SOCIO-ECONOMICS
Working Paper 1

December 2011

Characterization of Maize Producing Households in Drought Prone Regions of Eastern Africa

Olaf Erenstein, Girma Tesfahun Kassie, Augustine Langyintuo and Wilfred Mwangi

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International Maize and Wheat Improvement Center

The International Maize and Wheat Improvement Center, known by its Spanish acronym, CIMMYT® (www.cimmyt.org), is an international, not-for-profit research and training organization. With partners in over 100 countries, the center works to sustainably increase the productivity of maize and wheat systems to ensure global food security and reduce poverty. The center's outputs and services include improved maize and wheat varieties and cropping systems, the conservation of maize and wheat genetic resources, and capacity building. CIMMYT belongs to and is funded by the Consultative Group on International Agricultural Research (CGIAR) (www.cgiar.org) and also receives support from national governments, foundations, development banks, and other public and private agencies. CIMMYT is particularly grateful for the generous, unrestricted funding that has kept the center strong and effective over many years.

The Drought Tolerant Maize for Africa (DTMA) Project is jointly being implemented by CIMMYT and the International Institute of Tropical Agriculture (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 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), and the Eiselen Foundation. The project aims to develop and disseminate drought tolerant, high-yielding, locally-adapted maize varieties and to reach 30–40 million people in sub-Saharan Africa with these varieties in 10 years.

Correct citation: Erenstein, O., G.T. Kassie, A. Langyintuo and W. Mwangi. 2011. *Characterization of Maize Producing Households in Drought Prone Regions of Eastern Africa.* CIMMYT Socio-Economics Working Paper 1. Mexico, D.F.: CIMMYT.

AGROVOC descriptors: Africa; eastern Africa; Ethiopia; Kenya, Tanzania; Uganda; maize; plant breeding; food production; research project.

Additional keywords: comparative analysis; characterization; livelihoods; drought; production systems; varietal use; seed use

AGRIS category codes: F01 Crop-husbandry; F02 Plant-propagation; F08 Cropping-patterns-and-systems; E10 Agricultural-economics-and-policies; E15 Farm-organization-and-management; U40 Surveying-methods

Dewey decimal classification: 338.16676

ISBN: 978-970-648-183-2

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Acronyms

FAO	:	Food and Agricultural Organization of the United Nations
hh	:	Household
IMS	:	Improved maize seed
Masl	:	Meters above sea level
OPV	:	Open-pollinated variety
PCA	:	Principal component analysis
PFS	:	Probability of failed season
SSA	:	Sub-Saharan Africa
TLU	:	Tropical livestock unit

Acknowledgements

The present study and the underlying country level studies received financial support from the Drought Tolerant Maize for Africa (DTMA) initiative. This initiative joins the efforts of people, organizations and projects supporting the development and dissemination of drought tolerant maize in 13 countries in SSA. The initiative is supported by the Bill & Melinda Gates Foundation and Howard G. Buffet Foundation. For further information about the initiative reference is made to the project website (http://dtma.cimmyt.org).

The present report synthesizes the findings of the household surveys in the drought prone regions of four eastern Africa countries: Ethiopia, Kenya, Uganda and Tanzania. The authors gratefully acknowledge all those that contributed to the country level studies, in particular Getachew Legese and Moti Jaleta for Ethiopia (Legese et al., 2010); Lutta Muhammad, Domisiano Mwabu, and Richard Mulwa for Kenya (Muhammad et al., 2010); Johnny Mugisha, Gratious M. Diiro and William Ekere for Uganda (Mugisha et al., 2011) and Anna Temu, Appolinary Manyama, Charles Mgeni and Betty Waized for Tanzania (Temu et al., 2011) and CIMMYT colleague, Roberto La Rovere. We are grateful to Kai Sonder from the CIMMYT GIS lab, Mexico for generating the study site map, to reviewers for reviewing and to Wandera Ojanji for editing. The authors are responsible for any remaining errors and inferences.

Abstract

Agriculture in eastern Africa is predominantly rainfed and maize is a major food crop, primarily produced for home consumption and the market by small-scale family farms. The study characterized farm households in the drought prone maize growing areas of eastern Africa synthesizing data from parallel household surveys in Ethiopia, Kenya, Uganda and Tanzania. The study provides a comparative analysis of the farm households' assets, livelihood strategies and crop management practices, with an emphasis on maize and maize seed. This illustrates how farmers in a similar agro-ecological environment but with different socio-economic and institutional settings have variously adapted to living with drought and how the inherent weather risk co-determines the livelihood portfolio, agricultural intensification incentives and system development pathways. The study thereby illustrates the challenges for agricultural intensification in such drought prone environments and the scope for drought tolerant maize varieties and explores the research and development implications.

1. Introduction

Maize is the most important cereal food crop in sub-Saharan Africa (SSA), particularly in eastern and southern Africa where it accounts for 53% of the total cereal area (FAO, 2010) and 30-70% of total caloric consumption (Langyintuo et al., 2010). Maize production in SSA is typically rainfed and drought prone. Drought has an overwhelming importance to SSA, affecting people's livelihoods, food security and economic development. CIMMYT (1990) initially estimated that some 40% of the maize area in SSA experience occasional drought (defined as causing yield losses of 10-25%) and 25% experience frequent drought (defined as causing yield losses of 25-50%). Frequent drought is particularly problematic for tropical and subtropical maize in SSA, and causes a 33% further maize yield reduction compared to less stressed areas (Heisey and Edmeades, 1999). Effective approaches to combat current impacts of drought are of utmost importance, more so as the situation is set to become even worse as climate change progresses (Cooper et al., 2008; Jones and Thornton, 2003; Thornton et al., 2009; Thornton et al., 2008).When recurrent droughts in SSA ruin harvests, lives and livelihoods are threatened, even destroyed.

Developing, distributing and cultivating drought tolerant maize varieties in SSA is one highly relevant intervention to reduce vulnerability, food insecurity and damage to local markets due to food aid. But to succeed it needs to be embedded in local reality. Unfortunately for much of SSA basic descriptive statistics and data on farm livelihoods and practices that would inform such an intervention are not available. It is for this reason that rapid community assessments and detailed household surveys were conducted in drought prone areas of eastern Africa (Ethiopia, Kenya, Uganda and Tanzania) to characterize the maize producing households.

The original country level studies provide detailed descriptive accounts of the household survey findings (Legese et al., 2010; Mugisha et al., 2011; Muhammad et al., 2010; Temu et al., 2011). The present report synthesizes the findings of these four parallel household surveys in drought prone regions of eastern Africa. This synthesis thereby revisits and re-analyzes the original primary data and focuses on the sub-regional contrasts, similarities and implications. The present study is complemented by similar synthesis of parallel household surveys in southern Africa (Zambia, Zimbabwe, Malawi, Angola, and Mozambique) and western Africa (Nigeria, Ghana, Benin and Mali).

The present report is organized into six chapters. The second chapter presents the drought prone study areas of eastern Africa and the methodology. The third chapter characterizes the households based on their livelihood assets whereas the fourth chapter characterizes the household livelihood strategies. The fifth chapter presents the technology use in crop production, with an emphasis on maize and maize seed. The sixth chapter concludes.

2. Study area, materials and methods

2.1 Study area

The four eastern Africa study countries—Ethiopia, Kenya, Uganda and Tanzania—encompass a total population of some 200 million living in an area of 2.9 million km^2. At a country level, Ethiopia and Kenya have about average population densities, but Uganda is more densely populated and Tanzania least (Table 1). Only 12% of the area is considered arable (0.34 million km^2), although this share is about double in Uganda. In Kenya, agriculture contributes a quarter of the Gross Domestic Product (GDP) compared to over a third in the other countries. There is still widespread poverty, particularly in rural areas, although indicators vary as to the depth of poverty (Table 1). Maize is an important crop in the region, annually planted on 7.3 million ha (corresponding to 21% of the arable area and 41% of land under cereals). However, there are some marked regional variations in relative maize area (Table 1), being highest in Kenya and lowest in Ethiopia where maize comes second after teff (*Eragrostis tef*). Ethiopia has also quite diverse and substantial areas under sorghum, wheat and barley. Regional maize yields average only 1.6 tons per ha (Table 1).

Table 1. Selected characteristics of the study countries in eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania
Population density (km^{-2}) [census] [1]	67 [2007]	67 [2009]	103 [2002]	22 [2002]
Arable area (%) [2]	12	9	23	10
Agricultural share in GDP [3]	38	25	35	42
Poverty rate (%) [4]				
- National poverty line	44	47	31	36
- Purchasing power parity $1.25/d	39	20	52	89
- Multidimensional poverty	90	60	-	65
National maize (TE 2008) [2]				
- Area harvested (million ha)	1.7	1.7	.8	3.1
- Production (million tons)	3.7	2.8	1.3	3.6
- Yield (ton/ha)	2.2	1.6	1.5	1.2
Relative maize area [2]				
- % arable land	12	33	15	32
- % cereal area	19	81	47	61

Note: TE: Triennium ending. Sources: [1] Derived from http://en.wikipedia.org/ (accessed Jan 2011); [2]Derived from FAO, 2010; [3] Fan et al., 2008; [4] UNDP, 2010

The study focuses on the drought prone maize producing areas in these four eastern Africa countries. In each country, two maize growing districts were purposively selected from the medium drought risk zone, defined as having a 20-40% probability of failed season (Thornton et al., 2006). This indicator reflects the percentage of years in which an annual crop is expected to fail due to severe water stress based on simulated data using a weather generator and the estimated actual and potential evapo-transpiration and length of the growing period (Thornton et al., 2006).

The selected study areas primarily fall in the dry-subtropical ecology (i.e. 900-1500 meters above sea level [masl] with < 1000 mm pa, CIMMYT, 1990) - Table 2. This dry subtropical ecology typically represents a substantial share of the maize area in the respective countries, although its share in the total production is typically more limited due to the incidence of drought and correspondingly lower productivity levels. The study areas are characterized primarily by small-scale mixed crop-livestock systems. Irrigation is largely absent, with maize being a major crop in the main rain season. In areas with bimodal rainfall, maize is also grown in the second rain season, albeit that the main season remains dominant in terms of maize area and production.

The study areas in Ethiopia and Tanzania are centrally located and situated within or adjacent to the Rift Valley. In Kenya the study areas are in Eastern Kenya – east of the Rift Valley and Nairobi. In Uganda the study sites are located in the countries central-eastern parts, on opposite sides of Lake Kyoga, north of Kampala (Figure 1). With the exception of Uganda, the population densities in the study areas (Table 2) tend to be higher than for their respective countries (Table 1), reflecting that large swathes of the respective countries are even less favorable for agriculture.

Table 2. Selected characteristics of the study areas in eastern Africa.

	Ethiopia	**Kenya**	**Uganda**	**Tanzania**
Survey area	Rift valley & Central	Eastern	Central & Eastern	Central
Survey districts [1]	Adama	Machakos (Kangundo)	Nakasongola	Chamwino (Dodoma rural)
	ATJK	Makueni (Kaiti)	Soroti	Manyoni
Survey administrative region	East Showa, Oromia Region	Eastern Province	Central & Eastern Regions	Dodoma & Singida Regions
Population density (km^{-2})	184	118	41	31
Altitude (masl)	1200-1800	1000-1400	900-1800	800-1350
Rainfall (mm pa)	600-800	<800	750-1250	400-750
Rainfall modality	Mono-modal	Bimodal	Bimodal	Mono-modal

Note: [1] ATJK: Adami Tulu - Jido Kombolcha. In case of Kenya survey focused on a sub-district or constituency (name mentioned in brackets). In Tanzania Dodoma Rural district was divided in 2007 into 2 new districts - Bahi and Chamwino (http://en.wikipedia.org/), with the survey being implemented in the latter. Source: derived from country reports (Legese et al., 2010; Mugisha et al., 2011; Muhammad et al., 2010; Temu et al., 2011). Population density based on combined districts, except for Tanzania based on aggregate regional data (http://en.wikipedia.org/ accessed 26 Jan 2011). For Ethiopia rural population density for Adama was used.

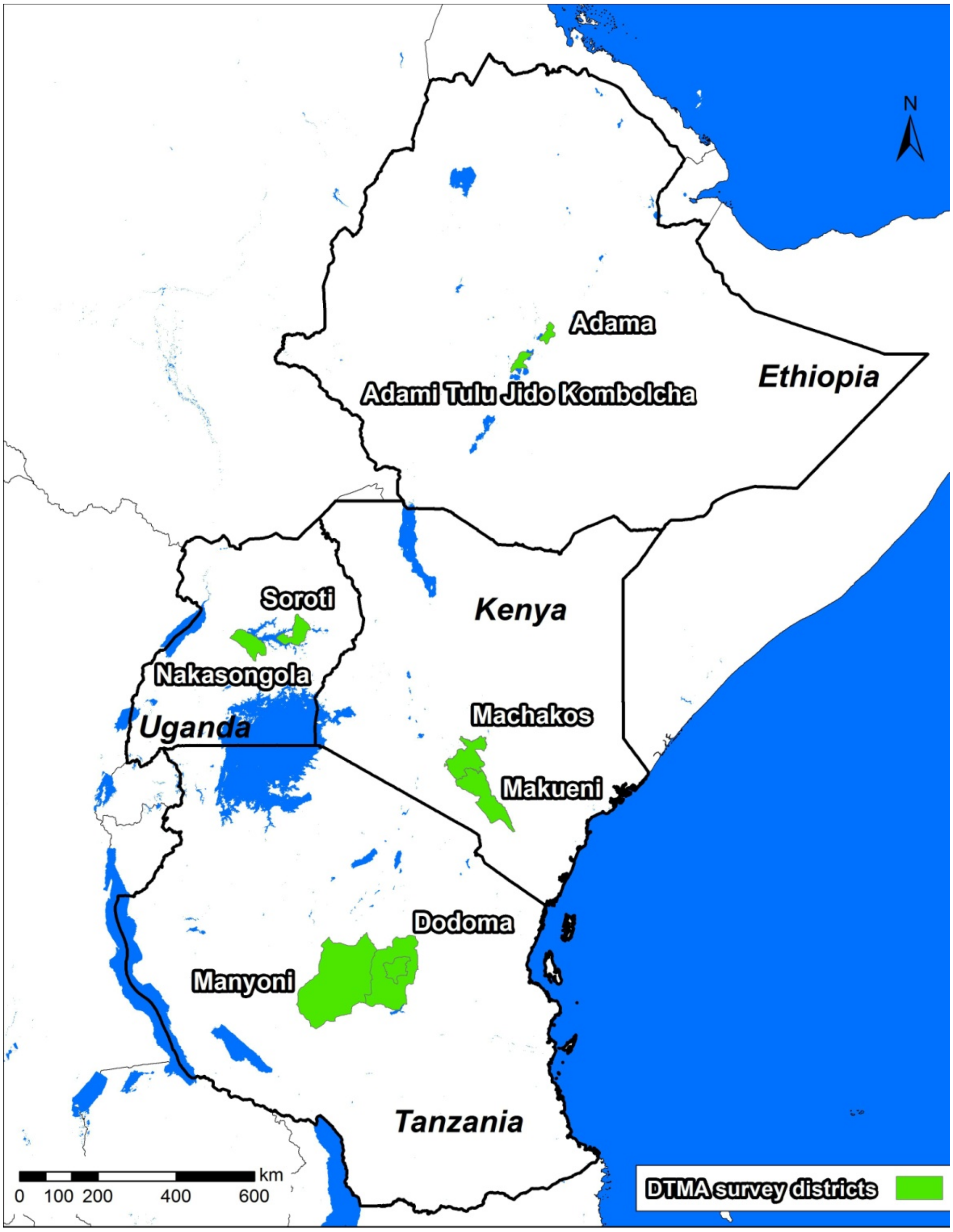

Figure 1. Location of survey districts in the sub-region.
Source: Created by Kai Sonder, CIMMYT GIS lab, Mexico

2.2 Material and methods

From the two selected drought prone maize producing districts, a multi-stage random sample of farm households was selected – with a number of random villages selected first (Annex 1) and from these, a number of random farmers. In the first batch of survey countries (Ethiopia and Kenya), the sample amounted to some 350 farm households with the survey being implemented mid-2007 (Table 3). The survey was subsequently extended to a second batch of survey countries (Uganda and Tanzania) with a sample size of some 150 farm households with the survey being implemented in mid-2008 (Table 3).

Table 3. Sample characteristics in the drought prone study areas of eastern Africa.

		Ethiopia	Kenya	Uganda	Tanzania
Surveyed districts	1	Adama	Machakos	Nakasongola	Chamwino
	2	ATJK	Makueni	Soroti	Manyoni
Sample size (# of hh)	1	172	175	71	75
	2	197	174	78	77
Total		**369**	**349**	**149**	**152**
Survey year		2007	2007	2008	2008

The comprehensive questionnaire was basically the same across the four countries – albeit that some additional questions were added to the second batch of survey countries.[1] In each country, the survey was collected by dedicated enumerators during a single visit. The information collected reflects the respondents' responses, with no additional measurements from the surveyor side (except for global-positioning system coordinates where collected). The enumerators typically interviewed the household head (80% of cases), with on average 28% of respondents being female (Table 4). Ethiopia and Kenya however stand out: in Ethiopia female and non-household head respondents were virtually absent, whereas in Kenya these amounted to about half the respondents. Household heads are typically male. Having the non-household head as respondent was typically associated with the temporary non-availability of the household head (Table 4).

Table 4. Selected characteristics of respondents in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (n)
Female respondent (% hh)	5	51	24	30	28 (1019)
Respondent not hh head (% hh)	1	46	15	13	20 (1018)
If other respondent, head absent >6 months p.a. (% hh)	0	25	0	5	20 (199)

The data was originally entered, analyzed and reported at the country level using a common data template and report outline (Legese et al., 2010; Mugisha et al., 2011; Muhammad et al., 2010; Temu et al., 2011). Since these are parallel studies, a synthesis based on the country reports alone is typically problematic (e.g. see Doss et al., 2003). For the purpose of this synthesis, the datasets were merged and standardized to allow for cross-site analysis. The data presented here may therefore differ somewhat from that reported in the original country studies in view of standardization of approach and data across the country studies.

The data analysis presented here is primarily descriptive – substantiated by simple statistics to the extent possible. Variances were typically not equal over the countries. The analysis therefore uses the Welch statistic to test for the equality of group means (which is preferable

[1] These are not synthesized here as they were only collected for the second batch countries (Uganda and Tanzania).

to the F statistic when the assumption of equal variances does not hold); and Tamhane's T2 for a conservative pair-wise comparison test of means (based on a t test which is appropriate when the variances are unequal - SPSS 16). Principal component analysis is used to assess the households' resource endowments. Limited dependent variable models are used to analyze improved maize seed purchases.

The present report aims to provide a comprehensive synthesis of a substantive survey. As such, all relevant variables for the four countries have been summarized in the numerous tables. However, to keep the report to a manageable length, the text tends to only summarize the pertinent findings. The interested reader is referred to the respective tables or underlying country reports for further substantiation.

