and thus enables the ranking of indicators according to their importance in determining a household's level of wealth.

Econometric specification: the double hurdle model

In principle, the decisions on whether or not to adopt and how much to adopt a given technology can be made jointly or separately (Berhanu and Swinton 2003). When the two decisions occur simultaneously and with the same explanatory variable, the double hurdle model is equivalent to a Tobit model (Young and Wilson 1996). The Tobit model is used under the assumption that the two decisions are affected by the same set of factors (Greene 1993). However, it is hypothesized in this study that the decision to adopt a given improved drought tolerant maize (IDTM) variety has to be made first because of the risk averse nature of small holder farmers where they try the technology at small plots of land. The decision to adopt the variety and to use it at wider scale may also not be affected by the same variables. Thus, the use of the Tobit model cannot be justified under these assumptions. An alternative modeling choice is the double-hurdle model which envisions a multi-step process where a simple discrete ('adopt or not') decision is followed by a quantitative ('how many') decision. In the double-hurdle model, both hurdles have equations associated with them, incorporating the effects of farmers' characteristics and circumstances. Such explanatory variables may appear in both equations or in either of one. Most importantly, a variable appearing in both equations may have opposite effects in the two equations. The double-hurdle model, originally due to Cragg (1971), has been extensively applied in several studies such as Burton et al (1996) and Newman et al (2001). However, this model has been rarely used in the area of adoption of agricultural technologies; exceptions would be Berhanu and Swinton (2003), Teklewold et al. (2006), and Langyintuo and Mungoma (2008).

The double hurdle model is a parametric generalization of the Tobit model, in which two separate stochastic processes determine the decision to adopt and the level of adoption of the technology (Green, 2000). The double-hurdle model has an adoption (D) equation:

$$\left.\begin{aligned} &D_i = 1 \quad if \quad D_i^* > 0 \\ &D_i = 0 \quad Otherwise \\ \\ &D_i^* = \alpha' Z_i + u_i \end{aligned}\right\} \tag{1}$$

where, D^* is a latent variable that takes the value 1 if the farmer adopts improved maize variety and zero otherwise, Z is a vector of household characteristics and α is a vector of parameters. The level of adoption (Y) has an equation of the following:

$$Y_i = \begin{cases} Y_i^* = \beta' X_i + v_i & if \quad Y_i^* > 0 \ \ and \ \ D_i^* > 0 \\ 0 & otherwise \end{cases} \tag{2}$$

where, Y_i is the observed answer to the proportion of area planted with improved maize varieties, X is a vector of the individual's characteristics and β is a vector of parameters.

The error terms, u_i and v_i are distributed as follows:

$$\left.\begin{aligned} &u_i \sim N(0,1) \\ &v_i \sim N(0,\sigma^2) \end{aligned}\right\} \tag{3}$$

The log-likelihood function for the double-hurdle model is:

$$LogL = \sum_0 \ln\left[1 - \Phi\left(\alpha_i Z_i^1\right)\left(\frac{\beta X_i'}{\sigma}\right)\right] + \sum \ln\left[\Phi\left(\alpha Z_i'\right)\frac{1}{\sigma}\phi\left(\frac{Y_i - \beta X_i'}{\sigma}\right)\right] \tag{4}$$

Under the assumption of independency between the error terms v_i and u_i, the model (as originally proposed by Cragg, 1997) is equivalent to a combination of a truncated regression model and a univariate probit model. The Tobit model arises if $\lambda = \frac{\beta}{\sigma}$ and X = Z. A simple test for the double hurdle model against the Tobit model can be used. It can be shown that the Tobit log-likelihood is the sum of the log-likelihood of the truncated and the probit models. Therefore, one simply has to estimate the truncated regression model, the Tobit model and the probit model separately and use a likelihood ratio (LR) test. The LR-statistic can be computed using (Green, 2000):

$$\Gamma = -2\left[\ln L_T - \left(\ln L_p + \ln L_{TR}\right)\right] \sim \chi_k^2 \quad (5)$$

Where, L_T = likelihood for the Tobit model; L_P=likelihood for the probit model; L_{TR}= likelihood for the truncated regression model; and k is the number of independent variables in the equations. If the test hypothesis is written as Ho: $\lambda = \frac{\beta}{\sigma}$ and $\lambda \neq \frac{\beta}{\sigma}$. Ho will be rejected on a pre-specified significance level, if $\Gamma \succ \chi_k^2$.

3 Household characteristics

3.1 Household access to capital assets

Households are endowed with different assets which are measured in different units. In this study, the major household assets are classified as human, natural, physical, financial and institutional (social) capital. It is not easy to summarize these asset groups with different units of measurement and differentiate households based on their wealth endowments. In order to simplify the categorization of households according to their wealth endowment, a principal component analysis (PCA) was run on 19 selected asset indicators which were perceived to be better indicators of wealth in their community (Table 1). Nineteen components were extracted in the first stage of PCA but only eight were significant (based on the Kieser Criterion of an eigen value greater than one) (Langyintuo and Mungoma 2008). The eigen value is a measure of standard variance with a mean of zero and standard deviation of 1. Each standardized variable contributes at least the variance of 1 to the principal components extraction (Filmer and Pritchet 2001). The first component was used in constructing the index because it explained 21% of the total variance in the 19 indicators and gave positive weight for all of them. The assigned weights were used to construct an overall standardized composite wealth index. Households were then ranked from the highest to lowest composite wealth index. Accordingly, about 61% of the sample households were found to have negative wealth indices and categorized as poorly endowed while the remaining 39% of households with positive wealth indices were categorized as well endowed (Figure 2). The mean index for poorly endowed households was -0.62 and that of well endowed households was 0.96 while the sample mean was 0.

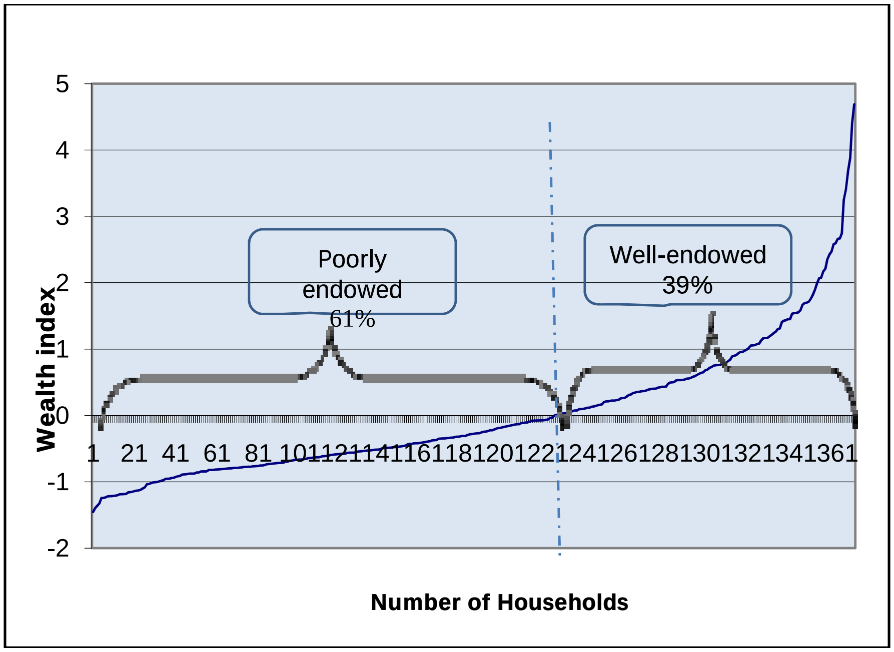


Figure 2. Distribution of households according to wealth groups.

Table 1. Total variance explained using principal components extraction method using standardized values of variables.

Component	Initial eigen values		SD	Scoring factor	Impact factor
	Total	% of variance			
Human capital					
Household labor capacity	3.920	20.634	0.161	0.134	0.835
Access to non family labor	0.000	0.000	0.501	0.072	0.144
Natural capital					
Total farm size	0.421	2.215	0.146	0.208	1.426
Total cropped land	0.396	2.085	0.134	0.205	1.537
Physical capital					
Total TLU	2.112	11.113	0.160	0.145	0.911
Own draught animal	1.287	6.773	0.206	0.192	0.934
Own animal cart	1.130	5.945	0.208	0.141	0.678
Own bicycle	1.408	7.413	0.241	0.153	0.633
Own television	1.245	6.552	0.154	0.060	0.386
Own wheel barrow	1.055	5.554	0.099	0.066	0.667
Own radio	1.013	5.330	0.188	0.102	0.542
Own private water well	0.916	4.819	0.099	0.064	0.647
Own water bore hole	0.803	4.226	0.116	0.026	0.226
Own water pump	0.773	4.071	0.082	0.029	0.352
Own mobile phone	0.708	3.729	0.122	0.123	1.014
Financial capital					
Access to consumption credit	0.574	3.021	0.069	0.029	0.421

Component	Initial eigen values Total	% of variance	SD	Scoring factor	Impact factor
Access to production credit	0.667	3.512	0.069	0.029	0.421
Social capital					
Number of extension contact	0.528	2.778	0.111	0.048	0.434
Member of other associations	0.044	0.230	0.490	0.042	0.087

Source: Survey data, 2007.

The impact factor, which indicates the relative adjustment of the wealth index by acquiring the corresponding asset is the score factor divided by the standard deviation. The number of top assets chosen is based purely on judgment. However, Langyintuo and Mungoma (2008) found out that three or four work very well. The four top assets with the largest impact factors were i) total cropped land ii) total farm size iii) mobile telephone and iv) draught animal. The relative impact of these assets on household wealth accumulation coincides with what is happening in most parts of Ethiopia. The first attempt of progressive (well to do) farmers is to increase their farm land either by renting or share cropping. Those farmers that have access to more cropped land are relatively better off than those who cultivate smaller land area. Those farmers that cultivate larger farms especially in the vicinity of large towns like Adama and Ziway buy mobile telephones to follow up the day to day market information for their products. Since access to mobile telephone is new in most parts of the country, farmers dream to be users of this service and buy it the moment they get a substantial amount of money. Moreover, farmers in the study districts are cultivating vegetable crops using irrigation water during dry seasons and they give priority to mobile telephones next to land.

Owning draught animals for land preparation and transportation of their products is the fourth impact factor. Though mechanization is expanding in the study areas mainly through tractor renting, animal traction is still the major source of farm power in these areas. Thus, when ever farmers get resources, they try to strengthen their draft power through acquisition of oxen and donkeys.

3.2 Human capital

Farmers' understanding and acceptance of technologies is expected to be influenced by his/her level of education. In this study, the level of education of sample household heads is categorized into illiterate and four literate categories (Table 2). Illiterate farmers are those that are not able to read and write while the literate group can read and write at different levels of education.

Gender of household head is an important factor that can influence adoption of agricultural technologies. The vast majority (95%) of household heads is male (Table 2). Female headed households usually face labor shortage and lack of access to resources and facilities such as credit and extension services. Though gender and level of education of the household heads seem to be associated with wealth and adoption categories, chi squares test indicates that there is no statistically significant relationship between them. The average household size in the study areas is seven members and differs significantly between wealth groups. It is nine among well endowed households and five for poorly endowed ones. Regarding marital status, the majority (97%) of household heads are married, 2.7% single, 1.4% divorced and the remaining 2% widowed. The average age of a household head is 42 years irrespective of wealth group.

Table 2. Demographic characteristics of sample households.

	Maize HYV		Whole sample (n=369)	
	Non Adopters (n=185)	Adopters (n=184)	Mean	SD
Age of household head (years)	41.6	42.8	42.2	14.6
Household size	6.6	6.7	6.7	3.9
– Children under 8 years	2.2	2.1	2.2	1.8
– Children 8-14 years	1.8	1.9	1.9	1.7
– Adult Female 15-60 yrs	1.6	1.7	1.6	1.1
– Adult Male 15-60 years	0.8	0.9	0.9	1.2
– Dependents >60	0.0	0.0	0.0	0.2
Education of household head (%)				
– Illiterate	30.3	27.9	28.7	
– Adult education	11.5	11.4	11.4	
– Primary school	47.5	48.9	48.0	
– Secondary school	10.4	9.8	10.0	
– Post secondary school	1.1	2.7	1.9	
Female household head (%)	7.0	3.8	5.4	

Source: Survey data, 2007.

