SOCIO-ECONOMICS
Working Paper 4

July 2012

# Characterization of Maize Production in Southern Africa: Synthesis of CIMMYT/ DTMA Household Level Farming System Surveys in Angola, Malawi, Mozambique, Zambia and Zimbabwe


**Girma T. Kassie, Olaf Erenstein, Wilfred Mwangi, Roberto LaRovere, Peter Setimela and Augustine Langyintuo**



CIMMYT®
International Maize and Wheat Improvement Center

Headquartered in Mexico, the International Maize and Wheat Improvement Center (known by its Spanish acronym, CIMMYT) is a not-for-profit agriculture research and training organization. The Center works to reduce poverty and hunger by sustainably increasing the productivity of maize and wheat in the developing world. CIMMYT maintains the world's largest maize and wheat seed bank and is best known for initiating the Green Revolution, which saved millions of lives across Asia and for which CIMMYT's Dr. Norman Borlaug was awarded the Nobel Peace Prize. CIMMYT is a member of the CGIAR Consortium and receives support from national governments, foundations, development banks, and other public and private agencies.

The Drought Tolerant Maize for Africa (DTMA) project is jointly implemented by CIMMYT and the International Institute of Tropical Agriculture (IITA). It's funded by the Bill & Melinda Gates Foundation and the Howard G. Buffett Foundation. The project is part of a broad partnership also involving national agricultural research and extension systems, seed companies, non-governmental organizations (NGOs), community-based organizations (CBOs), and advanced research institutes, together 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.

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

## Acronyms

| | |
|---|---|
| AE | Adult equivalent |
| AZ | Angolan Kwanza (Official Currency of Angola) |
| CGIAR | Consultative Group for International Agricultural Research |
| CIMMYT | International Maize and Wheat Improvement Center |
| CPI | Consumer price index |
| DTMA | Drought Tolerant Maize for Africa Project |
| HH | Household |
| IMF | International Monetary Fund |
| MC | Meticas (Official Currency of Mozambique) |
| MDE | Man-days equivalent |
| MK | Malawian Kwacha (Official Currency of Malawi) |
| NARES | National Agricultural Research and Extension Systems |
| No. | Number |
| OP | Open pollinated |
| OP-IV | Open pollinated improved variety |
| OPV | Open pollinated variety |
| Pa | per annum |
| PPP | Purchasing power parity |
| SADC | Southern Africa Development Community |
| UN | United Nations |
| UNECA | United Nations Economic Commission for Africa |
| US$ | United States Dollar |
| WM1 | 50% of median of measurement error adjusted total income |
| WM2 | 50% of median of measurement error adjusted total expenditure |
| ZK | Zambian Kwacha (official currency of Zambia) |

# Executive summary

This report presents the synthesis of household level surveys in five intervention countries (Angola, Malawi, Mozambique, Zambia, and Zimbabwe) of the Drought Tolerant Maize for Africa (DTMA) project designed and implemented by the International Maize and Wheat Improvement Center (CIMMYT), International Institute for Tropical Agriculture (IITA) and national research and extension institutions in 13 countries of Sub-Saharan Africa (SSA). In each of the study countries, two districts were randomly selected provided that the districts fall in predetermined categories (20-40%) of probability of failed season (PFS). A total sample of 1108 households was randomly drawn with sample sizes varying country to country. The report has different sections that focus, in order, on description of the sample households, extent and determinants of poverty and inequality among the sample population, characteristics of maize production, perception and management of drought risk, and determinants of likelihood and intensity of adoption of improved maize varieties.

The distribution of the age of the sample population shows that the population below the age of 16 years is 54% in Zambia, 47% in Malawi and more than 42% in the other three countries. Most of the sample households in each of the countries are headed by males. Only, Malawian sample has about one third of the households headed by women. The literacy level of household heads is considerably high by African standards. The proportion of literate household head ranges from 67% in Angola to 97% in Zimbabwe. The details of the literacy level show that about 48% of Zimbabweans have attended secondary school or higher followed by 32% in Zambia and to 28% in Angola. Most of the literate household heads in Malawi and Mozambique fall in the primary school category.

The farming systems in the study areas are predominantly traditional and semi-subsistence oriented. The plough culture is an important feature of the systems and hence the traction power of draft animals is indispensable. Nonetheless, only Zambian (44%) and Zimbabwean (42%) farmers use draft animals. No sample household in Angola and Malawi owns a draft animal. The livestock owned per household, in tropical livestock units (TLU), ranges from 0.41 in Malawi to 2.9 in Zambia. Accordingly, the current value in US$ of the livestock owned by a typical household ranges from 102.7 in Malawi to 1051 in Zambia. The average farm land holding is highest in Mozambique where a typical household owns nearly 8 hectares of land, followed by Zambia at 6.63 hectares, and Zimbabwe at 3 hectares. The smallest average farmland was observed in Malawi with a typical household owning 1.25 ha.

Wealth indices were computed based on asset holdings to look into the relative welfare distribution of the sample communities. Forty four percent of the sample households in Angola have negative wealth index. The households with negative indices can generally be considered as poor. Nearly 55% Malawian, 57% Mozambican, and 54% Zambian sample households do have negative wealth indices. Sixty two percent of the sample households in Zimbabwe have negative wealth indices, which is higher than any other country in the study.

Asset wealth based rough classification of the households has shown that most of the sampling households are poor.

A more detailed analysis of poverty and inequality was done based on reported income and expenditure. Household level determinants of poverty were identified using quantile regression. Generally, sample households in Mozambique and Zambia were found to be poorer than the sample households in Angola and Malawi. The poverty profiles show that the absolutely poor households in four of the countries (Angola, Malawi, Mozambique, and Zambia) do have significantly smaller family size, smaller number of illiterate household members, less number of important assets such as phones and radio, livestock and smaller farm sizes. An important observation is that the proportion of total land allocated to maize by absolutely poor households is significantly higher than that of better-off households. The study has also detailed the extent and determinants of poverty and inequality in the countries. The importance of maize technology use and resource allocation to the crop in determining magnitude of poverty and inequality is an important finding in view of the fact that the sample population is essentially semi-subsistent with limited market orientation. This finding also justifies the effort being exerted on development and deployment of maize and maize related technologies in rural communities of the study countries.

Maize production in the region has peculiar characteristics with important distinctions across countries. The land allocated to maize ranges from 45.9% in Mozambique to 69.8% in Malawi of the whole farmland. In Angola, Malawi and Mozambique, most of the maize land is covered with land races; whereas in Zambia and Zimbabwe, hybrid maize covers most of the maize area. All the sample farmers in Zimbabwe are aware of the difference between improved Open pollinated varieties (OPVs) and hybrid maize varieties. On the contrary, about 95% of the sample farmers in Angola do not know the difference between OPV and hybrid maize. Most of the sample farmers in Malawi (72.0%), Mozambique (98.0%), and Zambia (78.0%) are in fact aware of the difference between OPVs and hybrid maize varieties. Regarding recycling of hybrid seeds, it was found out that Zimbabweans hardly recycle, whereas Mozambicans do on average recycle 1.5 times. This pattern of recycling also applies to improved OPVs. Despite considerable number of farmers depending on the market to fetch maize seeds, 90.7% of the farmers in Angola purchased and planted only local maize varieties. Malawian and Zambian farmers, followed by Mozambicans and Zimbabweans, do mostly purchase and grow improved seeds. In terms of the proportion of seed types used, Zimbabwe stands out well-above others with 94.6% of the seed used being improved, followed by Zambia (64.3%) and Malawi (24.8%).

In Malawi, the most preferred varieties, in order of preference are: local, MH36, Kanyani, and Makolo. In Mozambique, Ndau ou Chindau, Matuba, SC513, Laposta, and Pan 67 were indicated to be the most preferred varieties in that order. In Zambia, the four most preferred varieties were identified to be Gankata, SC513, Pool 16, and Obatampa. In Zimbabwe, SC513 is the most preferred variety followed by ZM521 and the local Heckory King variety.

Drought was reported to be the most important challenge on the livelihoods of people in Malawi, Zambia and Zimbabwe, whereas it was indicated to be second, next to sickness and mortality of a family member, in Angola and Mozambique. Maize varieties in general and improved OPVs and hybrids in particular are being considered very risky in terms of predictability and reliability of yields. Given the importance of maize and the vulnerability of the farming communities in the region, drought and risks associated with it will have paramount and potentially irreversible consequences on the poor sections of the region.

The decisions regarding level and intensity of improved maize adoption have also been investigated to show that gender based intra-household division of labor was an important factor considered in deciding to adopt or not improved maize varieties. Asset endowments such as farm size and livestock wealth were found to be important determinants of level and intensity of adoption in the region. Similarly, membership in social groupings and engagement of off-farm activities influenced adoption decisions. Access to extension services has universally been identified as an important factor in determining the level and, when relevant, the intensity of adoption of improved maize varieties in the region. As important as this service is, however, the extent to which farmers are getting the service is not that encouraging according to respondents. It is, therefore, imperative to underline again the need for investment in the agricultural extension system and the effort that shall be exerted in enabling the private sector to engage in generation and deployment of agricultural information.

In designing and implementing any intervention that aims at contributing to the risk coping ability of farmers, it is essential to take into account heterogeneity of the farming communities. Due consideration of this heterogeneity shall be made while assessing the importance of drought risk and while analyzing the effectiveness of the contributions to be made with the intention of strengthening drought risk coping strategies. The trait preferences of farmers are for instance an important indicator of the heterogenous demand structure. This study has shown that despite the fact that yield size is among the most preferred traits, farmers' strong reference to maize as a risky crop urges refocusing breeding activities to generation of germplasms with reliable yield distribution. Farmers have also shown strong interest in traits such as drought tolerance, early maturity, and good performance under poor rainfall implying the need for multi-trait focused breeding schemes.

Public agricultural extension institutions and public mass media are by far the two most important sources of agricultural information in the region. Despite the political importance of agriculture in general and maize in particular, there is always a lack of incentive in publicly owned institutions to deliver the information as timely and as adequately it is needed. Agricultural extension efforts in the region should in fact be accompanied by comprehensive microfinance institutions to relieve farmers of the seasonal cash shortage which almost all of them experience every year. So far, except in Zimbabwe, access to rural credit and finance seems to be farfetched.

# Chapter 1: Introduction

The dynamics of the socioeconomic structure of livelihoods in most of African countries is governed by the magnitude and performance of the agricultural sector. The importance of the sector cannot, therefore, be overemphasized in Africa. It accounts for about 70% of the labor force, over 25% of Gross Domestic Product (GDP), and 20% of agri-business in most African countries (UNECA, 2009). Apart from its direct contribution to livelihoods as source of food and non-food income, agriculture has a high multiplier effect, which means that agricultural investment can generate high economic and social returns and enhance economic diversification as well as social development. UNECA (2005) estimates the multiplier effect to range from 1.5 to 2.7% for each dollar invested in the sector.

In southern Africa as well, agriculture is the key sector in broad based development and poverty reduction strategies (Draper, Kiratu, & Hichert, 2009; SADC, 2008). Majority of the population in the region depend directly on agriculture for its livelihood. Accordingly agriculture remains to be a key driving force for economic development in the region. The sector has always been the primary source of subsistence, employment and income for 61%, of the region's total population of 232 million and it accounts on average for close to 8% (ranging from 3 to 33%) of the region's gross domestic product (Chilonda & Minde, 2007).

The importance of agriculture is expected to increase essentially due to the depth of the direct effects and externalities of global phenomena such as the food price crisis of 2008 and the western world financial meltdown. In Southern Africa, agriculture's importance varies for middle income and low income countries of the region. Agriculture is less important for the region's middle-income countries (e.g., Angola) – contributing only 3% of total GDP of the countries (Chilonda & Minde, 2007). In the low-income countries such as Malawi and Mozambique, it accounts for 33% of total GDP.

The agricultural sector in Southern Africa Development Community (SADC) is dominated by crop production that accounts for 65% of total agricultural revenue. However, crop production's share of value in the sector has been declining over the years as livestock production has increased in importance. The increasing importance of livestock as a source of agricultural revenue implies that agricultural growth in the region will largely depend on the synergy between the crop and livestock sub-sectors combined with enhancing their respective productivity. Currently, the largest contributors to agricultural revenue are maize, fruits, beef, roots, tubers and milk (Chilonda & Minde, 2007).

Despite the sector's importance in the region in general and in the low income countries in particular, agricultural productivity has not been congruent with the ever-increasing human population. According to the United Nations Economic Commission for Africa (UNECA), the contribution of agriculture to GDP in SADC has been less than the African average since the late 1970's (UNECA, 2009). The low and declining productivity of agriculture in

Africa is generally attributed to under-capitalization of agriculture, inadequate funding of research, inadequate use of yield enhancing practices and technologies, and low land and labor productivity. Improved agricultural technologies can address at least two of these challenges faced by African agriculture.

CIMMYT along with National Agricultural Research and Extension Systems (NARES) and other Consultative Group for International Agricultural Research (CGIAR) centers has been exerting a lot of effort in developing and deploying agricultural technologies related to maize, wheat, and conservation agriculture over the last four decades. The need that agriculture shall be resilient and continuously high performing against the socio-economic and bio-physical uncertainties entails continuous and effective development and deployment of high yielding technologies. CIMMYT's focus on maize in Africa for the right reasons.

In addition to the fact that maize is one of the continental commodities identified by the African Union Abuja Food Security Summit (AU, 2006) to enhance food production at continental and sub-regional levels, maize mixed farming systems cover about 10% of the land area and about 15% of the agricultural population in Sub-Saharan Africa (SSA) (IAC, 2004). These farming systems are the most important food production system in east and southern Africa, extending across plateau and highland areas, and southern Africa accounts for 32% of the total maize consumption in Africa (IAC, 2004; UNECA, 2009).

In all of the study countries - Angola, Malawi, Mozambique, Zambia and Zimbabwe - maize stands out as the primary crop both in terms of acreage and absolute yield levels. Data from FAO (FAOSTAT, 2010) show an increasing trend in proportion of area allocated to maize whereas the yield data shows irregular trend with declining tendency (Figures 1 and 2). The importance attached to maize production by farmers in these countries is tantamount to that of rice and wheat in Asia (Cutts & Hassen, 2003).

DTMA project aims at enhancing farmers' drought risk coping ability through generation and deployment of drought tolerant maize germplasm. Building on previous breeding successes and on-going research, the project envisions to generate, by 2016, drought tolerant maize that provides a 1 ton/ha yield increase under drought stress conditions, increase the average productivity of maize under smallholder farmer conditions by 20–30% on adopting farms, reach 30–40 million people in SSA and add an annual average of US$ 160–200 million of additional grain. This vision will be accomplished by distributing OPVs and hybrid varieties with increased drought tolerance to small-scale farmers (LaRovere et al., 2010). The technologies of DTMA will certainly widen the diversity of the coping strategies at farmers' disposal and thus reducing the intensity of harmful strategies such as reducing food consumption, selling assets or withdrawing children from school. This paper synthesizes the household level baseline surveys done in the countries mentioned to characterize the maize production systems and to set the reference for future impact assessment of the technologies of the project.

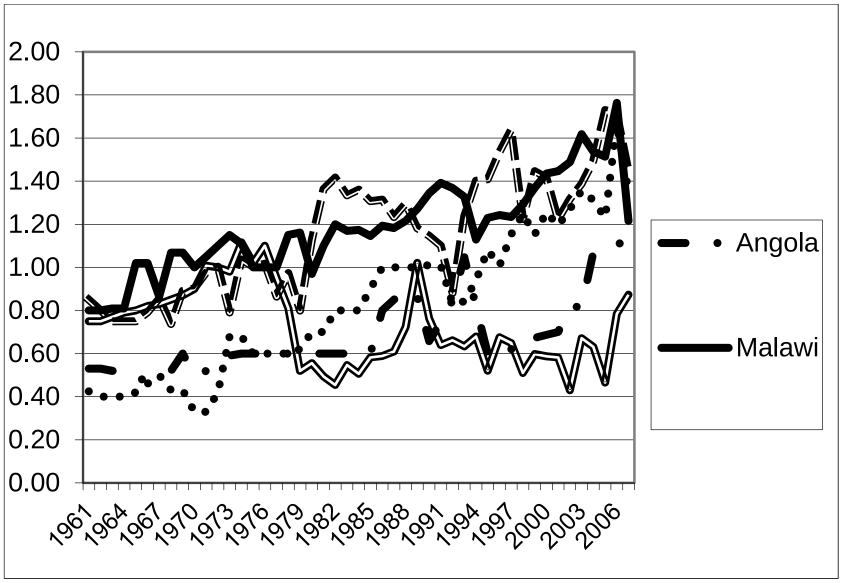



**Figure 1: Maize area harvested (1961-2006) in Southern Africa.**

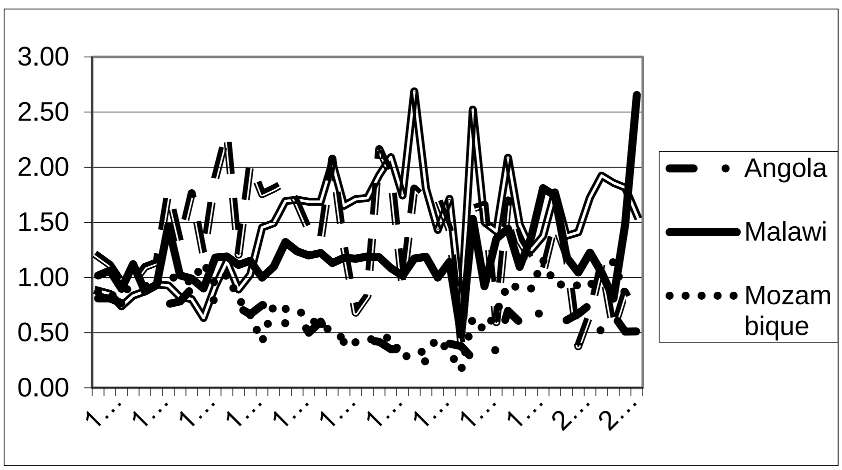



**Figure 2: Maize productivity (ton/ha) in Southern Africa (1961-2006).**

The baseline reports synthesized in this report are that of Angola (Kiakanua, Chichicuhua, Pedro, Nzambi, & Jezo, 2011), Malawi (Mangisoni, Katengeza, Langyintuo, LaRovere, & Mwangi, 2011), Mozambique (Uaiene, Mazuze, Mwangi, Langyintuo, & Kassie, 2011), Zambia (Kalinda, Tembo, Kuntashula, Langyintuo, Mwangi, & La Rovere, 2010), and Zimbabwe (Chikobvu, Chiputwa, Langyintuo, Rovere, & Mwangi, 2010). The surveys in Angola and Malawi were done in 2008 whereas in the remaining three countries they were conducted in 2007. The essential focus of the synthesis is drawing out comparable indicators for future relative measurement of changes and hence uses the country level data sets.

# Chapter 2: Methodology

## 2.1. The study area

This study covered five southern Africa countries, namely, Angola, Malawi, Mozambique, Zambia and Zimbabwe (Figure 3). Angola has a surface area of 1.25 million $Km^2$ and an estimated human population of 18 million in 2008 (UN data, 2010; World Bank, 2010).

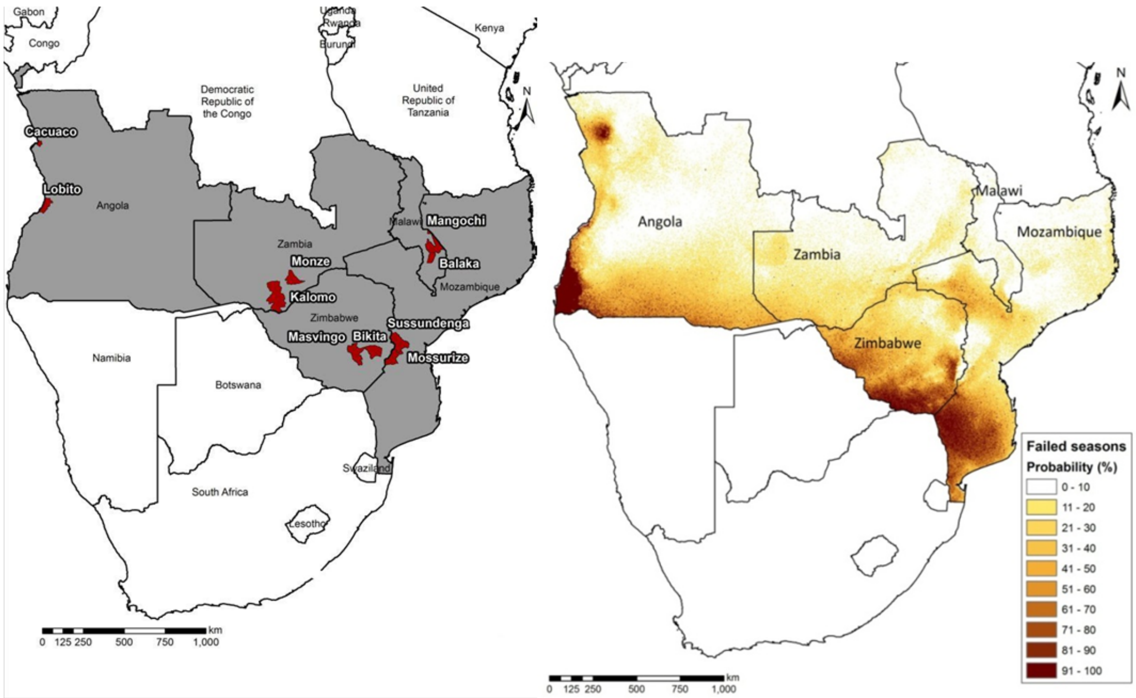



**Figure 3: Surveyed districts (left) and probability of failed season in the study countries (right).**

More than 43% of the population lives in the rural areas depending almost entirely on subsistence agriculture. Agriculture contributed 6.6% of the GDP in 2008 while the oil and mineral based industry sector contributed the grand share (WorldBank, 2010). About 93% of the crop farming is conducted by small holder farmers and maize is the major staple food crop in the country. In Angola, the survey was conducted in Cacuaco and Lobito municipalities in Central West of the country. Cacuaco Municipality is a suburb of Luanda situated at -8°50'00" latitude and 13°30'00" longitude. It has an average altitude of 7 meters above sea level (masl), average daily temperature of 24.3°C and average annual rainfall of 575 millimeter (mm). In 2008, the population density of the municipality was computed to be 46 people per square kilometer ($km^2$) (Table 1). Lobito municipality of Benguela province is located at -12°20'53" latitude and 13°32'44" longitude at an average altitude of 14 masl. It has an average daily temperature of 23.7 °C and average annual rainfall of 356 mm. Lobito Municipality had a population density of 221persons/ $km^2$.