To facilitate comparison, all monetary values have been converted to US dollars using the bank exchange rate for the survey year (http://www.oanda.com/currency/converter/ accessed October 2010).[2]

The original survey collected information on maize and other crops grown by the surveyed farm households. For the purpose of the present report and underlying analysis, the information on these other crops is typically categorized into either other cereals, legume crops, roots & tubers or other crops. Maize is categorized as local, improved open-pollinated variety (OPV) and hybrid based on the actual maize varieties reported by the surveyed farmers. However not all farmers are fully conversant with such categorization and the analysis thereby typically uses the prevailing categorization within the surveyed communities. Even so, this categorization remains indicative, for instance, the local category may include some of the older recycled improved varieties. The use of improved OPVs or hybrids also does not necessarily imply the use of fresh seed, as recycling of both categories is common.

It should be recalled that the surveys targeted the drought prone maize producing areas, and are limited to only two districts per country. The study results are thus not representative for the country as a whole, but were intended to be representative for the target area. Care should thus be taken when interpreting references to specific countries in the tables or text, with most instances unless otherwise specified, referring to the drought prone study areas and not to the country as a whole. Furthermore, the present synthesis aggregates the two study districts per country. Within country differences are explored in the respective country reports.

[2] ET: 8.8877 Ethiopian Bir/US$; KY: 66.55 KSh/US$; UG: 1555 USh/US$; TZ: 1149.4 TSh/US$.

3 Household characteristics

In the pursuit of their livelihood strategies, farm households in the drought prone areas of eastern Africa draw on a portfolio of assets. The present chapter characterizes the livelihoods assets of the farm households namely, human, natural, physical, financial and social capital. The chapter ends with a principal component analysis of the household asset base.

3.1 Human capital

The size of the surveyed rural households averages seven people, of which only half can be considered as economically active (i.e. being aged between 16-60 years) and the remainder primarily being children (i.e. less than 16 years old - Table 5). Households are typically male headed (90%) with households' head being married (87%), 46 years old and having completed only primary education (Table 5; Table 6).

The surveyed rural households are typically small-scale family farms, drawing on the family as their main labor source. Each household comprises an average of 4.3 adult equivalents, which implies 3.3 adult equivalents per ha of farm land and 0.6 adult units per capita. An annual average of 51 months of family labor (including children) is reportedly dedicated to the family farm. The household head is the main decision maker for farming activities – either solely (68%) or in consultation with other (27% - Table 5). Households are thereby somewhat constrained by the relatively limited educational level of the household head – with the household's educational status only being marginally better (i.e. when considering the highest educational status across household members), with an average of only 5 years of schooling per capita (Table 6).

The sample averages mask some substantial variations between the countries surveyed (Table 5; Table 6). For instance, household size in the study areas was substantially higher in Uganda and Ethiopia (8) and lowest in Tanzania (5), the latter also having the highest incidence of female headed households (18%). The Kenya study area combined relatively aged households (as illustrated by average household age; limited share of children; oldest household heads) with the most decentralized decision making with respect to farming; whereas the Ethiopia study area combined relatively young households, male dominance and relative low educational attainment levels of particularly the household head.

Table 5. Selected household characteristics of surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd, n)
Household size (#)	7.7^{c}	6.3^{b}	8.3^{c}	5.2^{a}	6.9 (±3.4, 1018)
Hh members by age bracket (% hh members, 1016)					
- <16	53^{c}	32^{a}	49^{c}	44^{b}	44 (±22)
- 16-60	43^{a}	54^{c}	46^{ab}	50^{bc}	48 (±21)
- >60	4^{a}	14^{b}	5^{a}	6^{a}	8 (±16)
Female headed hh (% of hh)	5	12	10	18	10 (±30, 1013)
Age (years)					
- household head	42^{a}	52^{c}	46^{b}	43^{ab}	46 (±15, 983)
- household members	16^{a}	28^{c}	21^{b}	23^{b}	22 (±11, 1017)
Marital status household head (%, n=1014)					
- Single	3	5	3	4	4
- Married	94	81	88	85	87
- Divorced/separated	1	1	3	3	2
- Widowed	2	13	7	8	7
Adult-equivalent units					
- Per household	4.4^{b}	4.3^{b}	5.2^{c}	3.2^{a}	4.3 (±2.3, 1017)
- Per farm ha	2.2^{b}	5.9^{c}	1.8^{a}	1.5^{a}	3.3 (±4.1, 1012)
- Per capita	$.59^{a}$	$.69^{c}$	$.64^{b}$	$.64^{b}$	.64 (±1.2, 1017)
Family farm labor (months/hh pa)	79^{d}	36^{b}	52^{c}	19^{a}	51 (±38, 1016)
Main decision maker farming (%, n=965)					
- Household head	97	30	58	86	68
- Household head with others	1	59	39	14	27
- Other than household head	2	12	2	0	5

Notes: sd: standard deviation; n: sample size; all p's (Welch or Chi-square) highly significant (0.00). Data preceding different letters differ significantly – Tamhane's T2 (significance level: 0.10), within row comparison.

Table 6. Selected education indicators of surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd, n)
Educational status hh head (%)					(1013)
- Illiterate	28	10	5	10	16
- Adult education	12	1	1	1	5
- Primary school	48	54	58	88	58
- Secondary school	10	27	31	1	18
- Post-secondary school	2	8	5	0	4
Years of schooling hh head	4.8 [a]	7.9 [b]	8.1 [b]	5.4 [a]	6.5 (±4.3, 1013)
Highest educational status household (%)					(1017, nr)
- Illiterate	4	0	0	3	2
- Adult education	1	0	0	1	1
- Primary school	61	33	32	84	51
- Secondary school	26	48	52	13	36
- Post-secondary school	7	19	15	1	11
Av years of schooling per capita (n=1017)	3.5 [a]	6.7 [b]	6.3 [b]	3.8 [a]	5.1 (±2.7)

Notes: sd: standard deviation; n: sample size; all p's (Welch or Chi-square) highly significant (0.00) unless otherwise indicated (nr: not relevant [empty cells]). Data preceding different letters differ significantly – Tamhane's T2 (significance level: 0.10), within row comparison.

3.2 Natural capital

Land and livestock are the main natural assets of the farm households, averaging 3 ha of land and 2.6 tropical livestock units, equivalent to about half a unit of each per capita. Land is primarily used for the cultivation of annual crops (2.1 ha), with only 0.2 ha under perennial crops and 0.6 ha under pasture/fallow (Table 7). These averages again mask substantial regional variation. The drought prone study areas in Kenya combine relatively small farms with a modest livestock herd – although this still implies relatively high livestock densities per unit farm area (Table 7). Farm and herd size was the largest in the Uganda study areas, but included a substantial area under fallow/pasture. Perennial crops were primarily limited to the Uganda study areas, linked inter alia to the more favorable rainfall regime (amount and bimodal distribution). Indeed, perennial crops were virtually absent in the study areas of Ethiopia and Tanzania with their limited and mono-modal rainfall.

Table 7. Selected natural capital indicators of surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd)
Average farm size (ha)					
- Per household	2.7 [b]	1.5 [a]	5.0 [c]	4.3 [c]	2.9 (±4.2)
- Per capita	0.38 [b]	0.27 [a]	0.81 [abc]	0.83 [c]	0.47 (±1.2, 1012)
Annual crop area (ha/hh)	2.4 [b]	1.1 [a]	2.8 [b]	2.7 [b]	2.1 (±2.2)
Perennial crop area (ha/hh)	0.03 [b]	0.12 [c]	0.78 [abc]	0.00 [a]	0.2 (±2.1)
Fallow/pasture area (ha/hh)	0.2 [a]	0.3 [a]	1.4 [b]	1.5 [b]	0.6 (±2.0)
Average herd size (TLU)					
- Per household	3.2 [b]	2.0 [a]	3.5 [b]	1.8 [a]	2.6 (±4.0)
- Per farm ha	1.2 [c]	2.1 [d]	0.9 [b]	0.5 [a]	1.4 (±2.6, 1014)
- Per capita	0.42	0.44	0.46	0.31	0.42 (±.98, 1017, ns)

Notes: sd: standard deviation; n: sample size (=1019 unless otherwise indicated); all p's (Welch) highly significant (0.00) unless otherwise indicated (ns: not significant). Data preceding different letters differ significantly – Tamhane's T2 (significance level: 0.10), within row comparison. TLU: tropical livestock unit.

3.3 Physical capital

The rural households in these drought prone study areas are relatively poor, and the physical assets correspondingly limited (Table 8). Indeed, despite the importance of farming for their livelihoods (see next chapter) and the incidence of drought, investments in irrigation have been limited, and largely restricted to Kenya and small-scale vegetable cultivation. Only about half of the households have been able to upgrade their lodging in terms of having improved walls or roofs, although both of these are common place in the Kenya study areas (Table 8).

Households were queried with respect to possession of specific physical asset types. On average about two assets were reported per household, although varying from less than one in Tanzania study areas to nearly three in Uganda (Table 8). The most common asset types are radio (64% overall, particularly common in Uganda and Kenya), draft animals (42% overall, particularly common in Ethiopia) and bicycles (40% overall, particularly common in Uganda). Mobile phones were owned by 22% of the surveyed farm households, but primarily concentrated in Kenya and Uganda (nearly 40%) and relatively absent in Ethiopia and Tanzania (5-7%, Table 8).

Table 8. Selected physical capital indicators of surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd)
Area share irrigated (%)	0.8 [a]	3.2 [b]	0.0 [a]	1.0 [ab]	1.6 (±10.2)
Dwelling (% of hh, n=1018)					
- Brick/block walls	2	90	52	21	42
- Iron sheets/tiles	29	94	48	43	56
Car (% owning)	0	3	4	0	2
Motorcycle (% owning)	0	1	11	0	2
Bicycle (% owning)	27	36	89	34	40
Tractor (% owning)	0	0	0	0	0 (nr)
Draft animals (% owning)	80	20	38	4	42
Draft animal implements (% owning)	83	30	38	6	47
Private well/borehole (% owning)	13	12	3	1	10
TV (% owning)	2	19	1	0	8
Radio (% owning)	53	84	81	30	64
Mobile (% owning)	5	38	39	7	22
Fixed phone (% owning)	2	2	0	0	1 (nr)
# of asset types reported*	1.8 [b]	2.1 [c]	2.7 [d]	0.8 [a]	1.9 (±1.4)

Notes: n=1019 unless otherwise indicated; all p's (Welch or Chi-square) highly significant (0.00) unless otherwise indicated (nr: not relevant [empty cells]). Data preceding different letters differ significantly – Tamhane's T2 (significance level: 0.10), within row comparison. * Asset types as mentioned above except draft animal implements (max 10).

3.4 Financial and social capital

The scarcity of funds reiterates the relative poverty of the rural households in these drought prone study areas (Table 9). The use of credit can help alleviate fund shortages, but was reported by only 15% of households, primarily for production purposes and for fertilizer. Credit use was primarily limited to the study areas in Ethiopia (28% of households reporting) and Uganda (21%). The non-use of credit was mainly linked to unavailability in the vicinity (39%) or lack of collateral (19%), whereas 31% reported not having sought credit (Table 9).

The relatively limited use of credit implies a limited sample size for various specific credit indicators. The credit-using households reported a variety of credit sources, but government programs were relatively important in Ethiopia. Repayments are mainly done in cash. The reported credit amounts (for those receiving) were relatively limited, be it production credit (average US$ 176, n=79), input credit (fertilizer 128 kg, n=49; maize seed 42 kg, n=24) or consumption credit (US$ 273, n=11).

Table 9. Selected credit indicators of surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean
Fund shortage (% reporting, n=1013)	91	74	97	96	87
Credit (% reporting)	28	1	21	5	15
Types of credit (% reporting)					
- Production	13	1	15	3	8
- Consumption	2	0	1	0	1 (nr)
- Fertilizer	13	0	1	0	5
- Maize seed	5	0	3	0	2
- Other seed	0	0	0	0	0 (nr)
# of credit types reported*	0.33 [c]	0.01 [a]	0.21 [b]	0.03 [a]	0.16 (±.44)
Reasons for not using credit (% reporting) **	(n=220)	(n=331)	(n=112)	(n=137)	(n=800, nr)
- no credit source in vicinity	53	27	39	43	39
- did not look for credit	29	37	35	16	31
- no collateral as guarantee	3	29	14	22	19
- high interest rate	8	4	15	1	6
- other	8	2	2	18	7

Notes: n=1019 unless otherwise indicated; all p's (Welch or Chi-square) highly significant (0.00) unless otherwise indicated (nr: not relevant [empty cells; multiple response]). Data preceding different letters differ significantly – Tamhane's T2 (significance level: 0.10), within row comparison. * Credit types as mentioned above (max 5).** Multiple responses possible – does not sum to 100%.

Social capital provides households with important additional social entitlements that are however problematic to measure empirically. The questionnaire did include a number of institutional support indicators that can be used as a proxy (Table 10). About two-fifths of the surveyed farm households were members of a farmers' association/cooperative, although this was markedly more common in Ethiopia (associated with access to inputs) and relatively uncommon in Tanzania. About a third of the surveyed farm households reported having received some aid/relief, mainly in the form of food relief or seed relief. Some 28% attended selected agricultural extension activities (i.e. field days, field demonstrations and/or maize discussions), such activities mainly being organized by agricultural extension services. About half the surveyed farm households reported the extension service as a frequent source of agricultural information, with 19% reporting mass media (i.e. radio, newspaper, television) and 34% other sources, including other farmers (e.g. reported by 35% of households in Kenya). Interestingly, the extension service was near universally reported as information source in Ethiopia compared to less than a fifth in Kenya. About half of the surveyed farm households in Ethiopia and Uganda reported any interaction with extension agents during the survey year against a quarter to a third elsewhere. Overall, surveyed farm households in Tanzania reported limited institutional support in terms of relief or extension, particularly compared to Uganda (Table 10).

Table 10. Selected institutional support indicators of surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean
Member farmers' association/-cooperative (% hh, 1005)	61	34	43	14	42
Hh receiving (% reporting during survey or preceding year)					
- Food relief	9	35	7	1	16
- Seed relief	15	2	18	4	10
- Fertilizer relief	11	0	2	0	4
- Livestock relief	0	0	8	0	1
- Other relief	1	12	15	1	7
- Any of relief/aid	35	44	42	6	35
Hh attending (% reporting for survey year)					
- Field days	4	22	45	6	17
- Demo's	4	13	35	4	12
- Maize discussions	28	18	38	2	22
- Any of above	29	27	48	7	28
Agricultural information source (%, n=924) *					
- Extension service	96	16	32	33	47
- Mass media	4	25	31	25	19
- Other	0	59	37	42	34
Interactions ag. extension agents					
- Any in survey year	45	27	50	33	38
- # of times	1.3 [b]	0.6 [a]	2.2 [c]	0.9 [ab]	1.1 (±2.3)

Notes: n=1019 unless otherwise indicated; all p's (Welch or Chi-square) highly significant (0.00) unless otherwise indicated (nr: not relevant [empty cells; multiple response]). Data preceding different letters differ significantly – Tamhane's T2 (significance level: 0.10), within row comparison. * Multiple responses possible – does not sum to 100%.

3.5 Categorizing household access to capital assets

The foregoing sections show that the surveyed farm households present different endowments in terms of the various livelihood assets. An asset based wealth index can be used to create a single cross-cutting indicator of the household's endowments. One way of creating such an index is the use of principal component analysis (PCA), which has been variously used to create wealth indices (Erenstein, 2011; Filmer and Pritchett, 2001; Langyintuo and Mungoma, 2008).

PCA is a popular data reduction tool. It has however two limitations for the construction of wealth/asset indices (Howe et al., 2008). Discrete data are particularly problematic, and thereby inherently limit the choice of asset variables available for inclusion in the PCA. PCA wealth/asset indices also tend to use only the first principal component which actually explains only a low proportion of the total variation in the asset data. In the current study we thereby exclude discrete asset data and also present all principal components having an *eigen* value larger than 1.

The PCA was applied to a set of eight non-discrete variables spanning the range of asset categories for the surveyed farm households both for the combined study areas (Table 11) and for each of the country specific study areas (Table 12). The number of principal components is two for the combined application (explaining 41% of variance) and three-four in the country specific applications (explaining 50-62%). The first principal component (PC) alone typically explains 21% to 33% of variance, but tends to be variously associated to the underlying assets. At the country level, the first PC is mainly associated with herd size (Ethiopia, Uganda and Tanzania), physical assets (Ethiopia, Uganda and Kenya), farm size (Ethiopia and Uganda), family labor (measured as adult equivalent units, Ethiopia and Uganda) and schooling (Kenya and Tanzania).

Based on the first PC alone and using zero as a cut-off point, some two-fifths of the households would be classified as well-endowed and the remainder as less-endowed in each study area.[3] At the regional level the first PC is most closely associated with herd size and physical assets. As a result, more than two-thirds of Ugandan surveyed farm households would be classified as relatively well-endowed based on the first regional PC alone, whereas Tanzanian households would be primarily classified as less-endowed.[4] The ease of interpretation of the PCs' could be enhanced by rotation, but this would reduce the explanatory power of the first PC.

Table 11. Descriptive statistics and PCA results for livelihood assets of surveyed farm households in the drought prone study areas of eastern Africa.

	Mean[a]	Sd	Component matrix		Component scores	
			PC_1	PC_2	PC_1	PC_2
Adult-eq. units (#/hh)	4.3	2.3	.56	−.17	.29	−.13
Schooling head (yr)	6.5	4.3	.43	.64	.22	.47
Farm size (ha)	2.9	4.2	.55	−.36	.28	−.26
Share irrigated (%)	1.6	10.2	.01	.36	.01	.26
Herd size (TLU)	2.6	4.0	.65	−.22	.33	−.16
Physical assets (#)[b]	2.9	1.8	.64	.52	.33	.39
Ext. interactions (#)[c]	1.6	2.8	.53	−.12	.27	−.09
Credit (# of types)	0.2	0.4	.20	−.57	.10	−.42
% of variance			24%	17%		

Notes: sd: standard deviation; n: sample size =1019. 2 components have *eigen* value > 1 explaining 41% of variance. [a] For each variable, missing values are replaced with the variable mean. [b] Sum of # of physical asset types including house improvements (i.e. improved walls and/or roof). [c] Sum of # of interactions with extension agents and number of types of agricultural events attended (field days, demos or maize discussions).

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[3] Based soley on PC_1 of the country specific PCA, the shares of households categorized as well endowed are 43% (ET), 44% (KY), 38% (UG), 45% (TZ) and 43% (sample mean).

[4] Based soley on PC_1 of the regional PCA, the shares of households categorized as well endowed are 38% (ET), 46% (KY), 68% (UG), 16% (TZ) and 42% (sample mean), with each country being statistically significantly different from the others (Duncan post-hoc).

Table 12. Descriptive statistics and PCA results for livelihood assets of surveyed farm households in the drought prone study areas of eastern Africa.