Human capital is the human resource that a household uses as a labor force. The number of people available in the household was converted into its adult equivalent units (Storck et al. 1991). On average, each sample household had 2.6 adult equivalent units of labor force. It was 1.96 for female headed households and 2.61 for male headed households. Though male-headed households seem to have larger labor force than the female-headed ones, the mean difference between the two was not statistically significant (F=2.79). There is a significant difference between well and poorly endowed households in family size and labor force available per household (Table 3). Well endowed households have a larger family size and labor force than others. Since the agricultural activities such as weeding and harvesting are labor intensive, households with a larger labor force can cultivate larger areas of land, rip better benefit out of it and fall into the wealthier category. In the same way, such well endowed households have better access to non-family labor during peak agricultural periods.

Table 3. Human capital indicators by wealth group.

	Poorly endowed (n=224)		Well endowed (n=145)		Total (n=369)		F-statistic
	Mean	SD	Mean	SD	Mean	SD	
Household size (number)	5.20	2.71	8.90	4.40	6.66	3.91	100.0***
Household labor force (adult equivalent)	1.99	1.20	3.48	2.00	2.58	1.72	79.722***
Access to non-family labor (proportion)	0.40	0.49	0.67	0.47	0.50	0.50	27.80***

Note: *** Significant at 1%.

Source: Survey data, 2007.

3.3 Natural capital

Land is the most important natural capital for agricultural production. The land holding per household ranges from 0 to 13.75 hectares with a mean of 2.8 ha (Table 4). For most

of the households, a major proportion of the holding was cropped. Fallow, abandoned and tree plots were extremely small. Presently, marginal lands are being cultivated in response to high population pressure. It is therefore rare to find abandoned areas. Female-headed households seem to have smaller land than male-headed households, but this difference is not statistically significant (
Table 5).

Table 4. Land use by households.

Type of land use	Minimum	Maximum	Mean	SD
Cropped	0	13.25	2.48	1.74
Abandoned	0	2.75	0.03	0.19
Fallow	0	4.00	0.06	0.28
Pasture	0	4.00	0.18	0.46
Tree	0	2.00	0.03	0.16
Total	0	13.75	2.78	2.01

Note: (n=369)

Source: Survey data, 2007.

The difference in average farm size and cropped land between well endowed and poorly endowed households is statistically significant, with the former wealth category owning over a double of farm size as a whole and cropped areas (Table 6). Since land is the major factor of production in agriculture, this distinction between the poor and the well endowed households is logical. The well endowed households have better access to crop and pasture lands than the poorly endowed households (Figure 3). The average holding sizes are 4.3 ha and 1.8 ha per well endowed and poorly endowed households, respectively. The mean difference between holdings of the two wealth groups is statistically significant for crop area (F=225.5, p=0.000), pasture area (25.0, p=0.000), and average total holding (F=221.0, p=0.000).

Table 5. Access to land by gender of household head (ha).

	Female (n=20)		Male (n=349)		
Type of land use	**Mean**	**SD**	**Mean**	**SD**	**F-statistic**
Cropped	1.96	1.55	2.51	1.75	1.85 NS
Abandoned	0.01	0.06	0.03	0.20	0.24 NS
Fallow	0.01	0.06	0.06	0.29	0.52 NS
Pasture	0.01	0.06	0.19	0.47	2.81 NS
Tree	0.01	0.06	0.03	0.16	0.24 NS
Total	2.01	1.56	2.82	2.02	3.07 NS

Source: Survey data, 2007.

Table 6. Indicators of access to land by wealth group.

	Poorly endowed (n=224)		Well endowed (n=145)		Total (n=369)		F-statistic
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Total farm size (ha)	1.79	0.85	4.30	2.30	2.78	2.01	221.0***
Total cropped area (ha)	1.61	0.76	3.81	1.97	2.48	1.74	225.5***

Note: *** Significant at 1%.

Source: Survey data, 2007.

Though the majority of the farmers have user rights to land, not all of them cultivate it. Some of them sharecrop or rent out their lands for different reasons. Factors that determine the size of land cultivated by households include lack of draft power, expected family labor, shortage of seed and cash availability to buy inputs (Table 7).

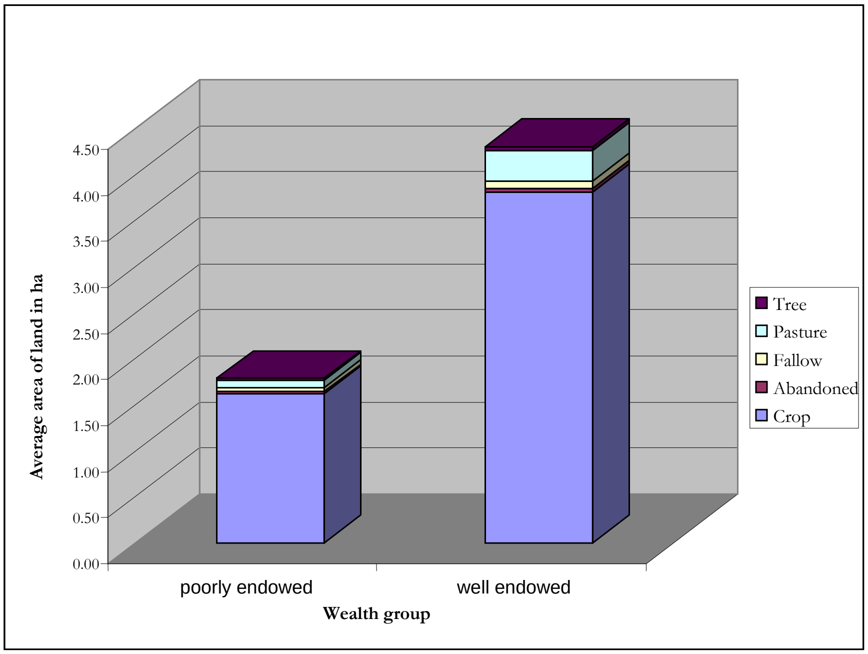


Figure 3. Distribution of land types by wealth groups.

Source: Survey data, 2007.

Table 7. Determinants of farm size (ranked from 1-3).

	Rank*		
Factors determining farm size	**1**	**2**	**3**
Expected family labor availability	23.6	8.9	7.9
Cash availability to hire labor	5.4	11.4	23.6
Cash availability to purchase other inputs	16.8	28.7	28.2
Current grain prices	1.9	1.6	4.1
Expected grain price after harvest	0.5	0.8	5.7
Food needs	3.8	7.9	5.4
Availability of seed	10.8	28.5	12.7
Draft power	33.6	7.3	5.1

Note: *1= very important and 3 = least important.

Source: Survey data, 2007.

Size of holding per household can increase or decrease depending on the factors indicated in Table 7. Accordingly, 41% of the respondents indicated their farm lands have increased as a result of increased access to sufficient seed (by 25%) and abundant labor (by 25%). About 25% of the respondents said that their farm lands have decreased due to high cost of inputs and shortage of rainfall that resulted in crop failure (Figure 4). The rest of the respondents indicated that there was no change in the size of their farm land.

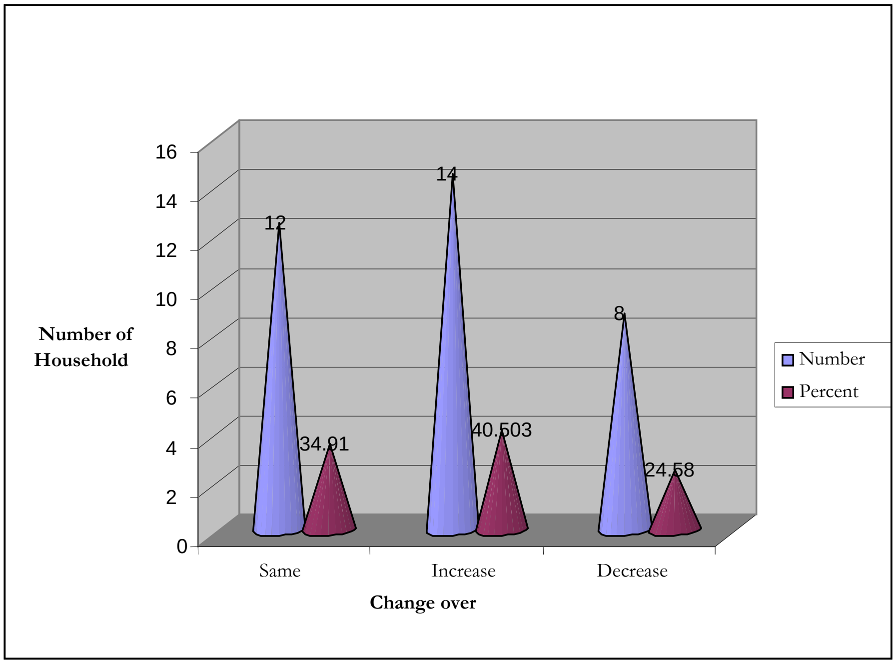


Figure 4. Change of farm size compared with previous years.

Source: Survey data, 2007.

3.4 Physical capital

As expected, there is significant difference in the type of housing between the two wealth groups (Table 8). While the majority of poorly endowed households own grass thatched huts with mud wall, the well endowed households own both grass thatched and iron roofed huts. The well endowed households use iron roofed houses as living rooms and the thatched roofed houses for barn, kitchen, and storage. Owning an iron sheet roofed house is usually a sign of enhanced livelihoods.

Table 8. Types of dwelling owned by households of different wealth category.

	Poorly endowed (n=172)	Well endowed (n=109)	Total (n=281)
Mud hut with grass thatch roof	56.3	35.2	48.0
Mud hut with asbestos/iron roof	20.5	35.2	26.3
Brick house with asbestos/ iron roof	0.0	2.1	0.8
Block house with grass thatch roof	0.0	0.7	0.3
Block house with asbestos/iron roof	0.0	2.1	0.8

Note: χ^2 30.78, Significant at 1%.

Source: Survey data, 2007.

Well endowed households own larger number of livestock and draft animals (Table 9). Since draft animals are the major sources of farm power, ownership of these animals determines the scale of farm operation of households. The well endowed households also own larger number of different types of physical assets such as bicycle, TV, radio and mobile phones. The difference between the two wealth categories in ownership of these physical assets is statistically significant.

Table 9. Ownership of physical assets by wealth group (average number by household).

	Poorly endowed (n=224)		Well endowed (n=145)		Total (n=369)		F-statistic
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Livestock (TLU)	3.12	4.82	14.08	14.47	7.43	11.17	109.9***
Draft animals	1.16	0.95	3.10	1.80	1.92	1.65	183.2***
Animal scotch cart	0.02	0.13	0.42	0.56	0.18	0.42	106.4***
Wheel barrow			1.00	0.00	1.00	0.00	
Bicycle	0.08	0.27	0.61	0.56	0.29	0.48	146.5***
Television	0.00	0.07	0.06	0.23	0.02	0.15	9.1**
Radio	0.42	0.49	0.77	0.60	0.56	0.56	37.9***
Private well	0.09	0.29	0.21	0.52	0.14	0.40	8.9**
Private borehole	0.00	0.07	0.03	0.16	0.01	0.12	3.5NS
Water pump	0.01	0.09	0.04	0.23	0.02	0.16	3.5NS
Mobile phones	0.00	0.07	0.14	0.37	0.06	0.24	28.4***
Wealth index	-0.62	0.33	0.96	0.92	0.00	1.00	551.0***

Note: *** Significant at 1%; ** Significant at 5%.

Source: Survey data, 2007.

3.5 Financial capital

Over 91% of the respondents indicated that they had financial problems. Only 22% of the sampled farmers received credit during the 2005–06 crop season. Use of credit seems to vary with wealth category, with well endowed households receiving credit than their poorly endowed counterparts (
Table 10). This trend of credit access has direct relation to the credit worthiness of and access to collateral by the users. Since most credit extended to farmers use group collateral, well endowed farmers are reluctant to include the poorly endowed ones with bad credit records and likely to default into their group. However, there is no statistically significant difference between the two wealth groups in terms of their credit access. Farmers that did not use credit attributed it mainly to unavailability of credit (40%), and lack of interest (38%).

Table 10. Credit and association membership by wealth group.

	Poorly endowed (n=224)	Well endowed (n=145)	Total (n=369)	Statistic
Received credit in 2005–06 (%)	19.6	25.5	22.0	1.77 NS
Membership to farmer associations (%)	56	66	60	3.66 NS

Source: Survey data, 2007.