**Table 1. Description of the study areas.**

| | Angola | | Malawi | | Mozambique | | Zambia | | Zimbabwe | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Cacuaco** | **Lobito** | **Balaka** | **Mangochi** | **Mossurize** | **Sussundenga** | **Monze** | **Kalomo** | **Masvingo** | **Bikita** |
| Area (ha) | 571 | 3648 | 2,117 | 6,273 | 5096 | 7060 | 6687 | 15000 | 7009 | 5250 |
| Average altitude | 7 | 14 | 625 | 492 | 600 | 500 | 1012 | 1300 | 750 | 656 |
| Latitude | -8°50'00" | -12°20'53" | -15o2’54” | -14o23’34” | -21o12’45” | -19o24’14” | -16o0’0” | -17o2’6” | -20o4’28” | -20o5’45” |
| Longitude | 13°30'00" | 13°32'44" | 35o3’32” | 35o20’47” | 33o22’48” | 33o17’25” | 27o15’0” | 26o29’6” | 30o49’58” | 31o36’55” |
| Rainfall | | | | | | | | | | |
| Minimum | 400 | | 700 | 658 | 800 | 600 | 332 | | | |
| Maximum | 750 | | 1100 | 1303 | 2070 | 1400 | 815 | 800 | | |
| Average | 575 | 356 | 800 | 983 | 1500 | 1155 | 650 | 350 | 615 | 1133 |
| Temperature | | | | | | | | | | |
| Minimum | 18 | 20.3 | 14 | 14.5 | 15.1 | 15.3 | 6.5 | 13 | 6 | 6 |
| Maximum | 35 | 27.2 | 32 | 33.5 | 25.1 | 27.2 | 32 | 32 | 29 | 30 |
| Average | 24.3 | 23.7 | 23 | 24 | 20 | 21 | 20 | 22 | 19 | 18 |
| Population | 26000 | 805000 | 314000 | 778338 | 195182 | 129851 | 190384 | 156066 | 307518.2 | 181863.1 |
| Pop. Density (pop./km2) | 45.53 | 220.67 | 148.31 | 124.08 | 38.30 | 18.39 | 28.47 | 10.40 | 43.87 | 34.64 |

Sources: (Chikobvu et al., 2010; CIA, 2012; climatedata, 2012; Kalinda et al., 2011; Kiakanua et al., 2011; Mangison et al., 2011; theweathernetwork, 2012; Uaiene et al., 2011; WorldWeatherOnline, 2012; yr.no, 2012)

Malawi is a landlocked country with a surface area of 118,484 $Km^2$ and human population of 14.8 million in 2008 (UN data, 2010; World Bank, 2010). Majority of Malawi's population (>80%) lives in the rural areas. Agriculture is a very important sector contributing about 34.3% of the GDP in 2008 (World Bank, 2010). The government's initiative to broaden seed and fertilize subsidy program has seen Malawi registering food surpluses over the last five years. Maize is the most important food crop in Malawi and availability equates to food security. The districts surveyed in Malawi are Balaka and Mangochi of the Central region. Balaka is located at -15°2'54" latitude and 35°3'32" longitude with an average altitude of 625 masl. It has an average daily temperature of 23°C and average annual rainfall of 800mm. In 2008, the district had a human population density of 148 persons/$km^2$. Mangochi is a district to the north of Balaka situated at -14°23'34" latitude and 35°20'47" longitude. Mangochi has an average altitude of 492 masl, average daily temperature of 24°C and average annual rainfall of 983mm.

Mozambique has a surface area of about 0.8 million $Km^2$and human population of 22.4 million in 2008 (UNdata, 2010). More than 63% of Mozambicans live in the rural areas depending on traditional and subsistence agriculture. Agriculture contributed 28.6% of the GDP in 2008 (WorldBank, 2010). Maize accounts for about 75% of the total value of smallholder crop production in Mozambique and is by far the most important staple food crop in the country. Mossurize and Sussundenga districts of Manica Province of Mozambique were surveyed in this study. Mossurize is located at -21°12'45" latitude and 33°22'48" longitude with an average altitude of 600 masl. It has an average daily temperature of 20°C and an average annual rainfall of 1500mm. In 2007, the district's human population density was computed to be 38 persons/$km^2$. Sussundenga is a neighboring district situated at -19°24'14" latitude, 33°17'25" longitude, and elevation of 500 masl. It has an average daily temperature of 21°C and average annual precipitation of 1155mm. The human population density of the district in 2007 was 18 persons/$km^2$.

Zambia is also a landlocked country with a surface area of about 0.75 million $km^2$ and human population of 13.3 million in mid-2010 (MCTI, 2010). About 65% of Zambians live in the rural areas depending mainly on agriculture which contributed 21.2% of the GDP in 2010. In Zambia, maize is the major staple food crop and accounts for about 80% of the total value of smallholder crop production. Zambia's current economic plan "Enhancing Growth through Competitiveness and Diversification" singles out agriculture as one of the sectors of focus as it has strong forward and backward linkages with regard to employment creation and income generation. Accordingly, agriculture is being given due emphasis as Zambia is shifting from its heavy dependence on metallic exports (MCTI, 2010). The districts surveyed were Monze and Kalomo in central south of the country. Monze is situated at -16°0'0" latitude and 27°15'0" longitude with an average elevation of 1012 masl. The average daily temperature in the district is 20°C whereas average annual rainfall is 650mm. The population density in 2007 was computed to be 28 persons/$km^2$. Kalomo

District is located at -17º2'6" latitude, 26º29'6" longitude and at an average elevation of 1300 masl. It has an annual average rainfall of 350mm and average daily temperature of 22ºC. The district has a human population density of 10 persons/km$^2$.

Zimbabwe is another land locked country with surface area of 390,757 Km$^2$ and estimated human population of 12.5 million (UN data, 2010). About 70% of Zimbabweans live in the rural areas eking a living out of agriculture. The agricultural sector is the backbone of Zimbabwe's economy providing livelihoods for more than 75% of the population and contributing 16 to 20% of the country's GDP. In recent years, the agricultural sector has struggled, more than most sectors in the economy, to cope with the combined effects of the Fast Track Land Reform Program, hyper-inflation, capital constraints and government controls on markets. However, the sector has also shown its resilience in the face of difficult market conditions (World Bank, 2010). Masvingo and Bikita districts in Masvingo Province of Zimbabwe were the districts where the survey was conducted. Masvingo is situated at -20º4'28" latitude, 30º49'58" longitude and at an average elevation of 750 masl. The average daily temperature of the district is 19ºC and the average annual precipitation is 615mm. The population density of the district in 2008 was 44 persons/km$^2$. Bikita is located at -20º5'45" latitude and 31º36'55" longitude. It has an average elevation of 656 masl, average daily temperature of 18ºC, and average annual rainfall of 1133 mm. Bikita is less densely populated than Masvingo at 35 persons/km$^2$.

## 2.2. Sampling

The five study countries are among the 13 African countries where DTMA is being implemented. In each of these five countries, two districts were randomly selected provided that the districts fall in predetermined categories (20-40%) of probability of failed season (PFS) (Figure 3). PFS implies the probability of growing season failure as a result of insufficient soil water availability (either a too-short growing season, or a too-severe level of water stress within the growing period) (Thornton et al., 2006) and was considered here to homogenize exposure to drought that results in crop failures.

A total sample of 1108 households was randomly drawn with sample sizes varying from country to country. Table 2 summarizes names of districts, and size of the random samples drawn from each of the countries.

**Table 2. Sample districts and sample size.**

| Country | Survey year | District | District Sample size | Sample | HH head respondent (%) | Sex of respondent (%) | |
|---|---|---|---|---|---|---|---|
| | | | | | | Male | Female |
| Angola | 2008 | Cacuaco | 82 | 150 | 79.9 | 65.3 | 34.7 |
| | | Lobito | 68 | | | | |
| Malawi | 2008 | Balaka | 68 | 155 | 62.3 | 29.3 | 70.7 |
| | | Mangochi | 87 | | | | |
| Mozambique | 2007 | Mossurize | 207 | 350 | 67.5 | 59.9 | 40.1 |
| | | Sussundenga | 143 | | | | |
| Zambia | 2007 | Monze | 204 | 350 | 89.1 | 71.7 | 28.3 |
| | | Kalomo | 146 | | | | |
| Zimbabwe | 2007 | Bikita | 59 | 100 | 66.7 | 49 | 51 |
| | | Masvingo | 41 | | | | |

*Unless indicated otherwise, all statistical computations are done based on all sample units.

## 2.3. Data Collection

The sample households were approached with a structured and detailed questionnaire to generate data on different variables. The variables of interest broadly included household characteristics, resource endowment, availability and access to institutional services, enterprise choice and resource allocation, maize variety selection, adoption and preferences, production and marketing risks, and perceived trends in the different aspects of maize production. The surveys were administered by senior researchers from the NARES of the countries with need-based and tailored technical backstopping from CIMMYT socioeconomics program. The national partners attended a series of training courses on data compilation, analysis and interpretation. As a result, all national partners wrote and submitted the household survey reports. This is a synthesis of the major findings and lessons learned from the efforts exerted and reported at national level.

The synthesis has involved enormous effort in compiling, cleaning, and re-analyzing the country level data sets. Both descriptive and inferential statistical techniques have been employed. Econometric models have been estimated to analyze adoption of improved maize technologies and determinants of poverty. The models used are binary logit to assess adoption in Angola, tobit model to assess intensity of adoption in Zimbabwe wherein virtually all sample households grow improved maize varieties, and Cragg's Double-Hurdle model to assess both level and intensity of adoption in Malawi, Mozambique and Zambia. Quantile regression was estimated to identify and analyze the determinants of poverty at household level. In analyzing drought risk perceptions and responses, we have also employed non-parametric statistical tests. Variables of our main interest being perception and subjective preference based, application of parametric tests is rather unappealing, and hence we opted for non-parametric tests. All the models estimated are discussed in detail in the Appendices.

# Chapter 3: Results and discussions

## 3.1. Characterizing the sample population

### *3.1.1. Demographic features*

The average family size in the study countries was computed to be 6.98 (3.59 female and 3.38 male) and it ranges from 5.8 in Malawi to 7.5 persons in Zambia. Average number of female family members is higher than that of male family members in all countries, except Angola. Age of the respondents across all countries averages around 45 years with Angolan respondents slightly older (49 years) than others. The distribution of the age of the sample population shows that in Zambia, 54% of the population is below the age of 16 years followed by Malawi which is 47%. In the other three countries, more than 42% of the sample population is below the age of 16. The highest dependency ratio (1.83) was observed in Malawi and the lowest (1.34) in Mozambique. Average man-day equivalent was computed to be 4.59 for Mozambique and only 3.52 for Malawi, which has the smallest average family size (Table 3).

**Table 3. Description of the sample population.**

| | Angola | Malawi | Mozambique | Zambia | Zimbabwe |
|---|---|---|---|---|---|
| Age of household head | 49 | 44.62 | 47.78 | 47.37 | 45.31 |
| Sex of household head (% male) | 84.56 | 64.18 | 85.09 | 82 | 81.25 |
| Family size | 6.85 | 5.82 | 7.24 | 7.49 | 6.29 |
| Male household members | 3.43 | 2.72 | 3.52 | 3.58 | 3.13 |
| Female household members | 3.38 | 3.08 | 3.71 | 3.91 | 3.16 |
| Man-day equivalent | 4.46 | 3.52 | 4.59 | 4.42 | 4.07 |
| Proportion of hh members aged < 16 years | 42.37 | 46.95 | 43.35 | 53.9 | 44.78 |
| Proportion of hh member aged 16-49 years | 42.6 | 35.15 | 42.06 | 36.82 | 42.5 |
| Dependency ratio | 1.37 | 1.83 | 1.34 | 1.73 | 1.4 |
| Marital Status (%) | | | | | |
| Single | 44.7 | 1.9 | 17.1 | 5.7 | 0 |
| Married | 40 | 73.4 | 68.3 | 79.1 | 82 |
| Separated/widow | 15.3 | 24.6 | 14.6 | 15.2 | 18 |
| Literacy of household head (%) | | | | | |
| Illiterate | 16.7 | 25.5 | 26.3 | 11.1 | 2 |
| Primary school | 38.7 | 57.5 | 59.4 | 54.6 | 49 |
| Secondary school | 26 | 12.4 | 9.7 | 30.3 | 44 |
| Post sec-school | 2 | 0 | 0.3 | 1.7 | 4 |
| Adult education | 16.7 | 4.6 | 4.3 | 1.7 | 1 |
| Main decision maker (%) | | | | | |
| Household head | 84.4 | 90.9 | 60.2 | 27.5 | 42.7 |
| Spouse | 6.1 | 3.8 | 37.9 | 2 | 5.2 |
| Children | 0 | 0 | 1.9 | 0.6 | 0 |
| Household head and spouse | 3.5 | 4.5 | 0 | 46.8 | 52.1 |
| Household head and children | 0 | 0.8 | 0 | 1.7 | 0 |
| Spouse and children | 0 | 0 | 0 | 21.4 | 0 |

The households were drawn randomly and the discussions were held with any adult member of the household. Nonetheless, considerably high number of female respondents was observed with the proportion going as high as 70.7% in Malawi. The least proportion of female respondents (28.3%) was observed in Zambia. Most of the sample households in each of the countries are headed by males. Only, Malawian sample has about one third of the households headed by women (Table 3).

Eighty five percent of the sample households in Mozambique and Angola are male headed, about 82% for Zambia and Zimbabwe and about 64% for Malawi. Majority of the respondents – except in Angola – are married with the highest frequency (82%) observed in Zimbabwe. Very few cases of divorcees or widows were observed in the whole sample. The literacy level of household heads is considerably high by African standards. The proportion of literate household head ranges from 67% in Angola to 97% in Zimbabwe.

The details of the literacy level show that about 48% of Zimbabweans have attended secondary school or higher followed by 32% in Zambia and to 28% in Angola. Most of the literate household heads in Malawi and Mozambique fall in the primary school category (Table 3).

In agreement with published literature, the sample population has shown the patriarchal model of agricultural decision making within the households. Only in Zambia and Zimbabwe are decisions made jointly by the household head and the spouse. Otherwise, only household heads make the main decision in 91%, 84%, and 60% of the cases in Malawi, Angola and Mozambique, respectively (Table 3).

The mean comparisons across the different demographic factors discussed above show that, with the variances of the measurements statistically different, there is no significant statistical difference in most of the cases. Demographic indicators of Malawi sample, however, show significant difference from others.

### *3.1.2. Resource Endowment and Assets of Households*

#### Asset ownership of households

Residential houses are important assets both in urban and rural settings. Apart from being a basic necessity, they also indicate the financial status of the residents. The data generated show that most of the families in Malawi (70.8%), Zambia (70.8%) and Mozambique (70.6%) live in less valuable mud-walled and grass thatched houses whereas 43% Zimbabweans live in iron or asbestos roofed houses. Almost all Angolans, however, live in iron and asbestos roofed houses (Table 4).

**Table 4. Resource endowments of the sample population.**

| Proportion of sample hh owning: | Angola | Malawi | Mozambique | Zambia | Zimbabwe |
|---|---|---|---|---|---|
| Iron/Asbestos roof | 84.1 | 29.2 | 27.4 | 29.2 | 43.0 |
| Mud/brick/block hut with thatch roof | 15.91 | 70.83 | 70.57 | 70.77 | 57.00 |
| Car | 0.7 | - | 1.7 | 1.7 | 1 |
| Motorcycle | 12 | 0.6 | 1.1 | 3.1 | - |

| | | | | | |
|---|---|---|---|---|---|
| Bicycle | - | 45.2 | 25.7 | 66.9 | 27 |
| Tractor | - | - | 0.3 | 0.3 | 1 |
| Tractor tilling tools | 0.7 | - | 0.6 | 20.6 | 4 |
| Draft animals | - | - | 1.1 | 43.7 | 42 |
| Draft animal tools | - | - | 1.4 | 47.4 | 56 |
| Private water well | 0.7 | 0.6 | 0.9 | 6.6 | 28 |
| TV | 30.7 | 1.3 | 2.3 | 10.3 | 14 |
| Radio | 46 | 56.8 | 34 | 66 | 28 |
| Mobile phones | 22 | 21.3 | 3.7 | 12 | 3 |
| Fixed phone | - | 0.6 | - | 0.3 | - |

Only 14 (1.3%) of the 1108 sample farmers reported to have a car of their own. Six (1.7%) farmers in Mozambique and Zambia each indicated to have cars, only one farmer in Angola and Zimbabwe each reported to own one. None of the farmers in Malawi owned a car. Only 34 (or 3.1%) of the 1108 sample farmers in the five countries reported to own motorcycles of their own. The highest frequency (12%) was observed in Angola followed by Zambia (3.1%) and Mozambique (1.1%). None of the sample farmers in Zimbabwe owned a motorcycle. About 38% of the respondents own a bicycle. Majority of respondents (67%) in Zambia own a bicycle, followed by Malawi (45%), Zimbabwe (27%), and Mozambique (26%). No single case of bicycle ownership was reported in Angola.

In an agricultural system where the plough culture is important, the indispensability of the traction power of animals is quite apparent. This study shows that only Zambian (44%) and Zimbabwean (42%) farmers use draft animals. No sample household in Angola and Malawi owns a draft animal. Cattle and small ruminants are not being raised in central Malawi essentially due to rampant theft and Angola's farming culture lacks virtually any pattern due to the same reason of theft and lack of security that lingered even after the end of the civil war. Our results; however, confirm the conventional wisdom that African smallholder agriculture is far from farm mechanization and hence commercialization. Despite the importance of tractors in saving human labor and realizing economies of scale, only 3 (0.3%) of our 1108 sample households reported to have owned a tractor. Angola and Malawi samples do not have a unit that owns a tractor while the others have one each.

Television ownership is not high either. Only 106 households (9.6%) of the whole sample own a TV set. As expected, about 31% of Angolans and only 1.3% of Malawians reported to have a TV set. Sample households in Zambia (10.3%) and Zimbabwe (14%) have comparable level of ownership whereas only 2.3% Mozambicans own a TV set. Reported cases of radio ownership are reasonably high. This obviously plays an important role in making information more accessible to farmers. Nearly half (48.4%) of the sample households own a radio set. The proportion of households that own radio ranges from 28% in Zimbabwe to 66% in Zambia. Angola and Malawi sample households do also have high level of radio ownership (Table 4).

Angola (22%) and Malawi (21.3%) sample households have the highest proportion of mobile phone ownership. Mozambique (3.7%) and Zimbabwe (3.0%) samples were found to have the least level of mobile phone ownership. Mozambique's abject rural poverty and Zimbabwe's unparalleled inflation might explain this low level of possession. Interestingly enough, virtually no fixed phones were reported by the sample households.

**Farm size and management**

The size and tenure security of farm land is the pillar of farming livelihoods under any circumstances. Despite the arguments for - e.g., (Schultz, 1964) - and against – e.g., (Collier & Dercon, 2009) - small-is-efficient theory in farm economics, size of land ownership means a lot to farming households and they are generally interested to have more than less farm land. For the sample population, the average farm land holding is highest in Mozambique whereby a typical household owns nearly 8 eight hectares of land, followed by Zambia at 6.63 hectares, and Zimbabwe at 3 hectares (Table 5). The smallest average farmland was observed in Malawi with a typical household owning only 1.25 hectares. Irrigation was found to be a rare practice in the region except in Angola where 71.3% of the household irrigate about 91% of their farm.

**Table 5. Farm land size, irrigation and fallowing.**

| | Angola | Malawi | Mozambique | Zambia | Zimbabwe |
|---|---|---|---|---|---|
| Farm size (ha) | 2.25 | 1.25 | 7.88 | 6.63 | 2.96 |
| Area (ha) rented out | 0.01 | - | 0.1 | - | 0.03 |
| Area (ha) rented in | 0.27 | 0.12 | 0.01 | - | 0.01 |
| Proportion of farm size irrigated (%) | 67.34 | 10.54 | 0.93 | 0.86 | 0.41 |
| Irrigation (% yes) | 71.3 | 22.6 | 4 | 1.4 | 3 |
| Proportion of farm irrigated (%) | 91.25 | 46.67 | 22.9 | 59.78 | 13.38 |
| Fallows (% yes) | 10.7 | 2.6 | 86 | 46 | 20 |
| Pre-fallow plowing (years) | 2.71 | 6 | 4.61 | 3.17 | 5.5 |
| Fallow length (years) | 2.13 | 3.25 | 3.21 | 2.65 | 1.89 |

Fallowing is a common practice among farmers with an intention of resting the land so that it regenerates and regains its fertility. It is more common in Mozambique (86%) and Zambia (46%) where farmers are practicing fallowing. Probably due to the shortage of farmland, only few Malawians (12.3%) reported to have been practicing fallowing. A look into the length of cultivation before fallowing and the length of fallowing periods for Mozambicans and Zambians reveal a comparable result. Mozambicans plow their land on average for 4.6 years before fallowing it on average for 3.2 years. Zambians likewise plow on average for 3.2 years before fallowing the plots for 2.7 years. The significant difference in the average land holding between the sample households of the two countries partially explains this variation.

**Household labor and allocation**

The most important source of farm labor in smallholder farming systems is the household itself (Ellis, 1994). Therefore, the quantity of labor supplied by the household is an important indicator of the viability of the farm business. Sample households in the study countries have a comparable level of family labor availability measured in man-day equivalent (MDE). Only Malawi has less than four (i.e., 3.52) whereas all other countries have MDEs that range from 4.1 to 4.6, implying the availability of labor equivalent of more than four adult males for an eight-hour per day work.

When assessing availability of these labor resources to agriculture, it was found out that Zimbabwe, Zambia, Mozambique and Malawi sample households, in order, do have higher number of household members that are readily available for agricultural activities. Angola has the least readily available family labor for agricultural activities. This is related to the demographic pattern of the sample population. Nearly 80% of the sample population in the study countries is below the age of 49 years.

As indicated in Table 6, for all activities from planting to threshing, family labor accounts for more than 95% of the labor expended. Although farmers almost entirely depend on family labor for all main maize farming activities, hired and communal labor sources are in peak-labor demand periods (Table 6). As expected, farmers in Angola used more hired labor compared to other countries.

**Table 6. Farm labor sources and allocation.**

| | Angola | Malawi | Mozambique | Zambia | Zimbabwe |
|---|---|---|---|---|---|
| Labor allocation (%) | | | | | |
| Manual labor for land preparation | 88.7 | 99.4 | 88.8 | 60.9 | 56.6 |
| Draft power for land preparation | 0 | 1.3 | 27.5 | 75.7 | 80.8 |
| Tractor for land preparation | 21.6 | 2.6 | 4.3 | 2.9 | 3 |
| Labor for weeding | 94.8 | 100 | 99.1 | 98.8 | 99 |
| Labor for fertilization | 77.3 | 98.1 | 5.4 | 70.7 | 93.9 |
| Family labor for maize | 95.9 | 99.4 | 100 | 99.7 | 100 |
| Hired labor for maize | 67 | 31 | 44.1 | 36.2 | 51.5 |
| Communal labor for maize | 0 | 5.8 | 4.9 | 0.6 | 18.2 |
| Shared labor for maize | 3.1 | 0 | 0 | 0.9 | 3 |
| Family labor use (%) | | | | | |
| Threshing | 74.89 | 96.67 | 99.56 | 97.69 | 97.48 |
| Harvesting | 80.35 | 91.3 | 95.46 | 95.64 | 94.72 |
| Fertilization | 74.5 | 92.83 | 94.74 | 98.57 | 97.63 |
| Planting | 78.87 | 93.07 | 94.1 | 98.47 | 96.15 |
| Weeding | 67.38 | 89.09 | 83.88 | 93.82 | 88.81 |
| Land preparation | 56.13 | 86.1 | 82.84 | 83.13 | 63.67 |
| Manual land preparation | 56.07 | 84.7 | 69.95 | 38.94 | 27.5 |
| Land preparation with draught | 0 | 0.22 | 12.2 | 43.27 | 35.51 |
| Hired labor use (%) | | | | | |
| Weeding | 31.59 | 10.01 | 14.46 | 6.18 | 8.54 |
| Manual land preparation | 26.12 | 12.87 | 8.19 | 2.68 | 6.02 |
| Land preparation draught | 0 | 0.32 | 6.43 | 13.38 | 20.23 |
| Planting | 19.9 | 5.23 | 5.79 | 1.38 | 2.6 |
| Fertilization | 23.8 | 6.18 | 5.26 | 1.43 | 2.37 |
| Harvesting | 18.07 | 6.5 | 4.54 | 4.22 | 2.35 |
| Land preparation (tractor) | 15.05 | 0 | 1.5 | 0.52 | 0.51 |
| Communal labor for weeding (%) | 0 | 0.9 | 1.65 | 0 | 2.65 |

**Access to financial capital**
In addition to the fixed assets indicated above, sample households have access to other variable capitals such as cash loan and livestock wealth. Almost all sample households – ranging from 93.3% in Malawi to 98.3% in Zambia – reported to have experienced shortage of liquid capital to carry out their farming activities. The inquiry whether the households have accessed any sort of credit from any source has shown that only Zimbabweans seem to have reasonable level of access to credit services. About 57% of the households in Zimbabwe reported to have taken credit of different forms whereas only 3% of Mozambicans have done so. Only 15.5% of the sample households in Malawi, 14.3% in Zambia, and 10% in Angola accessed credit of any form so far. In fact, the credit services accessed by sample households provided mainly production related loans. Focusing on Zimbabwe, 41% of the households have received maize seed credit, 38% for fertilizer, and 15% credit for other seeds. The general lack of credit was attributed essentially to absence of credit institutions, lack of collateral, and reluctance to take loans.