	Mean	Sd	Component Matrix				Component Scores			
			PC_1	PC_2	PC_3	PC_4	PC_1	PC_2	PC_3	PC_4
Ethiopia										
Adult-eq. units (#/hh)	4.4	2.4	.61	−.46	−.22		.26	−.37	−.19	
Schooling head (yr)	4.8	4.0	.20	.83	.15		.09	.67	.13	
Farm size (ha)	2.7	1.9	.80	−.20	.01		.34	−.16	.01	
Share irrigated (%)	0.8	6.7	−.09	.11	−.10		−.04	.09	−.09	
Herd size (TLU)	3.2	3.6	.81	−.01	−.21		.35	−.01	−.18	
Physical assets (#)	2.1	1.4	.68	.47	−.16		.29	.38	−.13	
Ext. interactions (#)	1.7	2.5	.31	.05	.70		.13	.04	.60	
Credit (# of types)	0.3	0.6	.20	−.24	.73		.08	−.20	.62	
% of variance			29%	15%	15%					
Kenya										
Adult-eq. units (#/hh)	4.3	2.2	.34	−.35	.29		.18	−.32	.27	
Schooling head (yr)	7.9	4.6	.64	.26	.19		.34	.24	.18	
Farm size (ha)	1.5	2.5	.55	−.46	−.25		.30	−.42	−.23	
Share irrigated (%)	3.2	14.9	.17	.71	−.03		.09	.64	−.03	
Herd size (TLU)	2.0	3.7	.46	−.29	−.37		.25	−.26	−.35	
Physical assets (#)	4.0	1.6	.72	.09	.23		.39	.09	.21	
Ext. interactions (#)	1.2	2.0	.51	.31	−.28		.28	.28	−.26	
Credit (# of types)	0.0	0.1	.10	−.10	.79		.05	−.09	.74	
% of variance			23%	14%	13%					
Uganda										
Adult-eq. units (#/hh)	5.2	2.6	.60	.24	−.19		.24	.23	−.18	
Schooling head (yr)	8.1	4.0	.30	−.67	.40		.12	−.62	.39	
Farm size (ha)	5.0	7.3	.68	−.04	−.08		.27	−.04	−.08	
Share irrigated (%)	0.0	0.4	.15	.68	.55		.06	.62	.54	
Herd size (TLU)	3.5	3.8	.82	.20	−.03		.32	.18	−.03	
Physical assets (#)	3.6	1.6	.75	−.05	.10		.29	−.05	.09	
Ext. interactions (#)	3.4	4.3	.49	−.25	.34		.19	−.23	.33	
Credit (# of types)	0.2	0.5	.38	−.06	−.62		.15	−.05	−.61	
% of variance			32%	14%	13%					
Tanzania										
Adult-eq. units (#/hh)	3.2	1.3	.68	.06	−.32	.27	.41	.05	−.31	.26
Schooling head (yr)	5.4	1.9	.23	−.74	−.02	.17	.14	−.62	−.02	.16
Farm size (ha)	4.2	5.5	.38	.33	.08	.72	.23	.28	.07	.70
Share irrigated (%)	1.0	8.5	−.21	−.16	.70	.23	−.13	−.13	.66	.22
Herd size (TLU)	1.8	5.0	.66	.31	.31	−.20	.40	.25	.30	−.20
Physical assets (#)	1.4	1.3	.45	.05	.51	−.38	.28	.04	.49	−.36
Ext. interactions (#)	1.0	2.2	.49	−.23	−.27	−.38	.30	−.19	−.26	−.37
Credit (# of types)	0.0	0.2	−.24	.60	−.16	−.17	−.15	.50	−.15	−.17
% of variance			21%	15%	13%	13%				

Notes: sd: standard deviation; sample size (n): Ethiopia (ET) n=369; Kenya (KY): n=349; Uganda (UG) n=149; and Tanzania (TZ) n=152. Except in Tanzania with 4 principal components, other countries have only 3 components with *eigen* value > 1 explaining respectively 59%, 50%, 58% and 62% of variance. For each variable, missing values are replaced with the variable mean. Same variables as in regional PCA.

4 Household livelihood strategies

The surveyed farm households in the drought prone areas of eastern Africa variously use their portfolio of assets reviewed in the previous chapter as building blocks for their livelihood strategies. The present chapter characterizes the livelihoods strategies pursued by the farm households, particularly in terms of crop production, livestock production and off-farm income. It subsequently provides profiles of reported household cash income and expenditures and summarizes the households' profitability and risk perceptions. The chapter ends with the outlook and implications for the farm households' livelihoods.

4.1 Crop production

Overall, annual crops average 83% of the farm area (Table 13). Fallow/pasture was reported by 36% of the households and occupying 13% of the farm area overall, albeit being more common in the Uganda and Tanzania study areas where the average farm size is relatively large. Perennial crops are relatively uncommon in the drought-prone study areas, reported by about a fifth of the households and occupying 4% of the farm area overall, and markedly concentrated in the Kenya and Uganda study areas (e.g. coffee:, 20% of households Kenya and13% in Uganda)

The study was targeted at maize growing drought prone districts in eastern Africa. The survey confirms the importance of maize in the study area, with maize cultivation near-universal and the maize area averaging 1 ha per household corresponding to some two-fifths of the farm area (Table 13). Maize thereby occupies about half the annually cropped area. In Kenya, maize intercropping prevails and intercrops include legumes, other cereals and roots and tubers.

Across the study areas, 75% of the surveyed farm households grow at least one legume, which account for 19% of the farm area. Legumes include:

- Beans (61% of households overall, albeit variously reported - Kenya 93%, Ethiopia 69%, Uganda 23% and Tanzania4%);
- Groundnut (17% of households overall, Uganda 77% and Tanzania 36%);
- Cowpea (10% of households overall, Kenya 25%, Uganda 7%); and
- Pigeon pea (Kenya 47%).

About a third of the surveyed farm households reported other cereals and a similar share of roots and tubers, which respectively accounted for 11% and 8% of the farm area. Other cereals include:

- Sorghum (9% of households overall, Uganda 29%, Tanzania 24%);
- Millet (9% of households overall, Uganda 37%, Tanzania 17%);
- Rice (2% of households overall, Tanzania 11%),

- Teff (Ethiopia only, 55%);
- Wheat (Ethiopia only, 3%).

Roots and tubers include:

- Sweet potato (26% of household overall, Uganda 71%, Ethiopia 36%);
- Cassava (5% of households overall, kenya11%; Uganda 3%); and
- Yam (UG 91%).

Only 14% of households reported other annual crops accounting for 3% of the farm area, including vegetables (Kenya 12%; Uganda 4%), sunflower (Tanzania 28%), sesame (Tanzania 13%) and cotton (Uganda 12%).

Table 13. Selected land use indicators of surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd)
Maize area (ha)	1.26 [b]	0.58 [a]	1.02 [b]	1.30 [b]	1.00 (±1.19)
Share maize area intercropped (%, n=987)	0 [a]	80 [b]	0 [a]	1 [a]	28 (±44)
Farm area share (%) planted to:					
- Maize	47 [c]	43 [b]	25 [a]	41 [bc]	41
- Other cereals	19 [c]	1 [a]	9 [b]	18 [c]	11
- Legumes	17 [c]	31 [d]	11 [b]	7 [a]	19
- Roots and tubers	9 [c]	4 [b]	22 [d]	0 [a]	8
- Other annual crops	0 [a]	3 [b]	3 [b]	10 [c]	3
- Annual crops (subtotal)	93 [c]	81 [b]	70 [a]	76 [ab]	83
- Perennial crops	1 [b]	8 [c]	7 [c]	0 [a]	4
- Fallow/pasture	6 [a]	11 [b]	23 [c]	24 [c]	13
Share farms reporting (% hh):					
- Maize	97	100	96	91	97
- Other cereals	58	7	45	47	37
- Legumes	69	94	81	39	75
- Roots and tubers	35	16	94	1	32
- Other annual crops	2	14	19	38	14
- Perennial crops	6	32	40	1	19
- Fallow/pasture	25	32	58	51	36

Notes: sd: standard deviation; n: sample size (=1019 unless otherwise indicated); all p's (Welch or Chi-square) highly significant (0.00). Data preceding different letters differ significantly – Tamhane's T2 (significance level: 0.10), within row comparison.

The total cultivated area was determined by a combination of food needs, cash availability for inputs and seed availability (Table 14), with food needs being particularly common in Kenya and Tanzania. There was no clear trend in terms of the household's maize area in the study areas (Table 15). A constant maize area was primarily associated with a constant farm size, whereas rainfall was the prime determinant in case of maize area changes followed by resource availability indicators (Table 15).

Table 14. Factors determining cultivated area of surveyed farm households in the drought prone study areas of eastern Africa (% of hh reporting, n=983).

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean
Food needs	18	91	48	75	56
Cash availability for inputs	77	44	43	45	56
Seed availability	55	64	27	58	54
Family labor availability	42	46	43	42	44
Cash availability to hire labor	42	20	54	30	35
Expected harvest grain prices	7	24	40	15	19
Current grain prices	8	3	24	7	8
Other	0	4	16	4	4

Notes: multiple response for household listing up to three factors; n: sample size. Statistical significance not relevant as multiple response.

Table 15. Trend maize area and associated factors for surveyed farm households in the drought prone study areas of eastern Africa (% of hh reporting).

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean
Trend maize area (n=989, p.=.00)					
- Increase	41	17	45	36	32
- Constant	35	58	9	28	38
- Decrease	25	25	46	37	30
Factors associated with increase (n=322)*					
- Better rainfall	10	65	35	75	36
- Enough labor	25	8	21	4	18
- Enough seed	27	12	7	8	17
- Interested in expanding	19	2	16	8	13
- Enough cash for inputs	11	3	4	6	7
- Enough land to expand	3	10	9	0	5
- Other	4	0	7	0	3
Factors associated with constant (n=390)*					
- Land size unchanged	56	56	62	45	55
- Rainfall unchanged	11	24	15	2	17
- Labor force unchanged	2	4	15	36	7
- Yield	7	4	0	0	5
- Other	25	11	8	17	16
Factors associated with decrease (n=295)*					
- Poor rainfall	21	56	65	55	47
- Reduced cash for inputs	30	1	1	5	11
- Reduced labor force	4	8	17	15	10
- Reduced land available	23	5	6	0	10
- Inadequate seed	7	6	7	2	6
- Other	15	24	3	24	16

Notes: n: sample size; p: statistical significance (Chi-square). *Statistical significance not relevant as too many empty cells.

4.2 Crop use and marketing

Maize production is primarily dual purpose in the study areas: to meet household food needs and sale of surplus. Maize consumption is thereby near universally reported by the surveyed farm households, with 58% (overall) reporting maize sales (Table 16). The relative volume of maize consumed (61% of produce, over the four sites) is about double the maize volume sold (31%) with the remainder (8%) either retained as seed, gifted or lost (Table 16). Only in the Uganda study areas is maize consumption more limited with the bulk of maize production being marketed (Table 16). Production of other cereals, legumes and roots and tubers are generally also dual purpose – reiterating that these are primarily small-scale family farms.

Table 16. Use of crop produce for surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (p)
Maize use reported (% hh, n=951)					
- Consumed	99	96	95	99	98 (.02)
- Sold	55	57	92	31	58
- Gifted	31	71	24	11	42
- Reserved as seed	66	86	65	47	70
- Lost	14	45	32	23	29
Maize use (% production, n=951)					
- Consumed	69 [c]	58 [b]	29 [a]	82 [d]	61
- Sold	22 [b]	31 [c]	68 [d]	12 [a]	31
- Gifted	3 [b]	6 [c]	1 [a]	1 [a]	3
- Reserved as seed	5 [b]	4 [b]	2 [a]	2 [a]	4
- Lost	1 [b]	1 [ab]	1 [a]	3 [c]	1
Other cereals use (% production, n=326)					
- Consumed	38 [a]	65 [ab]	45 [a]	76 [b]	45
- Sold	47 [b]	2 [a]	47 [b]	14 [a]	41
- Other	16 [b]	33 [ab]	8 [a]	10 [ab]	14
Legume use (% production, n=388)					
- Consumed	33 [ab]	57 [b]	43 [a]	60 [b]	53
- Sold *	31	23	40	28	29
- Other	36	19	18	12	18 (ns)
Roots & tubers use (% production, n=161)					
- Consumed *	12 [a]	28 [a]	53 [b]	-	46
- Sold	78 [ab]	63 [b]	45 [a]	-	50 (.02)
- Other	10 [b]	10 [ab]	2 [a]	-	4 (.02)

Notes: n: sample size; all p's (*ANOVA, Welch or Chi-square) highly significant (0.00) unless otherwise indicated. Data preceding different letters differ significantly – Duncan multiple range test/Tamhane's T2 (significance level: 0.10), within row comparison. -: no data (≤2 observations).

Maize is primarily sold to traders. In the case of Uganda and Tanzania, maize tends to be sold at the time of harvest from the farmer's home. In Kenya, and particularly in Ethiopia, farmers tend to take their maize grain to the market. Marketing patterns for other cereals are largely similar (Table 17). Grain prices are primarily determined by the buying agent, although in Tanzania prices tended to follow the government set prices and in Kenya prices were influenced by the neighboring markets (Table 17).

Table 17. Cereal sales indicators for surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean
Time of maize sales (% hh, p=.00)		(n=193)	(n=128)	(n=62)	(n=383)
- Soon after harvest	-	14	84	65	45
- Six months after harvest	-	62	15	34	42
- Just before planting	-	24	2	2	13
Place of maize sales (% hh) *	(n=188)	(n=192)	(n=128)	(n=61)	(n=569)
- At home	2	45	76	90	43
- In a market	97	51	23	8	55
- Marketing cooperative/other	1	4	1	2	2
Buyer of maize (% hh) *	(n=192)	(n=190)	(n=85)	(n=57)	(n=524)
- Trader	87	69	87	72	79
- Middlemen	9	24	11	19	16
- Others**	4	7	2	9	5
Time other cereal sales (% hh, p=.00)	(n=11)	(n=74)	(n=57)	(n=52)	(n=194)
- Soon after harvest	36	23	74	52	46
- Six months after harvest	64	49	18	46	40
- Just before planting	0	28	9	2	14
Place of other cereal sales (% hh) *	(n=268)	(n=75)	(n=58)	(n=52)	(n=453)
- At home	3	49	53	100	28
- In a market	96	51	45	0	71
- Marketing cooperative/other	1	0	2	0	1
Buyer of other cereals (% hh) *	(n=251)	(n=73)	(n=58)	(n=49)	(n=431)
- Trader	95	81	78	73	88
- Middlemen	4	18	19	24	11
- Others**	0	1	3	2	1
Grain price fixing agent (% hh) *	(n=320)	(n=188)	(n=131)	(n=94)	(n=733)
- Farmer/seller	5	41	6	19	17
- Buyer	77	56	69	27	64
- Government	18	2	25	54	20
Price determinants when seller fixes prices (% hh fixing) *	(n=16)	(n=54)	(n=7)	(n=17)	(n=94)
- Prices neighboring market	19	85	57	82	71
- Cost of production	63	11	43	12	22
- Other (including radio)	19	4	0	6	6

Notes: n: sample size; p: statistical significance (Chi-square). *Statistical significance not relevant as too many empty cells. ** Includes established agent; marketing coops, millers. -: no data

4.3 Livestock production

Livestock are an important component of the livelihood portfolio of the surveyed farm households, with over 90% of the surveyed households reporting some livestock. With the exception of Tanzania (with only a fifth reporting), three quarters of the surveyed farm households reported having cattle (Table 18). Cattle are primarily local, with an average herd size of 4.5 heads per household – with the largest average number in Ethiopia and Uganda. Reported ownership and numbers of small stock as a group (goats, sheep and pigs) are similar to cattle (Table 18). Goats are the main small stock in these drought prone areas, with pigs primarily limited to Uganda and sheep being relatively more common in Ethiopia. As a group poultry was the most commonly reported across the study areas – being reported by at least half the surveyed households in each area. Transport animals (like donkeys) were primarily only reported in Ethiopia, where they averaged one per farm household (Table 18).

Livestock play a varied role in the livelihood portfolio of the surveyed farm households – including the provision of food and income (and cash), asset accumulation, diversification/insurance and services (e.g. draft for tillage, particularly important in Ethiopia). Nearly half (45%) of the surveyed farm households reported having sold some livestock during the survey year, with 18% having acquired and 39% having consumed some of their livestock units during the same period. The reported herd value averaged US$ 750 per surveyed farm household (Table 18).

Table 18. Selected livestock indicators of surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd, n)
Herd size (# of heads)					
- Cattle	5.5 [b]	3.3 [a]	6.6 [b]	3.1 [a]	4.5 (±8.2)
- Small stock*	5.2 [c]	3.9 [b]	5.4 [c]	2.2 [a]	4.3 (±7.0)
- Poultry **	3.8 [a]	11.4 [b]	17.3 [b]	4.9 [a]	8.5 (±24.3)
- Transport animals	1.1 [c]	0.2 [b]	0.0 [a]	0.0 [a]	0.5 (±1.0)
Reported herd value (US$)	584 [a]	723 [a]	1,403 [b]	562 [a]	752 (±1392, 947)
Share of farms reporting (%hh):					
- Improved cattle	8	17	5	1	9
- Local cattle	73	68	74	18	63
- Any cattle	74	74	75	18	66
- Goats	56	73	67	16	58
- Sheep	33	12	14	4	19
- Pigs	1	0	46	4	8
- Any small stock*	69	74	81	21	65
- Poultry**	56	87	88	53	71
- Transport animals	57	11	1	0	25
- Any livestock (any of above)	95	97	97	63	91
Livestock changes survey year (% hh reporting any)					
- Consumption	20	54	66	22	39
- Sales	37	54	63	26	45
- Purchases/receipts	17	17	34	6	18

Notes: sd: standard deviation; n: sample size =1019 unless otherwise indicated; all p's (Welch or Chi-square) highly significant (0.00). Data preceding different letters differ significantly–Tamhane's T2 (significance level: 0.10), within row comparison. * goat, sheep, pigs. **chicken, duck, fowl, pigeon

4.4 Off-farm income

The surveyed farm households further complement their livelihood portfolio with off-farm income sources. Some 82% of the surveyed farm households reportedly had some of their household members engaged in off-farm income generating activities. Such off-farm income sources were markedly more common (near universal) in Ethiopia and Kenya, where they involved more than half the household members and most commonly related to farm labor (Table 19). Petty trading was the next most common off-farm income source based on household member activities, and actually the most commonly reported source in Uganda and Tanzania whereas it was virtually absent in Ethiopia. An array of other off-farm income sources was reported based on household member activities, particularly in Kenya and Uganda, including some relatively skilled and non-agricultural endeavors (Table 19).

Table 19. Selected off-farm income indicators of surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd, p)
Off-farm activities					
- Any hh member engaged (% of hh)	99	97	48	38	82
- % hh members engaged (%)	67 [c]	53 [b]	11 [a]	16 [a]	46 (±31)
Off-farm activity type (% of hh based on any hh members)					
- Farm labor	99	78	2	14	65
- Petty trading	1	28	19	20	16
- Teaching	1	7	7	0	4
- Masonry/carpeting	2	11	3	3	5
- Nursing	1	1	3	1	1 (nr)
- Arts & craft	0	10	0	2	4
- Driving	0	4	1	1	2
- Fitting mechanic	0	4	4	1	2
- Other	1	16	20	2	9
Off-farm cash income (% of hh)					
- Hh labor based [1]	35	78	40	47	52
- Other source [2]	13	68	17	5	32
- Any off-farm cash income	45	96	53	50	65

Notes: sd: standard deviation; n: sample size =1017; all p's (Welch or Chi-square) highly significant (0.00) unless otherwise indicated (nr: not relevant [empty cells]). Data preceding different letters differ significantly – Tamhane's T2 (significance level: 0.10), within row comparison. [1] Includes petty trading, paid employment or self employed. [2] Includes remittances or other off-farm income.