Several uncertainties associated with rainfed agriculture coupled with lack of crop insurance are the main reasons why farmers are always skeptical about using input related credit. Past experiences from frequent drought and the resulting crop failure that compelled farmers to sell their livestock to repay input credit was fresh in their minds during the survey. Consistent with the earlier argument, only the resource poor respondents mentioned lack of collateral as the main reason for their not taking credit. Amongst them, about 8% indicated that the interest rates (or commission) charged by the cooperatives and other input distributors is often high (over 15%) compared to less than 7% usually charged by the banks.

The sampled farmers used both production and consumption credit. The former was in the form of cash and inputs. About 13% of the respondents used cash credit in 2005–06, receiving on average, 1,275 birr per household per year from various sources, namely, financial institutions (4%), money lenders (26%), relatives (2%), NGOs (2%) and the government program (51%) with varying interest rates. Credit from relatives is usually interest-free while money lenders charge up to 100%. Such very high interest rate and non availability at the right time, as mentioned by 36% of the respondents, often discourage farmers from using credit.

Input credit, which was received by 5% of the respondents from sources similar to those for cash credit, was mainly in the form of maize seed and fertilizer. The interest rate on maize seed averaged 6% with maximum of 10%. Repayment of seed credit was in terms of seed, grain, or cash. The majority (77%) repaid in cash, about 18% repaid in the form of seed and the remaining repaid in grain.

In terms of fertilizer credit, both basal and top dressings were received and the interest repayments by about 12% of the respondents that received it in 2005–06 crop season was in terms of seed or cash depending on the source. The problem with the maize fertilizer credit is its availability at the right time. About 43% of those farmers that used fertilizer credit indicated that it is not available at the required time. The problem is related with the earlier planting date of maize relative to other cereals in the country for which companies supply fertilizer.

Consumption credit was available in the form of cash. Only 2% of the respondents reported using consumption credit in 2005–06 crop season. On average, these households took birr 687 during the same period from money lenders and the government program (43% each), and neighbors (14%). The average interest rate on consumption credit was 85%. Similar to the production cash credit, money lenders charged as much as 100% interest on consumption credit. Since farmers look for consumption credit when they are desperate to feed their family, they have to accept whatever high interest rate they are charged. The majority of these users (85%) indicated that consumption credit is available on time and its repayment is in cash.

3.6 Institutional and social capital

Social capital refers to the participation of households in associations for example, peasant association, local insurance associations, and other labor pooling arrangements that need interaction with people. Respondents were asked if they were members of any of these associations. About 60% of them were found to be members of at least one of the farmers' associations in their area (
Table 10). On average, every respondent has been a member of these associations for 4 years but some up to about 30 years. Regarding the institutional support, there are both governmental and non governmental institutions operating in the area (Table 11). Among the three NGOs reported to support farmers in the study areas, World Vision Area Development program has wider coverage, next to the government support activities.

Table 11. Sources of institutional support to households by wealth group.

	Wealth category							
	poorly endowed		well endowed		Total		Duration of support (months)	
Source of Support	**N**	**%**	**N**	**%**	**N**	**%**	**Mean**	**SD**
World Vision	30	13.4	3	2.1	33	8.9	1.5	1.2
Catholic Relief Service	10	4.5	8	5.5	18	4.9	1.1	0.3
Government program	42	18.8	35	24.1	77	20.9	3	3.3
World Food Program	0	0.0	2	1.4	2	0.5	1	0

Source: Survey data, 2007.

World Vision is providing food relief and also supports development activities including input (seed and fertilizer) supply relief (Table 12). The other NGO, Catholic Relief Service (CRS) is not involved in food relief but is working on other development activities. The two NGOs focus on poorly endowed households while the government is working to support both wealth categories (Table 11). The government is also working on all activities at a wider scale compared to the NGOs. Though it was indicated that WFP is operating in their area, respondents did not explain the benefit package obtained from this organization.

Table 12. Support rendered by different institutions by wealth group.

		Wealth category					
		poorly endowed		well endowed		Total	
Source of support	**Benefit package**	**N**	**%**	**N**	**%**	**N**	**%**
World Vision	Food relief	5	2.0	1	0.7	6	1.6
	Seed relief	15	6.1	1	0.7	16	4.3
	Fertilizer relief	3	1.2	0	0.0	3	0.8
	Other	6	2.5	1	0.7	7	1.9
	Total	29	11.9	3	2.1	32	8.7
Catholic Relief Service	Food relief	0	0.0	0	0.0	0	0.0
	Seed relief	9	3.7	7	4.8	16	4.3
	Fertilizer relief	1	0.4	0	0.0	1	0.3
	Other	0	0.0	1	0.7	1	0.3
	Total	10	4.1	8	5.5	18	4.9
Government program	Food relief	18	7.4	11	7.6	29	7.9
	Seed relief	6	2.5	6	4.1	12	3.3
	Fertilizer relief	12	4.9	10	6.9	22	6.0
	Other	2	0.8	3	2.1	5	1.4
	Total	38	15.6	30	20.7	68	18.4

Source: Survey data, 2007.

The most important institutional support for small holder farmers is the dissemination of information that helps to improve adoption of agricultural technologies in order to improve agricultural productivity and livelihoods. Agricultural information could be disseminated using different methods (Table 13). However, the most effective mechanism in the study areas was personal communication through the agricultural extension workers.

Table 13. Sources of agricultural information.

	Wealth category of households					
	Poorly endowed		Well endowed		Total	
Sources of Agricultural Information	**N**	**%**	**N**	**%**	**N**	**%**
Agricultural extension staff	175	98.3	105	92.9	280	96.2
Newspaper	0	0.0	1	0.9	1	0.3
Radio	3	1.7	7	6.2	10	3.4
Total	178	100	113	100.0	291	100.0

Source: Survey data, 2007.

Since the majority of the respondents were illiterate, newspaper and other written media were not the common means of communication to disseminate agricultural information. Whereas radio was a better means of communicating extension information relative to newspaper, its effectiveness depended on the wealth category of households because acquisition of a radio costs money. This implies a need to work on ways of providing radio receivers to farmers at affordable prices.

The number of interactions farmers made with extension workers varied from farmer to farmer depending on factors such as the wealth category and social acceptance of the farmer. On average, farmers interacted with the extension workers three times a year. By wealth category, however, the poorly endowed interacted 2.4 times compared with 3.1 for the well endowed ($F=3.07$, $p=0.08$). The implication of this difference is the inclination of extension workers to pay more attention to the relatively resource-endowed farmers compared to the less endowed. On the other hand, the difference in wealth could emanate from the effort of farmers in taking agricultural innovations delivered by the extension system and improving their agricultural production.

With regard to other extension methods, different organizations were found to target different wealth groups of the community. Contrary to the usual arguments, the government agricultural extension services targeted the poorly endowed households (Table 14). The difference in the number of public extension field days indicates that these have a pro-poor orientation. On the other hand, the number of field days, field demonstrations, and discussions on maize production organized by the research system tended to be higher for well-endowed households relative to their counterparts (albeit not statistically significant). This is related to the level of risk associated with newly released technologies. Relative to the resource-poor farmers, resource-endowed farmers can take more risk and use technologies developed by the research system. The NGOs purposively target the resource poor farmers and they mostly support them financially and technically—but the mean difference in number of field days, demonstrations and discussions on maize production between the two categories of wealth was not statistically significant.

Table 14. Access to field demonstrations by wealth categories.

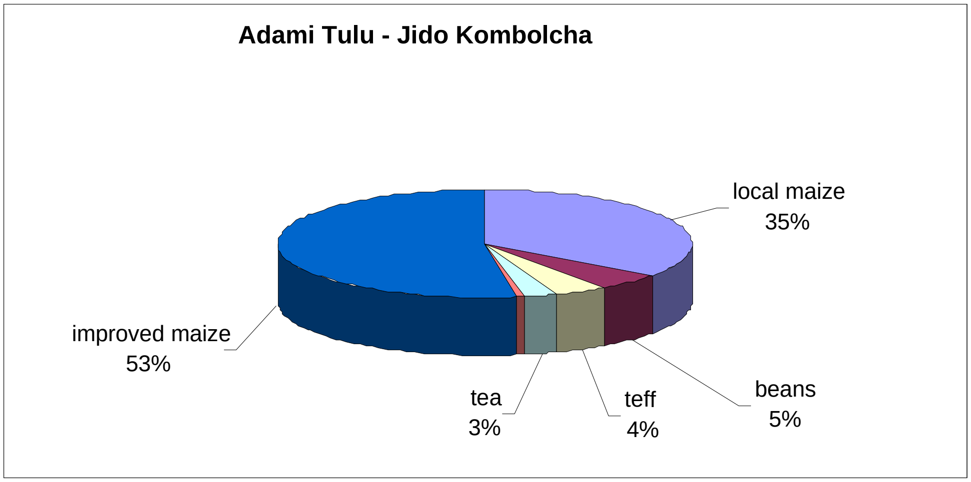
	Organizer	Poorly endowed		Well endowed		Total	
		Mean	SD	Mean	SD	Mean	SD
Number of field days	Agricultural extension services	3		1.2	0.4	1.5	0.8
	Agricultural research Institute	1		2.8	2.1	2.4	1.9
	NGOs	2		1.0	.	1.5	0.7
	Other agricultural development agencies			2.3	1.5	2.3	1.5
Number of field demonstrations	Agricultural extension services	2		1.8	0.8	1.8	0.8
	Agricultural research institute	1		2.3	1.3	2.0	1.2
	NGOs	2		3.0	.	2.5	0.7
	Other agricultural development agencies			1.7	0.6	1.7	0.6
Number of discussions on maize production	Agricultural extension services	2.8	2.3	3.9	4.1	3.3	3.2
	Agricultural research institute	2.0	1.4	2.3	1.3	2.2	1.2
	NGOs			5.0	.	5.0	.
	Other agricultural development agencies	1.5	0.7	2.0	1.3	1.9	1.1

Source: Survey data, 2007.

4 Household livelihood strategies

4.1 Crop production and marketing

Farmers in the study areas are subsistence oriented, cultivating multiple crops and raring livestock for several reasons. The most important reason for crop diversification (Figure 5) is to minimize risk of crop failure and ensure self-sufficiency. Analysis of the survey data revealed that households produce teff, maize, sorghum, and some other cereals (in trace amounts) (Table 15). Teff is the dominant crop in terms of harvest (46% of total harvest) followed by OPV maize varieties (22%) and local maize (19%). With regard to maize, area allocated to both local and improved maize varieties is higher in Adami Tulu - Jido Kombolcha (ATJK) District than in Adama District. More specifically, there is a statistically significant difference between average ha of land allocated to local maize varieties (0.2 ha per household in Adama and 0.1 ha in ATJK) (F=1.54, P=0.000) and improved maize varieties (0.7 ha per household in Adama and 1.4 ha in ATJK) (F=28.11, P=0.000). Sorghum is cultivated only in ATJK District on very small plots of land (0.01 ha/household on average).



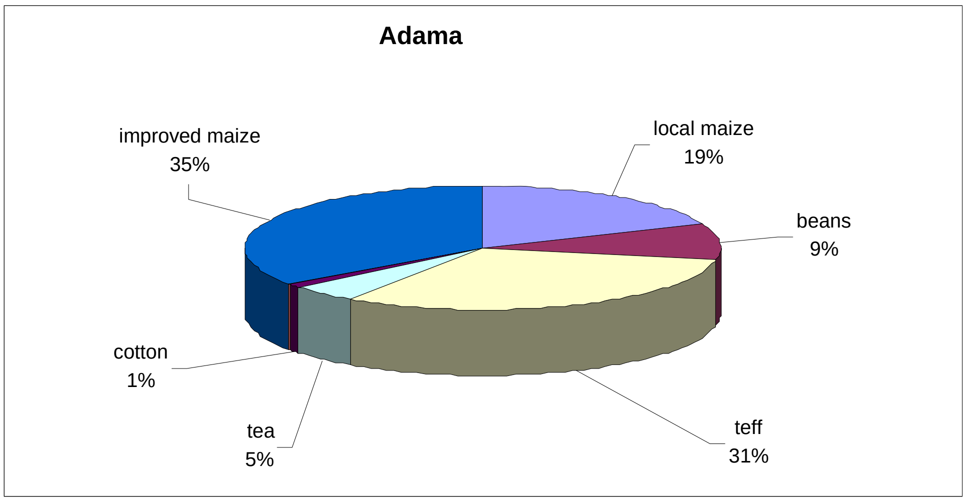


Figure 5. Distribution of farm land among crops by district.

Source: Survey data, 2007.