**Livestock ownership**
Another important capital asset for smallholder farmers in Africa in general and in southern Africa in particular is livestock. The average livestock owned per household in tropical livestock units shows a significant difference among the study locations of the five countries. The livestock owned per household, in tropical livestock units (TLU), ranges from 0.41 in Malawi to 2.9 in Zambia. Accordingly, the current value in USD of the livestock owned by a typical household ranges from 102.7 in Malawi to 1051 in Zambia. Livestock wealth in Malawi and Angola is peculiarly small. As indicated above, households in central Malawi do not want to keep livestock (particularly cattle) because of security reasons whereas Angolan farmers do have legal restrictions in raising and keeping cattle in addition to their resource intensive irrigated crop farming (Table 7).

The data on the number and types of animals show that Zambian households excel virtually in all animals except in poultry. Ownership of local cattle breed and goats is high in Zimbabwe as well. More than 67% of the sample households in Mozambique have goats. Poultry farming seems to be a common practice among farmers in the region except in Angola (Table 7).

**Table 7. Livestock wealth of the sample households.**

| | Angola | Malawi | Mozambique | Zambia | Zimbabwe |
|---|---|---|---|---|---|
| Households owning livestock (%) | | | | | |
| Improved cattle | - | - | 0.3 | 24.3 | 6 |
| Local cattle | 4 | 1.3 | 18.3 | 45.4 | 56 |
| Goat | 23.3 | 50.3 | 67.1 | 1.4 | 57 |
| Sheep | 4 | - | 1.4 | 1.1 | - |
| Pig | 9.3 | 3.9 | 8.6 | 72.3 | 3 |
| Poultry | 44 | 68.4 | 90.3 | 96 | 83 |
| Equines | - | - | - | 6 | - |
| Livestock owned/household | | | | | |
| Improved cattle | - | - | 0.01 | 0.73 | 0.15 |
| Local cattle | 0.28 | 0.21 | 1.32 | 2.67 | 2.21 |
| Small ruminants | 2.31 | 2.19 | 4.72 | 5.4 | 2.27 |
| Poultry | 3.69 | 7.92 | 14.31 | 12.14 | 6.87 |
| Total livestock wealth (in TLU) | 0.43 | 0.41 | 1.18 | 2.9 | 1.04 |
| Value of livestock (USD) | 133.99 | 102.66 | 347.98 | 1050.67 | |

### *3.1.3. Asset ownership based wealth index for the sample households*

Wealth indices were calculated for each of the countries based on the different categories of assets indicated to be measures of wealth by the study communities. Asset endowment based wealth status indicators are estimated to reinforce the information presented in the next chapter. The rationale behind the estimation of wealth indices based on asset ownership is in fact the difficulty and irregularities of wealth indicators based on reported income and expenditure data. According to Montgomery, Gragnolati, Burke, and Paredes (2000), the collection of accurate income data is quite demanding as it requires extensive resources for household surveys. And in some cases, an indicator of income is difficult to use. For example, income information does not capture the fact that people may have income in kind, such as crops which are traded (Cortinovis, Vela, & Ndiku, 1993). Therefore, asset based indicators have become quite common in characterizing welfare states of people (Filmer & Pritchett, 2001; McKenzie, 2005).

Selection of the assets for the poverty index calculation is an important procedure in generating the index using Principal Component Analysis (PCA). However, there is no any 'best practice' approach of selecting variables to proxy living standards such that in many studies variables were chosen on an 'ad-hoc' basis (Montgomery et al., 2000). It is however suggested that asset variables shall be correlated and their distribution shall vary across households (Vyas & Kumaranayake, 2006). While selecting assets one has to ensure that the range of asset variables included is broad enough to avoid problems of clumping and truncation (McKenzie, 2005). Clumping or clustering is described as households being grouped together in a small number of distinct clusters. Truncation implies a more even distribution of socio-economic status, but spread over a narrow range, making differentiating between socio-economic groups difficult (e.g., not being able to distinguish between the poor and the very poor) (Vyas & Kumaranayake, 2006). It is also suggested that asset selection shall start with assets strongly correlated to testing the level and direction of correlation among a wide array of ordinal and interval variables with a benchmark poverty indicator; i.e., per capita expenditures or income (Henry, Sharma, Lapenu, & Zeller, 2003). Accordingly, we checked different sets of asset variables for their correlation with reported income and expenditure levels. Comparable sets of assets were found to be significantly correlated with reported income and/or expenditure in the study countries. Table 8 presents the assets considered in the socioeconomic status index computation using PCA.

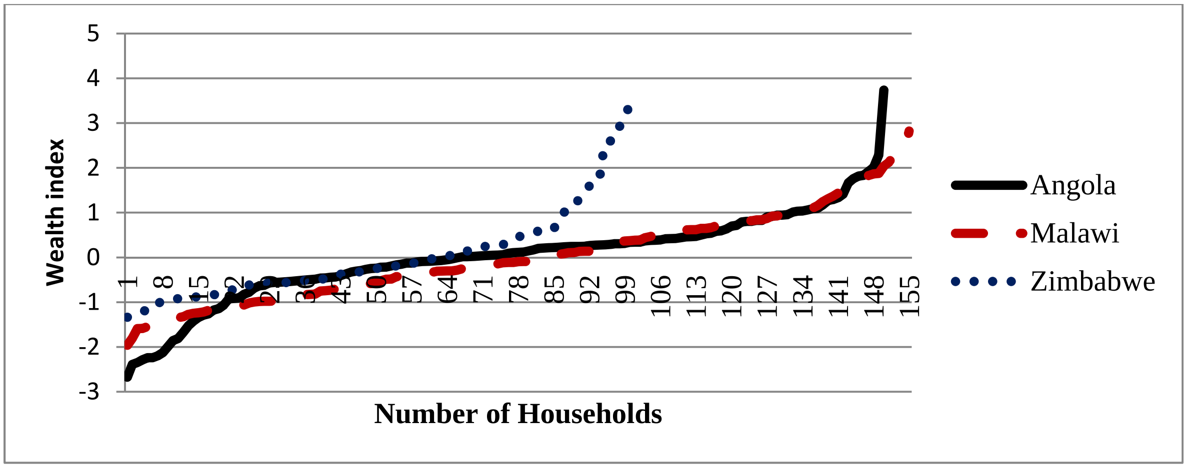
**Table 8. Descriptive statistics of assets considered in computation of wealth index.**

| | Angola | | Malawi | | Mozambique | | Zambia | | Zimbabwe | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | Standard Deviation | Mean | Standard Deviation | Mean | Standard Deviation | Mean | Standard Deviation | Mean | Standard Deviation |
| Household size in Man Equivalent Units (MEU) | 4.46 | 1.60 | 3.52 | 1.77 | 4.59 | 2.53 | 4.42 | 2.17 | 4.07 | 1.92 |
| Farm size (ha) | 2.25 | 4.67 | 1.25 | 0.95 | 7.88 | 7.35 | 6.63 | 18.89 | 2.96 | 2.26 |
| Household head is member of farmer association (1 = yes) | 0.49 | 0.50 | 0.21 | 0.41 | 0.11 | 0.32 | 0.51 | 0.50 | 0.67 | 0.47 |
| Household received any credit (1 = yes) | 0.10 | 0.30 | 0.15 | 0.36 | 0.03 | 0.17 | 0.14 | 0.35 | 0.57 | 0.50 |
| Livestock wealth in Tropical Livestock Units (TLU) | 0.43 | 0.93 | 0.42 | 1.37 | 1.18 | 1.92 | 2.91 | 3.66 | 1.05 | 1.64 |
| Dependency ratio of the household | 1.38 | 1.19 | 1.84 | 1.42 | 1.34 | 1.15 | 1.73 | 1.13 | 1.41 | 1.19 |
| Household headed by female (1 = yes) | 0.15 | 0.36 | | | 0.15 | 0.36 | 0.18 | 0.38 | 0.19 | 0.39 |
| Household head is illiterate (1 = yes) | 0.17 | 0.37 | 0.25 | 0.44 | 0.26 | 0.44 | 0.11 | 0.32 | 0.02 | 0.14 |
| A household members earns off-farm income (1 = yes) | 0.66 | 0.48 | 0.28 | 0.45 | 0.26 | 0.44 | 0.59 | 0.49 | 0.92 | 0.27 |
| Farm area share of maize (%) | 51.24 | 25.32 | 69.75 | 26.62 | 45.92 | 24.69 | 54.33 | 29.32 | 49.18 | 23.15 |
| Number of bicycle owned | - | - | 0.57 | 0.73 | 0.43 | 0.98 | 0.81 | 0.68 | 0.30 | 0.54 |
| Number of draft animals owned | - | - | - | - | - | - | 1.60 | 2.39 | 1.12 | 1.63 |
| Number of private well owned | - | - | - | - | - | - | 0.07 | 0.29 | 0.28 | 0.47 |
| Number of motor cycle owned | 0.12 | 0.33 | - | - | - | - | - | - | - | - |
| Number of television owned | 0.32 | 0.50 | - | - | - | - | 0.10 | 0.30 | 0.15 | 0.39 |
| Number of radio owned | 0.50 | 0.62 | 0.75 | 0.79 | 0.51 | 1.00 | 0.79 | 0.71 | 0.29 | 0.48 |
| Number of mobile phones owned | 0.27 | 0.56 | 0.26 | 0.62 | 0.06 | 0.36 | 0.12 | 0.34 | - | - |

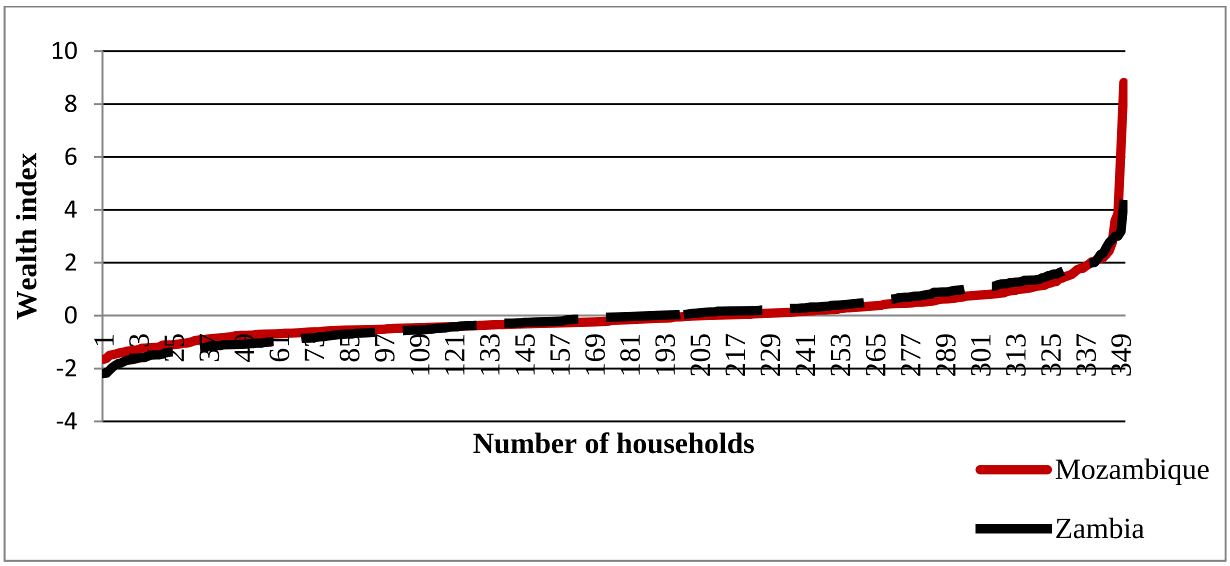
Principal component analysis was run to generate the indices by way of reducing the dimension of the various indicators in such a way that most of the variation and contribution of each of the assets is captured. The wealth classification can be formed in two ways. The first option is to divide the households as poor and rich based on whether indices are less or greater than zero, respectively. In this case, it is implied that those households with less than average asset ownership are poor and those above average are rich. The second option is to calculate the mean of the negative indices and the mean of the positive indices to classify the sample into three. The households will be poor, middle or rich if the index value is less than the mean of the negative indices, between the two means, or higher than the mean of the positive indices. We have adopted both options as discussed below.

Forty four percent of the sample households in Angola have negative wealth index. The households with negative indices can generally be considered as poor. In a way that reflects the relativity of wealth status as such, the sample households can also be classified into three as poor (16%), middle (63.3%) and rich (20.7%). Nearly 55% of Malawians do have negative wealth indices. In this case, 26.5% of the households fall in to the poor category, 55.5% in the middle class, and 18.1% in the rich category. In Mozambique, about 57% of the sample households have negative wealth indices and they can be categorized as 23.7% poor, 62.6% middle, and 13.7% rich. Nearly 54% of the sample households in Zambia have negative wealth indices. Classification based on the indices results in 23.1% poor, 58% middle, and 18.9% rich households. Sixty two percent of the sample households in Zimbabwe have negative wealth indices, which is higher than compared to other countries. Based on these indices, 27% of the households belong to the poor category, 59% to the middle class, and 24% to the rich class. Notwithstanding the difference in sample size and the slight variation in what locally determines wealth, the figures below show the relative distribution of the wealth indices of the sample households in the study countries (Figure 4: a and b).

In summary, only in Angola does it happen that more than 50% of the sample households belong to the rich (> 0 wealth index) group. In all four other countries, more than half the households do have negative wealth index. Particularly, in Zimbabwe and Mozambique, three households out of five are poor implying the extent of impoverishment in terms of wealth accumulation.




a – Angola (n=150), Malawi (n=155), and Zimbabwe (n=100) sample households




b - Mozambique (n = 350) and Zambia (n=350)

**Figure 4: (a and b) - Distribution of wealth index for sample communities.**

# Chapter 4: Poverty and inequality

Poverty, defined in anyway, is a common characteristic feature of farming communities in southern Africa. Poverty is known to be context specific and vary due to, among others, age and sex composition, socio-cultural characteristics, connection to the rest of the world and means of information sharing, and opportunities and constraints within the livelihood systems of the households. This clearly shows the difficulty of defining poverty and the poor.

The contemporary general consensus on the meaning of poverty is that it is multidimensional and multifaceted, manifested by conditions that include malnutrition, inadequate shelter, unsanitary living conditions, unsatisfactory and insufficient supplies of clean water, poor solid waste disposal, low educational achievement and the absence of quality schooling, chronic ill health, and widespread common crime (UN, 2005). Although the definition of poverty seems to be agreed upon, there is still a problem in developing an all-encompassing measure for poverty. The World Bank has rather a handy definition of poverty being a pronounced deprivation of wellbeing (Haughton & Khandker, 2009); wellbeing implying both access to material necessities and capabilities of the individual to function in a society.

Despite the breadth of concerns, social scientists still find it useful to focus largely on poverty as a lack of money measured either as low income or as inadequate expenditures (UN, 2005). One reason for focusing on money is practical: inadequate income is clear, measurable, and of immediate concern for individuals. Another reason is that low incomes tend to correlate strongly with other concerns that are important but harder to measure. Income is universally an important element, even while most agree that money metrics are too narrow to capture all relevant aspects of poverty. Still, the challenges of measuring poverty narrowly defined by a lack of money are substantial in themselves (UN, 2005). Accordingly, we are using reported total income and reported total expenditure to measure the well-being of the households in Angola, Malawi, Mozambique, and Zambia. In some cases, Angola is dropped because of poor quality data. The analysis depends entirely on reported income and expenditure data and we have presented results using both measures for comparison and cross-checking purposes. In fact, the expenditure measure is strongly recommended for statistical reasons (Haughton & Khandker, 2009; UN, 2005). However, the results shall be taken in general as cautiously indicative because of the limited sample size per country.

## 4.1. Household income, income sources and expenditure

**Household income and income sources**

The main income generating activities of the sample households are crop sales, fruit and vegetable sales, livestock and livestock products sales, petty trading, paid employment, self-employment, and remittances. About 85% of the annual income for Angolan sample households is generated from crop and fruit/vegetable sales, whereas 64% of the income of the Malawian respondents is generated form non-farm activities that include paid and self-employment, remittances and other activities. Irrigation must have enabled Angolan sample farmers to have higher cropping intensity and more diversity making crop farming rather a rewarding enterprise.

Mozambicans generate about 78% of their income from crop sales, petty trading and paid employment. The sample households in Zambia generate 82% of their income from crop and fruit/vegetable sales, and livestock sales (Table 9).

**Table 9. Household level income sources.**

| | Angola | Malawi | Mozambique | Zambia |
|---|---|---|---|---|
| Share of sources of income (%) | | | | |
| Crop sales | 44 | 17 | 19 | 40 |
| Fruits & vegetables sales | 41 | 4 | 6 | 21 |
| Livestock/fish sales | 1 | 7 | 14 | 21 |
| Petty trading | 1 | 8 | 19 | 2 |
| Paid employment | 4 | 11 | 20 | 2 |
| Self-employment | 1 | 11 | 8 | 3 |
| Remittances | 0 | 13 | 5 | 9 |
| Other sources | 9 | 29 | 8 | 2 |
| Access to off-farm activities (%) | | | | |
| Petty trade | 32.7 | 28.4 | 26.3 | 11.3 |
| Teaching | 1.3 | 2.6 | 7.7 | 0.6 |
| Masonry/carpentry | 7.3 | 3.2 | 6.3 | 0.9 |
| Nursing | 6 | 1.3 | 0.6 | 0.6 |
| Art and crafting | 5.3 | 3.9 | 5.4 | 1.7 |
| Driving | 3.3 | 0.6 | 2 | 0.3 |
| Mechanic | 3.3 | 0 | 1.1 | 0 |
| Working on other farms | 10.7 | 5.8 | 3.1 | 33.3 |
| Other activities | 32 | 30.3 | 20.3 | 16.5 |
| Household members working off-farm (%) | 66 | 65.2 | 60 | 58.6 |
| Reported Household income - US$ pa | 899.04 | 412.61 | 477.18 | 327.82 |
| Per capita income US$ pa | 134.41 | 73.96 | 76.02 | 45.77 |

In our sample, 64% of the sample households reported to have at least one family member engaged in off-farm activities. Zimbabweans, Angolans and Malawians respondents, in order, indicated the three highest frequencies of a family member engaging in off-farm activities. Petty trading is the most frequent off-farm activity in all countries, except Zambia where working for other farmers is the most common form of off-farm employment.

Generally, working for other farmers and masonry/carpentry are important off-farm activities in the region (Table 9).

Generally, off-farm activities serve not only as an alternative source of income but also as employer of the labor that might or might not be required for agricultural activities. These activities are nonetheless crucially important aspects of the rural livelihoods in Southern Africa. About 66% of Angolans and Malawians and about 60% of Mozambicans and Zambians engage in off-farm activities. The reported household income is US$ is highest in Angola followed by Mozambique. The per capita income follows the same order as well.

### Household expenditure

The expenditure data were reasonably complete only for Malawi, Mozambique, and Zambia. The main expenditure item for the sample populations in all three countries is food. Food items claim 41%, 48%, and 31% of the annual expenditure of Malawian, Mozambican, and Zambian sample households, respectively. The results also show that clothing is the second important expenditure item for Malawians and Mozambican households while education is for Zambians (Table 10). The reported total expenditure shows that Malawians spend more than Mozambicans and Zambians. The per capita expenditure was also found to be much higher for Malawians.

**Table 10. Expenditure items.**

| | Malawi | Mozambique | Zambia |
|---|---|---|---|
| Expenditure items (%) | | | |
| Food | 41 | 48 | 31 |
| Tobacco/alcohol | 2 | 6 | 1 |
| Education | 4 | 3 | 27 |
| Medication | 6 | 4 | 7 |
| Clothing | 14 | 27 | 17 |
| Fuel | 12 | 6 | 8 |
| Transfers | 2 | 1 | 2 |
| Direct social costs | 4 | 1 | 1 |
| Other items | 15 | 5 | 5 |
| Reported expenditure - US$ pa[1] | 394.96 | 322.32 | 328.48 |
| Per capita expenditure - US$ pa | 74.28 | 51.24 | 45.45 |

[1]In 2007, the official exchange rates for Mozambique and Zambia were 25.67 MC and 3671 ZK, respectively. In 2008, the official exchange rates for Angola, Malawi and Zimbabwe were 75 AZ, 138 MK, and 29,330 Zimbabwean Dollars, respectively.

## 4.2. Poverty Line

Determining poverty line is the first step in analyzing the extent and determinants of poverty. The international absolute poverty line $1/day per capita was initially determined in 1985 and revised to 1.08 in 1993 and then to $1.25[2] in 2005 prices (Chen & Ravallion, 2008). The first step in determining the absolute poverty line will, therefore, be to calculate the local currency equivalent of $1.25/day/capita at current prices. Accordingly, the absolute poverty lines in local currency were calculated in 2007 prices for Mozambique and Zambia and in 2008 prices for Angola and Malawi. The calculation is a simple adjustment of the $1.25 in 2005 prices for accumulated price inflation since 2005. The data required; i.e., purchasing power parity (PPP) for 2005, consumer price indices (CPI) for 2007 and 2008, and inflation rates for 2007 and 2008, were generated mainly from World Bank, UN and International Monetary Fund (IMF) web portals and other reliable sources[3].

The steps we followed are; first, we calculated the current (2007 and 2008) PPP exchange rate by adjusting the 2005 PPP for cumulative inflation since 2005. Second, we multiplied the poverty line by the current PPP exchange rate to find the local currency equivalent in 2005 prices of the $1.25. Third, we updated the poverty line in local currency using the inflation rates in 2007 and 2008. Finally, the poverty lines (in local currency per adult equivalent per day) were computed to be 18.34 Meticais for Mozambique and 3979 Zambian Kwacha for Zambia in 2007 prices and 98.27 Kwanza for Angola and 72.53 Malawian Kwacha for Malawi in 2008 prices.

In addition to absolute poverty lines which are essential for international comparison of intensity of poverty, relative poverty lines are also important when targeting of program or interventions is the purpose (Haughton & Khandker, 2009). The data generation process in this study aimed at understanding the structure of poverty and inequality in areas where the drought tolerant maize for Africa (DTMA) will be implemented and hence the relative poverty measures are deemed relevant. Three relative poverty indicators; i.e., 40%, 50% and 60% of the median value of the reported total income and total expenditure were computed. Table 11 presents the relative poverty lines for all study countries based on the data collected from sample households. The absolute poverty line is less than the 50% median of the total reported income and expenditure per day per adult equivalent.

[2] It is referred to in the literature as $1.00 absolute poverty line. Note that it is different from the $2.00 poverty line which is used as frequently as the $1.00 threshold.

[3] PPP data were generated from http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=699 and http://iresearch.worldbank.org; CPI data were generated from http://www.imf.org/external/pubs/cat/longres.cfm?sk=17165.0; and inflation rate data were generated from http://www.economywatch.com/economic-statistics/economic-indicators/

**Table 11. Absolute and relative poverty lines and poverty incidence.**

| Country | Measure | Poverty line | | % of households below poverty line | |
|---|---|---|---|---|---|
| | | Total income | Total expenditure | Total income | Total expenditure |
| Angola ((AZ) | Absolute | 98.27 | 98.27 | 21.95 | 22.92 |
| | Relative (% of median) | | | | |
| | 40 | 170.40 | 244.41 | 28.05 | 31.25 |
| | 50 | 213.00 | 305.51 | 34.15 | 31.25 |
| | 60 | 255.59 | 366.62 | 41.46 | 39.58 |
| Malawi (MK) | Absolute | 72.53 | 72.53 | 14.47 | 13.55 |
| | Relative (% of median) | | | | |
| | 40 | 115.01 | 120.59 | 22.37 | 21.94 |
| | 50 | 143.76 | 150.74 | 25 | 27.74 |
| | 60 | 172.52 | 180.88 | 29.61 | 30.97 |
| Mozambique (MC) | Absolute | 18.34 | 18.34 | 25.22 | 11.75 |
| | Relative (% of median) | | | | |
| | 40 | 21.27 | 29.70 | 27.60 | 20.34 |
| | 50 | 26.58 | 37.13 | 32.64 | 27.22 |
| | 60 | 31.90 | 44.55 | 36.80 | 33.81 |
| Zambia (ZK) | Absolute | 3979.00 | 3979.00 | 33.95 | 34.01 |
| | Relative (% of median) | | | | |
| | 40 | 2968.23 | 2890.28 | 26.43 | 24.13 |
| | 50 | 3710.28 | 3612.85 | 32.43 | 30.52 |
| | 60 | 4452.34 | 4335.42 | 36.94 | 36.92 |

The absolute poverty lines of all, but Zambia, are less than all relative poverty lines computed based on total reported income and expenditure. Despite the need to correct for measurement error – which we have reported below, the absolute poverty line based computation shows that Zambian sample households are more deprived than samples in other countries. The relative poverty lines also single out Angolan and Zambian sample households as the poorest.