The foregoing off-farm indicators are based on the off-farm activities as reported for individual household members aggregated to the household level. The reported sources of household cash income (see next section) however provide a somewhat different categorization. Based on these reported cash income sources, two-thirds of the surveyed farm households (overall) reported some sort of off-farm cash income, and half the households (overall) reported any labor related off-farm cash income - such as petty trading, paid employment or self employed. Off-farm cash income sources were nearly universally reported by the surveyed farm households in Kenya, against about half elsewhere (Table 19).

4.5 Income and expenditure profiles of households

This study sought to establish cash income sources and expenditures of the surveyed farm households during the survey year. The monetary responses should however be interpreted with the necessary caution in view of the sensitivity of the data and the survey being a single visit survey. It should also be recalled that this relates to cash only, whereas a substantial share of household income is in-kind, particularly the self-produced crops which are to a large extent consumed over the year by the household to meet daily food needs. Still, the results provide rough indicators of annual cash income and expenditures and their breakdown over categories (Table 20; Table 21).

As a category, crop sales were most frequently reported as a cash income source by the surveyed farm households (79% of households overall), followed by other farm sources such as livestock sales (42%) and fruit and vegetable sales (23% - Table 20). Overall, 91% of the surveyed farm households reported some cash income from their farm, whereas 65% of households reported some cash income from off-farm sources. Various off-farm cash income sources were reported at relatively similar rates overall, including remittances (25%), petty trading (22%), paid employment (22%) and self employed (19% - Table 20). The Kenya study site shows a marked deviation from the other study areas, with crops being least commonly reported, whereas the incidence of the various off-farm sources is markedly higher (Table 20).

Annual reported cash income averaged about US$900 per surveyed farm household, with a marked regional variation: being less than US$ 400 (i.e. less than half the regional average) in Ethiopia and Tanzania, and US$1200-1500 in Uganda and Kenya (Table 20). Overall, sales of crop products (including fruit and vegetables) accounted for nearly half the reported cash income (48%), followed at a distance by a portfolio of other sources, including livestock sales (12%) and paid employment (12% - Table 20). The contribution of crop products was least for the surveyed farm households in Kenya (24%), where paid employment provided a similar share and with a more even spread over the various other income sources – off-farm income sources thereby contributing 65% of annual cash income (Table 20). Overall, the farm contributed 61% to annual cash income with off-farm sources contributing the remaining 39% (Table 20).

Table 20. Reported cash income sources for surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd, p)
Sources (% hh reporting)					
- On-Farm cash income					
o Crop sales	89	60	96	79	79
o Fruit/vegetable sales	7	53	11	0	23
o Livestock/fish sales	32	53	66	13	42
o Any on-farm	94	87	98	82	91
- Off-farm cash income					
o Petty trading	5	39	22	26	22
o Paid employment	14	40	10	11	22
o Self employed	21	23	10	13	19
o Remittances	2	62	12	5	25
o Other	12	18	6	0	12
o Any off-farm	45	96	53	50	65
Reported hh cash income (US$ pa)					
- Per household	376 [a]	1479 [b]	1217 [b]	399 [a]	894 (±1511)
- Per capita	58 [a]	285 [c]	157 [b]	83 [ab]	157 (±313, 962)
Sources (% of reported income)					
- On-Farm cash income					
o Crop sales	61 [b]	13 [a]	55 [b]	60 [b]	43
o Fruit/vegetable sales	3 [b]	11 [c]	3 [b]	0 [a]	5
o Livestock/fish sales	12 [a]	11 [a]	19 [b]	8 [a]	12
o Sub-total	76 [b]	35 [a]	77 [b]	67 [b]	61
- Off-farm cash income					
o Petty trading	2 [a]	11 [bc]	8 [b]	16 [c]	8
o Paid employment	6 [a]	24 [b]	4 [a]	8 [a]	12
o Self employed	11 [b]	8 [ab]	5 [a]	7 [ab]	8 (.01)
o Remittances	0 [a]	19 [c]	3 [b]	1 [b]	7
o Other	5 [b]	4 [b]	3 [b]	0 [a]	4
o Sub-total	24 [a]	65 [b]	23 [a]	33 [a]	39

Notes: sd: standard deviation; n: sample size = 964 unless otherwise indicated; all p's (Welch or Chi-square) highly significant (0.00) unless otherwise indicated. Data preceding different letters differ significantly – Tamhane's T2 (significance level: 0.10), within row comparison.

The surveyed farm households reported a range of expenditure categories, typically including clothing, fuel and medical expenses (Table 21). Although these are farm households, food expenditures were similarly widely reported. Annual reported cash expenditure averaged US$640 per surveyed farm household, with a marked regional variation similar to income (Table 21). Overall, food expenditure made up the largest expense category (37% overall, and about half in Kenya and Tanzania), despite these being farm households. This was followed by clothing (15%), education (13%), medical (9%) and array of smaller categories (Table 21). Overall a third of the surveyed farm households thereby was a net food buyer (i.e. reported expenditures on food exceed reported on-farm cash income), whereas this amounted to three-fifths in Kenya and Tanzania study areas (Table 21).

Somewhat less (29%) of the surveyed farm households reportedly were cash deficient (i.e. reported expenditures exceed reported cash income), although this amounted to two-thirds in the Tanzania study areas (Table 21).

Table 21. Reported cash expenditure categories for surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd, p)
Expense categories (% hh)					
- Food	77	99	63	93	85
- Clothing	93	93	99	74	91
- Education	76	53	88	37	65
- Medical	69	99	95	88	86
- Fuel	86	97	99	58	88
- Remittances	93	79	43	36	73
- Tobacco/alcohol	40	25	30	32	32
- Social	2	92	60	59	49
- Other	62	70	95	58	69
Reported hh expenditures survey year (US$ pa)					
- Per household	245 [a]	1023 [c]	849 [c]	491 [b]	638 (±997)
- Per capita	37 [a]	189 [c]	119 [b]	92 [b]	109 (±173, 970)
Expense categories (% of reported expenditures)					
- Food	27 [b]	51 [c]	16 [a]	48 [c]	37
- Clothing	25 [c]	7 [a]	12 [b]	10 [b]	15
- Education	6 [a]	14 [b]	34 [c]	8 [a]	13
- Medical	9 [ab]	9 [a]	12 [b]	10 [ab]	9 (.05)
- Fuel	8 [b]	7 [ab]	6 [a]	6 [ab]	7
- Remittances	10 [c]	3 [b]	2 [ab]	2 [a]	5
- Tobacco/alcohol	4 [b]	2 [a]	3 [ab]	5 [b]	3
- Social	0 [a]	4 [c]	2 [b]	3 [bc]	2
- Other	10 [b]	3 [a]	14 [c]	8 [b]	8
Net food buyer (% hh) [1]	15	60	5	56	35 (987)
Cash deficient (% hh) [2]	19	27	27	65	29 (987)

Notes: sd: standard deviation; n: sample size = 972 unless otherwise indicated; all p's (Welch or Chi-square) highly significant (0.00) unless otherwise indicated. Data preceding different letters differ significantly –Tamhane's T2 (significance level: 0.10), within row comparison. [1] I.e. reported expenditures on food exceed reported on-farm cash income. [2] I.e. reported hh expenditures exceed reported hh cash income during survey year.

4.6 Profitability and risk perceptions

To enhance our understanding of the current livelihood portfolio of the surveyed farm households, we sought their perceptions of relative profitability and risk. These perceptions are summarized below, whereas in the next section we review the outlook and implications for their livelihoods.

Overall, surveyed farm households generally rated improved maize (open pollinated variety [OPV] or hybrid) as relatively profitable and roots and tubers as least profitable, with local maize, other cereals and legumes in-between. There are however some marked regional variations (Table 22) – typically associated with the underlying cropping pattern. Profitability of local maize was generally rated relatively medium, but scored favorably in Kenya where it is widely grown (see next chapter). In contrast, improved OPVs scored relatively high in Uganda and Tanzania and hybrids in Ethiopia and Kenya, again in line with their use. The profitability of other cereals scored relatively high in Ethiopia, associated with teff cultivation.

Table 22. Selected crop profitability indicators for surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd, n, p)
Profitability index (0 least – 1 most profitable)					
- Local maize	.57 [a]	.75 [b]	.50 [a]	.53 [a]	.64 (±.35, 655)
- Improved OPV maize	.79 [a]	.71 [a]	.86 [b]	.81 [ab]	.81 (±.27, 429, .02)
- Hybrid maize	.87 [b]	.78 [a]	.65 [ab]	.58 [ab]	.78 (±.27, 205, .03)
- Other cereals	.74 [c]	.32 [a]	.41 [a]	.58 [b]	.64 (±.31, 350)
- Legume crops	.65 [b]	.67 [b]	.50 [a]	.75 [b]	.64 (±.24, 789)
- Roots & tubers	.57 [b]	.26 [a]	.47 [b]	-	.40 (±.31, 243)
Profitability trend (-1 decreasing – +1 increasing)					
- Local maize	−.1 [a]	.2 [b]	.3 [b]	.2 [ab]	.1 (±.8, 654)
- Improved OPV maize	.3 [a]	.4 [ab]	.8 [b]	.4 [a]	.5 (±.8, 429)
- Hybrid maize *	.6	.4	.4	.3	.4 (±.8, 202, ns)
- Other cereals	.6 [bc]	.1 [ab]	.7 [c]	.3 [a]	.6 (±.7, 348)
- Legume crops	.5 [b]	.4 [a]	.6 [b]	.6 [ab]	.5 (±.6, 791)
- Roots & tubers	.5 [ab]	.1 [a]	.6 [b]	-	.4 (±.6, 245)
Plans to enhance crop profitability (% hh)	(n=364)	(n=340)	(n=146)	(n=109)	(n=959)
- Increase production	67	92	98	74	81
- Reduce costs	13	36	9	3	19
- Grow profitable crops	49	35	21	7	35
- Diversify	15	35	29	17	24
- Other	10	2	11	11	7

Notes: sd: standard deviation; n: sample size; all ps (*ANOVA, Welch or Chi-square) highly significant (0.00) unless otherwise indicated (ns: not significant). Data preceding different letters differ significantly –Tamhane's T2 (significance level: 0.10), within row comparison.

Overall, the surveyed farm households generally perceived a positive profitability trend for the various crop types (Table 22). An exception was the profitability trend for local maize, which was generally perceived as static and even as declining in Ethiopia. Increasing production was reported as the main plan to enhance crop profitability, followed by growing profitable crops, with less than a quarter reporting diversification or cost reduction (Table 22).

Surveyed farm households were presented with a number of crop production scenarios and asked how they would respond (Table 23). Crop area was relatively inelastic in face of unfavorable conditions—low produce price, low yield, fertilizer unavailability—with only about a third of the households intending to reduce area in response (Table 23). Crop area was more elastic in face of favorable conditions—high produce price, high yield, fertilizer availability, credit availability—with some two-thirds intending to increase area (Table 23). In part, these responses reflect the dual purpose nature of crop production (particularly the importance of home consumption) and the limited alternative income generating options available—whereby crop production will thus persist even under unfavorable conditions. The farm household's asset portfolio provides an important buffer against crop production and crop price risks. Farmers thereby reportedly tend to accumulate such assets when conditions are favorable—higher yields, higher crop prices—whereas they may have to sell some when conditions are dire—crop failure, low crop prices (Table 23). The dual purpose nature of crop production also explains the relative importance of the selling price for crop sales. Over half the surveyed farm households would also increase input and credit use in response to favorable crop prices (Table 23). There are some regional variations in the reported responses, particularly in terms of the magnitude, but overall the direction of responses is relatively similar across study sites (Table 23).

Table 23. Management responses to selected scenarios for surveyed farm households in the drought prone study areas of eastern Africa (% households).

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (n)
Effects on area					
Lower crop price reduces crop area	61	11	42	17	35 (1019)
Higher crop price increases crop area	76	46	90	49	64 (1019)
Lower yields reduces crop area	50	13	31	26	31 (1019)
Higher yields increases crop area	80	50	75	64	67 (1019)
Limited fertilizer availability reduces area	58	18	19	5	30 (1002)
Fertilizer availability increases area	75	65	55	22	60 (1003)
Credit availability increases area	78	73	65	52	71 (1013)
Effects on assets					
Crop failure reduces assets	94	53	25	76	67 (954)
Crop yield enhancement increases assets	94	70	71	31	74 (963)
Lower crop prices reduces assets	76	40	65	16	54 (972)
Higher crop prices increases assets	92	66	77	23	72 (975)
Price effects					
Selling price determines crop sales	80	84	92	73	82 (983)
Higher crop price increases input use	75	52	61	35	60 (931)
Higher crop price increases credit use	52	67	73	66	63 (973)

Notes: n: sample size; all p's (Chi-square) highly significant (0.00).

Overall, surveyed farm households generally rated roots and tubers (particularly sweet potato) as less drought susceptible and legumes as most drought susceptible (Table 24).

Local maize and improved OPVs were also rated as relatively susceptible, whereas hybrid maize rated at par with other cereals. Except for hybrid maize, there are again marked regional variations (Table 24).

Table 24. Perceived drought susceptibility of selected crops by surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd, n, p)
Drought susceptibility index (0 least – 1 most susceptible)					
- Local maize	.69 [b]	.71 [b]	.60 [a]	.86 [c]	.71 (±.27, 642)
- Improved OPV maize	.76 [bc]	.65 [a]	.68 [ab]	.80 [c]	.73 (±.25, 412)
- Hybrid maize	.63	.61	.58	.72	.62 (±.25, 199, ns)
- Other cereals	.66 [b]	.92 [c]	.45 [a]	.68 [b]	.62 (±.24, 333)
- Legume crops *	.95 [b]	.68 [a]	.71 [a]	.74 [a]	.78 (±.22, 782)
- Roots & tubers	.80 [b]	.32 [a]	.28 [a]	-	.32 (±.32, 233)

Notes: sd: standard deviation; n: sample size; all ps (ANOVA, *Welch) highly significant (0.00) unless otherwise indicated (ns: not significant). Data preceding different letters differ significantly – Duncan multiple range test/Tamhane's T2 (significance level: 0.10), within row comparison.

Yield risk was rated relatively similar to drought susceptibility, with roots and tubers rated as the least risky in terms of yield and legumes and local maize as relatively risky (Table 25). Agricultural diversification was the prevailing coping strategy for yield risk among the surveyed farm households (70% overall), followed by asset accumulation (27%) and non-agricultural diversification (21% - Table 25). Other farmers were the main information source on yield risk (63%) followed by extension (36%) and the mass media (16% - Table 25).

Price risk was rated relatively high for maize (especially local and improved OPVs) and relatively low for roots and tubers (Table 26). Asset accumulation was the prevailing coping strategy for price risk among the surveyed farm households (74% overall) followed by participation in government/NGO programs (18% - Table 26). For price risk, other farmers were again the main information source (65%) followed by extension (22%) and the radio (18% - Table 26).

Table 25. Crop yield risk indicators for surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd, n, p)
Yield riskiness index (0 least – 1 most risky)					
- Local maize	.78 [b]	.72 [b]	.69 [ab]	.61 [a]	.71 (±.32, 683)
- Improved OPV maize	.77 [b]	.67 [b]	.70 [b]	.31 [a]	.69 (±.33, 431)
- Hybrid maize	.62	.65	.55	.56	.63 (±.31, 226, ns)
- Other cereals	.67 [b]	.40 [ab]	.51 [a]	.49 [a]	.61 (±.28, 360)
- Legume crops	.79 [d]	.72 [c]	.65 [b]	.43 [a]	.71 (±.25, 805)
- Roots & tubers	.65 [b]	.36 [a]	.33 [a]	.50 [ab]	.35 (±.27, 249)
Yield risk coping strategies used (% hh, n=997)					
- Agricultural diversification	55	91	50	75	70
- Asset accumulation	44	27	12	1	27
- Non-ag. diversification	16	27	17	25	21
- Program participation	11	4	2	1	6
- Other	12	6	83	9	20
Yield risk information sources (% hh, n=954)					
- Other farmers	40	94	59	42	63
- Extension	59	14	24	48	36
- Radio/newspaper	19	8	26	20	16
- NGOs	3	2	8	1	3
- Field days	1	1	5	0	2

Notes: n: sample size; all p's (Welch or Chi-square) highly significant (0.00) unless otherwise indicated (ns: not significant). Data preceding different letters differ significantly–Tamhane's T2 (significance level: 0.10), within row comparison.

Table 26. Crop price risk indicators for surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd, n, p)
Price riskiness index (0 least – 1 most risky)					
- Local maize	.80 [c]	.73 [b]	.80 [c]	.56 [a]	.73 (±.33, 640)
- Improved OPV maize	.73 [c]	.57 [b]	.83 [bc]	.31 [a]	.71 (±.33, 411)
- Hybrid maize *	.46 [a]	.66 [b]	.73 [b]	.80 [b]	.62 (±.34, 220)
- Other cereals	.46	.25	.45	.52	.46 (±.29, 357, ns)
- Legume crops	.77 [c]	.61 [b]	.40 [a]	.44 [a]	.62 (±.30, 786)
- Roots & tubers	.64 [c]	.28 [a]	.40 [b]	-	.37 (±.31, 250)
Price risk coping strategies used (% hh, n=845)					
- Asset accumulation	80	96	9	89	74
- Program participation	25	18	5	0	18
- Other	18	22	99	16	33
Price risk information sources (% hh, n=947)					
- Other farmers	47	92	68	35	65
- Extension	31	17	14	23	22
- Radio	21	12	32	6	18
- Other (including combinations)	28	6	30	50	23

Notes: n: sample size; all p's (*ANOVA, Welch or Chi-square) highly significant (0.00) unless otherwise indicated (ns: not significant). Data preceding different letters differ significantly–Tamhane's T2 (significance level: 0.10), within row comparison.

4.7 Outlook of livelihoods

The study targeted the maize producing drought prone areas. It is therefore not surprising that the surveyed farm households nearly universally reported at least one crop failure due to drought during the last decade (>99% overall, with the lowest average being 96% Tanzania). The number of crop failures due to drought during the last decade averaged 3, with the lowest average being reported in Kenya and Tanzania (2.6-2.8) and the highest in Ethiopia and Uganda (3.3-3.7 - Table 27). What is more, the site selection thereby proved robust in each of the countries as the study targeted areas with a probability of failed season of 20-40%. Still, although the survey averages fell within the target range, individual responses oscillated widely (from 0 to 10). About half (46% overall) of the surveyed farm households had been compelled to sell off some assets during the survey year due to difficulties (i.e. for some reason or another, not necessarily due to drought), a fraction that was relatively similar across the study sites (Table 27). The need to buy food was the main reason (48% overall) for those that had to sell assets (Table 27).

Somewhat more than half (58% overall) of the surveyed farm households considered themselves as food secure during the survey year (Table 27). The remaining 42% averaged four months without adequate food, a duration that was again relatively similar across the study sites (Table 27). The actual timing of food shortage varied, typically associated with the incidence of rains—e.g. falling during the main rains in the Ethiopia and Tanzania study sites. The surveyed farm households reported an array of food shortage coping mechanisms, the most frequent being reducing other expenditures (38% overall), working more off-farm (30%), selling small animals (27%) and selling cattle (24% - Table 27).