With respect to disposal of the total harvest for the year, the majority of household's harvest is consumed at home. The crop that is consumed the most is teff (86%) followed by sorghum (69%) and maize (41%). After storing small quantities for seed, gifts to relatives and against lean season household demand, the rest is sold. Post-harvest losses are estimated up to 5% (for sorghum).

Table 15. Disposal of crops harvested (kg).

Crop type	Harvested	Consumed	Sold	Given out	Reserved	Lost
Teff	1593 (24492)	1373 (24490)	177 (557)	3 (20)	38 (190)	2 (14)
Local maize	664 (1434)	382 (725)	186 (683)	36 (232)	40 (213)	20(142)
OPV maize	773 (1987)	335 (583)	335(1552)	27 (118)	63 (440)	15 (94)
Hybrid maize	413 (2171)	120 (606)	258(1530)	18 (100)	5 (26)	13 (106)
Sorghum	16 (105)	11 (89)	4 (38)	0 (0)	1 (6)	1 (16)
Rice	16 (119)	2 (37)	10 (94)	1 (10)	3 (19)	0 (0)

Note: (standard deviations) in parentheses.

Source: Survey data, 2007.

Emanating from the seasonal nature of grain price, there is a need to consider the time of the year when farmers sell their produce. The usual trend is selling crops immediately after harvest (usually in the 1st quarter of the year) and suffering from shortages especially in the third and fourth quarters. Though the number of responses was not large enough, about 33% and 67% of the respondents indicated that they sell both maize and cereal grains, respectively, in the first and second-quarters of the year.

The other important aspects of crop disposal are the places where the transaction occurs and the buyers of the commodities. Both of these variables are important in targeting potential consumers of the crops and their marketing behavior. Analysis of the survey data reveals that 89% of the maize and 65% of other cereal grains are purchased by traders, while middle men and established agents buy respectively, 9% and 2% of maize and other cereal grains. This implies that the most important agents absorbing producer supplied grain are traders. Regarding the place where transaction takes place, the majority of the producers (98% of maize and 96% of other cereals) sell their produce in the market and remaining sell at home.

Respondents have different views on who determines the market price of their cereals. About 64% of the sampled farmers indicated that price is determined by buyers, 15% said government while only 8% said that producers are the price makers. Those farmers who indicated that producers themselves are price makers mentioned cost of production (42% of the respondents), price in neighboring markets (32%), prices announced on the radio (13%), and prices published in the newspaper (10%) as reference prices when asked what they used in determining their prices.

4.2 Livestock production and marketing

In a mixed crop livestock farming systems, livestock plays a pivotal role in supplying households with draft power, milk, meat, and source of income. Analysis of the survey data revealed that an average sample household owned about 5.8 TLU of animals, but this is 2.7 for poorly endowed households and 10.7 for well endowed households ($F=181.588$, $p=0.000$). Households own different species of livestock and there is a statistically significant difference between the number of each type of livestock owned by the poor and well endowed farmers except for young bulls, pig, and improved chicken (Figure 6).

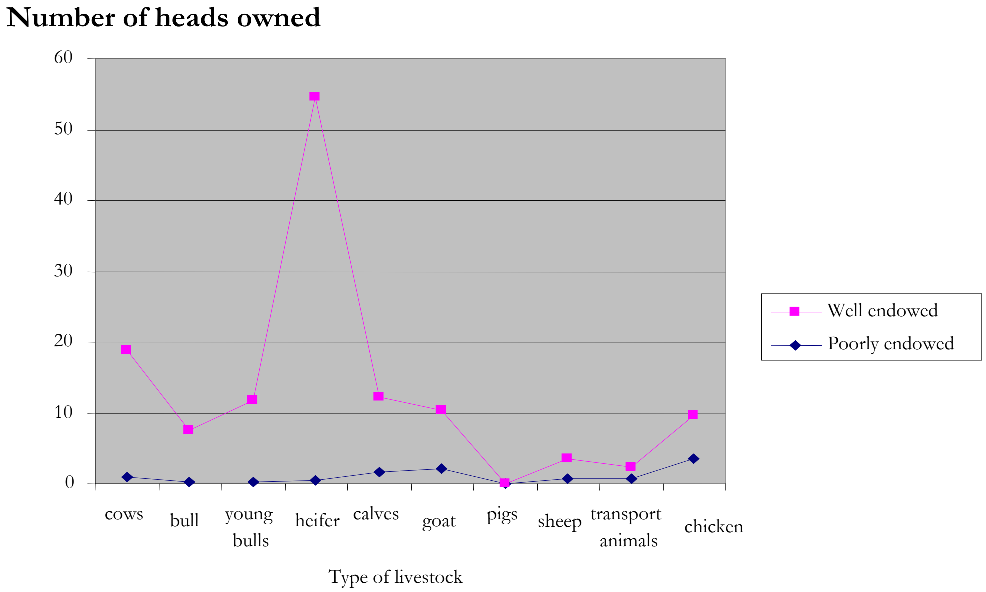


Figure 6. Distribution of livestock ownership by wealth category.
Source: Survey data, 2007.

The number of livestock marketed varies between households depending on the herd size. The data shows that households sold chickens (improved, local), goats, sheep, young bulls, bulls and cows in order of their importance but generally maintained cattle as living banks in which they save their assets. These are sold only under conditions of highly demanding cash needs, during drought, or replacement stock (for fattened animals). They also consumed chicken and small ruminants during holidays. Cattle may also be slaughtered by groups during holidays or individually for special ceremonies such as weddings.

4.3 Income and expenditure profiles of households

The major sources of household income are crop and livestock sales, the former being dominant (Table 16). The contribution of different crops, livestock and off-farm activities to household income varies between the poorly- and well endowed households. In line with expectations, crop sales are higher for the well endowed, whereas self-employment and other sources are higher for the poorly endowed. The proportion of households engaged in off-farm activities is also higher for the poorly endowed group compared with the well endowed group. As indicated earlier, the most important off-farm employment activity is self-employment followed by paid employment and petty trade.

Table 16. Sources of household income by wealth category (Ethiopian Birr, year basis).

Income sources	Poorly endowed	Well endowed	Whole sample	F statistic
Sales of crops	1330 (1299)	2939 (3472)	1962 (2521)	39.63***
Sales of fruits and vegetables	90 (421)	197 (1099)	132 (764)	1.72
Sales of livestock	297 (1110)	922 (4734)	542 (3100)	3.61
Petty trade	52 (312)	44 (287)	49 (302)	0.06
Paid employment	134 (508)	180 (602)	152 (546)	0.63
Self employment	369 (778)	159 (914)	287 (839)	5.61***
Remittances	11 (69)	7 (59)	9 (65)	0.27
Other sources	166 (535)	60 (327)	125 (467)	4.59**

Note: *** Significant at 1%; (Standard deviation) in parentheses.

Source: Survey data, 2007.

Households have different expenditure types governed by their income, household size, and lifestyle. As expected, the major proportion of poorly endowed household's expenditure is on food items followed by clothing and medical expenses (Table 17). Contrary to this, larger proportion of the well endowed farmers' expenditure goes to clothing followed by food and educational expenses. Well endowed households spend larger proportion of their income on non-food items and education of their children compared with their poorly endowed counterparts. As indicated in Table 17, there is a statistically significant difference between average amount of expenditure on education, health, clothing, remittances to relatives, gifts and bicycle repairs. Even, the amount of expenditure on food is significantly higher for well endowed households.

Table 17. Mean expenditure patterns of households by wealth category (Ethiopian Birr, year basis).

Expenditure items	Poorly endowed	Well endowed	Whole sample	F statistic
Staple foods	516 (536)	734 (1224)	602 (879)	5.45**
Tobacco/alcohol	77 (154)	107 (228)	89 (187)	2.27
Educational expenses	107 (441)	293 (725)	180 (576)	9.44***
Medical expenses	141 (277)	289 (415)	199 (346)	16.92***
Clothing	349 (279)	759 (675)	510 (515)	65.44***
Fuel wood, paraffin, etc	124 (112)	151 (173)	135 (139)	3.23
Bicycle repair, gift, etc	58 (108)	251 (479)	134 (325)	33.52***
Remittances	140 (193)	254 (347)	185 (270)	16.20***
Miscellaneous	80 (217)	165 (625)	113 (428)	3.55
Social contributions	3 (25)	13 (109)	7 (71)	1.95

Note: *** Significant at 1%; ** Significant at 5%. (Standard deviation) in parentheses.

Source: Survey data, 2007.

4.4 Impact of shocks on household livelihood outcomes

Considering the importance of understanding the major livelihood outcomes of households and the shocks affecting their livelihood in developing technologies that can address these problems, households were asked to rank their important livelihood outcomes (Table 18). Accordingly, increased agricultural production was found to be the most important livelihood outcome for both the poor and well endowed households where as improved social status was found to be the least important outcome. The difference between the two wealth categories was observed in their second and third important livelihood outcomes in that increased land ownership and food security are respectively the second and third important outcomes for poorly endowed households. For well endowed households, the second and third most important outcomes were increased education level of household members and land. Improved food security is the fourth important livelihood outcomes for well endowed households. This shows the clear difference between households of different wealth categories in their priorities.

Table 18. Important household livelihood outcomes (proportion of households).

	Wealth category										Whole sample (n=369)				
	Poorly endowed (n=232)					Well endowed (n=137)									
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Increase agricultural production	40.1	20.7	14.2	3.9	0.4	51.8	13.1	10.2	2.9	1.5	44.4	17.9	12.7	3.5	0.8
Reduce agricultural production risk	3.9	3.4	3.4	0.0	0.0	0.0	2.9	0.7	0.7	2.9	2.4	3.3	2.4	0.3	1.1
Reduce marketing risk	2.2	5.6	1.7	0.0	0.0	0.0	0.0	0.7	0.7	0.7	1.4	3.5	1.4	0.3	0.3
Increase food security	12.5	13.8	11.2	3.4	0.9	8.0	18.2	11.7	7.3	2.9	10.8	15.4	11.4	4.9	1.1
Improve health status of members	3.9	12.5	11.2	3.9	1.3	2.2	13.9	16.8	8.0	1.5	3.3	13.0	13.3	5.4	1.4
increase volume of household assets	6.5	8.6	4.7	0.9	2.6	2.9	13.9	11.7	1.5	0.7	5.1	10.6	7.3	1.1	1.9
Increase education level of household members	8.6	9.9	14.2	6.0	1.3	14.6	16.8	21.9	10.9	2.9	10.8	12.5	17.1	7.9	1.9
Increase land ownership	13.8	11.6	13.4	2.2	0.9	10.9	13.1	7.3	2.9	2.2	12.7	12.2	11.1	2.4	1.4
Improve its social status	0.4	1.7	0.4	0.9	0.0	0.0	0.7	0.0	0.0	0.7	0.3	1.4	0.3	0.5	0.3
Increase its income/Reduce income risk	4.3	4.7	6.0	1.3	1.3	8.0	3.6	0.7	1.5	1.5	5.7	4.3	4.1	1.4	1.4
Increase job opportunities/earn wages	3.0	3.4	2.2	2.2	1.7	0.7	1.5	2.9	0.0	0.0	2.2	2.7	2.4	1.4	1.1

Source: survey data, 2007.

After they identified their major livelihood outcomes respondents were asked what they would do to achieve their important livelihood outcomes. Households in both wealth categories use improved seed and fertilizer as their first strategy to increase their agricultural production. However, they differ in their second important actions to increase agricultural production in that poorly endowed households use cultivating more land while the well endowed households go for hard work and intensive management. Saving followed by increasing crop production were found to be the most important actions taken by both wealth groups to ensure their household food security. Selling grain at the right time was the third important action taken by poorly endowed households to ensure their food security. Regarding land ownership, renting-in was found to be the most important strategy to increase size of land holding by both wealth categories.

In addition to the important livelihood outcomes of households and actions taken to achieve them, it is important to understand the most important threats to these livelihood outcomes. Households in different wealth categories prioritize the important threats to their livelihoods with respect to their own condition. Poorly endowed households ranked household food insecurity, drought and household health, respectively as the first, second and third threats (Table 19). On the other hand, well endowed households ranked drought as the first important threat, food insecurity and household health as the second and large family size as the third most important threat to their livelihood.

Table 19. Perceived shocks to household livelihoods (proportion of households).