## 4.3. Measuring poverty

A common phenomenon in household level rural surveys (to collect data on income and expenditure) is measurement error. It is apparent that there happens a considerable level of underreporting and non-reporting of income and expenditure. This usually occurs for two reasons. One, due to the natural tendency of human beings in rural areas to under-report their incomes merely because of lack of confidence in the confidentiality and ultimate use of the data being collected; and two, due to lack of records of expenses made on different items. The irregularity in income and expenditure flow and the inherent spontaneous and conspicuous consumption patterns can as well be reasons why rural communities tend to report less than what they earn and/or spend.

Accordingly, the welfare measures have been adjusted for measurement error. Following Haughton and Khandker (2009), it is assumed that the measurement error is a random normal variable with a standard error as big as one-tenth of the standard error of total reported income or expenditure. It is also assumed that the measurement error is additive to the reported values of income and expenditure. This error is, by design, independent of reported income/expenditure and of any other household or community characteristics. The poverty measures presented and discussed in Table 12 and 13 are calculated based on the measurement error adjusted values (50% of median) of total reported income (WM1) and total reported expenditure (WM2).

The poverty measures estimated are headcount ratio, poverty gap ratio, income gap ratio, Watts index, Sen index, Thon index, and Takayama index. The poverty level estimation was done with all these measures to ascertain consistence and robustness of results (Haughton & Khandker, 2009). Head count ratio measures the incidence of poverty, which is simply the proportion of individuals in a society who are poor. Poverty gap ratio measures the amount of resources (income or expenditure) needed to raise the poor from their present outcomes to the poverty line, as a proportion of the poverty line and averaged over the total population. Income-gap ratio measures the percentage of the average income shortfall of the poor to the poverty line. Watts index is the first distribution sensitive poverty measure computed by dividing the poverty line by income (or expenditure), taking logarithms, and finding the average over the poor. The Thon index (also known as Sen-Shorrocks-Thon index) is a weighted sum of the poverty gap ratios of the poor. The weights decrease with the rank order in the income distribution such that more weight is given to the poverty gap of the poorer individuals. The index is normalized to take values between zero and one: it is equal to zero when all the incomes (or expenditures) are above the poverty line and so there are not poor people; it reaches a unit value in the extreme case where all the individuals are poor and they have zero income (or expenditure) (Blackwood & Lynch, 1994; Haughton & Khandker, 2009).

Using both the absolute and measurement error-corrected half-median reported income poverty lines, it is clear that sample households in Mozambique and Zambia standout to be poorer than the sample households in Angola and Malawi (Table 12). The poverty measures computed based on the corrected poverty line are rather comparable than those computed based on the absolute poverty line. Nearly 33% of Mozambicans are in absolute poverty while about 27% Angolans live below the absolute poverty line. Both poverty gap and income gap ratios that measure the income level required to bring the poor up to the poverty line show that Mozambican farmers need the highest income injection to move out of abject poverty. Similarly, the other poverty measures; i.e., Sen, Thon, and Takayama indices show that Mozambicans are by far the poorest of the countries; whereas, Watts index - distribution sensitive and theoretically sound poverty measure – identifies Angolan sample households to be the poorest.

**Table 12. Poverty measures based on measurement error adjusted total reported income.**

| Poverty measure | Total reported income Absolute poverty line | | | | Total reported income Adjusted 50% median | | | |
|---|---|---|---|---|---|---|---|---|
| | Angola n=82 | Malawi n=152 | Mozambique n=337 | Zambia n=333 | Angola n=82 | Malawi n=152 | Mozambique n=337 | Zambia n=333 |
| Headcount ratio (%) | 13.42 | 14.47 | 27 | 35.7 | 26.83 | 27.63 | 32.64 | 32.43 |
| Poverty gap ratio (%) | 13.3 | 23.25 | 46.3 | 31.36 | 16.44 | 22.42 | 39.74 | 35.55 |
| Income gap ratio (%) | 99.1 | 160.6 | 171.5 | 111.05 | 61.29 | 81.15 | 121.75 | 109.61 |
| Watts index (%) | 11.87 | 7.93 | 10.1 | 15.15 | 22.83 | 16.97 | 15.81 | 15.8 |
| Sen index *100 | 18.13 | 31.73 | 64.7 | 49.3 | 23.07 | 31.87 | 55.11 | 48.9 |
| Thon index *100 | 25.36 | 44.3 | 85 | 64.24 | 30.17 | 41.2 | 71.48 | 63.85 |
| Takayama index *100 | 14.1 | 27.58 | 72.3 | 44.53 | 16.62 | 24.36 | 52.82 | 44.04 |

The poverty measures computed based on WM2 show a slightly different pattern in levels of poverty despite the fact that the two poorest countries are still the same (Table 13). In this case, the sample households in Zambia are the poorest. Taking the poverty gap index, for example, the minimum cost of eliminating poverty (relative to the poverty line) is much higher in Zambia as compared to all other countries. The income gap ratio value reaffirms Zambia's poverty. This means the magnitude of the transfer that has to be made to the poor to bring their expenditure up to the poverty line (as a proportion of the poverty line) is highest in Zambia. Watts index, differently from the other measures, identified sample households in Mozambique to be the poorest. The income gap ratio in this case shows the percentage of the average expenditure shortfall of the poor to the poverty line computed based on expenditure, while reported expenditure is used as a proxy for income.

**Table 13. Poverty measures based on measurement error adjusted total reported expenditure.**

| Poverty measure | Total reported expenditure Absolute poverty line | | | | Total reported expenditure Adjusted 50% median | | | |
|---|---|---|---|---|---|---|---|---|
| | Angola n=48 | Malawi n=155 | Mozambique n=337 | Zambia n=344 | Angola n=48 | Malawi n=155 | Mozambique n=337 | Zambia n=333 |
| Headcount ratio (%) | 14.58 | 9.03 | 12.61 | 32.56 | 27.1 | 27.74 | 27.2 | 35.47 |
| Poverty gap ratio (%) | 25.24 | 10.94 | 9.5 | 59.43 | 23.9 | 15 | 14.83 | 54.46 |
| Income gap ratio (%) | 173.1 | 121.12 | 74.94 | 182.52 | 88.23 | 54.1 | 54.5 | 153.55 |
| Watts index (%) | 0.1 | 5.03 | 9.4 | 9.32 | 10.94 | 14.92 | 21.23 | 12.06 |
| Sen index *100 | 32.4 | 14.32 | 13.1 | 85.4 | 30.6 | 21.52 | 20.48 | 77.78 |
| Thon index *100 | 47.5 | 21.15 | 18.15 | 107.9 | 42.9 | 27.6 | 27.15 | 97.82 |
| Takayama index *100 | 30.44 | 11.54 | 9.64 | 119.81 | 25.47 | 14.9 | 14.5 | 95.48 |

Although the data generation processes do vary so much so that comparison can hardly be made, the asset wealth index, reported income, and reported expenditure poverty measures computed based on the sample data and national poverty figures from different sources reveal that – apart from Zimbabwe, which was dropped for lack of data – Mozambique and Zambia stand out to be the poorest of the four countries.[4]

[4] Poverty measurement summaries are available from the corresponding author upon request.

## 4.4. Poverty profiling

Poverty groups (poor and non-poor) were formed using both welfare indicators such that those who earn/spend below the absolute poverty line are poor. Mean comparison of owned quantities of important assets and access to social services (education and extension services) has shown important tendencies in the sample communities. Comparing the poor and non-poor groups formed based on WM1, Angolan sample does not show so much difference between poor and non-poor groups (Table 14). Only household size – which is significantly higher in non-poor households – and proportion of land allocated to maize – which is significantly higher for the poor households - were found to be statistically different in the two groups.

**Table 14: Poverty profiles of sample households based on daily income per adult equivalent.**

| Daily income per adult equivalent | Angola n = 82 | | Malawi n=152 | | Mozambique n= 337 | | Zambia n=333 | |
|---|---|---|---|---|---|---|---|---|
| | **Mean diff.** | **t - stat.** | **Mean diff.** | **t - stat.** | **Mean diff.** | **t - stat.** | **Mean diff.** | **t - stat.** |
| Household size | 1.57 | 3.35 | 2.31 | 4.01 | 2.57 | 5.65 | 2.05 | 6.18 |
| Dependency ratio | -0.02 | -0.06 | 0.47 | 1.30 | -0.01 | -0.04 | -0.02 | -0.16 |
| No. of illiterate hh members | 0.02 | 0.08 | 0.81 | 2.61 | 0.85 | 2.38 | 0.55 | 2.81 |
| Number of household members in off-farm activities | -0.09 | -0.35 | 0.41 | 1.34 | 0.61 | 4.43 | 0.85 | 4.48 |
| Number radio owned | 0.06 | 0.39 | 0.35 | 1.91 | -0.05 | -0.42 | 0.18 | 2.22 |
| No. of credit types received | 0.12 | 1.04 | 0.12 | 1.63 | 0.01 | 1.01 | -0.02 | -0.42 |
| No. of extension contacts in last 12 months | 0.55 | 0.87 | 0.27 | 0.18 | 0.35 | 1.37 | 0.49 | 0.27 |
| Farm size (ha) | 1.48 | 1.02 | 0.39 | 1.78 | 2.01 | 2.17 | 1.72 | 0.77 |
| Land allocated to maize (% of total land) | -10.41 | -1.92 | -0.10 | -1.22 | 0.05 | 1.54 | 0.02 | 0.60 |
| Livestock wealth in TLU | 0.31 | 1.45 | 0.21 | 0.64 | 0.87 | 3.63 | 1.98 | 4.76 |
| Number of phones owned | 0.00 | 0.01 | 0.27 | 1.87 | 0.06 | 1.39 | 0.12 | 3.18 |
| Average education of the household (years) | 0.64 | 0.73 | -0.38 | -0.91 | 0.86 | 3.23 | 0.59 | 2.62 |
| Number of farm plots | | | 0.12 | 0.42 | 0.00 | 0.03 | 0.20 | 1.23 |
| Number of bicycles owned | | | 0.39 | 2.36 | 0.03 | 0.23 | 0.38 | 4.98 |

mean diff = mean(non-poor) - mean(poor)

In the case of Malawi, household size, number of illiterate family members, farm size, and number of bicycles owned are significantly higher in the non-poor group compared to the poor. In Mozambique, the poor are characterized by significantly less household size, less number of illiterate household members, less education of the household head (in years), less number of household members engaged in off-farm activities, less number of plowing animals, less farm size, and less livestock wealth than the non-poor group. In Zambia, the non-poor households are characterized by significantly higher farm size; higher number of illiterate household members; higher number of household members engaged in off-farm activities; higher number of plowing animals, higher number of radios, phones, and bicycles owned; and higher livestock wealth.

The profiling of poor and non-poor groups formed using WM2, showed more elaborate differences in Malawi, Mozambique and Zambia (Table 15). The poor in Malawi possess significantly less household size, illiterate household members, average education of household in years, farm size, phones and bicycles compared to the non-poor. However, the poor allocate significantly higher proportion of their land to maize. In Mozambique, once again, the non-poor group has significantly higher family size, dependency ratio, illiterate household members, education of household head (in years), number of household members engaged in off-farm activities, farm size, and livestock wealth. In Zambia, except for the proportion of land allocated to maize, the poor own less of all assets and household head education as compared to non-poor households. In fact, poor households do have significantly less number of illiterate household members.

An interesting observation in the poverty profiling is the fact that the poor households allocate significantly higher proportion of their land to maize as compared to the better offs. This implies the magnitude of the importance poor and vulnerable households attach to maize. It is therefore imperative to emphasize the contribution of interventions on and about maize technology development and deployment to alleviate poverty - and ultimately reduce the relative importance of maize in the household economy.

**Table 15. Poverty profiles of sample households based on daily expenditure per adult equivalent.**

| Daily expenditure/adult equivalent | Malawi n=155 | | Mozambique n=349 | | Zambia n= 344 | |
|---|---|---|---|---|---|---|
| | Mean diff. | t - stat. | Mean diff. | t - stat. | Mean diff. | t - stat. |
| Household size | 2.47 | 4.23 | 4.24 | 7.10 | 2.36 | 7.33 |
| Dependency ratio | 0.48 | 1.31 | 0.47 | 2.35 | 0.01 | 0.04 |
| No. of illiterate household members | 0.53 | 1.68 | 2.14 | 4.67 | 0.71 | 3.76 |
| No. of hh members engaged in off-farm activities | 0.35 | 1.13 | 0.63 | 3.45 | 0.66 | 3.53 |
| Number radio owned | 0.26 | 1.41 | 0.17 | 1.02 | 0.27 | 3.46 |
| Number of credit types received | 0.01 | 0.12 | 0.01 | 0.63 | -0.02 | -0.64 |
| No. extension contacts in the last 12 months | 0.86 | 0.56 | 0.27 | 0.82 | 1.04 | 0.59 |
| Farm size (ha) | 0.55 | 2.48 | 3.26 | 2.70 | 3.04 | 1.40 |
| Land allocated to maize (% of total land owned) | -0.19 | -3.11 | 0.02 | 0.42 | -0.06 | -1.67 |
| Livestock wealth in TLU | 0.22 | 0.69 | 0.79 | 2.47 | 1.71 | 4.20 |
| Number of phones owned | 0.31 | 2.15 | 0.06 | 1.09 | 0.13 | 3.35 |
| Average education of household in years | 0.55 | 1.29 | 0.39 | 1.09 | 0.55 | 2.50 |
| Number of farm plots | 0.48 | 1.64 | 0.18 | 0.92 | 0.60 | 3.73 |
| Number of bicycles owned | 0.44 | 2.60 | 0.02 | 0.11 | 0.44 | 5.95 |

## 4.5. Determinants of poverty

Income and expenditure are not expected to follow normal distribution and hence the quantile (median) regression model was estimated to explain the household level absolute poverty (measured in per capita reported daily income and expenditure). The model results have shown that different factors influence poverty comparably across countries. Due to limited observation and poor quality of data for Angola and Zimbabwe the econometric results are reported only for Malawi, Mozambique and Zambia.

### Malawi

Possession of assets such as farm land, livestock, bicycle, telephone (fixed and mobile), houses with modern roofing, and access to credit were found to be positively related to wellbeing of sample households in Malawi. On the other hand, number of farm plots was found to be negatively related to the wellbeing of the households (Table 16).

**Table 16. Determinants of poverty in rural Malawi.**

| **Dependent Variable**<br>**[ln(daily reported expenditure/adult equivalent) in local currency]** | **Coefficient** | **Std. Err.** | **t** |
|---|---|---|---|
| Constant | 2.041*** | 0.584 | 3.500 |
| Age of household head | -0.004 | 0.006 | -0.700 |
| Household head is illiterate (1=yes) | 0.162 | 0.234 | 0.690 |
| Female headed household (1 =yes) | -0.117 | 0.247 | -0.480 |
| Dependency ratio | -0.060 | 0.076 | -0.790 |
| Number of hh members engaged in off-farm activities | 0.061 | 0.058 | 1.050 |
| Average education of the household in years | -0.088 | 0.062 | -1.420 |
| Number of bicycles owned | 0.188* | 0.105 | 1.790 |
| Household owns phones (1=yes) | 0.850*** | 0.233 | 3.640 |
| Household owns radio (1=yes) | -0.145 | 0.199 | -0.730 |
| Household has improved roofing (1=yes) | 0.494** | 0.200 | 2.470 |
| Received any credit (1 = yes) | 0.450* | 0.233 | 1.930 |
| Number of farm plots | -0.316*** | 0.090 | -3.500 |
| Farm size (ha) | 0.623*** | 0.115 | 5.430 |
| Land allocated to maize (% of total land) | 0.341 | 0.420 | 0.810 |
| Livestock wealth (TLU) | 0.046* | 0.025 | 1.820 |
| Continuous user of improved maize (1=yes) | -0.199 | 0.190 | -1.040 |
| District (1= Balaka) | -0.222 | 0.209 | -1.060 |
| N = 92 | | | |
| Raw sum of deviations = 81.955 | | | |
| Min sum of deviations = 51.935 | | Pseudo R2 = 0.37 | |

*****, **, and * significant at alpha < 0.01, 0.05, and 0.1, respectively.**

Asset wealth is known to have a positive contribution on the wellbeing of households. In rural areas of Malawi, in particular, owning livestock means having a buffer for trying times and yet demands incurring a lot of cost in looking after the animals as theft is the most important challenge farmers are facing in trying to keep livestock.

The propensity to keep livestock might arise from initial wealth and yet proves to be positively influencing the spending the household can make. Given the importance of crop farming, the positive relationship between farm size and household level wellbeing is also expected. Nonetheless, the negative relationship between number of plots – which indicates land fragmentation probably more than anything else – and wellbeing implies the need for farm land consolidation. Consolidation of farmlands would apparently increase farmers' financial performance as they will certainly reduce the cost of their crop production per unit of land.

More importantly, ownership of cell phones was found to be highly significant in positively influencing the wellbeing of the households. This implies the importance of access to information and better networking in terms of opening up opportunities and reducing uncertainties in making production and marketing decisions. Concomitantly, it is imperative to highlight the importance of developing communication infrastructure and access to information in rural areas of Malawi to improve livelihoods. The importance of bicycle in Malawian rural areas cannot be overemphasized as it is serving as the means of transportation to and from the market just like donkeys in East Africa. Accordingly, the positive relationship between number of bicycles owned and wellbeing implies the direct and positive effect the asset has on the economic viability of a given household. In fact, one can easily see the role bicycles are playing by looking at the deftly arranged loads of fuel wood or grain along the main roads to and from rural Malawi. Households who own houses with improved roofing are also better off than those who live in thatched or other traditional roof houses. Clearly, this is related to the additional cost households have to incur in maintaining or attending to their ailments that happen due to exposure to harsh temperature levels or even flooding while living under poorly built roofs. In line with this, access to agricultural credit, as expected, positively influences the wellbeing of the households apparently through increasing their propensity to invest on productivity enhancing inputs and probably postponing selling decisions when prices are not right.

**Mozambique**

Regression results for Mozambican households showed that participation in off-farm activities, assets - bicycle, livestock and farm size etc. – ownership, and being in Mossurize District (as compared to Sussundenga) are positively related to the wellbeing of the households. On the contrary, households who are headed by females or illiterates, and those who have exposure to rural credit were found to be worse off than otherwise (Table 17).

In line with the theory of diversification of income sources, the results show that as the number of household members engaged in off-farm activities increases, the wellbeing of the household improves. The importance of off-farm income sources in re-enforcing rural livelihoods is a well-proven truth that applies to Mozambican farmers.

**Table 17. Determinants of poverty in rural Mozambique.**

| Dependent Variable [ln(daily reported expenditure/adult equivalent) in local currency] | Coefficient | Std. Err. | t |
|---|---|---|---|
| Constant | 1.055*** | 0.331 | 3.180 |
| Age of household head | 0.003 | 0.004 | 0.870 |
| Household head is illiterate (1=yes) | -0.244* | 0.130 | -1.870 |
| Female headed household (1 =yes) | -0.471*** | 0.163 | -2.880 |
| Dependency ratio | -0.004 | 0.045 | -0.080 |
| Number of hh members engaged in off-farm activities | 0.180*** | 0.048 | 3.710 |
| Average education of the household in years | 0.019 | 0.025 | 0.750 |
| Number of bicycles owned | 0.104** | 0.052 | 1.990 |
| Number of cell phones owned | -0.183 | 0.117 | -1.560 |
| Received any credit (1 = yes) | -0.475* | 0.254 | -1.870 |
| Number of farm plots | -0.037 | 0.057 | -0.650 |
| Farm size (ha) | 0.019** | 0.008 | 2.390 |
| Land allocated to maize (% of total land owned) | -0.128 | 0.236 | -0.540 |
| Livestock wealth in TLU | 0.111*** | 0.032 | 3.510 |
| Continuous user of improved maize (1=yes) | 0.137 | 0.113 | 1.210 |
| District (1= Mossurize) | 0.225** | 0.110 | 2.030 |
| N = 264 | | | |
| Raw sum of deviations = 188.047 | | | |
| Min sum of deviations = 153.021 | | Pseudo R2 = 0.2 | |

***, **, and * significant at alpha < 0.01, 0.05, and 0.1, respectively.

It is interesting; nonetheless, that access to credit rather worsens household wellbeing. In fact, if credit schemes are deliberately targeting poor households, this can be acceptable. The credit system in the study areas seem to be universal as the main provider is the public sector. However, it is also likely that poorly designed and implemented rural credit systems can aggravate poverty and hence vulnerability of rural households who rarely have buffer resources to lean on at hard times.

The importance of assets in the viability of the households' economy is clear. Bicycles serve the same purpose as in Malawi being essentially the main means of transportation for the rural households. Hence, owning a bicycle means a smooth flow of production and marketing activities thereby reducing the cost of life altogether. The bigger the farm size a household owns the better its wellbeing is. Livestock has positive and significant impact on wellbeing in Mozambique, probably because it serves as sources of cash and security. Households in Mossurize District were found to be better off compared to those in Sussundenga District. This is perhaps because farmers in Mossurize have access to Maputo which might increase farmers' access to inputs including labour and outputs markets.

Households headed by females and illiterates have less spending per adult equivalent. The fact that women are structurally incapacitated over the years due to socio-cultural and political-economic phenomena makes women headed households poorer compared to male-headed households. Similarly, households headed by illiterates can hardly deal efficiently with the challenges they face and/or exploit the opportunities they might face. Improving knowledge and skills through education is paramount in enabling and empowering individuals. Heading a household under limited resources is a challenge and with limited personal capabilities even worse.

### Zambia

Only dependency ratio was found to be unexpectedly positively influencing wellbeing in Zambia. Otherwise, all asset wealth related variables; i.e., number of bicycles, cellphones, and plowing animals owned, number and size of farm plots, access to credit, number of household members engaged in off-farm activities, average education of the household members in years, proportion of total land allocated to maize, continuous use of improved maize varieties, and residing in Kalomo District were all found to be positively influencing the wellbeing of the sample households (Table 18). Only age of the household head was found to be negatively related to household wellbeing. This shall be due to the limitations age brings about in accessing and exploiting opportunities such as labor intensive off-farm activities, seasonal migration to generate income, etc.