Table 27. Selected risk indicators for surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd, n, p)
# years out of 10 crop failure due to drought	3.3 [b]	2.6 [a]	3.7 [b]	2.8 [a]	3.0 (±1.8, 855)
Whether compelled to sell assets in survey year (% hh)	50	45	47	40	46 (968, ns)
Reason for selling assets (% hh selling)	(n=190)	(n=151)	(n=70)	(n=70)	(n=481)
- To buy food	23	57	64	80	48
- Family events	41	9	6	1	20
- To pay debt	5	8	21	6	9
- Other	31	26	9	13	23
Hh food secure during survey year	46	59	78	63	58 (±49, 1002)
# months without adequate food	3.9	4.3	4.1	3.8	4.0 (±2.2, 426, ns)
Time inadequate food (month)	Jul-Sep	Aug, Dec-Jan	Apr-Jun	Jan-Mar	
Food shortage coping mechanisms (% hh) *	(n=331)	(n=334)	(n=139)	(n=125)	(n=929, nr)
- Reducing other expenditure	10	83	33	0	38
- Working more off-farm	17	41	32	34	30
- Selling small animals	27	28	47	3	27
- Selling cattle	53	7	12	6	24
- Reducing food intake	5	19	19	4	12
- Working at Food-for-work	9	10	6	34	12
- Selling assets	14	10	23	1	12
- Receiving food aid	4	5	4	1	4
- Other	16	4	46	18	17

Notes: sd: standard deviation; n: sample size; all p's (Welch or Chi-square) highly significant (0.00) unless otherwise indicated (ns: not significant; nr: not relevant [multiple response]). Data preceding different letters differ significantly– Tamhane's T2 (significance level: 0.10), within row comparison. * Multiple responses possible (≤3) – column % does not sum to 100%.

Drought (71% overall) and food security issues (61%) also prevailed as the most widely reported threats to the livelihoods of the surveyed farm households (Table 28). Health issues were reported as a threat by half the households, followed by an array of other threats that include poverty (15%), pest and diseases (13%) and insecurity (10% - Table 28). Other weather related threats included erratic weather/rain/climate (including climate change, 6%), floods (4%) and excess rains (2%).

Table 28. Reported threats to livelihoods for surveyed farm households in the drought prone study areas of eastern Africa (% households reporting).

	Ethiopia (n=365)	Kenya (n=334)	Uganda (n=144)	Tanzania (n=152)	Sample mean (n=995)
Drought	51	85	74	85	71
Food security issues	64	68	24	75	61
Health issues	73	41	33	1	46
Poverty	24	16	4	1	15
Pests & diseases	0	1	24	60	13
Insecurity/conflict/social problems	13	13	8	3	10
Family problems	15	1	2	0	6
Erratic weather/rain/climate	15	0	3	0	6
Household income issues	0	15	8	0	6
Floods	1	0	7	18	4
Land availability issues	2	1	19	0	4
(Output) Market issues	0	0	24	0	4
Education issues	1	3	8	1	3
Capital/assets issues	0	0	5	10	2
Land/soil quality issues	0	3	6	0	2
Finance issues	1	0	7	0	2
Excess rain	1	0	9	0	2
Other	12	9	34	4	13

Note: n: sample size. Listed here are the categorized responses to an open question of the 3 most serious threats, retaining categories that were named at least by 1.5% of households across countries, with remainder lumped under others. Multiple responses possible (≤3) – column % does not sum to 100%.

Drought (17% overall) was also reported as a constraint to livelihood improvement by the surveyed farm households (Table 29). However, a number of other constraints were more widely reported, including health (36% overall), input issues (36%), market issues (32%) and agricultural productivity (23%). Other reported constraints partly associated with drought included erratic weather/rain/climate (11%) and crop failure/production risk (5%).

Table 29. Reported constraints to livelihood improvement for surveyed farm households in the drought prone study areas of eastern Africa (% households reporting).

	Ethiopia (n=363)	Kenya (n=343)	Uganda (n=144)	Tanzania (n=151)	Sample mean (n=1001)
Health issues	40	38	29	31	36
Input issues	39	53	26	3	36
(Output) Market issues	10	34	73	40	32
Agricultural productivity	18	29	14	27	23
Drought	27	12	23	2	17
Land/Soil quality issues	5	37	10	5	17
Land availability issues	33	3	17	1	16
Erratic weather/rain/climate	25	3	2	8	11
Poverty	19	13	1	0	11
Transport/infrastructure issues	1	21	14	11	11
Capital/assets issues	2	0	4	54	10
Farm equipment issues	0	0	1	48	7
Finance issues	9	3	19	1	7
Education issues	10	5	1	1	5
Food security issues	13	0	2	2	5
Crop failure/production risk	0	13	0	0	5
Other issues	27	18	50	1	23

Note: n: sample size. Listed here are the categorized responses to an open question of the 3 most serious constraints, retaining categories that were named at least by 4.5% of households across countries, with remainder lumped under others. Multiple responses possible (≤3) – column % does not sum to 100%.

The surveyed farm households were also requested to enlist the most serious shocks they had been affected by during the last decade (Table 30). As expected, these overlap in part with the reported threats to their livelihoods reported earlier (Table 28). Drought again prevailed as the most widely reported shock (89% overall), but this time followed by floods/excess rain (38%) and plant pests/diseases (34%). The health status and even death of the breadwinner/wife was another common shock (23% and 10% respectively). An array of other shocks was reported, including erratic rain (14%), price shocks (maize & input prices, 21% each), livestock shocks (death/loss and disease, 18% and 14% respectively) and damage to crops by animals (including wildlife) and birds (17% and 8% respectively - Table 30).

Table 30. Reported shocks by surveyed farm households in the drought prone study areas of eastern Africa (% households reporting amongst 5 most serious over last decade).

	Ethiopia (n=359)	Kenya (n=323)	Uganda (n=144)	Tanzania (n=133)	Sample mean (p) (n=959)
Drought	96	77	94	98	89
Flood/excess rain	8	52	58	65	38
Plant pests/diseases	20	37	47	50	34
Illness/disability breadwinner/wife	23	15	35	28	23
Maize price (drop)	12	19	48	22	21
Input price (increase)	25	24	21	3	21
Livestock death/loss	19	24	16	4	18
Animal damage to crops	16	11	17	36	17
Livestock disease	16	9	33	5	14
Erratic rain	8	24	9	10	14
Weeds	18	2	8	13	10
Death breadwinner/wife	8	13	2	9	9
Birds	8	2	0	32	8
Theft	7	6	8	5	6 (ns)
Frost/hailstorm	3	1	16	0	4
Conflict	3	2	10	0	3
Fire	5	1	1	2	3
Other staple crop price (drop)	3	2	13	1	3
Other	9	5	10	0	7

Notes: n: sample size; all p's (Chi-square) highly significant (0.00), unless otherwise indicated (ns: not significant).

Agriculture remains the pivot in the livelihood portfolio of farm households. Despite their location in drought prone areas, the large majority of the surveyed farm households (80% overall) thereby sought to increase agricultural production as their preferred strategy to enhance their livelihoods—with only a negligible few considering an exit from agriculture (Table 31). An array of complementary strategies was reported by the surveyed farm households with some regional variation, including increasing food security (50% overall, especially common in Tanzania), improving educational status (31%), increasing land ownership (26%) and improving health status (25% - Table 31).

Table 31. Preferred strategies to enhance livelihoods for surveyed farm households in the drought prone study areas of eastern Africa (% households reporting amongst their 3 priorities).

	Ethiopia (n=366)	Kenya (n=332)	Uganda (n=145)	Tanzania (n=149)	Sample mean (p) (n=992)
Increase agricultural production	76	78	89	86	80
Increase food security	38	53	56	68	50
Improve education	41	29	19	26	31
Increase land ownership	36	24	15	19	26
Improve health	30	27	18	14	25
Increase hh assets	23	12	22	3	16
Increase income/reduce income risk	14	14	24	12	15 (.01)
Reduce agricultural risk	8	16	33	14	15
Reduce marketing risk	6	6	17	25	11
Increase job opportunities/earn wages	7	16	3	11	10
Improve social status	2	8	2	7	5
Exit from agriculture	0	0	1	1	0 (ns)

Notes: n: sample size; all p's (Chi-square) highly significant (0.00), unless otherwise indicated (ns: not significant).

5 Maize production and technology use

Crop and particularly maize production plays a pivotal role in the livelihoods of the surveyed farm households in the drought prone areas of eastern Africa as reviewed in the previous chapter. The present chapter characterizes maize production further with a particular emphasis on technology use in general and seed use in particular. The chapter ends with an analysis of the factors affecting improved maize seed purchases.

5.1 Knowledge of maize varieties and desired attributes

Surveyed farm households enlisted 2.8 known maize varieties per household on average, including 1 local maize variety, 0.8 improved Open Pollinated Varieties (OPVs) and 1 hybrid (Table 32). This relatively even distribution across the three distinguished maize seed types however masks some marked regional variations. Particularly striking is the contrast between the surveyed households in Uganda and those in Kenya, with a marked contrast in terms of knowledge of OPVs and hybrids, in line with the prevailing seed availability in the respective countries. Knowledge of local varieties was relatively evenly distributed over the countries, although the surveyed households in Uganda also enlisted the most local varieties (Table 32).

The surveyed farm households were asked about the perceived drought tolerance of the known varieties. Overall, the perceived tolerance was somewhat higher for known hybrids compared to known local maize varieties, with known OPVs in-between (Table 32). However, these perceptions again showed marked regional differences. Striking is that the perceived drought tolerance of known OPVs were rated highest in Uganda (particularly compared to known local there), but lowest in Ethiopia (Table 32).

Table 32. Selected maize varietal indicators of surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd, n, p)
Share of farms reporting known maize varieties (% hh)	95	99	98	91	96
# maize varieties known (per hh, n=982)					
- Local varieties	1.0 [b]	1.0 [b]	1.4 [c]	0.8 [a]	1.0 (±0.7)
- Improved OPVs	1.1 [c]	0.3 [a]	1.5 [d]	0.6 [b]	0.8 (±0.9)
- Hybrids	0.4 [b]	2.1 [d]	0.2 [a]	1.0 [c]	1.0 (±1.3)
- Total #	2.5 [a]	3.3 [b]	3.1 [b]	2.4 [a]	2.8 (±1.5)
Perceived drought tolerance index known varieties (0 low - 1 high)	(n*=739)	(890,.01)	(402)	(219,ns)	(n*=2250)
- Local varieties	.53 [y]	.43 [x]	.46 [x]	.46 [x]	.48 [x]
- Improved OPVs	.36 [x]	.55 [y]	.67 [y]	.57 [x]	.50 [xy]
- Hybrids	.64 [z]	.51 [y]	.51 [xy]	.58 [x]	.54 [y]

Notes: sd: standard deviation; n: sample size (=1019 households, unless otherwise indicated); all p's (Welch or Chi-square) highly significant (0.00) unless otherwise indicated (ns: not significant). Data preceding different letters differ significantly– Tamhane's T2 (significance level: 0.10), [abcd] - within row comparison; [xyz] - within column comparison. n*: number of known varieties reported by surveyed households (758 households reporting local varieties; 478 improved OPVs and 425 hybrids overall).

Surveyed farm households were queried as to what they perceived as the best known maize variety for local, improved OPV and hybrid (Table 33) and to make subsequent pair-wise contrasts for a number of attributes (Table 34).

Table 33. Preferred maize varieties as stated by surveyed farm households in the drought prone study areas of eastern Africa.

Type	Ethiopia	Kenya	Uganda	Tanzania
Local				
(n=745)	(n=279)	(n=297)	(n=118)	(n=51)
	Shaye (54%)			
	Habasha (13%)		Munandi (35%)	
	Nano (7%)		Ekwakoit (27%)	
	Hararge (5%)		Mweraigoro (8%)	
	Marid (4%)		Nylon (8%)	
	Chore (3%)	Kikamba (96%)	Egwanapa (7%)	
	Katumani* (3%)	Kangundo (2%)	Muganda (5%)	Asila (96%)
OPV				
(n=416)	(n=225)	(n=18)	(n=128)	(n=45)
	Katumani (24%)			
	Hawasa (22%)			
	Pioneer* (33%)			Cargil* (24%)
	Mirtzer (32%)		Longe 5 (34%)	Llongo (22%)
	Melkasa (22%)	Katumani (56%)	Longe 4 (31%)	Kilima (20%)
	Limati (21%	DLC1 (33%)	Longe 1 (30%)	Staha (13%)
Hybrid				
(n=276)	(n=58)	(n=195)	(n=14)	(n=9)
		Pioneer3253 (72%)		
		Duma 41 (14%)		
		Pan 67 (6%)		
	BH540 (24%)	Duma 43 (3%)	Longe 2H (64%)	- **

Notes: Response to best variety for each seed type. Listed here are varieties that were named at least 5 times by country. * As reported under the respective category by respondents – although original material likely classified otherwise. ** No single name reported >5 times.

In line with expectations, (*the best known*) local maize was perceived to have the lowest seed price and lowest yield potential and (*the best known*) hybrid the highest on both accounts (Table 34).[5] The perceived seed availability showed a marked opposite trend; whereas cob and grain size showed similar contrasts as the yield potential. OPVs were markedly shorter duration than the two other types. OPVs were also reportedly better performing under low soil moisture, followed by hybrid and with local maize rated poorest. OPVs also performed better under low soil fertility, although hybrid and local swapped places, with hybrid now lowest, perhaps associated with the perceived need for chemical fertilizer. OPVs however ranked poorly in terms of the perceived resistance to pests and diseases, with hybrids being most prone to storage pests. Local maize was perceived to be particularly lodge prone. OPVs were also rated favorably in terms for various post harvest attributes, particularly poundability, thereby contributing to local maize having the lowest maize grain price (Table 34).

[5] The results presented in this paragraph and in Table 34 refer to *the best known* maize variety of each type. For simplicity and to reduce repetition this is implicit in the text here.

Table 34. Index scores for preferred maize varieties by type as stated by surveyed farm households across the drought prone study areas of eastern Africa.

Attribute	Best local	Best improved OPV	Best hybrid	n
Seed price	−.8 [a]	.6 [b]	.9 [c]	652
Seed availability	.2 [c]	.0 [b]	−.5 [a]	658
Yield potential *	−.5 [a]	.3 [b]	.8 [c]	657
Cob size	−.4 [a]	.2 [b]	.6 [c]	640
Grain size	−.4 [a]	.2 [b]	.6 [c]	632
Maturity	.4 [b]	−.8 [a]	.4 [b]	660
Performance under low soil moisture	−.3 [a]	.4 [c]	.1 [b]	639
Performance under low soil fertility	−.1 [b]	.4 [c]	−.4 [a]	640
Disease tolerance *	.0 [b]	−.2 [a]	.2 [c]	635
Field pest resistance *	.1 [b]	−.2 [a]	.0 [b]	619
Storage pest resistance	.3 [c]	−.2 [b]	−.5 [a]	652
Resistance to lodging*	−.5 [a]	.4 [b]	.5 [b]	653
Market price grain	−.3 [a]	.3 [b]	.2 [b]	647
Palatability	−.2 [a]	.4 [b]	−.2 [a]	648
Poundability	−.5 [a]	.7 [c]	.0 [b]	557
Roasted green maize palatability	−.1 [b]	.3 [c]	−.3 [a]	590

Note: Index with maximum of 2 (higher than both other types) and minimum of -2 (lower than both other types) derived from pair-wise contrasts between best varieties for each type at household level. n: sample size (i.e. # households making at least one pair-wise contrast). For instance 652 households made seed price comparisons, with average scores presented here based on 643 hh for local, 437 for improved OPV and 278 for hybrid. All p's (*ANOVA or Welch or Chi-square) highly significant (0.00). Data preceding different letters differ significantly – Duncan multiple range test or Tamhane's T2 (significance level: 0.10) - within row comparison.

Surveyed farm households were queried about the desired attributes of their ideal maize variety (Table 35). In line with expectations, yield potential was the most widely reported (69% overall). However next most common were early maturity (56%) and drought tolerance (43%), whereas performance under poor rainfall was reported by an additional 14%. Early maturity typically has a dual purpose—being associated with shortening the hungry season and being drought escaping. Drought thereby featured prominently, clearly associated with the study targeting drought prone areas. The factors determining maize varietal choice thereby were relatively similar, with yield potential being most prominent followed by maturity period and drought resistance (Table 36).

Table 35. Desired characteristics of ideal maize variety for surveyed farm households in the drought prone study areas of eastern Africa (% of households).

	Ethiopia (n=358)	Kenya (n=345)	Uganda (n=146)	Tanzania (n=147)	Sample mean (n=996)
Yield potential	71	71	62	67	69
Early maturity	69	41	68	44	56
Drought tolerance	30	49	53	55	43
Grain size	15	15	18	39	19
Cob size	14	8	24	22	14
Pest/disease resistance	12	12	12	23	14
Performance under poor rainfall	4	31	7	1	14
Number of cobs per plant	14	17	14	3	13
Cob filling	14	11	3	17	12
Performance on poor soils	11	14	8	2	10
Storage pest resistance	8	6	1	7	6
Yield stability	2	13	4	1	6
Resistance to lodging	13	1	3	0	5
Grain color	3	1	3	7	3
Other	9	8	19	6	10

Notes: multiple response for household listing up to three most desired characteristics; n: sample size.

Table 36. Factors influencing maize varietal choice for surveyed farm households in the drought prone study areas of eastern Africa (% of households).

	Ethiopia (n=351)	Kenya (n=296)	Uganda (n=146)	Tanzania (n=99)	Sample mean (n=892)
Yield potential	80	86	79	76	81
Maturity period	79	45	68	42	62
Drought resistance	32	72	60	61	53
Pest/disease resistance	12	21	16	44	19
Performance on poor soils	15	10	12	4	12
Storage pest resistance	12	17	2	5	11
Cob size	7	3	25	31	11
Taste of meal	21	2	12	2	11
Number of cobs per plant	15	5	14	2	10
Cost of seed	5	0	7	4	4
Other	6	34	3	3	15

Notes: multiple response for household listing up to three factors; n: sample size.

Reasons for not using any of the maize varieties known to the households typically revolved around grain yield (particularly prominent for non-use of local maize varieties), expensive seed (particularly for non-use of hybrids) and non-availability of seed (most common for non-use of OPVs, although also reported by a fifth to a fourth for the non-use of the two other seed types - Table 37).

Table 37. **Reasons for not using known maize varieties by seed type for surveyed farm households in the drought prone study areas of eastern Africa.**

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean
Known hybrids (% hh)	(n=33)	(n=144)	(n=10)	(n=54)	(n=241)
- Poor grain yield	36	35	20	13	29
- Poor grain storage	3	2	0	6	3
- Poor grain price	0	0	10	0	0
- Expensive seed	30	70	20	54	59
- Poor food taste	0	1	0	2	1
- Seed not available	18	23	40	43	27
- Other	36	40	20	19	34
Known improved OPVs (% hh)	(n=76)	(n=32)	(n=34)	(n=37)	(n=179)
- Poor grain yield	32	47	38	19	33
- Poor grain storage	4	0	3	0	2
- Poor grain price	3	0	3	0	2
- Expensive seed	26	19	9	38	24
- Poor food taste	1	0	9	3	3
- Seed not available	34	13	53	59	39
- Other	38	25	18	8	26
Known local varieties (% hh)	(n=148)	(n=24)	(n=62)	(n=28)	(n=262)
- Poor grain yield	67	67	69	57	67
- Poor grain storage	2	0	2	4	2
- Poor grain price	1	0	5	0	2
- Expensive seed	3	8	0	7	3
- Poor food taste	2	0	2	0	2
- Seed not available	14	4	47	18	21
- Other	43	21	31	14	35

Notes: multiple response for household for known specific maize varieties not used during survey year; n: sample size.