	Wealth category														
	Poorly endowed					Well endowed					Whole sample				
	1	2	3	4	5	1	2	3			1	2	3	4	5
Drought	80.6	7.8	4.3	1.3	1.3	75.9	10.2	0.0	1.5	0.7	78.9	8.7	2.7	1.4	1.1
Too much rain	0.9	4.7	0.4	1.3	0.9	1.5	3.6	0.0	0.7	1.5	1.1	4.3	0.3	1.1	1.1
Land slide	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.3
Frost or hailstorm	0.4	1.7	0.4	0.0	0.4	0.0	1.5	0.0	0.7	0.7	0.3	1.6	0.3	0.3	0.5
Plant pests and diseases	0.9	13.8	3.4	1.3	0.0	2.9	5.8	5.8	0.0	2.2	1.6	10.8	4.3	0.8	0.8
Livestock diseases	0.4	3.4	5.6	0.0	0.4	0.7	7.3	10.2	2.9	2.2	0.5	4.9	7.3	1.1	1.1
Destruction of crops by animals	1.3	6.5	7.3	1.7	0.0	2.2	3.6	4.4	2.9	2.2	1.6	5.4	6.2	2.2	0.8
Dangerous weeds	0.4	6.5	5.2	2.2	2.2	4.4	5.8	4.4	2.2	1.5	1.9	6.2	4.9	2.2	1.9
Large increase in input prices	1.3	8.2	11.6	3.9	0.9	2.9	2.9	5.1	4.4	1.5	1.9	6.2	9.2	4.1	1.1
Large drop in maize prices	1.7	3.9	4.7	0.9	0.4	2.9	4.4	2.2	2.2	1.5	2.2	4.1	3.8	1.4	0.8
Loss of farm land	0.0	0.4	0.0	0.0	0.0	0.7	1.5	0.0	0.0	0.7	0.3	0.0	0.8	0.0	0.3
Death or loss of livestock	2.6	6.9	3.0	2.6	1.7	0.7	2.9	10.9	5.8	2.2	1.9	5.4	6.0	3.8	1.9
Death of breadwinner	2.2	1.3	0.9	0.9	0.4	0.0	0.7	2.2	0.0	0.7	1.4	1.1	1.4	0.5	0.5
Illness/disability of breadwinner/wife	4.3	8.6	6.0	2.6	0.4	3.6	16.1	0.7	2.9	0.7	4.1	11.4	4.1	2.7	0.5
Theft of property(other assets)	4.3	8.6	6.0	2.6	0.4	1.5	1.5	0.7	1.5	1.5	1.1	1.4	0.5	2.2	0.5
Burning of property(arson)	0.9	3.0	1.3	0.0	0.0	2.9	0.7	0.0	0.7	1.5	1.6	2.2	0.8	0.3	0.5
Household's breakdown	0.9	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.7	0.5	0.0	0.0	0.5	0.3
Erratic rainfall	0.4	0.4	0.9	2.2	1.3	1.5	0.7	2.9	3.6	4.4	0.8	0.5	1.6	2.7	2.4
Birds	0.0	0.0	1.7	1.7	3.4	2.2	1.5	0.7	2.2	2.2	0.8	0.5	1.4	1.9	3.0
Conflict	0.9	0.9	0.4	0.9	0.0	1.5	1.5	0.0	0.7	1.5	1.1	1.1	0.3	0.8	0.5
Ranking of other shock as a serious shock in past 10 years	1.3	2.6	0.9	0.0	0.0	4.4	3.6	1.5	0.0	1.5	2.4	3.0	1.1	0.0	0.5
Risk/shock on livestock	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0

Source: Survey data, 2007.

With respect to the food security situation of households, the results of this study reveal that 55% of the poorly endowed and 40% of the well endowed households are food insecure. On average, each of the poorly endowed households get enough and adequate food for four months a year while the well endowed households get for five months. This implies that the seven to eight months in a year are lean in terms of the food security situation of households. However the difference between the two wealth groups in terms of number of food abundance months is not statistically significant (F=0.515). The most critical months when households face food shortages are August and September. Respondents were asked about the history of drought in the last 10 years. They indicated that they faced drought in three out of the last ten years which means almost one in three years.

4.5 Production and price risk analysis

Households' perception about production risk and their coping mechanisms

Perception of households about the nature of different crop and livestock enterprises with respect to production risks influences their decision on the size of resources allocated to a given enterprise. Taking this into account, households were asked to rank the riskiness of the three maize types and other major crops in terms of their yield fluctuation (Table 20). Their responses vary according to their wealth category. For poorly endowed households, improved OPV varieties followed by local land race maize varieties were found to be the most risky while hybrid maize varieties were the least risky. For well endowed households, the local land races were found to be the most risky while hybrid maize varieties were least risky among the maize varieties. Among other crops, beans was found to be the most risky and sorghum was least risky for both wealth groups.

Table 20. Perception of households about the riskiness of crops.

Crop type	Wealth category				Total	
	Poorly endowed		Well endowed			
	n=232	%	n=137	%	n=137	%
Local land race maize	52	22.4	30	21.9	82	22.2
Improved OPV maize	78	33.6	25	18.2	103	27.9
Hybrid maize	7	3.0	12	8.8	19	5.1
Sorghum	3	1.3	1	0.7	4	1.1
Beans	52	22.4	62	45.3	114	30.9
Teff	29	12.5	9	6.6	38	10.3

Source: Survey data, 2007.

An attempt was made to understand the responses of households to the fluctuations in the yield of different crops. As indicated in Table 21, more proportion of respondents indicated that they wouldn't change area of land allocated to maize varieties in general. This shows the importance of maize in the livelihood of farmers and their tolerance to cultivate this crop despite the fluctuations its yield.

The reaction of respondents to decrease in yield was highest for beans and teff. This could be because of the purpose for which the crops are grown. Beans are a cash crop and is grown for market. Farmers grow such crops only if it has a good return while staple food crops such as maize and sorghum which can tolerate drought and adapt to the area should be grown in order to produce food for the household.

Table 21. Adjustment in area of land allocated to different crops in response to crop yield reduction (% of responses).

Wealth category	Responses to decrease in yield	Crop type					
		Local land race maize	OPV maize	Hybrid maize	Sorghum	Beans	Teff
Poorly endowed	Decrease	12.5	-	1.3	0.4	36.2	30.6
	Same	28.9	-	5.2	3.4	27.2	28.4
	Increase	1.7	-	1.3	0.4	5.2	6.5
Well endowed	Decrease	14.6	19	8.8	0	39.4	13.1
	Same	27.7	28.5	13.1	3.6	35	21.2
	Increase	5.1	10.9	2.2	2.2	11.7	10.2
Total	Decrease	13.3	19	4.1	0.3	37.4	24.1
	Same	28.5	30.9	8.1	3.5	30.1	25.7
	Increase	3	6.8	1.6	1.1	7.6	7.9

Farm households use different coping strategies to reduce the impact of production risks. These strategies vary between different wealth groups and maize varieties (Figure 7). Generally the coping strategies are divided into two: ex-ante and ex-post strategies. Ex-ante coping strategies include agricultural diversification and asset accumulation while ex-post strategies include non-agricultural diversification and participation in NGO/government programs. For all the three maize types, ax-ante coping strategies were found to be more important than the ex-post strategies. The most important ex-ante strategy for all the three maize types is agricultural diversification implying the risk averse nature of farmers. Asset accumulation is the second most important coping strategy and it is used by well endowed households. Ex-post coping strategies are not as common as ex-ante strategies. Among the three maize types, ex-post strategies are more commonly used for OPV varieties.

The more proportion of households using ex-ante strategies and the relative importance of crop diversification shows a need to support farmers in their effort to diversify their agricultural activities given the risky nature of rain fed agricultural practices in the study areas. This could be in terms of growing different types of crops, growing different varieties of maize and other crops, practicing crop and livestock mixed farming. In the case of the drought tolerant maize project, encouraging farmers to use the different drought tolerant maize varieties should be the first priority both in technology development and using well targeted dissemination system that can reach the farmers of different wealth groups.

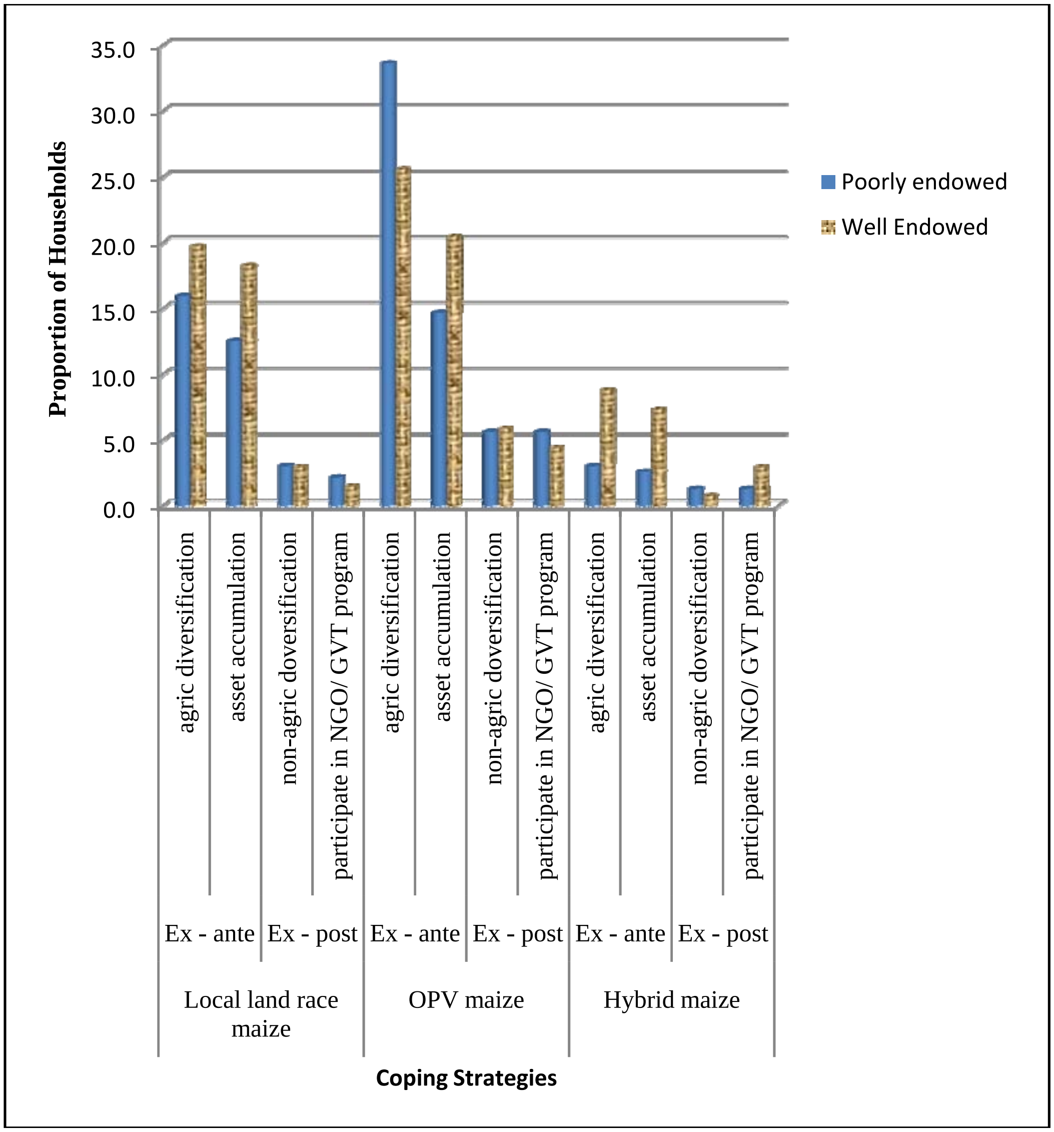


Figure 7. Production risk coping strategies adopted by wealth groups.

Households' perception about price risk and their coping mechanisms

The major types of price risk that farmers usually face are low output price and/or high input prices. Farmers perceive the effect of changes in output price differently for different maize varieties (Table 22). More proportion of farmers indicated that selling price determines the quantity sold of OPV maize varieties sold than the local and hybrid varieties. Regarding the effect of decrease in grain price on household assets about 43% of the sample households indicated that they would sell some assets if price of OPV maize varieties decreases, 31% said they would sell some of their assets if price of local maize varieties decreases while only 3.8% said they would sell some of their assets if price of hybrid maize varieties grain is decreased. An increase in input use as a result of attractive output price was also reflected more on OPV varieties followed by the local varieties. This shows the relative importance of OPV varieties as compared to hybrid maize varieties which could be associated with the availability and cost of seed of these varieties.

Table 22. Perception of farmers about crop price risks (Proportion of farmers).