**Table 18. Determinants of poverty in rural Zambia.**

| **Dependent Variable [ln (daily reported expenditure/adult equivalent) in local currency]** | **Coefficient** | **Std. Err.** | **t** |
|---|---|---|---|
| Constant | -1.423*** | 0.177 | -8.050 |
| Age of household head | -0.005*** | 0.002 | -2.630 |
| Household head is illiterate (1=yes) | -0.063 | 0.101 | -0.620 |
| Female headed household (1 =yes) | -0.098 | 0.075 | -1.300 |
| Dependency ratio | 0.126*** | 0.021 | 5.960 |
| Number of hh members engaged in off-farm activities | 0.034** | 0.017 | 1.990 |
| Average education of the household in years | 0.083*** | 0.015 | 5.350 |
| Number of bicycles owned | 0.273*** | 0.041 | 6.730 |
| Number of cell phones owned | 0.718*** | 0.076 | 9.410 |
| Number of plowing animals owned | 0.029** | 0.013 | 2.270 |
| Received any credit (1 = yes) | 0.291*** | 0.077 | 3.790 |
| Number of farm plots | 0.119*** | 0.024 | 4.900 |
| Farm size (ha) | 0.005*** | 0.001 | 7.800 |
| Land allocated to maize (% of total land owned) | 0.286** | 0.118 | 2.430 |
| Livestock wealth in TLU | 0.089*** | 0.007 | 11.830 |
| Continuous user of improved maize (1=yes) | 0.394*** | 0.071 | 5.510 |
| District (1= Monze) | 0.299*** | 0.057 | 5.240 |
| N = 323 | | | |
| Raw sum of deviations = 320.10 | | (about 0.9) | |
| Min sum of deviations = 244.20 | | Pseudo R2 = 0.24 | |

***, **, and * significant at alpha < 0.01, 0.05, and 0.1, respectively.

The importance of assets in positively influencing wellbeing has already been discussed above in Malawian and Mozambican cases. Both number and size of farm plots are positively related to household wellbeing. This might have happened because the plots are close to each other and to the residence of the household with no significant transaction costs. Access to credit and engagement of household members in off-farm activities are also positively related to wellbeing. The average literacy – in years of education - of the household is, as expected, positively related to wellbeing as well. Households in Kalomo were also found to be better off than their counterparts in Monze. One possible explanation can be that Monze is far from the urban areas such that their sources of income and hence spending could be limited.

In the case of Zambia, we have also observed that proportion of farm area allocated to maize and continuous use of improved maize varieties do positively influence wellbeing. This is an important finding in view of the fact that the sample population can be characterized as essentially semi-subsistent with limited market orientation. This finding also justifies the effort being exerted on development and deployment of maize and maize related technologies in rural Zambia.

**4.6. Inequality**

The inequality measures computed were based on the welfare indicators and two important assets that strongly influenced wellbeing in all countries – livestock wealth and farmland size. The results show that inequality is an important problem in all sample communities. Particularly for Angola and Zambia, welfare indicator variables were found to be distributed unevenly among the individual households. The values of Gini coefficient also show that farm size ownership is relatively more equally distributed than livestock wealth or the other welfare measures (Table 19). Livestock wealth inequality is magnified by the decile dispersion ratio especially in Angola and Zambia whereby the richest 10% own 96 times (in Angola) and 52 times (in Zambia) that of the poorest 10%. Atkinson measures also show a similar pattern that livestock wealth and welfare measures are highly uneven in Angola and Zambia. In general, inequality in both welfare measures and important assets is magnified in Angola and Zambia.

**Table 19. Magnitude of inequality measures.**

| | | Gini coef. | p90/p10 | Atkinson (0.5) | Atkinson (1) | Atkinson (2) |
|---|---|---|---|---|---|---|
| Angola | WM1 | 0.65 | 26.3 | 0.34 | 0.58 | 0.86 |
| | WM2 | 0.67 | 94.6 | 0.36 | 0.67 | 0.95 |
| | TLU | 0.68 | 96 | 0.39 | 0.69 | 0.9 |
| | farm size | 0.56 | 16 | 0.32 | 0.51 | 0.75 |
| Malawi | WM1 | 0.64 | 31.1 | 0.33 | 0.56 | 0.88 |
| | WM2 | 0.58 | 21.3 | 0.27 | 0.48 | 0.76 |
| | TLU | 0.61 | 21 | 0.37 | 0.57 | 0.83 |
| | farm size | 0.39 | 6.5 | 0.12 | 0.23 | 0.41 |
| Mozambique | WM1 | 0.71 | 63.2 | 0.42 | 0.68 | 0.94 |
| | WM2 | 0.53 | 13.4 | 0.22 | 0.4 | 0.69 |
| | TLU | 0.63 | 39.3 | 0.32 | 0.58 | 0.88 |
| | farm size | 0.39 | 5.83 | 0.15 | 0.27 | 0.44 |
| Zambia | WM1 | 0.67 | 34.7 | 0.39 | 0.64 | 0.98 |
| | WM2 | 0.68 | 19.5 | 0.4 | 0.61 | 0.95 |
| | TLU | 0.56 | 51.7 | 0.27 | 0.53 | 0.91 |
| | farm size | 0.55 | 10.4 | 0.35 | 0.5 | 0.68 |

Lorenz curves were drawn for daily expenditure per adult equivalent in local currency (Figure 5). The daily expenditure per adult equivalent values of Angola and Zambia are the farthest from equality.

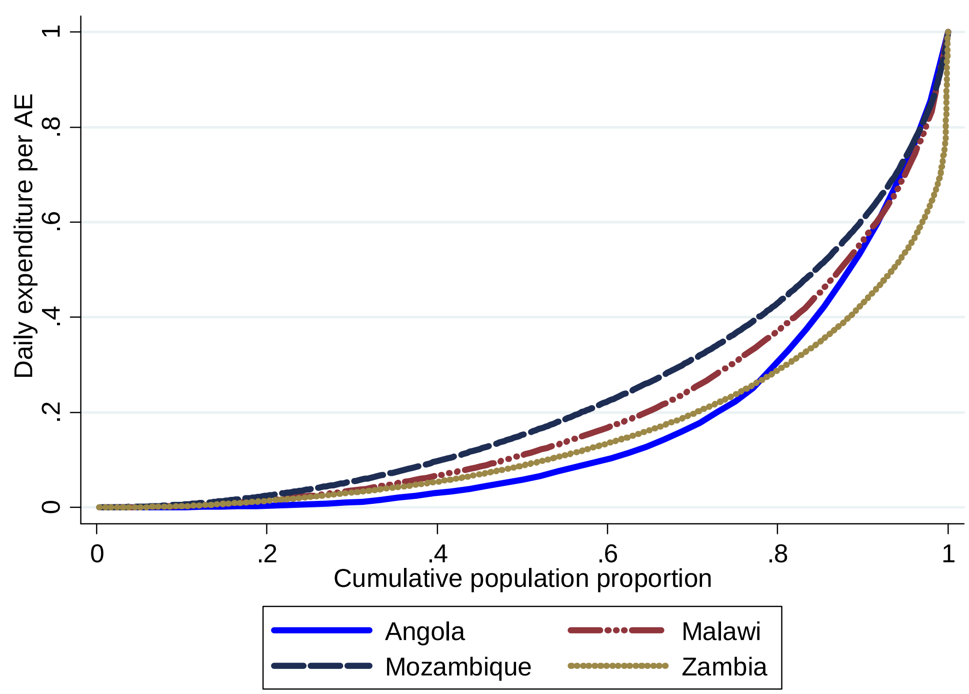



**Figure 5: Lorenz curve for daily expenditure per adult equivalent in local currency.**

# Chapter 5: Characterizing Maize Production

## 5.1. Farm land under maize and other crops

Land is by far the most important resource of the sample farming communities. Allocation of this scarce resource apparently indicates the importance farmers attach to the different crops they are growing. Accordingly, a look into the proportion of area allocated to different types of maize vis-à-vis other types of crop verifies the importance of maize at household level. The proportion of total crop-land allocated to land race maize production ranges from 2.58% in Zimbabwe to 97.86 in Angola. The proportion of land allocated to improved OPVs ranges from 2.14% in Angola to 17.2% in Mozambique. Excluding Angola – where there is no hybrid maize production, the proportion of total crop land allocated in hybrid maize ranges from 7.12% in Mozambique to 88.72% in Zimbabwe, in any given year. Legumes, fallow/pasture plots, and others are far second in the countries in terms of magnitude of land allocation (Table 20).

Generally, the land allocated to maize ranges from 45.9% in Mozambique to 69.8% in Malawi of the whole farmland. In Angola, Malawi and Mozambique, most of the maize land is covered with land races, whereas in Zambia and Zimbabwe, hybrid maize covers most of the maize area. Angolan and Malawian farmers grow maize intercropped with other crops whereas it is grown as a sole crop in other countries.

**Table 20. Land allocation to crops and maize varieties.**

| | Angola | Malawi | Mozambique | Zambia | Zimbabwe |
|---|---|---|---|---|---|
| Farm area share maize (%) | 51.29 | 69.76 | 45.92 | 54.33 | 49.2 |
| Maize area (ha) | 0.92 | 0.76 | 3.32 | 2.35 | 1.39 |
| Share local varieties (%) | 97.86 | 80.14 | 75.69 | 28.5 | 2.58 |
| Share improved OPV (%) | 2.14 | 3.22 | 17.19 | 6.01 | 8.7 |
| Share hybrids (%) | - | 16.64 | 7.12 | 65.49 | 88.72 |
| Area share other cereals (%) | - | 2 | 11.82 | - | 8.53 |
| Farm share legumes (%) | 7.85 | 14.95 | 11.94 | 12.32 | 24.54 |
| Farm share roots & tubers (%) | 11.53 | 1.99 | 8.89 | 2.83 | 3.86 |
| Farm share perennials (%) | 0.86 | 0.2 | 0.17 | 0.6 | 1.76 |
| Farm share fallow/pasture (%) | 2.99 | 4.48 | 13.81 | 29.43 | 8.57 |
| Farm share other crops (%) | 25.47 | 6.62 | 7.44 | 0.5 | 3.55 |

### Fertilizer use

Fertilizer is also an indispensable input for crop production in the region. Nearly all of the basal and top-dressing fertilizer is applied onto maize fields in all countries, except in Mozambique where still 80% of the basal and 67% of the top-dressing fertilizer is applied on maize. This enormous magnitude of fertilizer share shows again the priority given to maize and maize production. Despite the high proportion of fertilizer applied to maize compared to other crops, the average use per unit of land for maize production widely varies from country to country. The average quantity applied in kilogram per hectare of maize, only for those who applied fertilizer, is 2.33 (N=6), 101.5 (N=63), 165 (N=143), 196 (N=204), and 760 (N=99) in Mozambique, Zimbabwe, Malawi, Zambia and Angola, respectively. The mean comparison done with ANOVA shows that the fertilizer use level is significantly different among the countries (Table 21).

The high level of fertilizer use in Malawi, Zambia and Zimbabwe is obviously associated with the well-established culture of farmers in growing improved maize varieties under high input conditions. All these countries have farm input subsidy programs of different age and magnitude that enable farmers access and use farm inputs - including fertilizer. Since the end of the civil war, Angolan government has also been reaching out to farmers with farm inputs such as fertilizer, seed, and chemicals. Despite the challenge the country is facing in terms of availing improved seed for farmers (Kassie et al., 2011), farmers' access to other farm inputs, particularly fertilizer has been significantly improved. That is the reason behind the high level of fertilizer use despite low level of improved maize variety adoption rate.

**Table 21. Fertilizer use in the sample communities.**

| | Angola | Malawi | Mozambique | Zambia | Zimbabwe |
|---|---|---|---|---|---|
| Fertilizer adoption (% of hh) | 66 | 92.3 | 1.7 | 58.3 | 63 |
| Total fertilizer used (kg) | 271.69 | 103.11 | 202.57 | 2369.4 | 148.03 |
| Proportion of total fertilizer applied on maize (%) | 93.79 | 99.21 | 83.33 | 100 | 97.25 |
| Total average fertilizer use kg/ha | 366.62 | 116.76 | 32.49 | 99.38 | 64.33 |
| Intensity of fertilizer use on maize (kg/ha) | 760.04 (n=99) | 165.43 (n=143) | 2.33 (n=6) | 195.99 (n=204) | 101.45 (n=63) |
| Proportion of basal fertilizer applied on maize (%) | 93.83 | 99 | 80 | 100 | 97.47 |
| Proportion of top dressing fertilizer applied on maize (%) | 92.47 | 99.29 | 66.67 | 100 | 98.04 |

### Knowledge of Improved maize seed and seed sources

The use of improved seed is preceded by the knowledge about the different types of seeds. All the sample farmers in Zimbabwe are aware of the difference between improved OPVs and hybrids. On the contrary, about 95% of the sample farmers in Angola do not know the difference between OPV and hybrid maize. This gap of knowledge can be attributed both to mere unavailability of the technologies and to the lack of timely and adequate agricultural extension service that sufficiently conveys the information about the technologies. Most of the sample farmers in Malawi (72.0%), Mozambique (98.0%), and Zambia (78.0%) are in fact aware of the difference between OPVs and hybrids.

The lack of knowledge about the types of maize varieties seems to be reflected in the seed purchases. Despite considerable number of farmers depending on the market to fetch maize seeds, 90.7% of the farmers in Angola purchased and planted only local maize varieties. This highlights the lack of availability of the maize technologies – despite the effective demand for seeds – and hence the need for investment in this line.

Malawian and Zambian farmers, followed by Mozambicans and Zimbabweans, do mostly purchase and grow improved seeds. Farmers purchased maize seed both for major and minor rainy seasons. Minor rainy seasons are important in Mozambique and Angola. Farmers predominantly depend on the market for their maize seeds. They also retained seed and free provisions from governmental and non-governmental entities (Table 22).

**Table 22. Improved maize seed sources and use.**

| | Angola | Malawi | Mozambique | Zambia | Zimbabwe |
|---|---|---|---|---|---|
| Know difference b/n OPV and hybrids (% yes) | 5 | 72 | 98 | 78 | 100 |
| **Purchased maize seed (% yes)** | 57.3 | 45.8 | 54 | 87.4 | 76 |
| Major season (% yes) | 56.7 | 45.2 | 53.4 | 87.4 | 76 |
| Minor season (% yes) | 22 | 5.8 | 16.9 | 0.3 | - |
| **Type of seed purchased** | | | | | |
| Local seed | 90.7 | 14.3 | 12.2 | 6.3 | 31.6 |
| Improved seed | 7 | 81.4 | 73.5 | 80.2 | 68.4 |
| Local and improved seed | 2.3 | 4.3 | 14.3 | 13.5 | - |
| **Proportion of seed type (% maize seed used)** | | | | | |
| Local seed | 96.78 | 75.24 | 80.1 | 35.72 | 5.38 |
| Improved seed | 3.22 | 24.76 | 19.9 | 64.28 | 94.62 |
| **Sources of Seed** | | | | | |
| Retained from last season | 49 | 3.6 | 21.6 | 2.5 | 2 |
| Purchased seed from | 21.6 | 83.3 | 68 | 92.6 | 56.1 |
| Another farmer | 2 | 6 | 1.4 | 2.2 | 2 |
| Market | 19.6 | 20.2 | 42.7 | 2.2 | 18.4 |
| Seed company | | 32.1 | 6.9 | 3.4 | |
| NGO | | 1.2 | | 4 | |
| Agro-dealer | | 23.8 | 17 | 73.7 | 31.6 |
| Ministry of Agriculture | | | | 6.5 | 4.1 |
| Seed fair | | | | 0.6 | |
| **Free seed and others** | 29.4 | 13.2 | 8.7 | 3.7 | 41.7 |
| Free seed from neighbor | | 4.8 | 3.2 | | 2 |
| Free seed from government | | 3.6 | 2.3 | 1.2 | 6.1 |
| Free seed from NGO | | 4.8 | 1.4 | 0.6 | 6.1 |
| Other | 29.4 | | 1.8 | 1.9 | 27.5 |

In terms of the proportion of seed types used, Zimbabwe stands out well-above others with 94.6% of the seed used being improved, followed by Zambia (64.3%) and Malawi (24.8%). As expected, only 3% of the seed used by Angolan farmers was improved. Zimbabwe's situation was in fact even better (100% hybrid maize seed use) before the crisis that followed the infamous land reform.

## 5.2. Maize varieties under production

Farmers in the region are growing different local and improved varieties of maize. Cateta, Branco, Vermelho, and Mabuya are the four most frequently grown varieties in Angola. In Malawi, the local variety is the most common followed by Kanyani, MH18, and NSCM41. In Mozambique, the four most commonly grown varieties are Matuba, Ndau on Chindau, SC513, and Pannar 1. SC513, Gankata, Pool 16, and MM604 are the most frequently grown varieties in Zambia. Similarly in Zimbabwe, SC513, Heckory King, and pioneer varieties are the most commonly grown varieties (Table 23).

**Table 23. Varieties grown by farmers.**

| Angola | | Malawi | | Mozambique | | Zambia | | Zimbabwe | |
|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **%** | **Variety** | **%** | **Variety** | **%** | **Variety** | **%** | **Variety** | **%** |
| Cateta | 24.21 | Local | 17.34 | Matuba | 24.44 | SC 513 | 13.20 | SC 513 | 22.31 |
| Branco | 22.11 | Kanyani | 15.31 | Ndau ou Chindau | 23.37 | Gankata | 12.93 | SC 403 | 8.02 |
| Vermelho | 15.79 | MH18 | 13.47 | SC 513 | 12.33 | Pool 16 | 6.82 | Heckory King | 6.52 |
| Mabuya | 12.11 | NSCM41 | 8.49 | Pannar 1 | 7.93 | MM 604 | 6.76 | Pioneer | 6.52 |
| Nakangojo | 5.26 | Makolo | 4.61 | Pan 67 | 7.72 | MRI 614 | 6.01 | Pannar | 6.27 |
| Luvonga | 3.16 | MH41 | 4.24 | Laposta | 6.00 | MM 603 | 4.22 | ZM 521 | 5.51 |
| Kanjala | 2.63 | Pannar | 3.87 | Sussuma | 4.61 | MRI 534 | 4.00 | SC 401 | 4.76 |
| Cassenha | 2.11 | Pan 67 | 2.95 | Chinhamuana | 3.22 | MRI 634 | 3.90 | Pannar 413 | 4.26 |
| Dente de c | 2.11 | DK8033 | 2.77 | Pannar 57 | 2.04 | MRI 734 | 3.90 | SC 517 | 3.76 |
| Kalahari | 2.11 | Pioneer | 2.77 | Chigogoyo | 1.39 | MMV 400 | 3.79 | SC 525 | 3.01 |
| Minha | 2.11 | DK8031 | 2.58 | Chitonga | 0.86 | Obatampa | 3.41 | red cork | 2.76 |
| Amarelo | 1.58 | OPV | 1.29 | Pan 3 | 0.86 | Pannar 6363 | 3.08 | SC 501 | 2.51 |
| Mbelali | 1.58 | Bantamu | 1.11 | SC 501 | 0.86 | MRI 624 | 2.54 | ZM 421 | 2.26 |
| Boelo | 0.53 | DK8071 | 1.11 | Candjere | 0.54 | MRI 594 | 2.16 | Tsoko | 2.01 |
| Dombe | 0.53 | Kagolo | 1.11 | Semoc 501 | 0.43 | MRI 514 | 2.06 | CG4141 | 1.75 |
| Grosso | 0.53 | Mkango | 1.11 | Chiute | 0.32 | Pan 67 | 2.06 | Matuba | 1.75 |
| Matuba | 0.53 | MH17 | 1.11 | Manica-SR | 0.32 | MRI 513 | 1.95 | R 201 | 1.75 |
| Miha | 0.53 | Masika | 0.92 | Chinaka | 0.21 | SC 403 | 1.79 | SC 413 | 1.75 |
| Vombo | 0.53 | Mkango | 0.92 | Chitombodzi | 0.21 | SC 709 | 1.35 | SC 521 | 1.75 |
| | | Sundwe | 0.92 | Local | 0.21 | DK8051 | 1.08 | SR 52 | 1.75 |
| | | Katswinn Pan | 0.74 | R 201 | 0.21 | Sc 621 | 1.08 | Mbidzi | 1.00 |
| | | Njubua | 0.55 | R 52 | 0.21 | Sc 514 | 0.81 | Pannar 473 | 1.00 |
| | | Others | 10.15 | Others | 1.71 | Others | 11.09 | Others | 7.02 |

The level of knowledge of maize seed technologies can also be assessed based on the number of varieties farmers are aware of. Considering all maize types, an average Zambian farmer knows 5.3 maize varieties of which 3.8 are hybrid maize and 0.8 are improved OPVs. In Zimbabwe, a typical farmer is aware of about four maize varieties of which 3.2 are hybrids and 0.4 are improved OPVs. On the other end, an average Angolan farmer knows only 1.9 maize varieties of which 1.8 are landraces. In the case of Malawi and Mozambique, farmers know of 3.7 and 2.7 maize varieties, respectively, predominantly hybrids for the former and landraces for the latter (Table 23).

Zimbabwean farmers were also found to be on average early adopters of hybrid maize with an average use-year of 4.42. Mozambicans and Zambians follow with 3.83 and 2.63 years of using, respectively. Regarding recycling of hybrid seeds, it was found out that Zimbabweans hardly recycle, whereas Mozambicans do on average recycle 1.5 times. This pattern of recycling also applies to improved OPVs (Table 24).

**Table 24. Knowledge and use of maize varieties.**

| | Angola | | Malawi | | Mozambique | | Zambia | | Zimbabwe | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **N** | **Mean** | **N** | **Mean** | **N** | **Mean** | **N** | **Mean** | **N** |
| No. of varieties known | 1.86 | 103 | 3.72 | 151 | 2.68 | 348 | 5.31 | 348 | 4.12 | 99 |
| Landraces | 1.82 | 103 | 0.94 | 151 | 1.01 | 348 | 0.70 | 348 | 0.47 | 99 |
| OP-IV | 0.05 | 103 | 0.17 | 151 | 0.79 | 348 | 0.81 | 348 | 0.41 | |
| Hybrid | 0.00 | 103 | 2.62 | 151 | 0.88 | 348 | 3.80 | 348 | 3.23 | 99 |
| No. of varieties used | 1.47 | 87 | 1.41 | 140 | 1.65 | 333 | 2.14 | 339 | 1.60 | |
| Landraces | 0.84 | 150 | 0.72 | 155 | 0.83 | 350 | 0.44 | 350 | 0.14 | 100 |
| OP-IV | 0.01 | 150 | 0.01 | 155 | 0.35 | 350 | 0.24 | 350 | 0.22 | 100 |
| Hybrid | 0.00 | 150 | 0.55 | 155 | 0.38 | 350 | 1.39 | 350 | 1.18 | 100 |
| Frequency of recycling (years) | 0.29 | 75 | 8.65 | 148 | 10.86 | 344 | 2.08 | 348 | 0.33 | 98 |
| Landraces | 0.29 | 73 | 18.88 | 114 | 19.70 | 311 | 6.05 | 221 | 2.66 | 18 |
| OP-IV | 0.00 | 3 | 1.62 | 13 | 1.63 | 173 | 1.43 | 146 | 0.71 | 29 |
| Hybrid | | | 0.93 | 122 | 1.52 | 166 | 0.86 | 319 | 0.16 | 95 |
| Unidentified | 0.15 | 103 | 0.25 | 151 | 0.01 | 348 | 0.23 | 348 | 0.12 | 99 |
| Length of variety use (years) | 12.22 | 81 | 10.28 | 150 | 14.21 | 343 | 4.21 | 347 | 4.15 | 96 |
| Landraces | 12.32 | 79 | 21.04 | 116 | 23.67 | 310 | 9.20 | 221 | 3.96 | 21 |
| OP-IV | 7.00 | 3 | 2.00 | 15 | 3.58 | 173 | 2.53 | 144 | 1.91 | 29 |
| Hybrid | | | 2.54 | 124 | 3.83 | 169 | 2.63 | 319 | 4.42 | 95 |

Sole-cropping is the dominant way of growing maize and yet intercropping is also practiced in the region. More than 67% Angolans and about 13.6% of Malawians practice intercropping in growing maize. No farmer reported intercropping in the other three countries. The intercropping is done usually with landraces and only three farmers in Angola have reported intercropping their improved maize varieties with other crops.

As much as farmers have problems in precisely telling the names of the varieties they are growing, especially improved varieties, they can easily identify the varieties they prefer most. In Malawi, the most preferred varieties, in order, are local, MH36, Kanyani, and Makolo. In Mozambique, Ndau ou Chindau, Matuba, SC513, Laposta, and Pan 67 were indicated to be the most preferred varieties, in that order. In Zambia, the four most preferred varieties were identified to be Gankata, SC513, pool 16, and Obatampa. In Zimbabwe, SC513 is the most preferred variety followed by ZM521 and the local Heckory King variety.