5.2 Maize seed use by farm households

The surveyed farm households planted some 35 kg of maize seed per year overall, although this oscillated around the 20 kg for Tanzania and about 50 for Ethiopia (Table 38). Although the surveyed farm households knew 2.8 maize varieties on average, they actually only used 1.3 varieties in the survey year—an average that was similar in the two preceding years and somewhat higher in Uganda and Kenya (Table 38). Except in Ethiopia, the portfolio of maize varieties used by the surveyed farm households typically featured two-three prominent varieties in each study area (Table 39). In the case of Uganda three improved Longe varieties were most prominent, being grown by at least a quarter of the households, whereas in Tanzania local varieties were most widely reported. Kenya presents an interesting contrast, with the portfolio being dominated by one popular local maize and a third of the households reporting one particular hybrid. In Ethiopia, the most popular variety was only grown by 16% of the surveyed households, with the top spot being shared between a local variety and a hybrid, followed by a range of other varieties (Table 39).

Table 38. Selected maize seed indicators for surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd, n)
Maize seed planted (kg)					
- Survey year	49 [c]	29 [b]	31 [b]	19 [a]	35 (±43, 1004)
- Preceding year	48 [c]	30 [b]	31 [b]	21 [a]	34 (±43, 881)
- 2 years back	45 [b]	29 [a]	27 [a]	22 [a]	33 (±43, 732)
# of maize varieties planted					
- Survey year	1.2 [a]	1.5 [b]	1.4 [b]	1.1 [a]	1.3 (±.6, 996)
- Preceding year	1.1 [a]	1.4 [b]	1.4 [b]	1.1 [a]	1.3 (±.5, 919)
- 2 years back	1.1 [a]	1.3 [b]	1.3 [b]	1.1 [a]	1.2 (±.5, 787)
Seed use in survey year (% hh)					
- Local varieties	36	90	37	67	59 (1018)
- Improved (OPV or H)	78	45	83	40	62 (1018)
o Improved OPV	59	2	81	20	38 (959)
o Hybrid	23	41	6	25	27 (959)
Seed share survey year (%)					
- Local varieties	31 [a]	78 [c]	26 [a]	64 [b]	51 (±46, 1018)
- Improved (OPV + H)	69 [c]	22 [a]	74 [c]	36 [b]	49 (±46, 1018)
o Improved OPV	51 [c]	1 [a]	71 [d]	18 [b]	32 (±45, 959)
o Hybrid	20 [b]	19 [b]	3 [a]	19 [b]	17 (±34, 959)
Years of growing specific maize variety					
- Local varieties	5.9 [a]	11.8 [b]	11.5 [b]	12.7 [b]	9.4 (±8.8, 418)
- Improved OPVs	3.0 [b]	1.7 [a]	4.3 [c]	4.6 [c]	3.5 (±2.8, 410)
- Hybrids *	2.5	2.5	3.2	2.6	2.5 (±1.8, 342, ns)
- Any maize variety	4.0 [a]	3.8 [a]	7.7 [b]	9.0 [b]	5.3 (±6.1, 799)
Years of recycling specific maize variety					
- Local varieties	4.6 [a]	5.3 [ab]	6.5 [ab]	8.4 [b]	6.0 (±7.6, 397)
- Improved OPVs	2.3 [c]	0.3 [a]	1.6 [b]	3.5 [c]	2.0 (±1.9, 363)
- Hybrids	1.8 [b]	0.5 [a]	0.4 [a]	1.9 [b]	1.0 (±1.6, 271)
- Any maize variety	3.0 [b]	1.6 [a]	3.6 [bc]	5.7 [c]	3.2 (±5.1, 717)

Notes: sd: standard deviation; n: sample size; all ps (Welch, *ANOVA or Chi-square) highly significant (0.00) unless otherwise indicated (ns: not significant). Data preceding different letters differ significantly – Tamhane's T2 (significance level: 0.10), within row comparison.

Overall, improved and local maize varieties were about equally common among the surveyed farm households—be it in terms of households reporting their use (respectively 62% and 59% overall) or their share in reported seed use (49% and 51% - Table 38). However, local varieties are particularly widespread in the Kenya and Tanzania study areas, being reported by about a third of the surveyed households in Ethiopia and Uganda (Table 38). Interestingly, the Kenya study thereby combines the highest use rate of local varieties with the highest penetration of hybrids (41% of households) and a relative absence of (improved) OPVs. In contrast, the use of OPVs is widespread in the Ethiopian and Ugandan study areas (Table 38).

Farmers have been growing the maize varieties they use for an average of five years – this being somewhat shorter in the Ethiopian and Kenyan study areas (Table 38). In line with expectations, local varieties have the longest durations of use (9.4 years overall), followed by OPVs and hybrids (Table 38). On average, surveyed farmers reported recycling their maize varieties for 3.2 years - this duration again being longest for local varieties as expected (Table 38). However, even hybrids were reportedly recycled for an average of one year, a practice particularly common in the Ethiopian and Tanzanian study areas (Table 38). OPVs were reportedly recycled for an average of two years (Table 38). Recycling of maize seed is indeed commonplace—with 70% of surveyed households (overall) reportedly retaining some of their maize harvest as seed, amounting to 4% of the maize produced on average (see earlier Table 16 - page 19).

Table 39. Reported maize varieties used in survey year by surveyed farm households in the drought prone study areas of eastern Africa.

Ethiopia (n=357)	**Kenya (n=343)**	**Uganda (n=144)**	**Tanzania (n=145)**
Shaye* (16%)	Kikamba* (88%)	Longe 5 (35%)	Asila* (34%)
BH540 (16%)	Pioneer 3253 (33%)	Longe 4 (29%)	Local* (34%)
Katumani (14%)	Duma 41 (15%)	Longe 1 (28%)	Seedco (14%)
Hawasa (14%)	Pan 67 (4%)	Ekwakoit* (13%)	Kilima (10%)
Mirtzer (10%)	Duma 43 (2%)	Mweraigoro* (6%)	Cargil (6%)
Limati (8%)	Katumani (2%)	Egwanapa* (6%)	Ilonga (6%)
Pioneer (8%)	DK8031 (1%)	Munandi* (5%)	Staha (3%)
Habasha* (8%)	Kangundo* (1%)	Kasoli Muganda* (4%)	Other (3%)
Malkasa (7%)	Other (7%)	Longe 2H (4%)	
Nano* (4%)		Other (10%)	
Marid* (3%)			
Hararge* (2%)			
Key Maize (2%)			
Other (8%)			

Note: % of households reporting use of the maize variety during the survey year. Listed here are varieties that were named at least 5 times by country, with remainder lumped under others. Column % do not add up to 100% as multiple responses (up to 4 per season) possible. * Primarily reported as local varieties

Overall, 70% of the surveyed farm households reported having used improved maize varieties (OPVs or hybrids) during the five years preceding the survey, with about three quarters of users reporting continuous use (Table 40). Lack of money was the main reasons for those not using any improved varieties, followed by them being satisfied with existing varieties and not having heard/seen any better varieties (Table 40). Lack of money and satisfaction with existing varieties were also reported as the main reasons for not using improved varieties in the survey year (Table 40), whereas non-continuous use of improved varieties was primarily associated with non-satisfaction and again lack of money (Table 40).

Table 40. Selected improved maize seed use indicators for surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (n)
Planted any improved maize variety last 5 years (%)	87	56	86	49	70 (1019)
Continuous use over last 5 years (% hh, for those that planted)	78	66	94	75	78 (640)
Reasons for not using any improved varieties (% hh)	(n=46)	(n=132)	(n=20)	(n=67)	(n=265, nr)
- Lack of money	35	40	35	36	38
- Satisfied with existing	7	33	20	15	23
- Not heard/seen better varieties	17	23	25	13	20
- Cannot get the seeds	15	3	20	34	14
- Other	26	1		1	5
Reasons for not continuously using improved varieties (% hh)	(n=37)	(n=44)	(n=6)	(n=13)	(n=100, nr)
- Not satisfied with performance	30	43	33	38	37
- Lack of money	16	48	50	31	34
- Preferred seed no longer available	22	0	0	15	10
- Other	32	9	17	15	19
Reasons for not using improved varieties in survey year (% hh)	(n=109)	(n=23)	(n=73)	(n=64)	(n=269, nr)
- Lack of money	43	41	53	61	47
- Satisfied with existing	52	59	47	9	44
- Other	5	0	0	30	9

Notes: n: sample size; all p's (Chi-square) highly significant (0.00) unless otherwise indicated (nr: not relevant [empty cells]).

5.3 Sources of maize seed for farm households

The surveyed farm households started using improved maize seed varieties relatively recently—on average some five years before the survey (2002-03 across study sites). The maize varieties that were first used by the surveyed farm households are listed in Table 41—many of which were still in use during the survey year (Table 39). The households were queried as to their sources of improved variety seed and related information (Table 42).[6] The main information sources were fellow farmers and the public extension—reported about equally overall but with a marked regional variation. Public extension is strikingly prominent in Ethiopia and Tanzania whereas fellow farmers are much more prominent in the Kenya and Uganda study areas. Improved maize variety seed was primarily acquired through purchases, mainly from agro-dealers. In the Ethiopia and Tanzania study areas it was relatively more common for farmers to acquire seed through public channels. A quarter of

[6] The indicators were collected for both the initial adoption and for the survey year. In view of the recent nature of adoption they proved very similar and the data in the table presents the combined responses for those households that have used any improved variety during the 5 years preceding the survey.

the surveyed farm households used saved seed and 16% seed from another farmer. About half the surveyed households reported availability as the main reason for the choice of seed source.

Table 41. Reported *initial* improved maize varieties by surveyed farm households in the drought prone study areas of eastern Africa (n=635).

Ethiopia (n=293)	Kenya (n=154)	Uganda (n=124)	Tanzania (n=64)
Katumani (20%)	Pioneer 3253 (56%)	Longe 1 (41%)	Cargil (25%)
Hawasa (17%)	Duma41 (10%)	Longe 4 (27%)	Seedco (23%)
BH540 (14%)	H511 (10%)	Longe 5 (26%)	Kilima (19%)
Mirtzer (12%)	Katumani (8%)	Other (6%)	Ilonga (16%)
Pioneer (10%)	Pan67 (3%)		Other (17%)
Limati (9%)	Other (12%)		
Melkasa (7%)			
Key Maize (3%)			
Other (8%)			

Notes: Listed are varieties that were named at least 5 times by country, with remainder lumped under others.

Table 42. Improved maize varieties access indicators for surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (n)
Information source (% hh)	(n=316)	(n=192)	(n=126)	(n=65)	(n=699)
- Fellow farmers	37	80	60	17	51
- Ministry/extension	77	8	27	45	46
- Radio	7	24	10	35	15
- Other	14	28	25	17	20
Seed source (% hh)	(n=316)	(n=193)	(n=126)	(n=65)	(n=700)
- Agro-dealer purchase	6	70	37	19	31
- Market purchase	22	24	13	5	19
- Ministry purchase	22	3	3	19	13
- Other purchase	3	2	7	15	5
- Free from institution	17	3	18	22	14
- From another farmer	22	3	16	28	16
- Saved seed	40	21	7	11	26
- Other	9	0	1	2	4
Availability as main reason for seed source choice (% hh)	37	72	78	56	56 (688)

Notes: only for 716 households that used any improved variety during the 5 years preceding the survey. n: sample size [valid responses]; all p's (Chi-square) highly significant (0.00). Responses do not sum to 100% as multiple responses for household possible.

About half (55% overall) of the surveyed farm households reported purchasing maize seed during the survey year, this being more common in the Kenya study site (63%) and least common in Tanzania (42% - Table 43). The maize varieties reportedly purchased by the surveyed farm households during the survey year are listed in Table 44. In line with expectations, the majority of the households that purchase maize seed, purchased improved varieties. However, a substantial number also purchase local varieties (32% of households overall), be it alone (20%) or in combination with improved varieties (12% - Table 43). Purchase of local varieties was most commonly reported in Kenya (54% of households), with the local Kikamba being the main maize variety being purchased in both major and minor seasons. For those that purchased, an average of 1.7 maize varieties were purchased, amounting to 30 kg of maize seed at an average cost of US$1 per kg—the reported seed prices being lowest in Ethiopia (US$ 0.4/kg) and highest in Kenya (US$ 1.6 - Table 43). The main time for maize seed purchases is in the run-up to the main season, although in Kenya and Uganda purchases for the minor season are also common (Table 43). This, in combination with varying rain seasons across the region, results in marked maize sales peaks per country, but with peaks spread throughout the year for the region as a whole (Figure 2).

Table 43. Maize seed purchase indicators for survey year of surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd)
Purchased maize seed (% hh)					
- For major season	54	62	43	42	53
- For minor season	0	47	42	0	22
- Annually (major & minor)	54	63	52	42	55
Type of seed for those that purchased (% hh, n=557):					
- Improved	88	47	88	60	69
- Improved and local	3	23	4	10	12
- Local	9	31	8	30	20
For those that purchased (n=560):					
- # of varieties purchased	1.1 [a]	2.3 [c]	1.9 [b]	1.1 [a]	1.7 (±0.9)
- Kg maize seed purchased	45 [b]	20 [a]	27 [a]	26 [a]	30 (±47)
- Average price (US$/kg)	0.4 [a]	1.6 [c]	0.8 [b]	0.7 [ab]	1.0 (±1.3)
Purchased improved maize seed					
- Share hh (%)	50	44	49	30	45 (±50, 1004)
- Share maize seed purchased (%)	85 [b]	47 [a]	76 [b]	85 [b]	70 (±34, 449)

Notes: sd: standard deviation; n: sample size =1019 unless otherwise indicated; all p's (Welch or Chi-square) highly significant (0.00). Data preceding different letters differ significantly – Tamhane's T2 (significance level: 0.10), within row comparison.

Table 44. Reported maize varieties purchased in survey year by surveyed farm households in the drought prone study areas of eastern Africa.

Ethiopia (n=200)	Kenya (n=224)	Uganda (n=78)	Tanzania (n=75)
BH540 (24%)	Kikamba* (89%)	Longe 5 (62%)	Seedco (28%)
Hawasa (17%)	Pioneer 3253 (70%)	Longe 4 (53%)	Local* (24%)
Pioneer (13%)	Duma41 (28%)	Longe 1 (35%)	Asila* (21%)
Katumani (12%)	Pan 67 (10%)	Longe 2H (9%)	Kilima (17%)
Melkasa (12%)	Duma43 (5%)	Others (28%)	Ilonga (11%)
Mirtzer (8%)	Kangundo* (4%)		Cargill (9%)
Limati (7%)	DK8031 (3%)		Others (7%)
Shaye* (6%)	DH04 (3%)		
Key Maize (4%)	Katumani (3%)		
Others (7%)	Others (12%)		

Notes: % of households reporting the maize variety for households that purchase maize seed. Listed here are varieties that were named at least 5 times by country, with remainder lumped under others. Column % do not add up to 100% as multiple responses (up to 3 per season) possible across main and minor season.
* Primarily reported as local varieties

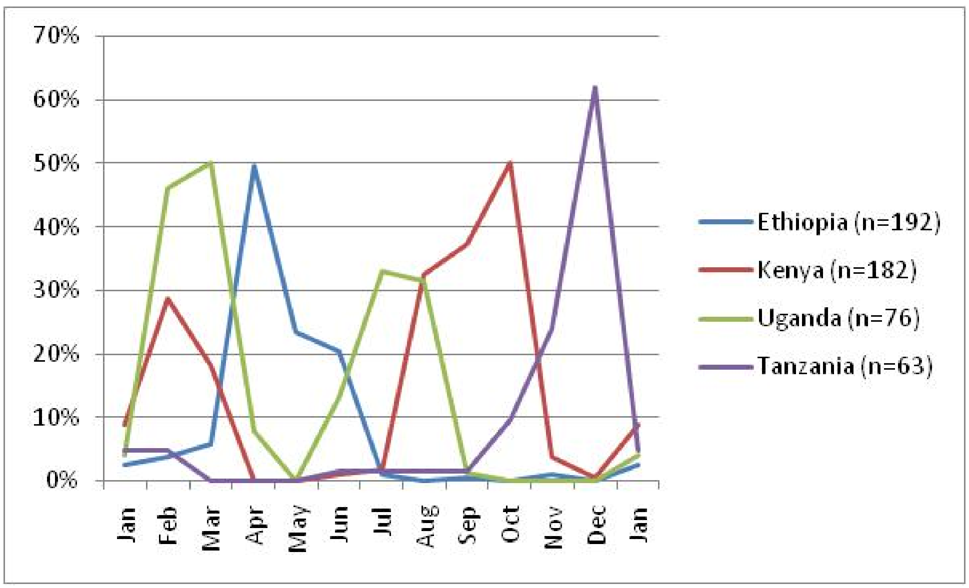

Figure 2. Time of maize seed purchase for surveyed farm households in the drought prone study areas of eastern Africa.

Notes: % of households reporting the month for households that purchase maize seed. % do not add up to 100% as multiple responses (up to 3 per season) possible across main and minor season.

5.4 Other seed use by farm households

Maize is the major crop for the surveyed farm households. Maize seed alone thereby comprises half of the reported household's seed grain use (by weight - Table 45). Legumes accounted for the bulk of the remaining seed weight, with other cereals only contributing a fraction (Table 45). Whereas over half of the surveyed households purchased maize seed, purchases of other seeds was relatively uncommon (Table 45). Most common was the purchase of legume seed, reported by 28% of the surveyed households (overall - Table 45). The actual seed purchased varies by country, directly associated with the underlying cropping pattern. For instance, in the case of Tanzania study areas, groundnut was the main legume seed purchased. Other cereal purchases included millet, rice and sorghum with sunflower and sesame making up the other seed purchases.

Table 45. Annual seed use indicators by surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd, n, p)
Annual seed used (kg pa)					(n=1011)
- Maize	49 [c]	29 [b]	31 [b]	19 [a]	35 (±43)
- Other cereal	2 [ab]	0.3 [a]	9 [bc]	5 [c]	3 (±18)
- Legume	55 [d]	35 [c]	26 [b]	7 [a]	37 (±54)
- Total grain seed (cereal + legume)	105 [c]	64 [b]	66 [b]	31 [a]	75 (±83)
Maize share total grain seed (%)	58 [b]	45 [a]	50 [a]	70 [c]	54 (1011)
Purchased seed (% hh, n=1019)					
- Other cereal seed	9	2	8	16	7
- Legume seed	9	50	32	20	28
- Tuber seed	0	7	1	1	3
- Root cuttings	0	6	5	0	3

Notes: n: sample size; sd: standard deviation; all p's (Welch or Chi-square) highly significant (0.00). Data preceding different letters differ significantly – Tamhane's T2 (significance level: 0.10), within row comparison.

5.5 Fertility management by farm households

To maintain soil fertility the surveyed households rely on a combination of fallowing, animal manure and chemical fertilizers—each practice being equally reported (43-44% overall), albeit with marked regional variations.