Price risk		Local land race	OPV	Hybrid
Selling price determine quantity sold	yes	27.6	30.4	8.4
	no	11.9	27.6	3.5
Effect of decrease in crop price on hh assets	sell some	30.9	42.8	7.6
	unaffected	7.9	16.5	3.8
	keep more	0.8	1.9	0.3
Change in input use as a result of attractive output prices	increase	23.8	30.1	8.4
	same	8.9	16.5	2.7
	decrease	3.0	4.1	0.3

Households in different wealth categories react differently to these risks. For instance, more proportion of well endowed households indicated that they would decrease area of the different maize varieties if there is a tendency of grain price decline in the market while more proportion of the poorly endowed households maintain the area allocated to maize varieties. The difference in the responses against changes in price by the two wealth groups emanates from the purpose for which they grow maize. Since poorly endowed households grow maize mainly for their household consumption, they did not show a response to decrease in maize price in terms of area allocated to the crop. On the other hand, the well endowed households target both household consumption and market and when there is unattractive market price; they react by decreasing area allocated to maize. Similar response was observed for other staple food crops such as sorghum and teff where by the response to price change is not as such important. However, households in both wealth groups indicated that they would reduce the area allocated to beans production if there is unattractive price in the market. This is because beans are a cash crop mainly produced for market.

Table 23. Adjustment in crop portfolio to mitigate price risks (proportion of farmers)

Crop type	Responses to low grain price by wealth category						Whole sample		
	Poorly endowed			Well endowed					
	Decrease	Same	Increase	Decrease	Same	Increase	Decrease	Same	Increase
Local land race maize	11.2	30.6	1.3	19.0	27.7	1.5	14.1	29.5	1.4
OPV maize	15.5	40.9	0.9	21.2	32.1	6.6	17.6	37.7	3.0
Hybrid maize	1.3	6.0	1.3	10.9	13.1	0.7	4.9	8.7	1.1
Sorghum	0.9	3.0	0.4	0.7	2.2	1.5	0.8	2.7	0.8
Beans	45.7	20.7	2.2	59.9	22.6	5.1	50.9	21.4	3.3
Teff	28.4	30.6	6.9	16.1	21.9	6.6	23.8	27.4	6.8

Households use different coping strategies against price risks. Like that of the coping strategies against production risks, there are two types of strategies against price risks (Figure 8). Ex-ante strategy includes only accumulation of assets while ex-post strategy includes participation in NGO/government programs, forward contracting and informal insurance. Among the two types of strategies, the most important is asset accumulation mainly by well endowed households. Asset accumulation could be in the form of livestock and other household assets. Participation in government or non-governmental organizations programs like safety net programs are the second important coping strategies and are practiced by more proportion of poorly endowed households relative to the well endowed group.

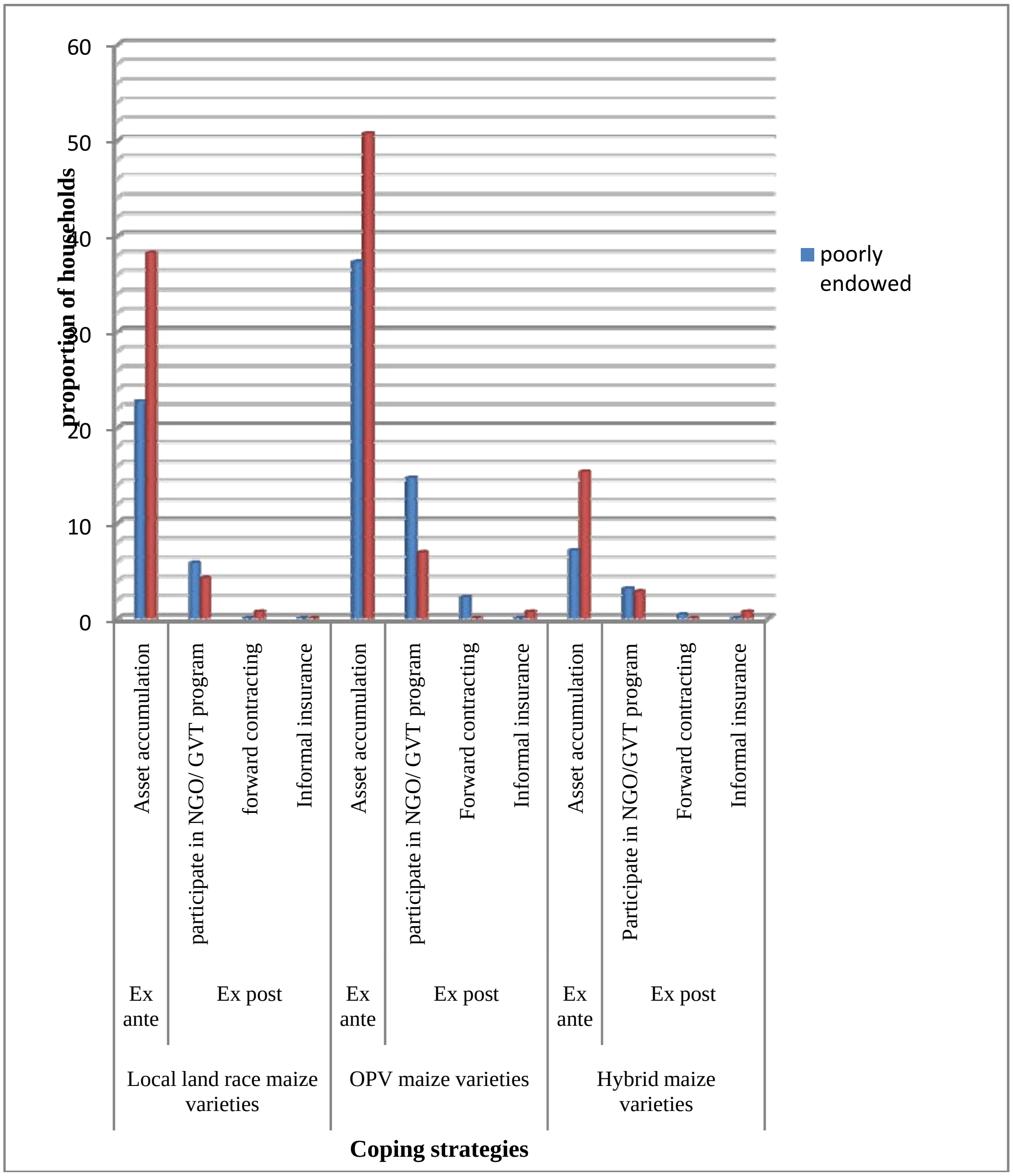


Figure 8. Coping strategies of households against price risks by wealth category.

Though mentioned as one of the ex-post coping strategies, forward contracting and informal insurance are not commonly used in the study areas.

5 Technology use in crop production

5.1 Input use by farm households

Farm households in the study areas use inputs such as chemical fertilizers, herbicides, seeds, insecticides, and animal manure for crop production (Table 24). Among the chemical fertilizers, the most commonly used is NPK fertilizer for basal application. Though some amount of urea is used, it is in very small amounts. The ever increasing fertilizer price discourages using the recommended rates. There is significantly higher level of fertilizer use in Adama District compared to ATJK District. By wealth group there is significantly higher level of fertilizer use by the well endowed households than the poorly endowed ones.

Table 24. Use of non-seed inputs by region and wealth category.

Season	Type of input (kg or lt)	Poorly endowed		Well endowed		Whole sample		F test statistic
		ATJK	Adama	ATJK	Adama	ATJK	Adama	
Major	Basal NPK	61(21)	95(84)	133(117)	285(253)	114(106)	144(168)	27.0***
	Top dress urea	52(23)	61(39)	75(67)	103(112)	65 (53)	76 (75)	5.2**
	Herbicide	4 (4)	2(2)	3(3)	3 (3)	3 (3)	2 (2)	0.2NS
	Insecticide	100(0)		12(11)	1 (0.4)	41 (51)	1 (0.4)	82.6***
	Manure	6(4)	202(305)	12(6)	48 (68)	8 (6)	145(253)	1.9 NS
Minor	Basal NPK	-	30(28)	-	100		53 (45)	4.1 NS

Note: *** Significant at 1%; ** Significant at 5%. (Standard deviation) in parentheses.

Source: Survey data, 2007.

Other inputs such as herbicides, insecticides, and manure are used in the major season only. Herbicides, especially broad leaf killers are commonly used on cereals. This is because of the higher price of selective grass weed killer herbicides relative to the former one. The use of herbicides is higher in Adama relative to ATJK (F=9.49, p=0.000).

Regarding sources of inputs, respondents indicated that they purchased them from different sources. The major sources of chemical fertilizers are agricultural offices followed by traders and cooperatives. However, most farmers consider cooperatives as agricultural offices and it is fair enough to consider the two sources as one. On a day-to-day basis, fertilizer distribution is carried out by cooperatives; it is for this reason that most farmers cannot differentiate names of sources since agricultural extension agents are the ones that facilitate distribution of inputs.

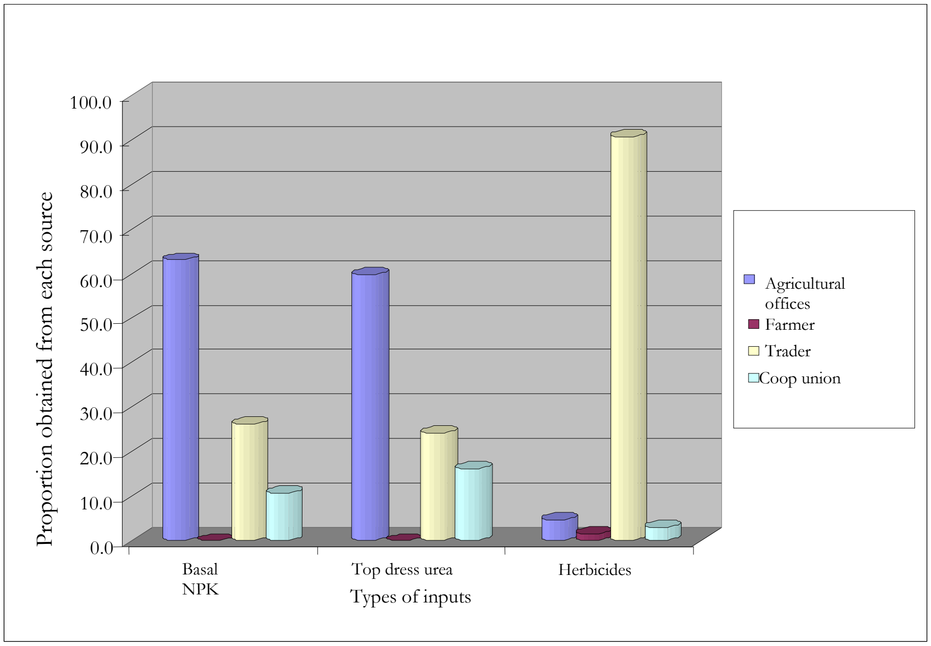


Figure 9. Sources of non-seed crop inputs.

Source: Survey data, 2007

Traders are the main suppliers of herbicides. Farmers buy herbicides from the market and the quality of such herbicides is usually questionable due to possible adulteration by retailers. The recommended rates of application are often not followed due to the high price of herbicides. In principle, the recommended times of application have significant effect on the efficiency of herbicides yet farmers do not follow them. On the issue of safety, almost no farmer takes the recommendations from experts when using herbicides. Herbicides are applied using knapsack sprayers without using any protective clothing.

Information from farmers suggests that about 25 different cultivars of maize are grown in the study areas (Table 25). The most common variety is BH540 followed by Hawassa and Pioneer. It should be noted that these are the names given to varieties by farmers, often reflecting the source of seed.

About 50% of the whole sample farmers have adopted improved maize varieties on 30% of their cropped fields. These figures appear somewhat higher for the well endowed, but the difference is not statistically significant (Table 26).

Table 25. Maize cultivars planted by households in the two selected districts.

	ATJK		Adama	
Variety	**N**	**%**	**N**	**%**
BH540	51	13.8		
Choremo			5	1.4
Habasha			22	6
Hawasa	39	10.6	11	3
Katumani	4	1.1	49	13.3
Keymaize			8	2.2
Limat	9	2.4	17	4.6
Local	9	2.4	7	1.9
Melkasa	10	2.7	15	4.1
Merid	9	2.4		0
Pioneer	31	8.4		
Shaye	33	8.9	12	3.3
Others	12	3.3	44	11.6
Total	207	56.1	190	51.5

Source: Survey data, 2007.

Table 26. Adoption indicators for improved maize varieties by wealth group.