## 5.3. Trends in maize production

Crop farming is a dynamic enterprise with lots of uncertainties and risk. Trends in yield and price levels, particularly as perceived by the growers themselves are important indicators of the resilience of the enterprise. Given the socioeconomic and political forces in the region -

such as end of the civil war in Angola and Mozambique and the economic crisis in Zimbabwe - the perceived trends of maize production are worth investigating. Accordingly, 21% of Angolan sample farmers believe that profitability of local maize varieties is declining whereas 36.4% think that it is increasing. The rest believe that it has not changed at all. Looking at susceptibility to drought, 61.5% of the responding Angolan farmers indicated that the local varieties they grow are highly susceptible to drought. About 63% of the respondents have also indicated the prices to the grains of their varieties as highly variable resulting in high uncertainty and hence risk[5].

In Malawi, 57% of the responding farmers (n = 125) indicated that local maize variety production is becoming more profitable while 35% of the respondents believe that the profitability is declining. However, among the 65 respondents on profitability trend of hybrid maize in Malawi, 77% believe that profitability is increasing while only 17% think that it is declining. This is an important perceptive advantage of hybrids over local maize production. More than 43% of the sample farmers in Malawi believe that the local varieties being grown are highly susceptible to drought. In Malawi, 68 respondents believe that hybrid maize varieties are as susceptible to drought as the local varieties. About 49% of the respondents (n=127) in Malawi consider local maize varieties highly risky in terms of price variability while 45% of them believe that they are less so. Farmers are evenly divided in believing that the hybrids are highly price risky (47%) and less risky (45.3%).

Most (60.6%) Mozambicans believe that profitability of local maize production is increasing whereas 27% believe that it has not changed at all. Similarly, 85% of the sample farmers believe that improved OPV maize production is becoming increasingly profitable. This opinion seems to be dominant as only 5.4% of the farmers believe that profitability of improved OPVs is decreasing. Majority (79%) of Mozambican farmers also believe that hybrid varieties have increasing trend of profitability. Only 7.6% of the farmers feel that the contrary is happening. Local maize varieties were rated highly susceptible to drought risk by more than 90% of the sample farmers in Mozambique. When considering the susceptibility of improved OPVs, this proportion falls down to 51% and for hybrid maize it falls further to 47%. This simply shows that improved OPVs and hybrids are being preferred for drought tolerance.

The price variability (or riskiness) of all the varieties being grown by farmers was reported to be high. Relatively, however, fewer farmers (65%) think that hybrid maize varieties do show high price variability as compared to local (84.4%) and improved OPVs (94.9%). Production level (yield x area) has increased only in Mozambique and Zambia. Malawi and Zimbabwe farmers have experienced a rise and then drop of production level over the three years period. Angolan sample farmers, however, have experienced declining production level over the period (Figure 6).

[5] Riskiness of varieties in terms of yield variability is discussed in chapter six below.

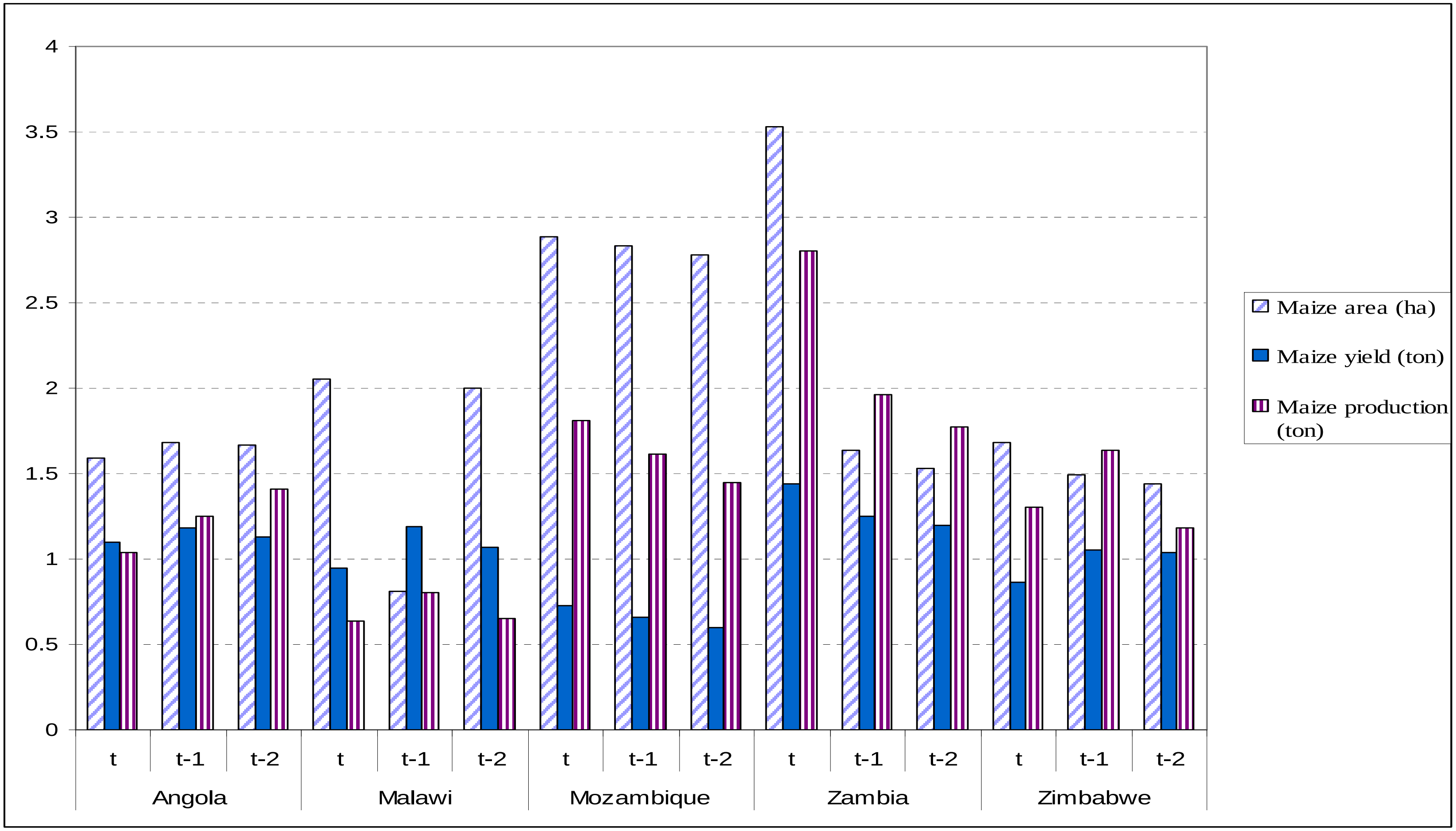



**Figure 6: Trends of maize area, yield, and production over three years**[6]

[6] t – denotes the survey year (see Table 1); t-1, denotes the year before; and t-2 denotes two year before.

The area allocated to maize has shown a general increase over the last three years except in Angola where there is a drop at the third year (Figure 6). Similarly, yields show different trends in different countries. Mozambique and Zambia have increasing trend over the last three years whereas the sample farmers in the other three countries observed a rise and then a drop in the yield level. The production level follows the same pattern except that Angolan farmers' maize production level is in the decline (Figure 6).

## 5.4. Access to agricultural information

Access to timely and adequate information on the different aspects of farming is crucially important particularly for resource constrained farming households. Farmers rarely have the luxury of getting the information they need when and how they need it. The public agricultural extension institutions and the public mass media have always been the prime sources of information for farmers in Sub-Saharan Africa in general and in southern Africa in particular. This study has shown that 92% of sample Zimbabweans, 65% Malawians, and 63% Zambians receive information on agricultural issues from the public agricultural extension system. Mass media (radio, TV and print) also serve as a source for about 54% of the sample Mozambicans, 37% Zambians, and for 32% Malawians. There are also different unspecified sources which serve 55% of Angolans and 32% of Mozambicans in providing information on agricultural technologies.

Zimbabweans were found to have higher level of attendance of field days, more number of participation in demonstration plot visits, and frequent discussions with extension agents. About 71%, 47%, and 67% Zimbabweans have attended field days, visited demonstrations and had discussions with extension agents about maize, respectively, over a one year period. Zambian sample households follow as far second in terms of participating in such extension activities. Angolans and Mozambicans seem to be the least privileged in terms of access to field days, extension demonstrations, and discussions on maize related issues (Table 25).

**Table 25. Access to agricultural extension.**

| | Angola | | Malawi | | Mozambique | | Zambia | | Zimbabwe | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | N=96 | | N=127 | | N=344 | | N=347 | | N=97 |
| Sources of agricultural information (%) | | | | | | | | | | |
| Government extension staff | 28.1 | | 64.6 | | 14.2 | | 63.1 | | 91.8 | |
| Mass media (radio/tv/print) | 16.7 | | 31.5 | | 53.5 | | 36.9 | | 5.2 | |
| Other | 55.2 | | 3.9 | | 32.3 | | - | | 3.1 | |
| Attended maize extension activities | 12.7 | 150 | 14.8 | 155 | 13.7 | 350 | 27.4 | 350 | 76 | 100 |
| Number of field days attended | 3 | 19 | 0.26 | 23 | 2.73 | 48 | 1.73 | 96 | 2.5 | 76 |
| Number of demonstrations attended | 2.47 | 19 | 1.13 | 23 | 2.48 | 48 | 0.82 | 96 | 1.58 | 76 |
| Number of maize related discussions | 1.37 | 19 | 1.96 | 23 | 2.92 | 48 | 1.57 | 96 | 2.59 | 76 |
| Interacted with extension staff | 15.3 | | 45.2 | | 15.1 | | 70.9 | | 94 | |
| No. of interactions with extension staff | 2.65 | 23 | 6.07 | 70 | 3.36 | 53 | 11.16 | 248 | 5.98 | 94 |

The inquiry about the frequency with which farmers have discussed with extension agents revealed that 94% Zimbabweans, 71% Zambians, and 45.2% Malawians have had an interaction with extension agents. On the contrary, only 15.3% Angolans and 15.1% Mozambicans have had discussions with extension staff (Table 25).

Farmers' access to extension services seems to be evenly distributed in Zimbabwe whereas it seems concentrated on few households in Angola, Malawi and Mozambique. Despite the importance of the context, it is plausible to suggest adoption of a framework that addresses the wider community. The recent developments in Malawian agriculture could be a very good example of successful broad based extension.

# Chapter 6: Drought risk perception and management

## 6.1. Drought and drought risk management

Maize production in Sub-Saharan Africa in general and in southern Africa in particular is constrained by natural forces in addition to the formidable institutional bottlenecks that characterize most of the countries. Amongst the natural forces, drought has repeatedly been reported to be the most important challenge of maize production in the region. It is a slow-onset, creeping phenomenon with serious economic, environmental, and social impacts. It affects more people than any other natural hazard (Anderson, 2006; Glantz & Katz, 1977; ISDR, 2003). It might be considered in general terms, a consequence of a reduction over an extended period of time in the amount of precipitation that is received, usually over a season or more in length.

Not all types of drought are equally harmful and not all people are equally vulnerable to drought's negative consequences. The risk associated with drought is defined by a region's exposure to the natural hazard and society's vulnerability to it. Because climate is variable through time, exposure to drought also varies from year to year and decade to decade. Global warming and the probability that drought and other extreme climatic events may become more frequent in the future may translate into increased exposure to drought (ISDR, 2003; Wilhite, Hayes, Knutson, & Smith, 2000; WolrdBank, 2006). Risk and vulnerability go hand in hand such that frequent exposure to considerable magnitude of risk increases vulnerability of households and vulnerable households suffer more than better off households – resulting in a vicious cycle of risk-vulnerability-risk.

Understanding people's vulnerability to drought is complex, yet essential for designing drought preparedness, mitigation and relief policies and programs. In addition to vulnerability, the indigenous strategies of coping with risk in general and drought risk in particular should be identified and analyzed to design risk management interventions that enhance the sustainability of farming livelihoods in drought prone-areas. Risk management strategies in agriculture have been categorized differently by different authors. Fleisher (1990) classified the strategies into three, namely self-protection, self insurance, and market-insurance. Market insurance and self-insurance reduce the impact of losses on the individual or the firm. Self–protection, on the other hand, reduces the probability that a loss will occur.

Examples of self-protection include the use of a drought resistant variety in a drought prone area, preventive maintenance on equipment, and spreading sales. Maintaining cash reserves or holding reserves of feed for livestock are examples of self-insurance. Purchasing hail insurance or multi-peril crop insurance are examples of market insurance. Hardaker, Huirne, Anderson, and Lien (2004) classified risk management strategies into two: on-farm strategies; and strategies to share risk with others. On-farm strategies include collecting information, avoiding or reducing exposure to risks, selecting less-risky technologies, diversification of activities, and flexibility of farm business (in terms of asset, product, market, cost, and time flexibility). The strategies to share risk with others include farm financing, insurance, and contract marketing and future trading.

Walker and Jodha (1986) classified management measures as risk reducing and risk coping strategies. Risk reducing strategies include crop diversification, intercropping, farm fragmentation, and diversification into non-farm sources of income. Crop-sharing arrangements in land renting and labor hiring contracts can also provide an effective way of sharing risks between individuals thereby reducing a farmer's risk exposure. The risk coping strategies are relevant for dealing with catastrophic income losses once they occur. In order to repay loans and to meet essential living costs in disastrous years, farmers may rely on new credit (especially consumer credit from local stores), sale of assets, use of own food stocks, or temporary off-farm employment. In many rural societies, mutual aid or kin-support systems also provide an important safety net for member households (Hazell, 1992). This study considers risk coping strategies as part and parcel of the farm management strategies of the farming communities and farmers' strategies include both risk reducing and risk coping practices.

## 6.2. Importance of drought in southern Africa

Farmers in southern Africa do face different challenges that constrain their livelihoods. Notwithstanding the fact that there is always an overlapping of causes and effects in listing the problems faced by rural communities, drought was mentioned to be among the three most important livelihood challenges in all study countries. The other constraints farmers are facing include lack of food, sickness and mortality of family members, pests and diseases of plants and livestock, inflation, lack of financial resources, erratic rainfall, and flooding.

Farmers ranked the importance of each of the main livelihood bottlenecks they have been facing. The ranks given to drought are summarized in Table 26. Drought was reported to be the most important challenge on the livelihoods of people in Malawi, Zambia and Zimbabwe, whereas it was second to sickness and mortality of a family member, in Angola and Mozambique. An important point of discussion is whether drought is equally important in all of the farming communities considered here. The non-parametric Kruskal-Wallis test employed indicated that drought is not equally important in all of the farming communities. The test rejected the null hypothesis very significantly ($P < 0.001$) with Chi-square test statistic value of 70.171 at 3 degrees of freedom.

**Table 26. Relative ranking of drought risk as constraint of agriculture.**

| Rank (1 highest; 5 = lowest) | Angola (%) | Malawi (%) | Mozambique (%) | Zambia (%) |
|---|---|---|---|---|
| 1 | 90.4 | 74.4 | 57.6 | 79.7 |
| 2 | 0.0 | 17.6 | 18.0 | 14.5 |
| 3 | 0.0 | 7.2 | 12.9 | 3.2 |
| 4 | 1.1 | 0.8 | 7.5 | 1.0 |
| 5 | 8.5 | 0.0 | 4.1 | 1.6 |
| N | 94 | 125 | 295 | 310 |

## 6.3. Experiences of crop failure due to drought

Drought has different intensities and thus different levels of damages to household level livelihoods. It is easier to remember, however, the serious devastations than the mediocre variations in yield level which farmers can rightly attribute to different factors altogether. Total crop failure due to drought was assessed in this study as it captures the experience and the vulnerability of the households to drought and similar vagaries of nature. The descriptive statistics of the crop failure due to drought across the countries shows that Malawian and Zambian farmers experience total crop failure every three years on average. Mozambican farmers experience drought induced crop failure every four years and Angolan farmers every nine years (Table 27).

**Table 27. Mean number of crop failures due to drought over the last 10 years.**

| Country | N | Mean | Std. Deviation |
|---|---|---|---|
| Angola | 150 | 1.13 | 1.49 |
| Malawi | 148 | 3.07 | 1.81 |
| Mozambique | 344 | 2.33 | 1.13 |
| Zambia | 344 | 3.03 | 1.33 |

An important question in this case is whether this number of crop failures due to drought varies significantly across the farming communities in these four countries. After the variances of the distributions of the number of crop failures experienced by each of the sample households were found to be heterogeneous, we ran Games-Howell test (Games & Howell, 1976) to compare across the countries. The results indicate that Angola has significantly less mean number of drought caused crop failures compared to respondents in Malawi, Mozambique and Zambia. Malawi has higher and significantly different mean of frequency of drought induced crop failure compared to Angola and Mozambique. Malawi and Zambia have statistically comparable mean implying that the distribution of crop failures due to drought happen in similar frequencies. Mozambique has higher and statistically different mean number of crop failures compared to Angola and significantly less mean number of crop failures than Malawi and Zambia (Table 28).

**Table 28: Games-Howell Multiple Mean Comparison test on number of crop failures experienced.**

| (I) Country | (J) Country | Mean Difference (I-J) | Std. Error | Sig. |
|---|---|---|---|---|
| Angola | Malawi | -1.95* | 0.172 | 0.000 |
| | Mozambique | -1.2* | 0.105 | 0.000 |
| | Zambia | -1.91* | 0.112 | 0.000 |
| Malawi | Angola | 1.95* | 0.172 | 0.000 |
| | Mozambique | .75* | 0.161 | 0.000 |
| | Zambia | 0.04 | 0.165 | 0.995 |
| Mozambique | Angola | 1.2* | 0.105 | 0.000 |
| | Malawi | -.75* | 0.161 | 0.000 |
| | Zambia | -.71* | 0.094 | 0.000 |
| Zambia | Angola | 1.91* | 0.112 | 0.000 |
| | Malawi | -0.04 | 0.165 | 0.995 |
| | Mozambique | .71* | 0.094 | 0.000 |

*The mean difference is significant at 0.01 level of statistical error.

## 6.4. Farmers' assessment of riskiness of different maize types

Risk and uncertainty are critical issues in selecting enterprises and allocation of resources for the enterprises of choice. In this particular case, farmers' perception regarding the relative riskiness of the different maize varieties is assessed. Farmers' understanding of riskiness of a variety in terms of yield level is mainly about the variability of the level over time and space (Hardaker et al., 2004; Tesfahun, Emana, & Abdoulaye, 2006). This perception is very important as it relates to the choices farmers make and hence interest in new maize germplasm developed for specific or composite traits. Farmers in Malawi and Zambia grow local, improved open pollinated and hybrid maize varieties; whereas farmers in Angola grow virtually only local varieties and almost all farmers in Zimbabwe grow hybrids. About 69% of the respondents (N = 106) in Angola consider the local varieties they are growing to be quite risky and only 31% regard them as least risky as compared to all other crops they grow.

Similarly, 62.4% of the respondents (N = 149) in Malawi referred to the local maize varieties they grow as risky, while more than half of these respondents consider these varieties most risky of all the crops they are growing. More than 74% of the respondents (N = 35) indicated that improved OPVs are risky as compared to all crops they are growing. The reference to hybrid maize varieties as risky is less frequent than the reference to other maize varieties and yet 59.4% (N = 69) think that hybrids are risky as compared to all other crops grown (Table 29).

**Table 29. Riskiness of maize varieties (in terms of yield variability) in study countries.**

| Maize type | Riskiness | Angola | Malawi | Zambia | Zimbabwe |
|---|---|---|---|---|---|
| | | Frequency (%) | Frequency (%) | Frequency (%) | Frequency (%) |
| Local | Most risky | 67.9 | 32.89 | 27.1 | |
| | More risky | - | 10.07 | 23.2 | |
| | Just risky | 0.9 | 10.74 | 25.9 | |
| | Risky | - | 8.72 | 5.1 | |
| | Less risky | - | 13.42 | 7.1 | |
| | Least risky | 31.1 | 24.16 | 11.6 | |
| | N | 106 | 149 | 336.0 | |
| Improved OPV | Most risky | | 25.71 | 38.1 | |
| | More risky | | 8.57 | 43.8 | |
| | Just risky | | 14.29 | 6.7 | |
| | Risky | | 25.71 | 1.6 | |
| | Less risky | | 20.00 | 2.2 | |
| | Least risky | | 5.71 | 6.7 | |
| | N | | 35 | 315.0 | |
| Hybrid | Most risky | | 23.19 | 76.3 | 20.0 |
| | More risky | | 13.04 | 8.4 | 8.9 |
| | Just risky | | 13.04 | 8.4 | 40.0 |
| | Risky | | 10.14 | 3.0 | 22.2 |
| | Less risky | | 15.94 | 1.8 | 2.2 |
| | Least risky | | 24.64 | 2.1 | 6.7 |
| | N | | 69 | 333.0 | 45 |

In Zambia, more than 81% of the respondents (N = 336) believe that local maize varieties they are growing are riskier than other crops. Improved OPVs were indicated to be even riskier by 90.2% of the respondents (N = 315) as compared to all other crops grown. Hybrids are considered the most risky of all the maize types and all other crops grown by farmers as reported by 96.1% of the respondents (N=333) (Table 29). Similarly, the riskiness of hybrid maize varieties as compared to all other crops was indicated by 91.1% of the respondents (N = 45) to be quite high in Zimbabwe.

It seems that maize varieties in general and improved OP and hybrid varieties in particular are being considered very risky in terms of predictability and reliability of yield levels. Given the precarious rainfall pattern and the irregularities in management of crop production under small holder conditions, it is imperative to emphasize the need to invest on development of technologies that enhance not only yield level but also stability of yield of maize.

## 6.5. Land allocation pattern as a response to risk expectation

Farmers have different ways of dealing with the different risks embedded in their agricultural activities. Risk management is entrenched in the regular farm management activities of farmers manifested through selection of enterprises and allocation of their meager resources (Tesfahun et al., 2006). The shifts in allocation of all resources need to be seen to fully capture the dynamics of the risk management efforts of the farming households. However, as data are limited, it suffices to focus on the allocation of the most important resource in relation to the different sources of risk. This study has looked at five scenarios and concomitant changes in the allocation of land to the different maize types grown by farmers.

The scenarios are expectation of lower yield than normal average, and inaccessibility of fertilizer, as sources of negative risk; and expectation of higher yield than normal average, better access to fertilizer, and better access to credit as sources of positive risk. The decisions of farmers were captured in three categories: allocation of more land, keeping the same land share, and decreasing the land allocated to the maize type.

Angolan farmers seem to be less responsive to all conditions and tend to keep the status quo of the land allocation to the landrace maize they are growing (Table 30). Access (or lack of it) to fertilizer was found to be a very important stimulus as farmers tend to change their allocation of land as a result. In fact, farmers tend to react more to positive sources of risk than to negative stimuli. This implies that if farmers are informed in advance about the likelihood of yield levels, accessibility of fertilizer, and credit, they tend to grow more of their local maize.

In Malawi, farmers tend to stick more to their current allocation of land to local maize varieties under the negative sources of risk. Expectation of lower yield than normal average makes farmers not change the proportion of land allocated to local varieties and if they change, they tend to increase the proportion of land planted with local varieties (Table 30).

Under better fertilizer and credit access, however, they tend to allocate more land to the local maize varieties they are growing. For both local and improved OPVs, farmers tend to maintain the current proportion of land allocated under inaccessibility of fertilizer and expectation of higher yield than normal. For hybrids, farmers tend to keep the current land allocation unchanged when faced with negative sources of risk and when they expect higher yield than normal average. They actually tend to allocate more land to hybrid maize when they have better access to fertilizer and credit (Table 30). This, at least, implies the importance of risk perception and concomitant resource allocation in selecting and then deciding the extent of use of improved technologies.