Fallowing is particularly common in the Uganda study area (72%) and to a lesser extent Tanzania (Table 46), but only reported by about a third of households in Ethiopia and Kenya—linked *inter alia* to the prevailing population density. For those fallowing, the crop duration averaged 3.6 years and fallow duration 2.2 years (Table 46). About half the surveyed households reported maize as the first crop grown after fallowing, although this was less common in Ethiopia and Tanzania (Table 46).

Table 46. Fallow management indicators of surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd, p)
Reported use of fallowing (%, n=1019)	32	37	72	55	43
If fallowing, duration (years)					
- Cropping (n=146)	5.2 [b]	3.3 [ab]	2.9 [a]	4.3 [ab]	3.6 (±3.4, .08)
- Fallow (n=150)	1.6	4.1	1.8	3.9	2.2 (±2.1, .02)
Crops grown following fallow (% of hh fallowing, n=179)*					(nr)
- Maize	27	91	48	15	45
- Groundnut	31	0	10	15	15
- Beans	0	70	0	0	9
- Cassava	0	4	16	0	9
- Sweet potato	0	4	13	0	7
- Pigeon pea	0	52	0	0	7
- Sunflower	0	0	0	62	4
- Other	42	4	12	8	20

Notes: sd: standard deviation; n: sample size; all p's (Welch or Chi-square) highly significant (0.00) unless otherwise indicated (nr: not relevant [multiple response]). Data preceding different letters differ significantly – Tamhane's T2 (significance level: 0.10), within row comparison. *In Kenya intercropping of maize with legumes is common, hence column total does not sum to 100%; otherwise column totals may not add up to 100% due to rounding.

The use of animal manure and chemical fertilizers showed a marked regional variation, being largely limited to the Ethiopia and Kenya study areas (Table 47). Animal manure originated from the farm, with no purchases being reported. Chemical fertilizer use averaged less than 100 kg per surveyed household in Ethiopia and Kenya, with usage being somewhat more common in Kenya but application rates somewhat higher in Ethiopia (Table 47). Chemical fertilizer primarily included basal fertilizer, and to a lesser extent top dress. The chemical fertilizer cost averaged US$ 0.5 per kg, with the average transport costs amounting to an additional 10% (Table 47).

Table 47. Fertilizer use indicators for surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd)
Use of (% hh):					
- Basal chemical fertilizer	53	61	1	0	40
- Top dress chem. fertilizer	25	55	0	0	28
- Any chemical fertilizer	57	66	1	0	43
- Manure	36	87	9	0	44
Av fertilizer use, kg/hh pa:					
- Basal fertilizer	71 [c]	42 [b]	1 [a]	0 [a]	40 (±98)
- Top dress	23 [b]	30 [b]	0 [a]	0 [a]	19 (±75)
- Total	94 [b]	72 [b]	1 [a]	0 [a]	59 (±144)
For those that purchased fertilizer, annual kg/hh:	(n=199)	(n=227)			(n=426)
- Basal fertilizer	129 [b]	60 [a]	-	-	92 (±131)
- Top dress	39	39	-	-	39 (±106, ns)
- Total	168 [b]	99 [a]	-	-	131 (±191)
Fertilizer cost (US$/kg)					
- Basal fertilizer (n=384)	0.42 [a]	0.56 [b]	-	-	0.50 (±.34)
- Top dress (n=266)	0.57	0.49	-	-	0.51 (±1.15, ns)
Fertilizer transport cost (US$/kg)					
- Basal fertilizer (n=126)	0.05	0.04	-	-	0.05 (±.16, ns)
- Top dress (n=68)	0.05	0.07	-	-	0.06 (±.18, ns)

Notes: sd: standard deviation; n: sample size =1019 unless otherwise indicated; all p's (Welch, t-test or Chi-square) highly significant (0.00) unless otherwise indicated (ns: not significant). Data preceding different letters differ significantly – t-test or Tamhane's T2 (significance level: 0.10), within row comparison.

In the case of the Kenya study areas, the use of chemical fertilizer and animal manure is primarily associated with maize production, with only limited application to other crops (Table 48). However, in the case of Ethiopia study areas the situation is mixed – animal manure being primarily applied to maize but maize only receiving a third of the chemical fertilizer and only a quarter of the surveyed households applying chemical fertilizer to maize (Table 48). Maize area also varies between the two study sites, and as a result the fertilizer rate in Ethiopian study sites only averages 12 kg per ha of maize, a fraction of the average 162 applied in Kenya (Table 48).

Table 48. Fertilizer use indicators by crop type for surveyed farm households in the drought prone study areas of eastern Africa.

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd, n)
Use fertilizer (% hh):					
- Maize	24	62	0	0	31 (987)
- Other crops	42	9	0	0	18 (935)
Fertilizer rate (kg/ha):					
- Maize	12 [b]	162 [c]	0 [a]	0 [a]	62 (±293, 987)
- Cropped area	30 [b]	68 [c]	0 [a]	0 [a]	34 (±90, 1012)
Share fertilizer applied to maize (% pa)	34 [a]	94 [b]	-	-	65 (±45, 421)
Use animal manure (% hh):					
- Local Maize	29	80	5	0	47 (630)
- Improved Maize	25	54	6	0	28 (521)
- Any maize	35	86	6	0	44 (987)
- Other crops	5	10	5	0	6 (935)

Notes: sd: standard deviation; n: sample size; all p's (Welch, t-test or Chi-square) highly significant (0.00). Data preceding different letters differ significantly – t-test or Tamhane's T2 (significance level: 0.10), within row comparison.

5.6 Other crop management by farm households

Mechanization in land preparation for maize is limited (5% overall), and largely confined to a tenth of surveyed households in Ethiopia (Table 49). Sole manual land preparation still prevailed amongst the Tanzanian surveyed households, whereas the other study areas relied on a combination of animal traction and manual tillage, with animal traction being particularly prominent in Ethiopia (Table 49). Maize weeding was near universally reported, primarily using physical weeding practices, herbicide purchases being relatively uncommon amongst the surveyed households (9% overall), and largely confined to a fifth of surveyed households in Ethiopia. Insecticide purchases were reported by a tenth of the surveyed households, but largely confined to a quarter of surveyed households in Kenya (Table 49).

The surveyed farm households nearly universally relied on family labor for maize production. About half the households used hired labor, although this was markedly more common in Kenya and Uganda study areas (Table 49). Communal labor and particularly shared labor were not commonly reported, with occurrences mainly in the Ethiopian study areas (Table 49). On average, family labor comprises at least three quarters of the labor used in the various maize production activities (Table 50). The contribution of other labor sources is highest for land preparation and weeding, with hired labor contributing about a fifth (Table 50).

Weevils were the most common storage problem reported for maize grain and seed (87% overall), with less common problems including rodents (31%), moulds (3%, but largely confined to Uganda) and others (7%, including other insects - Table 51). The number of observations for storage problems of other cereals and legume (both grain and seed) are more limited, but in the case of legumes were similar to maize (mainly weevils, followed by rodents) whereas in the case of other cereals these two problems were equally common (Table 51). Farmers frequently used pesticides to combat the storage problems. Post-harvest losses of maize were reported by 29% of surveyed households (overall), although estimated losses amounted to only 1% of the maize produced on average (see earlier Table 16 - page 19).

Table 49. Other input and labor use indicators by surveyed farm households in the drought prone study areas of eastern Africa (% of households).

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean
Maize land preparation (% hh) *:					
- Manual operation	51	97	66	95	76
- Draught animals	97	44	63	5	60
- Tractors	11	2	4	1	5
Labor use for maize weeding (% hh reporting any)	99	99	98	99	99 (nr)
Purchase of (% hh, n=1019):					
- Herbicide	19	4	5	0	9
- Insecticide	1	25	6	2	10
Maize labor sources (% hh) *:					
- Family labor	99	97	100	100	99 (nr)
- Hired labor	39	65	71	14	49
- Communal labor	24	12	7	0	14
- Shared labor	8	0	3	0	3

Notes: n: sample size =998 unless otherwise indicated; all p's (Chi-square) highly significant (0.00) except where otherwise indicated (nr: not relevant [empty cells]). * Multiple responses possible – does not necessarily sum to 100%.

Table 50. Maize labor source indicators in the drought prone study areas of eastern Africa (% contribution by source).

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean
Land preparation (% share, n=998)					
- Family	84 [b]	65 [a]	60 [a]	97 [c]	76
- Hired	7 [a]	33 [b]	38 [b]	3 [a]	20
- Communal/shared	9 [c]	2 [b]	2 [b]	0 [a]	4
Planting (% share, n=942)					
- Family	92 [b]	78 [a]	81 [a]	98 [c]	86
- Hired	3 [a]	22 [b]	18 [b]	2 [a]	12
- Communal/shared	4 [b]	0 [a]	1 [ab]	0 [a]	2
Weeding (% share, n=985)					
- Family	76 [a]	70 [a]	71 [a]	98 [b]	77
- Hired	19 [b]	28 [c]	26 [bc]	2 [a]	21
- Communal/shared	5 [c]	1 [b]	2 [abc]	0 [a]	3
Fertilization (% share, n=542)					
- Family	94 [b]	81 [a]	74 [abc]	99 [c]	88
- Hired	2 [a]	18 [b]	16 [ab]	1 [a]	10
- Communal/shared	4 [b]	0 [a]	9 [ab]	0 [a]	2
Harvesting (% share, n=990)					
- Family	79 [a]	74 [a]	78 [a]	98 [b]	80
- Hired	15 [b]	22 [c]	20 [bc]	2 [a]	16
- Communal/shared	7 [c]	4 [bc]	3 [b]	0 [a]	4
Threshing (% share, n=948)					
- Family	80 [a]	81 [a]	89 [b]	99 [c]	84
- Hired	15 [bc]	17 [c]	10 [b]	1 [a]	13
- Communal/shared	5 [c]	2 [b]	1 [ab]	0 [a]	3

Notes: n: sample size; all p's (Welch) highly significant (0.00). Data preceding different letters differ significantly–Tamhane's T2 (significance level: 0.10), within row comparison. Activity column totals may not add up to 100% due to rounding.

Table 51. **Storage problems for surveyed farm households in the drought prone study areas of eastern Africa (% households reporting).**

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean
Maize	(n=355)	(n=328)	(n=145)	(n=147)	(n=975)
- Weevils	86	96	89	66	87
- Rodents	34	30	40	15	31
- Moulds	1	1	12	0	3
- Other	6	1	10	25	7
Other cereals	(n=75)	(n=20)	(n=70)	(n=45)	(n=210)
- Weevils	15	95	66	56	48
- Rodents	85	0	27	38	48
- Moulds	4	0	14	0	6 (nr)
- Other	1	5	3	13	5 (nr)
Legumes	(n=3)	(n=189)	(n=108)	(n=10)	(n=310)
- Weevils	67	96	55	40	80 (nr)
- Rodents	0	6	47	50	22 (nr)
- Moulds	0	1	18	0	7 (nr)
- Other	33	0	6	10	3 (nr)

Notes: n: sample size; all p's (Chi-square) highly significant (0.00) except where otherwise indicated (nr: not relevant [empty cells]).

5.7 Maize productivity

The study also sought to establish surveyed farm households seasonal maize production patterns and areas planted during the survey year and preceding years. Maize yields were subsequently derived from these farmer reported estimates. The maize yield estimates should thus be interpreted with the necessary caution in view of the various potential measurement errors, including in terms of reported area, production levels and units and recall and enumeration error. Encouragingly though, the thus estimated yields compare reasonably with the regional average and country averages reported earlier (Table 1), also keeping in mind that the study targets the drought prone maize growing areas.

Farmer reported maize yields averaged 1.4 ton per ha in the survey year, and 100-200 kg per ha less in the two preceding years (Table 52). Maize yields in the Tanzania study area were markedly lower (only 0.7 ton per ha), but were similar in the other study areas (1.5 ton per ha - Table 52). Average yields also varied by maize type: 1.2 ton per ha for local maize, 1.4 ton for OPVs and 1.9 ton for hybrids. A similar yield trend over maize types was apparent in each of the study areas, except for Tanzania where yields were similar for each maize seed type (Table 52). The particular case of the Tanzania study area is perhaps associated with its marked home consumption orientation of maize production and the prevailing maize management practices there, including prevalence of local varieties and non-use of chemical fertilizer. Only in the case of Kenya and Uganda is a seasonal contrast of maize yields possible, but whereas in Uganda yields for the two seasons are similar, they are markedly higher for the main season in Kenya, a reflection of maize production being markedly riskier in the minor season and management practices correspondingly less intensive (Table 52).

Table 52. **Selected maize productivity indicators for surveyed farm households in the drought prone study areas of eastern Africa.**

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd, n)
Maize yield (ton/ha)					
- Survey year	1.5 [b]	1.5 [b]	1.5 [b]	0.7 [a]	1.4 (±1.0, 907)
- Preceding year	1.4 [b]	1.3 [b]	1.5 [b]	0.8 [a]	1.3 (±1.0, 793)
- 2 years back	1.3 [b]	1.3 [b]	1.5 [c]	0.7 [a]	1.2 (±0.9, 663)
Yield by type (ton/ha)					
- Local varieties	1.3 [b]	1.4 [b]	1.2 [b]	0.7 [a]	1.2 (±0.9, 521)
- Improved OPVs	1.4 [b]	1.7 [ab]	1.6 [b]	0.6 [a]	1.4 (±1.0, 359)
- Hybrids	2.1 [b]	2.1 [b]	1.9 [b]	0.7 [a]	1.9 (±1.3, 240)
Yield by season (ton/ha)					
- Main	1.5 [b]	1.8 [c]	1.6 [bc]	0.7 [a]	1.5 (±1.1, 913)
- Minor	-	1.2 [a]	1.6 [b]	-	1.3 (±1.1, 430)

Notes: sd: standard deviation; n: sample size; all p's (Welch or t-test) highly significant (0.00). Data preceding different letters differ significantly–Tamhane's T2 or t-test (significance level: 0.10), within row comparison.

5.8 Determinants of improved maize seed purchases

The present chapter illustrates the diversity in maize varietal use in the drought prone study areas of eastern Africa. Although knowledge of maize varieties is widespread, the number of varieties actually in use is substantially less. Although improved maize varieties comprise about half the seed volume used, there is widespread and long-lasting seed recycling of both local as improved varieties. Improved maize varieties also show marked variation in terms of the relative importance of hybrids vs. OPVs. Finally, a substantial number of households purchase local maize varieties. In line with expectations, the various maize varietal indicators are positively associated with the household's resource endowment (Table 53). This particular classification of the household's resource endowment is however based solely on the first principal component, whereas it is variously associated with the various household assets depending on the study site. The present section provides a further exploration of the various factors associated with maize varietal use. Amongst the various seed use indicators, it focuses on the determinants of improved maize seed purchases. This was perceived as the most relevant and reliable indicator across study sites. Indeed, it was the sole indicator that showed a significant association with asset endowments across all study sites (Table 53).

Table 53. **Selected maize varietal indicators by asset endowment for surveyed farm households in the drought prone study areas of eastern Africa.**

	Ethiopia	Kenya	Uganda	Tanzania	Sample mean (sd, n)
# maize varieties known per hh					2.8 (±1.5, 982)
- Less endowed	2.3**	3.1***	2.8***	2.2	2.6***
- Well endowed	2.6	3.7	3.5	2.5	3.1
# maize varieties used per hh					1.3 (±.6, 996)
- Less endowed	1.1***	1.4***	1.3	1.1	1.2***
- Well endowed	1.3	1.7	1.5	1.1	1.4
Use of improved maize (OPV or hybrid) in survey year (% hh)					62 (±49, 1018)
- Less endowed	76	34***	77***	31***	55***
- Well endowed	81	60	93	52	71
Use of improved OPV maize in survey year (% hh)					38 (±49, 959)
- Less endowed	64**	1	75**	15*	38
- Well endowed	53	3	91	27	37
Use of hybrid maize in survey year (% hh)					27 (±44, 959)
- Less endowed	15***	31***	4	19*	19***
- Well endowed	34	55	9	32	37
Purchase of improved maize in survey year (% hh)					45 (±50, 1004)
- Less endowed	40***	34***	41**	23**	36***
- Well endowed	62	57	61	39	56

Notes: See previous tables for country averages and contrasts, here only overall mean, standard deviation and sample size are repeated. Asset endowment classification based on first component of PCA at country level (see Table 12). Averages preceding *'s differ significantly–t-test (*** significant at 1% level; ** at 5%; * at 10%), within column comparison of less and well endowed for specific indicator.

The factors associated with improved maize seed purchases can be variously analyzed, with limited dependent variable models such as Probit particularly popular (CIMMYT, 1993). Probit models were variously used here to explore the improved maize seed purchases by the surveyed farmers both for the eastern Africa study areas as a whole and for the individual study sites. To facilitate comparison the models use the same dependent and independent variables (Table 54). The dichotomous dependent variable represents whether the surveyed farm household purchased improved maize seed varieties during the survey year (0: no purchases; 1: purchases). As independent variables we used various uncorrelated structural variables that characterize the farm household. The regional model also includes country dummies whereas the country models contain district dummies. The district dummy takes a value of 1 for the first of the two districts in each country (as listed in Table 3). To correct for the survey sampling design the cluster option was used in Stata 11 (clustering by country at the regional level and by district at the country level). Overall, we expect asset and income indicators to be positively associated with the purchase of improved maize seed. We would however expect the incidence of drought to be negatively associated. Female headed households are expected to be more resource constrained and thereby negatively associated with maize seed purchases. Use of fallowing suggests surplus land and thereby less resource constraints.[7] The district dummy is coded such that it captures proximity to the capital, and hence expected to be positively associated. The average incidence of improved maize seed purchases was highest in the Ethiopia study site, so we would expect the three country dummy's to be negatively associated.

Table 54. Descriptive statistics for variables used in limited dependent variable models of improved maize seed purchases.

Variable	Description	Mean	Std. Dev.	Min	Max	Obs
dMIsdpr	Purchased improved maize seed (dummy)	0.45	0.50	0	1	1004
dfemhead	Female headed household (dummy)	0.10	0.30	0	1	1013
schoolyrs	Schooling household head (years)	6.5	4.3	0	18	1013
dfallow	Reported fallowing of land (dummy)	0.43	0.49	0	1	1019
pmaize	Share farm allocated to maize	0.41	0.24	0	1	1014
dtransp	Own means of transport (dummy)	0.41	0.49	0	1	1019
dphone	Own mobile and/or fixed phone (dummy)	0.22	0.42	0	1	1019
ddraftan	Own draft animals (dummy)	0.42	0.49	0	1	1019
drtv	Owns TV and/or radio (dummy)	0.65	0.48	0	1	1019
dextens	Attended agriculture related extension activities (dummy)	0.28	0.45	0	1	1019
dcredit	Credit use during survey year (dummy)	0.15	0.35	0	1	1019
dofffarm	Off farm income during survey year (dummy)	0.61	0.49	0	1	1019
ndrghtyrs	Years of drought per decade	3.0	1.7	0	10	1018
nTLU	Aggregate livestock herd per hh (TLU)	2.6	4.0	0	50.4	1019
nlaborpc	Labor availability per household capita (man eq. units)	0.64	0.17	0.14	1	1017
nlandpc	Farm area per household capita (ha)	0.47	1.19	0.02	34.5	1012
nincompc	Annual reported cash income per household capita (US$ '000)	0.15	0.31	0	4.28	1019
dKY	Kenya (dummy)	0.34	0.47	0	1	1019
dUG	Uganda (dummy)	0.15	0.35	0	1	1019
dTZ	Tanzania (dummy)	0.15	0.36	0	1	1019
dDistrict	First district (dummy)	0.48	0.50	0	1	1019

The predictive power of the Probit models is reasonable and relatively similar for the regional and country specific models (Table 55). The signs of the coefficients are generally in line with expectations, but the contribution of individual variables varies between models. Having an own telephone is the only variable significant in all five models, generally enhancing the likelihood of IMS (improved maize seed) purchases (except Tanzania). Phone

[7] Alternatively one may argue that fallowing reflects severe resource constraints whereby a household was unable to cultivate (all) land because. We however expect voluntary fallowing to prevail over the incidence of such constrained fallowing, also in view of the limited fertilizer use and the importance of fallowing for soil fertility restoration in the region.

ownership primarily reflects mobile phones and thereby a willingness of the household to invest in modern communication technology, which thus appears associated with the willingness to invest in modern maize production technology.