	Poorly endowed (n=224)		Well endowed (n=145)		Total (n=369)		F-statistic
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Intensity of adoption (proportion of land)	0.30	0.29	0.31	0.30	0.30	0.29	0.05 NS
Rate of adoption (proportion of farmers)	0.48	0.50	0.53	0.50	0.50	0.50	0.00 NS

Source: Survey data, 2007.

With respect to the desirable characteristics of maize varieties: early maturity, palatability of the grain, resistance to lodging, drought tolerance, and performance under fragile soil condition are the most important factors that determine the acceptance and use of a certain maize variety (Table 27). Early maturity is a very important factor related to escape of the crop from terminal drought and also serving as a crop rescuing households earlier in the season when they face food shortage (before other crops mature). Since maize is cultivated mainly for household consumption, it should have a desirable taste and be palatable in different forms.

Table 27. Perceptions of desirable characteristics of maize varieties (% of respondents).

	Non Adopters	Adopters	Whole sample
Disease resistance	16.8	14.1	15.4
Field pest resistance	20.5	10.3	15.4
Storage pest resistance	20.5	10.3	15.4
Early maturity	54.1	83.2	68.6
High yielding	37.3	51.1	44.2
Performance under poor soil condition	38.9	50.0	44.4
Performance under drought condition	36.8	49.5	43.1
Resistance to lodging	40.5	60.9	50.7
Cob size	31.9	43.5	37.7
Grain size	36.8	47.3	42.0
Palatability	44.3	63.0	53.7

Source: Survey data, 2007

Farmers obtain maize and other crop seeds from different sources, especially from traders and agricultural offices (Figure 10). Farmer to farmer seed exchange is also indicated as an important source of seed next to offices of agricultural development. As indicated earlier, NGOs also supply seed to farmers.

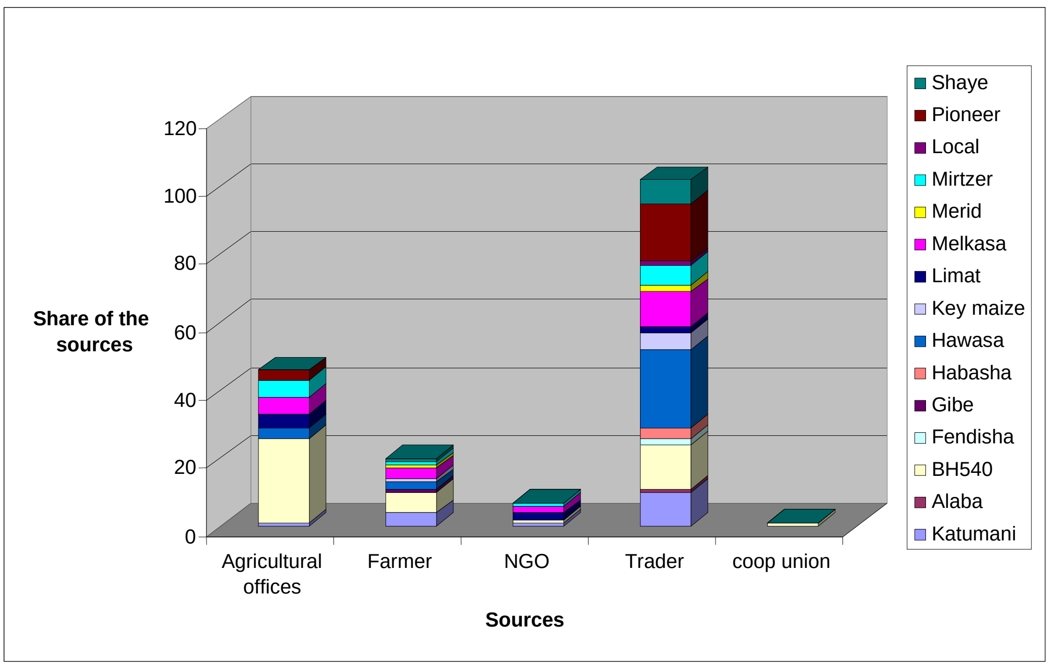


Figure 10. Sources of maize seed.

Source: Survey data, 2007.

5.2 Adoption of improved drought tolerant maize varieties

Results of data analysis reveal that 53% of the well endowed households have adopted improved drought tolerant maize (IDTM) varieties and planted them on 23% of their cultivated land. On the other hand, 47% of the poorly endowed households adopted these varieties and 20% of their cropped land is covered with these varieties. About 50%

of the whole sample farmers have adopted IDTM and planted them on 21% of their cropped field.

Factors affecting the probability of adoption and use intensity of improved drought tolerant maize varieties are separately discussed in this section based on the results of the double hurdle model (Table 30).

The observed adoption choice of an agricultural technology is hypothesized to be the end result of socio-economic characteristics of farmers (Table 28) and a complex set of inter-technology preference comparisons made by farmers (Adesina and Forson 1995). The empirical analysis permits the investigation of the decision whether or not to adopt improved drought tolerant maize varieties and the conditional level of the technology if the initial adoption decision was made. Several hypotheses can be derived on these two sets of decisions - factors that affect adoption and factors that affect intensity of adoption of IDTM varieties.

A farmer's age may negatively influence both the decision to adopt and extent of adoption of improved maize varieties. It may be that older farmers are more risk averse and less likely than younger farmers to be flexible; thus have a lesser likelihood of adopting new technologies. However, it could also be that older farmers have more experience in farming and are better than younger farmers at assessing the beneficial characteristics of modern technology; hence having a higher probability of adopting the practice. Adesina and Forson (1995) indicated that the expected result of age is an empirical question. There is no agreement in the adoption literature on this as the direction of the effect is generally location or technology specific.

Family size, a proxy for labor availability, may influence the adoption of IDTM varieties positively as its availability reduces the labor constraints faced in maize production. Education augments one's ability to receive, decode and understand information relevant to making innovative decisions (Wozniak 1984). This creates an incentive to acquire more information. Farmers with more education should be aware of more information sources, and be more efficient than those with less education in evaluating and interpreting information about innovations. Thus it is hypothesized that farmers with more education are more likely to be adopters than farmers with less education. Linear education scores, which allow the effect of education on adoption to vary according to the educational level (i.e., illiterate, read and write, primary and secondary education), are used in this study. Their coefficients are interpreted in the same way as a coefficient of a continuous schooling variable, that is, approximately the percentage effect that the variable has on adoption. This educational variable was classified so as to have quite a good number of farmers in each group and to make a distinction between the educational phases.

The decision to adopt any single innovation depends on the availability of interrelated inputs (Wozniak 1984). This suggests that the decision to adopt a current innovation may be conditional on the utilization of previously available complementary inputs. The availability of credit may positively influence adoption of improved maize varieties by relaxing the binding capital constraints that farmers face through financing the variable costs associated with production of IDTM varieties.

Agricultural extension may also enhance the efficiency of making adoption decisions. In the world of less than perfect information, the introduction of new technologies creates a demand for information useful in making adoption decisions (Wozniak 1984). Of the many sources of information available to farmers, agricultural extension is the most important for analyzing the adoption decision. Based on the innovation-diffusion literature (Adesina and Forson 1995), it is hypothesized that extension visits are positively related to adoption by exposing farmers to new information and technical skills. Also, the availability of off-farm income can affect the probability of adoption positively since it can increase the farmer's financial capacity to pay for improved inputs.

Table 28. Descriptive statistics of farm and farmer specific characteristics.

		Poor endowed		Well endowed	
		Mean	**SD**	**Mean**	**SD**
Age	Age of household head in years	41.54	14.7	43.22	14.57
Credit	1 if household has access to credit and 0 otherwise	44	19.6	37	25.5
Education	Education level of household head (ordered dummies 0= illiterate, 1= literate)				
Extension visit	number of contact with extension agents	1.08	1.92	1.63	2.59
Family size	Family size (number of people in the household)	5.2	2.71	8.9	4.39
TLU	Livestock ownership in Tropical Livestock Units (TLU)	2.7	2.51	10.67	8.3
Off farm income	1 if the household has access to off farm income and 0 otherwise	0.57	0.5	0.25	0.43
Farm size	Total farm size in ha	1.79	0.85	4.3	2.3

Source: Survey data, 2007.

Regarding the technology specific attributes affecting the probability of adoption and use intensity of agricultural technologies, it has been shown (Joshi and Pandey, 2005, Adesina and Forsen, 1995, Adesina and Zinnah, 1993) that farmer perceptions of the technology specific traits are the major factors influencing the adoption behavior. Considering this fact, each respondent was asked to compare the available best (IDTM) varieties with the best local varieties of their choice in terms of seed cost, availability, market grain price, diseases and pests resistance, storability, early maturity, yield potential, drought, lodging, and soil infertility tolerance, cob and grain size, and palatability when prepared in different forms (Table 29).

Since improved seeds are more expensive relative to local seeds, seed cost is hypothesized to be negatively related to the probability of adoption. In order to make use of technologies, farmers should be able to get seeds either in the formal or informal distribution systems. This is generally affected by the location of farmers (distance) from the center and activity of the extension system in the area. Areas closer to the administrative centers have better access to seeds and other inputs. Price in the grain market has also a direct impact on the adoption behavior of farmers. If farmers perceive that there will be low grain price, the probability of adoption and proportion of maize area under the IDTM varieties will decrease. If farmers perceive that a certain variety has better diseases, pests, and lodging tolerance, there will be higher probability for adoption of such varieties. Better yield potential and storability, early maturity and tolerance to poor soil fertility conditions are hypothesized to be positively related to the probability and use intensity of IDTM varieties. If farmers perceive that improved varieties have larger seed and cob sizes and are more palatable than the local varieties, rate and intensity of adoption are expected to be higher.

Table 29. Descriptive statistics of technology specific attributes.

		Poorly endowed		Well endowed	
		Mean	**SD**	**Mean**	**SD**
Seed cost	1 if farmer perceives the improved seed cheaper than the local one and 0 otherwise	0.15	0.36	0.14	0.35
Grain market price	1 if the farmer perceives grain price is higher for local maize than the improved one in the market and 0 otherwise	0.22	0.42	0.19	0.4
Early maturity	1 if improved varieties are perceived early maturing than the improved one and 0 otherwise	0.69	0.46	0.68	0.47
Yield Potential	1 if improved varieties are perceived high yielding than the local one and 0 otherwise	0.38	0.49	0.54	0.5

Source: Survey data, 2007.

5.3 Factors influencing the probability of adopting IDTM varieties

The empirical results indicate that age of household heads, availability of off farm income, farm size, perception of farmers about early maturity of improved maize varieties and expectation of grain market price significantly influence the probability of adoption of these varieties for the whole sample. Interestingly, different factors influence the probability of adoption of IDTM varieties for the different wealth categories. For instance, household size and availability of off-farm income influence the probability of adoption and use intensity of IDTM varieties only for poorly endowed households where as livestock ownership and farm size influence the probability of adoption and use intensity of these varieties for well endowed households only.

One of the interesting results of this study is the positive sign of age for all households which is contrary to the a priori expectation implying the higher probability of adoption of IDTM varieties for older household heads. This could be because of many years of experience of older farmers to understand the weather pattern of their areas and select varieties that can better tolerate drought.

The significant influence of livestock ownership on the probability of adoption of IDTM varieties could be because of two important reasons. First, the use of maize leaves and stem for livestock feed (Berhanu et al. 2007). The more the number of TLU a household owns, the more will be the need for feed and hence the higher the probability of adoption of IDTM varieties that can tolerate the drought conditions and provide feed to livestock. On the other hand, more TLU implies the availability of more draught power for seed bed preparation and better probability of adoption of IDTM varieties. The influence of livestock is significant only for well endowed households since there is a statistically significant difference (F=109.9) in the average number of TLU of animals owned by the two wealth groups (Table 9).

Family size significantly and positively influences the probability of adoption of IDTM varieties for poorly endowed households. This could be because of increase in food demand of the household as family size increases and dependence of poorly endowed households on their own production for household consumption. Moreover, more number of household members entails more labor force to work on maize fields and the poor farmers that can not afford to hire extra labor can make use of their family labor for maize production.

Farm size significantly and positively influences the probability of adoption of IDTM varieties for the well endowed households and the whole sample while it is not as such significant for poor households. This could be because poor households grow drought tolerant IDTM varieties regardless of their plot size in order to secure food for their household.

Contrary to a priori expectation, extension visit is found to negatively affect the probability of adoption of IDTM varieties. This is not surprising because there has been a tendency to use extension agents for other purposes like collecting taxes and loans rather than visiting farmers to advise on purely agricultural technical matters.