**Table 30. Responses of farmers for potential sources of production risk.**

| | Maize type | Scenario | Yield < normal | Yield > normal | fertilizer accessible | Fertiliser inaccessible | Credit accessible |
|---|---|---|---|---|---|---|---|
| Malawi | Local | Decrease | 1.34 | 0.67 | 0 | 12.08 | 0 |
| | | Same Area | 57.72 | 63.76 | 34.23 | 79.87 | 42.28 |
| | | Increase | 40.27 | 35.57 | 65.77 | 8.05 | 57.72 |
| | | N | 149 | 149 | 149 | 149 | 149 |
| | OPV | Decrease | 0 | 2.27 | 0 | 15.91 | 0 |
| | | Same Area | 31.82 | 59.09 | 27.27 | 70.45 | 27.27 |
| | | Increase | 68.18 | 38.64 | 72.73 | 13.64 | 72.73 |
| | | N | 44 | 44 | 44 | 44 | 44 |
| | Hybrid | Decrease | 8.62 | 0 | 1.72 | 24.14 | 1.72 |
| | | Same Area | 51.72 | 51.72 | 22.41 | 67.24 | 27.59 |
| | | Increase | 39.66 | 48.28 | 75.86 | 8.62 | 70.69 |
| | | N | 58 | 58 | 58 | 58 | 58 |
| Angola | Local | Decrease | 25.3 | 8.5 | 9.9 | 37.8 | 7.2 |
| | | Same Area | 44.6 | 48.8 | 46.9 | 45.1 | 43.5 |
| | | Increase | 30.1 | 42.7 | 43.2 | 17.1 | 49.3 |
| | | N | 83 | 82 | 81 | 82 | 69 |
| Zimbabwe | Hybrid | Decrease | 11.5 | 1.9 | 0 | 22.6 | 0 |
| | | Same Area | 78.8 | 37.7 | 34 | 75.5 | 28.8 |
| | | Increase | 9.6 | 60.4 | 66 | 1.9 | 71.2 |
| | | N | 52 | 53 | 47 | 53 | 48 |
| Zambia | Local | Decrease | 50.6 | 0.6 | 3 | 35.2 | 0.6 |
| | | Same Area | 34.3 | 18.5 | 11.6 | 62.7 | 25.7 |
| | | Increase | 10 | 79.7 | 85.1 | 1.8 | 72.8 |
| | | N | 335 | 335 | 335 | 335 | 335 |
| | OPV | Decrease | 69.3 | 0.6 | 4.1 | 76.3 | 0.9 |
| | | Same Area | 18.7 | 9.5 | 7 | 13.3 | 15.5 |
| | | Increase | 10.8 | 88.3 | 88 | 9.2 | 81.6 |
| | | N | 316 | 316 | 316 | 316 | 316 |
| | Hybrid | Decrease | 65.1 | 0.9 | 7.8 | 75.2 | 1.5 |
| | | Same Area | 21.2 | 9 | 1.8 | 14.3 | 12.8 |
| | | Increase | 12.5 | 89 | 90.1 | 10.1 | 84.8 |
| | | N | 335 | 335 | 335 | 335 | 335 |

Farmers in Zambia tend to decrease the land allocated to local maize varieties when they expect lower yield than the normal average. They, however, tend to maintain the current allocation when faced with lack of fertilizer. Under all sources of positive risk, Angolan farmers tend to increase the land allocated to local varieties. For improved OPVs and hybrids, farmers tend to decrease the land allocated to such varieties when faced with negative sources of risk and tend to increase under positive sources of risk.

Zimbabwean farmers on the other hand tend to keep the current allocation of land to hybrids as it is, when faced with sources of negative risk and tend to increase the land allocation when faced with sources of positive risk (Table 30). Zimbabwe's situation can be attributed to the fact that farmers grow virtually hybrids and have limited options to shift to.

Generally, farmers' tendencies show that allocation of the most important resource – land – is done with due consideration of the different sources of risk, including production risk. Farmers' responses for the two scenarios of expected yield, for instance, clearly show that the possible effects of constraints such as drought do influence the resource allocation and thus livelihoods of farmers in the region. This is all the more important as maize is the major staple food crop in each of the countries. Therefore, it is crucial to consider interventions that properly and timely inform the farming communities about the different sources of risk that have a bearing on their livelihoods.

## 6.6. Maize trait preference - how important is drought tolerance?

**Traits of an ideal maize variety**

Trait preferences tacitly indicate the objectives and priorities of farming households. The preferences are also dictated by the opportunities and constraints farmers face in their enterprise selection and management. Under smallholder and semi-subsistence scenarios, smallholders' trait preferences do overlap and revolve around yield parameters. The findings of this research verify this conventional fact as farmers in all countries (except Mozambique) mentioned yield potential of varieties more than any other trait as the most desired trait of an ideal maize germplasm (Figure 7).

Other traits mentioned most frequently in Angola include number and quality (size and filling) of cobs, early maturity, and performance under poor soil fertility. Pest and diseases resistance and drought tolerance were mentioned by farmers in Angola albeit less frequently. In Malawi, traits that followed yield potential include pest and disease resistance, early maturity, number and quality of cobs, and drought tolerance, in that order. In Mozambique, yield potential was second to field and storage pests and disease resistance. Yield potential was then followed by number and quality of cobs, performance under poor soils, and yield stability. Interestingly, early maturity and drought tolerance were not mentioned as desirable traits by Mozambican farmers (Figure 7).

Zambian farmers mentioned, next to yield potential, traits such as number and quality of cobs, drought tolerance, pest and disease resistance, early maturity, and performance under poor rainfall. The Zambian scenario shows farmers' clear interest in drought tolerant maize varieties. In Zimbabwe, farmers mentioned drought tolerance, early maturity, number and quality of cobs, pest and disease resistance, and performance under poor rainfall, in order, as traits considered along with yield potential of an ideal maize variety.

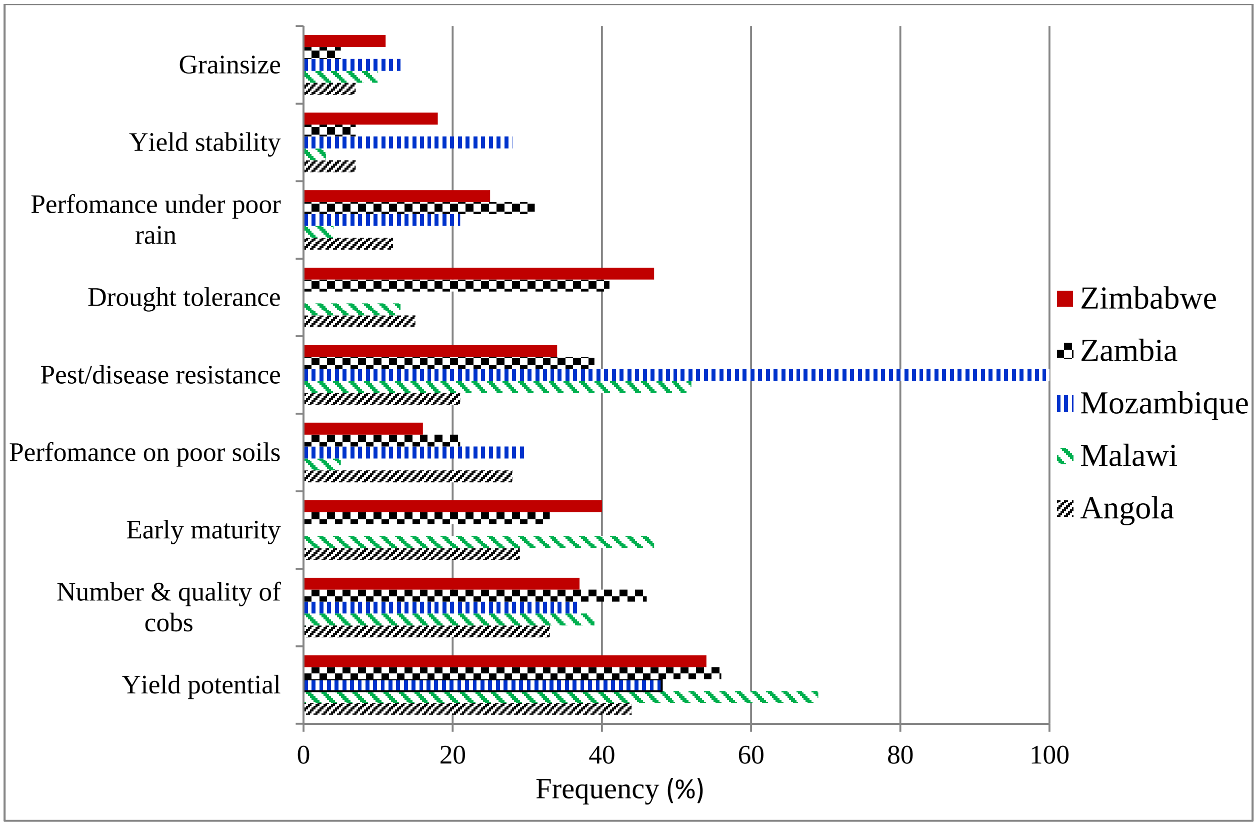



**Figure 7: Relative importance of traits that a good maize variety needs to contain.**

Yield potential is a composite trait explained by different specific traits which can include tolerance to drought, pests and diseases, and performance under erratic rainfall pattern. Nonetheless, the fact that farmers are mentioning these traits as important considerations when selecting maize varieties implies the importance of the respective challenges farmers are facing.

**Traits considered in selecting a maize variety to grow**

Poor farmers hardly have access to the ideal varieties of maize or of any other crop. More important, therefore, is the investigation of the traits preferred when farmers actually make variety selection for planting. Discussion on the attributes considered in selecting a maize variety to plant indicated once again that, except in Mozambique, yield potential is the most important trait. Angolan farmers mentioned early maturity, number and quality of cobs, drought resistance, and performance under poor rainfall, in order, as traits considered next to yield potential (Figure 8). Different from the hypothetical scenario is farmers' interest in drought tolerance and resilience under erratic rainfall. Malawian farmers emphasized the importance of pest and disease resistance, early maturity, number and quality of cobs, and drought tolerance attributes, in order.

Mozambican farmers' interest in the attributes considered when selecting maize seed for planting shows a considerable difference from that of ideal maize. In selecting maize for planting, early maturity, drought tolerance, and poor performance under poor rainfall come before yield potential. This clearly shows farmers effective demand in the traits related to drought escaping/tolerance and surviving under erratic rain. In Zambia, selection of maize varieties for planting is based on, next to yield potential, early maturity, performance under poor rainfall, pest and disease resistance, and number and quality of cobs. In Zimbabwe, farmers emphasize more on yield potential followed by early maturity, number and quality of cobs, and pest and disease resistance. Apparently, Zambians and Zimbabwean smallholder farmers undermine drought tolerance trait, which they attached higher importance to while characterizing ideal maize variety, in selecting the varieties they actually grow (Figure 8).

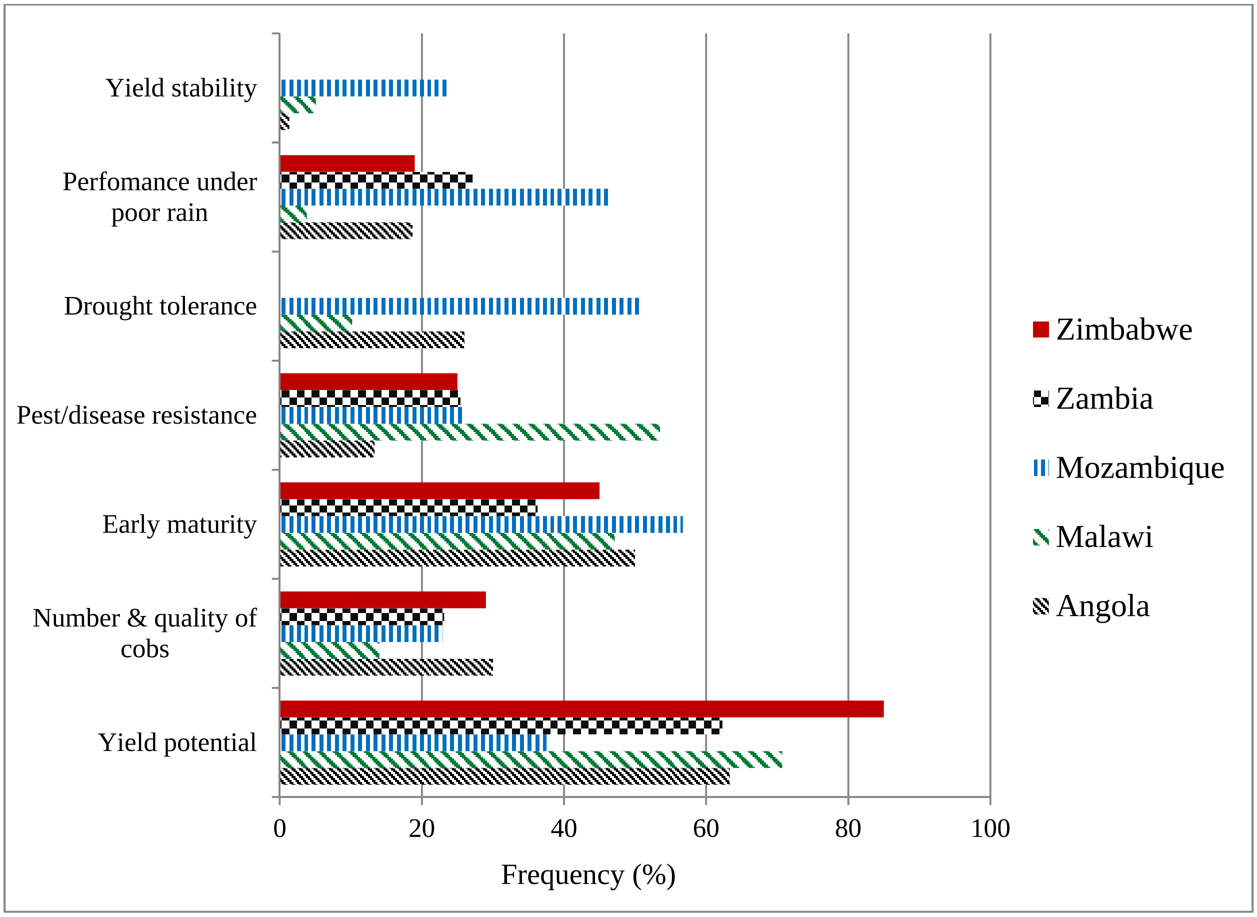



**Figure 8: Relative importance of traits considered in choosing a maize variety to grow.**

# Chapter 7: Determinants of adoption of improved maize varieties

Improved agricultural technologies are one of the two most important options, along with expansion of farm land, farmers have to improve their production and productivity. Given the limited resources farmers in the region have, it is imperative to focus on the technological options to enhance the poor livelihoods. This chapter discusses the different factors that drive the adoption of improved maize varieties in the study countries.

**Angola**

A binary logit model was estimated to identify the determinants of adoption of improved maize varieties in Angola. The gender of household head, participating in field days, demonstration plot visits, and discussions with extension agents about maize, interaction of sex of household head and access to extension services, participation of household members in an off-farm activity, and TV ownership were found to be important factors behind adoption or otherwise of improved maize varieties (Table 31).

**Table 31. Determinants of improved maize adoption in Angola.**

| | Logit estimates | | |
|---|---|---|---|
| **Dependent Variable = adoption of improved maize** | **Coefficients** | **Robust t statistics** | **marginal effect** |
| District (1 = Cacuaco) | -0.57 | -0.5 | -0.007 |
| Female headed household (1 =yes) | -16.70** | 20.26 | -0.136 |
| Attended FD/demo/maize discussions | 2.24* | 2.50 | 0.069 |
| Female headed household* attendance of maize extension | 16.92** | 9.37 | 0.156 |
| Education level of household head | 0.55 | -1.33 | 0.006 |
| No. of illiterate household members | 0.22 | -0.66 | 0.003 |
| Member of the household engaged in off-farm work (1= yes) | -1.93** | 2.58 | -0.035 |
| Faced fund shortage ( 1 = yes) | -0.13 | -0.1 | -0.002 |
| Age household head (years) | -0.03 | -1.31 | 0.000 |
| Farm size (ha) | -0.12 | -0.54 | -0.001 |
| Owns radio (1 =yes) | 0.80 | -1.07 | 0.010 |
| Owns Television (1 =yes) | -1.36+ | -1.700 | -0.013 |
| Has received credit (1 = yes) | 0.57 | -0.54 | 0.008 |
| Member of farmers association | 0.23 | -0.18 | 0.003 |
| Constant | -0.73 | -0.28 | |
| Number of observation | 149 | Wald chi2(14) | 680.090 |
| Log pseudolikelihood | -40.96 | Prob > chi2 | 0.000 |
| Pseudo R2 | 0.343 | | |
| + significant at 10%, * significant at 5%; ** significant at 1%, | | | |

Households headed by female are less likely to adopt improved maize varieties as compared to male headed ones. One important question that might arise is whether this is merely due to the basic fact that female headed households are less endowed and hence less inclined to try out new technologies. Another dimension is the lack of targeted extension services for female headed households. We introduced an interaction term to see whether female headed households with access to extension do have a different likelihood of adoption. The result showed that the interaction does not have any significant marginal effect. This implies that there is no any particular reason why extension services shall be targeted to female headed households as the challenges such households face are more complicated than the possible influence of a targeted extension service. It shall be noted, however, that the interpretation of the interaction terms needs to be done cautiously. The interaction effect calculated following (Norton, Wang, & Ai, 2004) shows the interaction effect to be positive and yet statistically insignificant.

Access to off-farm activities reduces the probability of adopting improved maize varieties by a factor of 3.5%. This is potentially because of two reasons. First, off-farm activities withdraw labor which is required for the resource intensive production of improved maize varieties in the predominantly irrigated crop farming of the sample households. Second, off-farm activities in Angola are rather rewarding and people tend to focus on the off-farm activity and the income generated thereof. Participation in field days, demonstration plots, and maize related discussions with extension staff was found to be positively influencing the likelihood of adopting improved maize varieties. The high marginal effect of attending extension activities implies that the probability of adopting improved maize varieties increases by 7% if farmers get the chance to involve in maize related extension activities. This is crucially important in enhancing adoption of improved maize germplasms in the country. Currently, the level of access to extension is very low.

Television owning was found to be negatively related to the likelihood of adoption of improved maize varieties. This can be due to two reasons: first, television is a luxury item in rural Angola owned by those who are rich enough not to be entirely engaged in maize agriculture. This means they do not need to invest on improved maize varieties as they can focus on cash crops that can immediately serve as sources of cash. Second, television owners may use it more for entertainment than as source of information. In this case, it at least fails to increase the awareness of the farmers about new maize technologies that are available, and hence less adoption.

**Malawi**

*Adoption of improved maize varieties*

The double hurdle model estimated showed that the decision to adopt improved maize in Malawi is influenced by different factors. Variations in district; labor power endowment; access to credit; membership in social groups; participating in field days, demonstration plot visits, and discussions with extension agents about maize; farm size; livestock wealth; and access to off-farm activities were found to determine the decision to adopt or not of improved maize varieties (Table 32).

Households in Mangochi are mainly engaged in fishery and other off-farm income generating activities. Compared to farming households in Balaka, the importance of maize is much lower. This is possibly the reason why farmers in Mangochi are less likely to adopt improved maize varieties than those in Balaka, *ceteris paribus*.

**Table 32. Determinants of improved maize adoption in Malawi.**

| | Coefficients | Robust st. error | p > Z |
|---|---|---|---|
| **Intensity of adoption (proportion of land under improved maize variety)** | | | |
| District (Mangochi = 1) | 0.080 | 0.109 | 0.465 |
| Age of household head | 0.006* | 0.004 | 0.095 |
| Sex of household head (female =1) | -0.257** | 0.118 | 0.029 |
| Labor (man-day equivalent) | 0.055** | 0.022 | 0.012 |
| Access to credit (yes =1) | 0.119 | 0.127 | 0.348 |
| Member to a social group (yes=1) | 0.106 | 0.111 | 0.339 |
| Attended field days (yes=1) | 0.139 | 0.194 | 0.473 |
| Livestock wealth (TLU) | -0.080*** | 0.026 | 0.002 |
| Proportion of hh members in off-farm activities | 0.005*** | 0.001 | 0.001 |
| Uses fertilizer (yes=1)7 | -0.770*** | 0.277 | 0.005 |
| Constant | -0.345 | 0.233 | 0.139 |
| **Adoption of improved maize** | | | |
| District (Mangochi=1) | -0.620** | 0.269 | 0.021 |
| Age of household head | -0.007 | 0.009 | 0.406 |
| Sex of household head (female =1) | -0.065 | 0.357 | 0.855 |
| Average years of education | 0.034 | 0.082 | 0.680 |
| Labor (man-day equivalent) | 0.333** | 0.132 | 0.012 |
| Access to credit (yes =1) | 2.740*** | 0.396 | 0.000 |
| Member to a social group (yes=1) | -1.763*** | 0.492 | 0.000 |
| Access to extension activities (yes =1) | 2.008*** | 0.613 | 0.001 |
| Farm size | 0.384** | 0.170 | 0.024 |
| Livestock wealth (TLU) | 3.172*** | 0.967 | 0.001 |
| Access to off-farm income (yes=1) | 1.408*** | 0.179 | 0.000 |
| Constant | -3.060*** | 0.676 | 0.000 |
| /athrho | 17.086*** | 0.205 | 0.000 |
| /lnsigma | -0.886*** | 0.093 | 0.000 |
| Rho | 1.000*** | 0.000 | |
| Sigma | 0.412** | 0.038 | |
| Lambda | 0.412** | 0.038 | |
| Number of observations | 115 | Uncensored observations | 51 |
| Censored observations | 64 | Log likelihood | -51.726 |
| Wald test of indep. Equations (rho = 0): chi2(1) = 6920.43 Prob > chi2 = 0.0000 | | | |
| Double hurdle model (model with selection and censoring) - correlated errors | | | |

*,**, and *** denote significance at 10, 5 and 1% statistical error level.

Households headed by members of different social groups were also found to be less likely to adopt improved maize varieties compared to non-member household heads. Social groupings, when

[7] In most of Southern African countries fertilizer input is supplied to farmers either for free or with heavy subsidization regardless of the level of access and use of improved maize varieties. Therefore, the assumption in the econometric models estimated in this section is that fertilizer use is exogenous in influencing the likelihood and intensity of adopting improved maize varieties.

serving as medium of agricultural information exchange and informative dialogue, can be expected to positively influence new technology consumption decisions. When they serve as social gatherings for pleasure, they might result in withdrawing labor and time that could be spent in working towards accessing and use of improved technologies. This seems to be the case in the study districts.

The importance of labor endowment of the household in positively influencing adoption decision re-enforces the argument above. The higher the labor endowment of the household, the higher the probability that improved maize is used by the household. This is expected and yet signifies the role each unit of labor plays in increasing the adoption level of improved varieties in these resource constrained communities.

The importance of access to credit cannot be overemphasized as the importance of cash constraint cannot be undermined in the study areas. Accordingly, the model result shows that those who have access to credit are more likely to adopt improved maize than those who do not have access. Access to credit obviously relieves the farming households of the financial constraint they are entangled with and hence enable them afford new technologies.

The public agricultural extension institution (Ministry of Agriculture and Food Security) is the most reliable information source in the study areas. It is through this extension institution that the national input subsidy program is being implemented thereby magnifying the importance of the extension system. Farmers therefore listen to and make use of the technical information they acquire from the institution on different agricultural issues including new maize technologies.

Farm size, livestock wealth, and access to off-farm income are important components of the asset wealth indices of households in the study areas (Kassie et al., 2011; Mangison et al., 2011). Households with more of these assets can generally be considered as endowed with buffer resources and hence less risk-averse in trying new technologies. Specifically, bigger farmland simply means more agriculture implying the capacity to try and use new agricultural technologies more than those who own small farmlands.

Livestock wealth also positively influences the decision to adopt improved maize varieties. The livestock wealth can only be positively influencing adoption as a source of income that can be spent on maize production. Otherwise, the competition between the livestock enterprise and the crop production (or maize production in particular) seems to be even stronger as described in the intensity model below. Access to off-farm activities means more cash income that alleviates one of the most important challenges of the households – cash shortage. This will obviously enable farmers to purchase the different components of the improved maize technologies.

*Intensity of improved maize variety use*

Female headed households are apparently resource constrained and less employable – for instance due to less mobility – as they have to actively and closely take care of the family with the meager resources at their disposal. This clearly limits their ability to invest on new technology, other things being equal. This argument is further substantiated with the fact that households with higher proportion of members engaged in off-farm activities do adopt improved maize more intensively than those with less proportion. This is again related to the additional income that can readily be available to production of improved maize varieties.