Table 55. Results of limited dependent variable models of improved maize seed purchases (Probit).

	Regional model			Country Model (dF/dx)			
Variable	**Coef.**	**S.Err.**	**dF/dx**	**ET**	**KY**	**UG**	**TZ**
dfemhead	-.109	.156	-.043	-.264	-.080***	.174***	.103
schoolyrs	.017	.008	.007**	.007	.006**	-.005	.010
dfallow	.326	.090	.129***	.172***	.087	.067	.161***
pmaize	.776	.247	.307***	.123	.582***	.703***	.228***
dtransp	.208	.087	.082**	.086	-.046	-.030	.172
dphone	.306	.090	.121***	.209***	.113**	.199*	-.224*
ddraftan	-.135	.134	-.053	.064***	.017	-.119	.137**
drtv	.010	.078	.004	.000	.043	.141***	-.076
dextens	.185	.084	.074**	.046	.018	.183**	.436***
dcredit [a]	.259	.069	.103***	.086	-	.069	.040
dofffarm	-.156	.147	-.062	.043	-.091	-.040	-.230*
ndrghtyrs	-.020	.022	-.008	-.033***	.002	-.016	-.041
nTLU	.009	.003	.004***	.004	.004	-.003	-.001
nlaborpc	-.089	.162	-.035	.248***	-.152***	.073	-.153**
nlandpc	.056	.028	.022**	-.112	-.015	.015***	.041
nincompc	.514	.133	.204***	1.080	.180	.419**	.733
ddistrict	-	-	-	-.143	.296***	.100	.004
dKY	-.301	.115	-.118***	-	-	-	-
dUG	-.386	.134	-.148***	-	-	-	-
dTZ	-.578	.119	-.216***	-	-	-	-
constant	-.554	.175					
Log pseudolikelihood			-625	-222	-202	-86	-71
Pseudo R2			.08	.10	.12	.16	.19
N			986	357	337	147	140
Cases predicted correctly			63%	65%	68%	68%	73%

Notes: See previous table for variable description. For regional model, model coefficients, standard errors, marginal effects and significance presented; for country models only marginal effects and their significance presented. Coefficients preceding *'s differ significantly from 0 (*** significant at 1% level; ** at 5%; * at 10%). For dummy variables dF/dx is for discrete change from 0 to 1. [a] In case of Kenya access to credit predicts success perfectly and dropped from model estimation.

The study targets drought prone maize producing districts. Still, the share of the farm allocated to maize was positively associated with the IMS purchases in four of the models except for Ethiopia. Reported drought incidence was however only significant and negatively associated with IMS purchases in Ethiopia, although it generally had a negative coefficient in line with expectations. When farm households attended agricultural related extension activities the likelihood of IMS purchases was enhanced at the regional level and in Uganda and Tanzania. Fallowing also enhanced the likelihood of IMS purchases in three models (regional, Ethiopia and Tanzania). Fallowing is associated with abundant land. Similarly households with abundant land (on a per capita basis) were more likely to purchase IMS (regional and Uganda). Abundant labor (on a per capita basis) was negatively associated with IMS purchases in Kenya and Tanzania, but positively in Ethiopia. This reflects the underlying household composition and factor scarcities. Amongst the study sites, Ethiopia combines the lowest average labor availability on a per capita basis with relatively young households. This suggests that Ethiopia farm households have many young dependants and may thus actually be labor constrained. In contrast, the Kenya study site has the highest labor to land ratios, suggesting surplus labor; whereas the Tanzania study site appears particularly capital constrained.

IMS purchases are generally cash based and hence facilitated by cash availability. The positive sign of abundant cash income (on a per capita basis) across models is thus in line with expectations, but the coefficient was only significant in the regional and Uganda models. Similarly, access to credit enhanced the likelihood of IMS purchases at the regional level and was even a perfect predictor in the case for Kenya. Contrary to expectations, having an off-farm income source reduced the likelihood of IMS purchases in Tanzania. This is likely associated with the surveyed Tanzanian households being highly cash deficient and maize production being primarily consumption oriented (Tanzania having the lowest share marketed with the highest share consumed), whereby farm households may prefer to allocate resources to off-farm activities instead of maize production. This may partially also explain the earlier observed negative association between phone ownership and IMS purchases in Tanzania.

The household head's years of schooling enhanced the likelihood of IMS purchases at the regional level and in Kenya. Having a female headed household head reduced the likelihood of IMS purchases in Kenya (likely reflecting resource constraints), but somewhat surprisingly enhanced the likelihood in Uganda. Having other assets enhanced the likelihood of IMS purchases, including draft animals (Ethiopia and Tanzania), livestock (regional), transport means (regional) and a radio and/or TV (Kenya). Only in Kenya was the district level dummy significant—i.e. the likelihood of IMS purchases was higher in Machakos district compared to Makeuni districts, associated inter alia with Machakos being closer to Nairobi, having a higher population density and a lower incidence of poverty (Muhammad et al., 2010). All the country dummies were negative and significant reflecting the higher average incidence of IMS purchases in the Ethiopia study site.

The Probit models thereby reiterate the positive association between the farm household's assets and income and the likelihood of purchasing improved maize seed. This is in line with expectations. However, it also reiterates the challenge of disseminating improved maize varieties in general and drought tolerant maize in particular to the poorer strata of the farming communities in drought prone areas of eastern Africa.

6 Conclusion and recommendations

The study characterized farm households in the drought prone maize growing areas of eastern Africa synthesizing household survey data collected in Ethiopia, Kenya, Uganda and Tanzania (Legese et al., 2010; Mugisha et al., 2011; Muhammad et al., 2010; Temu et al., 2011). The study results are not representative for the respective countries as a whole, but were intended to be representative for the target area—maize growing areas in the medium drought risk zone having a 20-40% probability of failed season. From a methodological perspective, it was encouraging that the study site selection proved robust with the average number of crop failures due to drought during the last decade falling within this target range in each of the countries, although individual responses still oscillated widely (from 0 to 10). However, from a humanitarian and development perspective, such a prevalence of drought proves particularly challenging. Indeed, drought risk was both the most widely reported threat to the livelihoods of the surveyed households (76% overall) as well as the most serious shock that affected the surveyed households during the last decade (89% overall).

The surveyed rural households in the drought prone study areas are typically small-scale family farms. Family labor is a key asset and the main labor source for farming activities; whereas land and livestock are the main natural assets. The rural households are relatively poor, and the physical and financial assets correspondingly limited. The livelihood asset base shows some marked variations between the countries surveyed. The Ugandan surveyed households combined the largest average family, farm and herd size and were relatively well-endowed compared to the other survey locations. Tanzanian surveyed households were relatively less-endowed; with intermediate classifications for the Kenya surveyed households (which combined the smallest average farm size with reasonable housing) and the Ethiopia surveyed households (which are relatively young and have relatively large families and herds). The household's asset endowment has a marked influence on the households' livelihood strategy, technology use and risk coping ability. A clear exponent is the positive association between the household's asset endowment and their use of improved maize varieties.[8]

The surveyed farm households are primarily mixed maize-livestock producers. Granted the study targeted maize growing districts, but the overarching presence of maize in terms of crop production was particularly striking. Maize cultivation in the sample was near-universal with an average 1 ha of maize per household, corresponding to some two-fifths of the farm area and about half the annually cropped area. Maize production is primarily dual purpose in the study areas: to meet household food needs and marketing of surplus. Overall, the relative volume of maize consumed is about double the maize volume sold; and only in the Uganda study areas do maize sales dominate consumption. Livestock are an important component of

[8] Other illustrations and endowment-based contrasts of various indicators have been developed in the underlying country reports (see Legese et al., 2010; Mugisha et al., 2011; Muhammad et al., 2010; Temu et al., 2011).

the livelihood portfolio of the surveyed farm households, ownership being near universal in the various study areas except in Tanzania; and primarily comprising cattle, goats and poultry. The surveyed farm households further complement their livelihood portfolio with off-farm income sources—with off-farm cash income sources nearly universally reported by the surveyed farm households in Kenya against about half elsewhere. Off-farm cash income thereby comprises 39% of annual reported cash income over all sites; with the highest cash incomes reported in Kenya followed by Uganda. Despite being farm households, food expenditure made up the largest expense category, with a third of the households being a net food buyer and only 58% considering themselves as food secure during the survey year. Indeed, after drought, food security issues were the most widely reported threat to the livelihoods of the surveyed farm households (63% overall). Some 29% of surveyed households were reportedly cash deficient—with Tanzanian households being particularly cash strapped. The precarious cash flow is illustrated by about half the surveyed households (overall) having had to sell off some assets during the survey year, most commonly so as to be able to buy food.

Despite their location in drought prone areas, agriculture remains the pivot in the livelihood portfolio of the surveyed farm households with 80% seeking to increase agricultural production as their preferred strategy to enhance their livelihoods. Maize was rated as relatively profitable – but also as relatively susceptible to drought and to yield and price risk. The farm households rely on various coping strategies that typically revolve around agricultural diversification, asset accumulation and non-agricultural diversification. The dual purpose nature of maize production implies maize production is relatively sticky downwards—i.e. farmers stated their reluctance to reduce maize production. This suggests great scope for drought tolerant maize varieties as these would reduce the drought and yield risk while maintaining maize production as the central and preferred livelihoods activity.

Drought tolerance and early maturity were indeed commonly reported as desired characteristics of the ideal maize variety and as influencing maize varietal choice, only being out-reported by yield potential. Although knowledge of maize varieties is widespread (2.8 varieties on average), the number of varieties actually in use is substantially less (1.3 varieties in the survey year), with non-use typically revolving around grain yield, expensive seed and non-availability of seed. Overall, 70% of the surveyed farm households reported having used improved maize varieties (OPVs or hybrids) during the five years preceding the survey. In the survey year the use of improved and local maize varieties were about equally common—be it in terms of households reporting their use (respectively 62% and 59% overall) or their share in reported seed use (49% and 51%). However, local varieties are particularly widespread in the Kenya and Tanzania study areas. Improved maize varieties also show marked variation in terms of the relative importance of hybrids vs. OPVs. Interestingly, the Kenya study combines the highest use rate of local varieties with the highest penetration of hybrids and a relative absence of (improved) OPVs. In contrast, the use of OPVs is widespread in the Ethiopian and particularly in the Ugandan study areas.

The surveyed farm households started using improved maize seed varieties relatively recently (on average 2002-03 across study sites). There is widespread and long-lasting seed recycling of both local as improved varieties. Lack of money was commonly reported as reason for not (continuously) using improved varieties, reiterating the prevailing cash constraints. Nearly half the farm households reported purchasing improved maize seed during the survey year; but a third also reported purchasing local varieties, something particularly common in the Kenya study site; whereas seed purchases for other grains are uncommon. Limited dependent variable models illustrate the positive association between the farm household's assets and income and the likelihood of purchasing improved maize seed. This is in line with expectations, but also reiterates the challenge of disseminating improved maize varieties in general and drought tolerant maize in particular to the poorer strata of the farming communities in drought prone areas of eastern Africa.

Other external input use for maize production is relatively uncommon and limited. Soil fertility is managed by a varying combination of fallowing (particularly Uganda and Tanzania) and animal manure and chemical fertilizers (particularly Kenya and Ethiopia). Land preparation primarily relied on a combination of manual tillage and animal traction and weeding was primarily manual. Family labor comprised at least three-quarters of the labor used in the various maize production activities; with about half the households using some hired labor. Farmer-reported maize yields averaged 1.4 ton per ha in the survey year overall; albeit being markedly lower in the Tanzania study area. Overall maize yields averaged 1.2 ton per ha for local maize, 1.4 ton for OPVs and 1.9 ton for hybrids.

The prevailing maize production practices and limited system productivity reiterate the great scope for drought tolerant maize varieties. Indeed, a greater drought tolerance will reduce productivity risk and enhance the expected returns to productivity enhancing investments. Still, the relatively extensive production practices and limited system productivity suggest a need for more comprehensive approaches that combine drought tolerant maize varieties with other productivity enhancing and risk reducing innovations. At the same time the prevailing poverty, the associated marked cash constraints and the dual purpose orientation of maize production call for a portfolio of improved drought tolerant maize varietal options. The Kenya study site is a case in point, whereby the farmers typically lack access to improved OPVs and buy hybrids and local maize varieties side by side. OPVs indeed provide a much needed option to drought prone areas with their inherent system constraints. Yet drought tolerant hybrids are also needed for those maize producing smallholders that are willing and able to invest in such seed. At the same time varietal options should extend beyond mere short duration or drought escaping. Medium duration varieties may provide viable and productive options provided they are drought tolerant.

Enhancing the options of drought tolerant maize varieties available to farmers would have a number of implications. Such diversity offers new opportunities to maize seed companies, although it would also increase the number of their products and competition among products, increase transaction costs and perhaps reduce the scope of any single dominant product. It would also call for the strengthening of innovation pathways and information provision to the smallholder farming community. Many stakeholders, and particularly the less educated and poorer smallholders, already have difficulty in fully understanding the difference between OPVs and hybrids; between drought escaping and drought tolerance. It should thereby be acknowledged that farmers rely on a variety of information sources that often extend beyond the traditional public extension services, and increasingly rely on novel communication channels such as mobile phones.

The present synthesis and underlying country studies were primarily intended as an initial characterization of the maize producing households in the drought prone areas of eastern Africa. This intended to provide the necessary context and enhance our understanding of the potential contribution of drought tolerant maize. Still, this only provides an initial piece of the puzzle. To address the complex challenges of realizing and enhancing the potential of drought tolerant maize in SSA this needs to be complemented by further socio-economic studies and interdisciplinary research. These will particularly enhance our ability to monitor, provide feedback and assess impacts and help facilitate enhanced research and development procedures and targeting of drought tolerant maize.

The present study also allows us to draw some useful lessons for future characterization endeavors. By adhering to a common research approach, questionnaire and dataset, the synthesis and regional contrasts were greatly facilitated vis-à-vis earlier regional studies (e.g. Doss et al., 2003). Still, the synthesis would have benefitted from a stronger adherence to the common research approach for at least the core data—including sample selection and data entry. The study would also have potentially benefitted from a larger sample size (particularly for the second batch countries, but also for the first batch countries) and more nationally representative samples (i.e. beyond the two drought prone districts). This would have enhanced the potential relevance of the characterization data to achieve the secondary objective of using the same as a baseline for future impact assessment. The study would also have benefitted from a shorter questionnaire to collect the core minimal data, perhaps supplemented with additional modules as appropriate. Such proposed adjustments have the benefit of hindsight but also imply trade-offs (e.g. single vs. multiple visits). Indeed, research resources and particularly staff time are typically limited and thereby directly imply trade-offs of any adjustments. For instance, the underlying country studies were originally intended only in the first batch countries (Kenya and Ethiopia in the case of eastern Africa), but were subsequently extended to the second batch countries. This clearly was advantageous in terms of providing a broader geographic coverage and perspective, but at the same time diluted the available resources and delayed the completion of the present synthesis.

Finally, it should be recalled that the present study purposively targeted the 20-40% probability of failed season (PFS) zone. For the characterization purposes of the present study, this proved adequate. The incidence of drought is however not limited to that area. Higher probabilities of failed season (i.e. 40-100% PFS) would correspond with even more frequent and severe droughts – but such areas become increasingly marginal for maize production and crop production for that matter. Some may argue that even the 20-40% PFS zone is not suitable to maize and that farmers would be better off cultivating other crops generally perceived as more drought tolerant than maize such as cassava and the array of semi-arid coarse cereals. However, such arguments miss the overarching rationale for growing maize in the first place – the widespread preference of the market and farm households alike for maize over other coarse cereals in large swathes of SSA. The drought risk in the 20-40% PFS target area thereby seems to affect *how* the maize is grown, not *whether* maize is grown. At the same time, a lower PFS (i.e. 0-20%) only implies a lower probability of failed season. Indeed, maize growing areas with higher potential also are subjected to random drought events. The most severe may lead to the occasional failed season, but even less severe drought can imply substantial maize production losses (also in view of the higher productivity levels and associated input use). Their lower probability and less visible incidence make understanding and quantifying the drought impact in such environments more problematic. Indeed, drought discussions with stakeholders and farmers tend to automatically gravitate towards situations where drought is tangible – such as the targeted 20-40% PFS zone and/or drier areas. It is therefore important to note that the potential contribution of drought tolerant maize varieties is not limited to the 20-40% PFS zone targeted here. Yet at the same time understanding that potential beyond the 20-40% PFS zone through household surveys and the like will be challenging. One may thus need to complement characterization studies such as the present with crop simulation endeavors to quantify the impact of drought in the more favorable areas.

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Annex 1 List of surveyed sample villages

	Ethiopia	Kenya	Uganda	Tanzania
1. District	*Adama*	*Machakos*	*Nakasongola*	*Chamwino*
- Villages	Awash Malkasa; Bati Bora; Batu Dagaga; Bokoji Dawaro; Cheka Alemtena; Dabula Sapho; Didimtu; Roge Balawaldi; Ulaga Malka Oba;	Kakuyuni; Kangundo; Kawethei; Kikambuani; Kivaani; Muisuni	Bijaabe; Buddu; Gaba; Igazi; Ilima; Kakoge; Kasambya; Kasozi; Kazwani; Kigejjo; Kijaluwo; Kimature; Kittanswa; Kyambaka; Kyambogo; Kyawakata; Malumu; Mbali; Mitanzi; Namiika; Namukago; Nayitonda; Ndayiga; Ntuti; Sasira; Wakiibomba; Wangoiro; Wantabya	Itiso; Manchari; Manda
- # of villages	9	6	28	3
2. District	*ATJK*	*Makueni*	*Soroti*	*Manyoni*
- Villages	Aanano Shisha; Chitu Geto; Dandi Adansho; Desta Abiyata; Garbi Widana; Halku Gulanta Boke; Horja Washgula; Hurua Lole; Ido Gojola; Oda Anshura	Iuani; Kilala; Kinyuani; Kithia; Kithunthi; Kiuva; Kyuasini; Makongo; Mukuyuni; Nduu Ndune; Utaati; Wathu	Abuket Odo; Adoku; Agule; Kabola; Kachorombo; Kagwara port cella; Kateta; Odoo; Okunguro;	Chikuyu; Msemembo; Sanjaranda
- # of villages	10	12	9	3
Overall # villages	19	18	37	6