One of the most important means of livelihood for poor households is involvement in off-farm activities to generate additional income. The results of this survey also reveal the fact that availability of off farm income generating activities significantly influences the probability of adoption of IDTM varieties. This could be because of additional income that could be spent to purchase more inputs and increase the capacity of farmers to take risks in growing these varieties. The non-significant effect on the well endowed households could be because of the less involvement of these wealth groups in off farm activities.

The other interesting result of this study is the sign and influence of expected grain market price on different wealth groups. As indicated above, expectation of lower grain market prices negatively influences the probability of adoption of IDTM varieties. This implies that when there is an expectation of lower grain prices, well endowed households could go for other crops. This could be because well endowed households consider the marketability of IDTM varieties in addition to food production for their household.

As expected, perception of farmers about the early maturity of IDTM varieties significantly and positively influences the probability of adoption of these varieties regardless of the wealth category of households. Early maturity is the characteristics of maize varieties needed to escape from terminal drought, and to use the crop when there is critical food shortage. Maize can be harvested green and consumed while other crops are at their early growth stage and households run out of their food reserve. The strong significant effect of this variable on the probability of adoption for both well groups shows the importance of maize for the household food security in the study areas.

Table 30. Maximum likelihood estimate of the double hurdle model.

Variables	Whole sample (n=369)	Poor (n=224)	Well endowed (n=145)
First hurdle: *probability of adopting improved maize varieties; Dependent variable: whether a farmer adopted improved maize varieties or not*			
Family size	0.007(0.005)	0.023(0.008) ***	0.000(0.005)
Age	0.009(0.001) ***	0.009(0.001) ***	0.007(0.001) ***
Number of extension contact	-0.003(0.008)	-0.003(0.014)	-0.002(0.008)
Livestock ownership (TLU)	0.002(0.002)	0.000(0.004)	0.005(0.001) ***
Farm size	0.024 (0.009) ***	0.005(0.029)	0.045(0.009) ***
Access to credit	0.058(0.039)	0.017(0.056)	0.075(0.050)
Have off farm income	0.121(0.031) ***	0.097(0.042) **	0.075(0.049)
Early maturity of the varieties	0.323(0.040) ***	0.295(0.053) ***	0.334(0.058) ***
Seed cost	0.018(0.044)	0.045(0.061)	-0.028(0.058)
Grain market price	-0.083(0.045) *	-0.061(0.064)	-0.165(0.060) ***
Yield potential of the variety	0.038(0.035)	0.061(0.046)	0.051(0.051)
Second hurdle: *adoption intensity; Dependent variable: proportion of area under IM varieties*			
Family size	0.027(0.019)	0.088(0.032) ***	-0.001(0.025)
Age	0.034(0.004) ***	0.034(0.005) ***	0.033(0.007) ***
Number of extension contact	-0.012(0.030)	-0.012(0.053)	-0.008(0.039)
Livestock ownership (TLU)	0.009(0.006)	0.000(0.017)	0.026(0.008) ***
Farm size	0.097(0.037) ***	0.018(0.109)	0.225(0.047) ***
Access to credit	0.231(0.156)	0.064(0.212)	0.370(0.249)
Have off farm income	0.479(0.130) ***	0.368(0.165) **	0.371(0.247)
Early maturity of the varieties	1.285(0.167) ***	1.122(0.207) ***	1.656(0.303) ***
Seed cost	0.070(0.176)	0.171(0.231)	-0.139(0.287)
Grain market price	-0.330(0.180) *	-0.234(0.245)	-0.815(0.300) ***
Yield potential of the variety	0.152(0.139)	0.231(0.176)	0.255(0.254)
Constant	-3.975(0.203) ***	-3.806(0.262)	-4.957(0.393)
Censored observations	*185*	*117*	*68*
Log likelihood	*-71.967*	*-53.022*	*-4.765*
Wald Ch2(10)	*2911.49****	*1575.72****	*1866.54****

Note: *** Significant at 1%; ** Significant at 5%; * significant at 10%. (Standard errors) in parentheses.

Source: Survey data, 2007.

5.4 Factors influencing the intensity of use of IDTM varieties

The second hurdle of the model examined the intensity of adoption of IDTM varieties as presented in the second section of Table 30 and the marginal effects in Table 31. The marginal effects are used to calculate percentage changes in the dependent variable when the exogenous variable shifts from zero to one for categorical variables and elasticities at the sample means for continuous variables.

Table 31. Marginal effects of adoption intensity after double hurdle estimation.

Explanatory variables	Whole sample (n=369)	Poorly endowed (n=224)	Well endowed (n=145)
Family size	0.007	0.023***	0.000
Age	0 .009***	0.009***	0.007***
Number of extension contact	-0.003	-0.003	-0.002
Livestock ownership (TLU)	0.002	0.000	0.005***
Farm size	0 .024***	0.005	0.045***
Access to credit	0.058	0.017	0.075
Have off-farm income	0.121***	0.097**	0.075
Early maturity of the varieties	0.323***	0.295***	0.334***
Seed cost	0.018	0.045	-0.028
Grain market price	-0.083**	-0.061	-0.165***
Yield potential of the variety	0.038	0.061	0.051

Note: *** Significant at 1%; ** Significant at 5%; * significant at 10%..

Source: Survey data, 2007.

Family size is found to significantly and positively influence the intensity of adoption of IDTM varieties for the poorly endowed households. If household size increases by one person above average household size of the group (5 persons/household), the area allocated to these varieties increases by 2.3%. Age of household head is also a positive and significant determinant of the intensity of adoption of IDTM varieties for households in both wealth groups. As the age of a household increases by one year above the average age (42 years), the area of IDTM varieties increases by 0.9% for the poorly endowed and 0.7% for the well endowed households. Similarly, livestock ownership (sometimes a proxy for wealth accumulation) is found to influence, positively and significantly, the intensity of use of IDTM varieties for the well endowed households. Each additional one TLU of livestock that a household owns increases the area allocated to these varieties by 0.5% for the well endowed households. Farm size also influences the intensity of use of IDTM varieties positively and significantly for the well endowed households. As farm size increases by one hectare above the average holding for the group (4.3ha), the area allocated to improved maize varieties increases by 4.3%. On the other hand, availability of off-farm income positively and significantly influences the proportion of crop area allocated to IDTM varieties for the poorly endowed households.

The other important factors influencing the proportion of cultivated land allocated to maize varieties are perceptions of the farmer about early maturity of the variety and expectation of lower grain price in the market. If a farmer perceives that a given IDTM variety is early maturing, she or he can increase area allocated to these varieties by 29.5% for a poorly endowed household and 33.4% for well endowed household. If a well endowed household expects lower grain price in the market, they can shift 16.5% of the area allocated to IDTM variety to other crops.

6 Conclusions and implications

Since technological change can affect the level of output, product quality, employment, trade, and profits—the adoption of new technologies offers economic opportunities and challenges. Consequently, understanding the adoption process continues to be of interest to researchers and policy makers. The impact of new technologies on the livelihood of farm households is of particular interest to policy makers.

Using a principal component analysis, a wealth index was constructed for the sample households. Accordingly, the index value for about 61% of the sample households was below zero and these households are categorized as poorly endowed. The rest 39% had a wealth index value greater than zero and are classified as well endowed households.

A double hurdle model was used to investigate factors affecting the probability and use intensity of improved maize varieties. This model was selected because of its capacity to take care of a two stage process in adoption of agricultural technologies. The first hurdle takes care of factors affecting the probability of adoption while the second hurdle handles factors affecting the intensity of use of the technology.

The results of this study indicated that factors influencing the adoption and use intensity of improved maize varieties are not the same for the two wealth categories implying the need for targeting them with different packages of technologies.

The other aspect in which the results are interesting is that more years of experience in farming is associated with higher use levels of improved maize varieties. This implies, as the farmer's age and experience in farming increases for adopters of IDTM varieties by 1 year above the average age (42 years), the area of land allocated to maize varieties increases by 0.9%. This suggests the need to focus on experienced, aged farmers to ensure wider coverage with maize varieties. As a farmer learns more about the technology through own experience, the scale of adoption increases. Therefore, having experience after adoption decisions makes farmers more efficient in carrying out the tasks necessary to expand the intensity of the technology, tasks such as the gathering and interpretation of information relevant to making the decisions.

The positive effect of livestock ownership on well endowed households is another issue needing due attention. As ownership of livestock increases by 1 TLU above the average of the group (14.1 TLU), the proportion of area allocated to improved maize varieties increases by 0.5%. This implies the need to consider alternative ways in which poorly endowed households can get access to draft power in order to use the IDTM varieties at wider scale.

The influence of farmers perception about the early maturity of IDTM varieties is another important issue that has to be given due consideration. Since households in drought prone areas rely on IDTM varieties for their household food they can increase the proportion of land allocated to these varieties by as much as 32% if they perceive the variety as early maturing. Thus, it is important to focus on the development and dissemination of early maturing IDTM varieties in order to achieve maximum adoption in the drought prone areas.

Expectations of lower grain prices in the market significantly and negatively influence the probability of adoption and use intensity of IDTM varieties. If a farmer expects lower grain price, she/he can divert as much as 16.5% of area allocated to IDTM varieties to other crops. This implies the need to consider the market scenario in the technology development and dissemination.

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Annexes

Annex 1. Maize varieties developed by the research system and their areas of adaptation.

Variety	Altitude (masl)	Rainfall (mm)	Days to maturity	Year Released	Experi-mental yield (Qt/ha)	On Farm yield (Qt/ha)	Source
Open Pollinated Varieties							
Melkasa-V	800-1600			2006			EIAR/MRC
Melkasa-IV	1000-1800			2006			EIAR/MRC
Hora	1800-2600			2005			EIAR/MRC
Melkasa-II	1200-1700			2004			EIAR/MRC
Melkasa-III	1200-1700			2004			EIAR/MRC
Melkasa-I	500-1600			2001			EIAR/MRC
Gusaw (Gambela Composite or Abobako)	500-1000			2002			EIAR/BRC
Gibe Composite-1	1000-1700			2001			EIAR/BRC
Rarare-1							Haramaya Univ.
Tesfa (AC9V-6)	1550	600-1000	110	1996	35-50	25-30	Hawassa Univ.
Fetene (ACV-3)	1550	600-1000	110	1996	35-50	25-30	Hawassa Univ.
Kuleni*	1700-2200	1000-1200	150	1995	60-70	40-45	EIAR/BRC
Gutto*	1000-1700	800-1200	130	1988	30-50	25-30	EIAR/BRC
Abo-Bako*	500-1000	1000-1200	150	1986	50-70	35-45	EIAR/BRC
Katumani	1550	600-1000	105		60-70	40-45	
Alemaya* Composite	1600-2200	1000-1200	163	1975	50-70	40-45	Haramaya Univ.
UCB*	1700-2000	1000-2000	163	1975	50-70	40-45	
A-511**	500-1800	800-1200	150	1970	50-60	30-40	Hawassa Research center (HRC)
Hybrid Varieties							
BH-670				2002			EIAR/BRC
BH-QP-542				2002			EIAR/BRC
BH-541				2002			EIAR/BRC
Shindi (Phb-30G-97)				2001			Pioneer
Tabor (30-H83)				2001			Pioneer
BH-540*	1600-2000	1000-1200	145	1995	80-100	50-65	EIAR/BRC
Jabi (PHB 3253)				1995			Pioneer
BH-543				2004			EIAR/BRC
BH-544				2005			EIAR/BRC
AMH-800				2004			EIAR/Ambo
BH-140*	1000-1800	1000-1200	140	1988	80-90	50-60	EIAR/BRC
BH-660*	1600-2200	1000-1500	165	1993	90-120	60-80	EIAR/BRC
BH-530*	1000-1300	1000-1500	137	1997	80-90	50-60	EIAR/BRC
Beletech*	1500-2000	800-1200	160	1990	50-70	40-45	EIAR/BRC

Annex 2. Conversion of Livestock Number into Tropical Livestock Unit (TLU).

Animals	TLU	Animals	TLU
Chicken	0.013	young bulls	0.80
Sheep/goat(adults)	0.13	Cows and oxen	1.00
Young sheep/goat	0.06	Donkey (young)	0.35
Calf	0.20	Donkey (adult)	0.70
Weaned Calf	0.34	Horses	1.10
Heifers	0.75	Camel	1.25

Sources: Storck *et al.(*1991), ILCA, 1993 in Freeman *et al.(*1996)