The result also shows that as labor endowment of the household increases, intensity of improved maize adoption increases. Therfore, labor has a positive marginal productivity when used in the production of improved maize varieties. This is very important as there is a lot of unemployed labor in rural Malawi and the higher labor demand of improved maize production can directly lessen the pressure on the agricultural labor market.

Those who use fertilizer, allocate less proportion of land for improved maize production. This looks counter-intuitive; however, farmers who apply fertilizer tend to know how important fertilizer is and would not risk increasing the land covered with improved maize whenever fertilizer cost is high and hence shortage. Therefore, farmers who apply fertilizer tend to allocate less land to improved maize than those who are not using fertilizer, *ceteris paribus*, if both of them are adopting.

It was also found out that as livestock wealth increases, intensity of use of improved maize decreases. They might tend to depend more on their livestock than crops such as maize. Households with more livestock might generate more income from livestock on a continuous basis and hence focus less on the relatively more seasonal crop production. Second, there is a competition for grazing and feed production. If the livestock population of a household is high, the land allocated to the livestock enterprise will be higher and less for maize. Third, the limited income has to be allocated among the different enterprises farmers are undertaking. This implies that if there are more animals, there will be more expenditure items, and hence less resources to spend on expanding production of improved maize.

**Mozambique**

Location, age of household head, maize related extension services, and proportion of land allocated to maize were found to be important factors influencing adoption of improved maize varieties (Table 33). Sussundenga District receives significantly less precipitation and higher temperature as compared to Mossurize (Uaiene et al., 2011). This might be among the reasons why farmers in Sussundenga are less likely to adopt improved maize as compared to those in Mossurize.

The likelihood of adopting improved maize varieties declines as age of the household head increases. This is in line with other reported observations that as farmers get older, they tend to be more risk averse and hence less likely to venture into trying new technologies – including improved varieties. In fact, the older generation of rural Mozambique has been through a lot of ups and downs that it hardly managed to accumulate any buffer stock to take any chances against. Accordingly, it is expected that only the younger generation will have the will and the means to try new technologies in the agricultural arena.

**Table 33. Determinants of improved maize adoption in Mozambique.**

| Results of Double hurdle model (model with selection and censoring) | | |
|---|---|---|
| | **Coefficients** | **Robust z statistic** |
| **Intensity of adoption model** | | |
| District (1 = Sussundenga) | -0.1949** | 2.69 |
| Age of household head | -0.0018 | -0.9800 |
| Female headed household (1 =yes) | -0.0883 | -1.4600 |
| Received any credit (1 =yes) | 0.0701 | -0.6300 |
| Member of farmers' association (1 =yes) | 0.0613 | -0.8900 |
| Average education of household (years) | 0.0190** | 2.64 |
| Access to extension services ( 1= yes) | 0.0544 | -1.2200 |
| Proportion of land allocated to maize (%) | 0.0023* | 1.99 |
| Livestock wealth (TLU) | 0.0011 | -0.2600 |
| Proportion of household members in off-farm activities | 0.0023+ | -1.73 |
| Uses fertilizer (1 = yes) | -0.2659** | 2.94 |
| Constant | 0.2624* | 2.11 |
| **Adoption Model** | | |
| District (1 = Sussundenga) | -0.8958** | 5.01 |
| Age of household head | -0.0118+ | -1.92 |
| Female headed household (1 =yes) | -0.1798 | -0.8500 |
| Household head has completed primary school | 0.1194 | -0.8400 |
| Household head has completed secondary school | 0.1435 | -0.6500 |
| Member of farmers' association (1 =yes) | 0.2075 | -0.8900 |
| Any maize related extension service (1=yes) | 0.3254+ | -1.93 |
| Proportion of land allocated to maize (%) | 0.0273** | 6.68 |
| Proportion of household members in off-farm activities | 0.0045 | -1.0200 |
| Received any credit (1 = yes) | -0.4997 | -1.2300 |
| Owns radio (1=yes) | -0.0117 | -0.0900 |
| Constant | -0.7394+ | -1.90 |
| /athrho | 1.9507** | 5.14 |
| /lnsigma | -1.2280** | 12.23 |
| rho | 0.9604 | |
| sigma | 0.2929 | |
| lambda | 0.2813 | |
| Number of observations | 325 | |
| Censored observations | 186 | |
| Uncensored observations | 139 | |
| Log likelihood = -136.4141 | | |
| Wald test of indep. eqns. (rho = 0): chi2(1) = 26.38, Prob > chi2 = 0.0000 | | |

+,*, and ** denote significance at 10, 5 and 1% statistical error level.

Expectedly, involvement of farmers in maize technology related demonstrations, field days and focused discussion with extension officers increases the likelihood of adoption of improved maize varieties. Similarly, the higher the proportion of household members engaged in off-farm income generating activities, the higher the likelihood of adoption of improved maize varieties. This association is likely due to the additional purchasing power generated from the income acquired from the off-farm activities. Given the lack of alternative sources for rural finance, the role off-farm employment plays in enhancing the propensity to adopt farm technologies is very high.

Increase in the proportion of land allocated to maize increases the likelihood of adoption of improved maize variety. Land is the most important input for the farming communities and the proportion of land allocated to any crop is an important indicator of the significance of the enterprise at household level. Accordingly, the proportion of land allocated to maize shows how important maize is for the household and concomitantly the willingness to allocate resources to it.

The extent or intensity of adoption of improved maize varieties in these two rural districts of Mozambique was found to be influenced by location, average literacy level of the household, proportion of land allocated to maize, and fertilizer use. Location (1= Sussundenga) is related negatively to intensity of adoption, whereas proportion of land allocated to maize and proportion of household members in off-farm activities affect intensity of adoption positively. The nature and pattern of their influence shall be similar to their relationship to the adoption decision.

Average education level of the household members was also found to be positively related to intensity of adoption of improved maize. The role education plays in increasing access and consumption of information is obvious. Higher education enables the rural households to identify the different options they have to address the different challenges they are facing. Low farm productivity characterizes farming communities in rural Mozambique (Uaiene et al., 2011) and it is expected that families with higher education level tend to use more high yielding technologies.

On the other hand, households that use fertilizer tend to grow less improved maize varieties as compared to non-fertilizer users. Fertilizer is an expensive input as compared to seed and farmers who are using fertilizer might have already realized the importance of growing maize with fertilizer. This again might lead to the rational decision of growing less maize with fertilizer than growing a lot of maize without any fertilizer. In fact, farmers could be tempted to grow maize without fertilizer on new lands that are being continuously available since the end of the civil war.

**Zambia**

The regression model with selection and censoring estimated for Zambian data revealed that both initial adoption and intensity of adoption decision are positively influenced by Monze location, proportion of farmland under irrigation, and membership in farmers' association. On the other hand, age of the household head was found to be negatively related to both decisions. Average education level of the household members was also found to influence initial maize technology adoption decision positively. Proportion of land allocated to maize was found to be negatively related to the extent of adoption of improved maize varieties (Table 34).

**Table 34. Determinants of improved maize adoption in Zambia.**

| Double hurdle model (model with selection and censoring) | | |
|---|---|---|
| | **Coefficients** | **Robust z statistics** |
| **Intensity of adoption** | | |
| District (1 = Monze) | 0.1468** | 5.34 |
| Female headed household (1 =yes) | 0.016 | -0.39 |
| Age of household head | -0.0016+ | -1.70 |
| Household head has completed primary school | -0.0097 | -0.21 |
| Household head has completed secondary school | 0.0567 | -1.13 |
| Access to extension services ( 1= yes) | 0.0256 | -0.86 |
| Proportion of land allocated to maize (%) | -0.0015** | 3.07 |
| Proportion of household members in off-farm activities | 0.0001 | -0.14 |
| Received fertilizer credit (1=yes) | -0.1632 | -1.27 |
| Proportion of  farmland irrigated | 0.0024** | 3.09 |
| Member of farmers' association (1 =yes) | 0.0619* | 2.26 |
| Constant | 0.8548** | 10.59 |
| **Adoption model** | | |
| District (1 = Monze) | 0.3278+ | -1.76 |
| Age of household head | -0.0131* | 2.06 |
| Female headed household (1 =yes) | -0.1724 | -0.77 |
| Average education of household (years) | 0.1570** | 3.21 |
| Man equivalent of the household | -0.0046 | -0.09 |
| Received any credit (1 = yes) | 0.0918 | -0.36 |
| Access to extension services ( 1= yes) | -0.2327 | -1.19 |
| Farm size (ha) | 0.034 | -1.40 |
| Proportion of household members in off-farm activities | 0.0051 | -1.08 |
| Proportion of  farmland irrigated | 1.0780** | 13.02 |
| Member of farmers' association (1 =yes) | 0.3633* | 2.00 |
| Owns radio (1 = yes) | 0.1058 | -0.53 |
| Constant | 0.3064 | -0.71 |
| /athrho | 0.1023 | -0.65 |
| /lnsigma | -1.5891** | 32.22 |
| rho | 0.102 | |
| sigma | 0.2041 | |
| lambda | 0.0208 | |
| Observations | 342 | |
| Number of obs | 342 | |
| Censored obs | 56 | |
| Uncensored obs | 286 | |

+ significant at 10%, * significant at 5%; ** significant at 1%

Monze District has areas which are very ideal for maize production (Kalinda et al., 2011) and hence farmers would be expected to have higher likelihood of adopting and using more of improved maize technologies compared to farmers in Kalomo District. Similarly, as proportion of farmland under irrigation increases, the likelihood and intensity of adopting improved maize technologies increases. Through increasing their cropping intensity and their returns, irrigation makes farmers resourceful and able to adopt and adopt with higher intensity improved maize technologies.

Age of household heads was found to be negatively related to the likelihood and intensity of improved maize varieties. Although age can indicate experience in farming, it might as well indicate risk aversion and reluctance to try out new technologies. Young farmers who are relatively more educated are more risk taking given they have the resources. The negative relationship between adoption probability and intensity is therefore expected and in line with published literature.

Farmers' associations and groupings also play an important role as sources of information and as sources of peer pressure influencing the decision farmers make. In this case, membership in a farmers' association was expected to influence both adoption and intensity of use of improved maize varieties. Farmers share the information through different gatherings and this enables them to synthesize and use empirically tested knowledge to make decisions related to the different enterprises and technologies. The importance of discussion among themselves to share information has been found to be more important than access to formal extension services and radio. This is an important finding that in these rural communities of Zambia, information can effectively transmitted by farmers than anything else.

Average literacy level within the household was found to be positively influencing the likelihood of adoption of improved maize technology. Education increases the capacity to generate and synthesize information that includes identification and selection of improved maize technologies. Therefore, households with higher literacy level are expected to have more sources of information and higher capability to use the information and hence higher adoption of improved maize technologies.
When looking at the intensity of improved maize adoption, increase in the proportion of land allocated to maize negatively influences the extent of use of improved maize varieties. This can be for two reasons: first, farmers could allocate smaller plots of land if they grow improved maize varieties and still harvest as much yield. Second, improved maize varieties are more demanding of inputs and hence farmers tend to reduce the land they allocate to maize when using improved maize varieties.

**Zimbabwe**

The tobit model estimated to analyze factors that explain the intensity of improved maize variety adoption in rural Zimbabwe showed that membership in farmers' associations, proportion of land allocated and education level of the household head to be very important factors explaining the extent to which farming households use improved maize varieties (Table 35).

Household heads that have literacy level of secondary and primary education, in order, have a much higher intensity of improved maize adoption compared to illiterate household heads. Moving from illiteracy to primary education increases the intensity of use of improved maize varieties by 0.34 units and a move from illiteracy to secondary education increases the intensity by 0.374 units. The probability of more intensive adoption is highest for household heads moving from illiteracy to secondary school.

Membership in farmers' associations also positively influences the intensity of use of improved varieties in rural Zimbabwe. Its marginal effect is very high second only to the education level of education of the household head. The importance of membership in social groups to exchange information is obvious in rural areas where reliable sources of information are scarce at best.

Increase in proportion of land allocated to maize also increases the intensity of improved maize variety use. Farmers in Zimbabwe are well aware of the importance of improved maize varieties and those who can afford to allocate more land to maize tend to use more improved varieties.

**Table 35. Determinants of intensity of improved maize adoption in Zimbabwe.**

| | | | Marginal effects | | |
|---|---|---|---|---|---|
| | Tobit coefficients | t | Unconditional expected value | Conditional on being uncensored | Probability uncensored |
| District (1 = Bikita) | -0.038 | -0.77 | -0.036 | -0.030 | -0.022 |
| Female headed household (1 =yes) | 0.033 | 0.51 | 0.031 | 0.026 | 0.019 |
| Household size | -0.014 | -1.20 | -0.013 | -0.011 | -0.008 |
| Member of farmers' association (1 =yes) | 0.158** | 2.72 | 0.147 | 0.122 | 0.089 |
| Any maize related extension service (1=yes) | -0.049 | -0.74 | -0.046 | -0.038 | -0.027 |
| Proportion of farmland irrigated | 0.006 | 0.67 | 0.005 | 0.004 | 0.003 |
| Proportion of land allocated to maize (%) | 0.004** | 3.26 | 0.003 | 0.003 | 0.002 |
| Livestock wealth (TLU) | -0.024 | -1.56 | -0.022 | -0.019 | -0.013 |
| Proportion of household members in off-farm activities | -0.001 | -0.58 | -0.001 | -0.001 | 0.000 |
| Household head has completed primary school | 0.364* | 2.01 | 0.340 | 0.283 | 0.205 |
| Household head has completed secondary school | 0.400* | 2.23 | 0.374 | 0.311 | 0.225 |
| Fertilizer used per cropped area | 0.000 | 0.93 | 0.000 | 0.000 | 0.000 |
| Constant | 0.452* | 2.24 | | | |
| /sigma | 0.224** | 12.84 | | | |
| N = 92 | | | | | |
| Log pseudolikelihood | -0.045 | | F( 13, 79) | 0.88 | |
| Pseudo R2 | 0.998 | | Prob > F | 0.573 | |
| * significant at 5%; ** significant at 1% | | | | | |

# Chapter 8: Conclusions and implications

The household level surveys in all countries showed the importance of maize in the livelihoods of farming communities in the region. Apart from justifying CIMMYT's focus on maize that has already been proved to be immensely useful in eradicating poverty (Alene et al., 2009; LaRovere et al., 2010), the studies detailed the characteristics of the sample populations, the perceived importance of maize, mechanisms of variety choice, perceived importance of drought and other risks (Kassie et al., 2011), the access to agricultural extension services, variety trait preferences, and perceived trends of production and profitability of land races and improved maize varieties.

Specific results of the study showed that majority of the sample population are below the age of 16. This is an important piece of fact that shall be reckoned in designing interventions in the agricultural sectors of the countries. The possibly better access to social services and information technology along with the possibly less access they might have to land - by far the most important resource in the rural communities - would have a bearing on the structure of agriculture and hence the mode of communication that research and extension should employ.

The average livestock wealth was found to be higher in Zambia and Zimbabwe. This is in line with the trends being seen in the region and, therefore, efforts aimed at enhancing maize production and productivity need to consider this growing importance of livestock in these countries in particular and in the region in general.

Most of the farmers generate their income from agriculture – particularly crop farming – and yet their most important expenditure item is food. This highlights the potential role of enhancement of maize production and productivity, as the most important staple food crop. The challenge of drought added to this, DTMA/CIMMYT can easily be argued to be the most relevant intervention which needs to continue its focus on improving maize productivity in highly vulnerable farming systems.

Farmers have already been growing different maize varieties of both land races and improved types. The diversity in the genetic materials - particularly the land races - at farmers' disposal can be an important resource for further scientific research.  Zambian and Zimbabwean farmers are on average more acquainted with improved OPVs and hybrids and know more maize varieties compared to an average farmer in Angola, Malawi and Mozambique. This distinction is an important attribute that needs to be considered in packaging information and production technology recommendations. It was also observed that most of the farmers in Angola, Malawi and Mozambique are still growing local maize varieties. This seems to be happening for two reasons. First, farmers do not have access to the information about the alternative technologies and second the technologies seem to be unavailable for most of the farmers.

Assessment of the perceived risk (variability) embedded in maize technologies showed that improved maize technologies – both OPVs and hybrids – are generally considered riskier than local varieties. The yield and price variability that improved OPVs and hybrid varieties show seems to have increased the uncertainty farmers make decisions on increasing the likelihood of downside risk they might experience. Stability of yield of the improved maize technologies and accompanying maize technologies with timely and adequate market information system can transform the framework within which farmers make decision of enterprise choice.

Public agricultural extension institutions and public mass media are by far the two most important sources of agricultural information in the region. Despite the political importance of agriculture in general and maize in particular, there is always a lack of incentive in publicly owned institutions to deliver the information as timely and as adequately it is needed. This is a challenge that might remain for a while and yet capacity building and transformational interventions can increase the efficiency and effectiveness with which agricultural information is made available to the farming community. Households' radio ownership was found to be quite high in the region. Radio can therefore be an important outlet for information on the drought tolerant maize varieties of DTMA/CIMMYT and other technologies. Agricultural extension efforts in the region should in fact be accompanied by comprehensive microfinance institutions to relieve farmers of the seasonal cash shortage which almost all of them experience every year. So far, except in Zimbabwe, access to rural credit and finance seems to be farfetched.

The decisions regarding level and intensity of improved maize have also been investigated to show that gender based intra-household division of labor was found to be an important factor considered in deciding to adopt or not improved maize varieties. Asset endowments such as farm size and livestock wealth were found to be important determinants of level and intensity of adoption in the region. Similarly, membership in social groupings and engagement of off-farm activities influenced adoption decisions.

Access to extension services has universally been identified as an important factor in determining the level and, when relevant, the intensity of adoption of improved maize varieties in the region. As important as this service is, however, the extent to which farmers are getting the service is not that encouraging according to respondents. It is therefore imperative to underline again the need for investment in the agricultural extension system and the effort that shall be exerted in enabling the private sector to engage in generation and deployment of agricultural information.

Generally however, the adoption studies strongly imply the need to develop a context-based and community specific approach in dealing with adoption and use of improved maize technologies as factors that influence such decisions in a given context can hardly be extrapolated with a similar rigor to other circumstances.

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# Appendices

## Appendix 1. Quantile regression used in the report

**Analytical framework**
Our dependent variables were generated through dividing the total reported income (Y) and total reported expenditure (ϕ) per adult equivalent by the poverty line ($z_i$) and then taking the natural logarithm of the values {i.e., $\ln(y_i/z_i)$ and $\ln(\phi_i/z_i)$}. We refer to ln of per adult equivalent income divided by poverty line as welfare measure 1 (WM1) and to ln of per adult equivalent expenditure divided by poverty line as welfare measure 2 (WM2).

The regression diagnostics we conducted showed that multicollinearity was not at all a problem in all cases whereas heteroscedasticity was found to be a problem in Mozambique and Zambia model formulations.

According to Haughton and Khandker (2009), a typical multiple regression equation as applied to poverty analysis would look like $\ln\left(\frac{y_i}{z_i}\right) = x_i'\beta_i$ where $z_i$ is the poverty line and, $y_i$ is the per capita income or expenditure, the $x_i$ are the explanatory variables and the β are the coefficients to be estimated. Such formulation, however, has two problems in this particular context. First, it only summarizes the average relationship between the wellbeing measure and the set of explanatory variables, based on the conditional mean function $E(\ln\left(\frac{y_i}{z_i}\right) | \boldsymbol{x})$. Second, when the random terms are heteroscedastic, the parameter estimates will be inefficient despite remaining unbiased. For a more complete formulation that provides information about the relationship between the outcome $\ln\left(\frac{y_i}{z_i}\right)$ and the regressors (x) at different points in the conditional distribution of y with inbuilt corrections for heteroscedasticity is therefore required.

Quantile regression (QR) is recommended under such circumstances (Cameron & Trivedi, 2005, 2009). Median regression is a special case of QR and it is more robust to outliers than is mean regression. QR permits us to study the impact of regressors on both the location and scale parameters of the model, thereby allowing a richer understanding of the data. And the approach is semiparametric in the sense that it avoids assumptions about parametric distribution of regression errors. These features make QR especially suitable for heteroscedastic data (Cameron & Trivedi, 2005).

The quantile q, $q \in (0, 1)$, is defined as that value of y that splits the data into the proportion q below and 1-q above, i.e., $F(y_q) = q$ and $y_q = F^{-1}(q)$. This concept extends to the conditional quantile regression. The conditional quantiles denoted by $Q_y(q|X)$ are the inverse of the conditional cumulative distribution function of the response variable, $Fy^{-1}(q|X)$, where $q \in [0, 1]$ denotes the quantiles (Cade, Terrell, & Schroeder, 1999; Koenker & Machado, 1999). Here we consider

functions of $X$ that are linear in the parameters; eg $Q_y(\mathrm{q}|\mathrm{X}) = \beta_0(\mathrm{q})X_0 + \beta_1(\mathrm{q})X_1 + \beta_2(\mathrm{q})X_2 + , ... , + \beta p(\mathrm{q})Xp$, where the (q) notation indicates that the parameters are for a specified q quantile. The parameters vary with q due to effects of the q$^{th}$ quantile of the unknown error distribution ε.
The computational implementation of the QR is different from OLS and Maximum likelihood as its optimization uses Linear programming methods.

The q$^{th}$ QR estimator $\hat{\beta}_q$ minimizes over $\beta_q$ the objective function

$$Q(\beta_q) = \sum_{i:y \geq x_i'\beta}^{N} q|y_i - \boldsymbol{x}_i'\boldsymbol{\beta}_q| + \sum_{i:y<x_i'\beta}^{N}(1-q)|y_i - \boldsymbol{x}_i'\boldsymbol{\beta}_q| \qquad (1)$$

where $0 < q < 1$, and $\beta_q$ used instead of β to underline the fact that different choices of q estimate different values of β. Apparently, when q > 0.5, higher weight is attached to the positive errors of prediction and when q < 0.5, higher weight is attached to the negative errors of model prediction. Often, estimation sets q = 0.5 (median), giving the least absolute-deviations estimator that minimizes $\sum|y_i - \boldsymbol{x}_i'\boldsymbol{\beta}_{0.5}|$.

The objective function (1) is not differentiable, and hence the usual gradient optimization methods cannot be applied. The classic solution is the simplex method of linear programming that is guaranteed to yield a solution in a finite number of simplex iterations.
The estimating equations in (1) are solved by a modification of the Barrodale and Roberts (1974) simplex linear program for any specified value of q (Koenker & d'Orey, 1987). With little additional computation, then entire regression quantile function for all distinct values of q can be estimated (Koenker & d'Orey, 1987; Koenker, Ng, & Portnoy, 1994). The estimator that minimizes $Q(\beta_q)$ is an m estimator with well-established asymptotic properties (Cameron & Trivedi, 2005). The QR estimator is asymptotically normal under general conditions and it can be shown that:

$$\widehat{\boldsymbol{\beta}}_q \; a \backsim \; N(\boldsymbol{\beta}_q, \boldsymbol{A}^{-1}\boldsymbol{B}\boldsymbol{A}^{-1}) \qquad (2)$$

where $\boldsymbol{A} = \sum_i q(1-q)x_i x_i'$, $\mathbf{B} = \sum_i f_{u_q}(0|\, x_i)x_i x_i'$, and $f_{u_q}(0|x_i)$ is the conditional density of the error term $u_q = y_i - \boldsymbol{x}_i'\boldsymbol{\beta}_q$ evaluated at $u_q = 0$.

Parameter estimates in linear quantile regression models have the same interpretation as those in any other linear model. They are rates of change conditional on adjusting for the effects of the other variables in the model, but now are defined for some specified quantile. The marginal effects for the J$^{th}$ (continuous) regressor after QR can be given as

$$\frac{\delta Q_q(y|\boldsymbol{x})}{\delta x_j} = \beta_{qj} \qquad (3)$$

Regression quantiles, like the usual 1-sample quantiles with no predictor variables, retain their statistical properties under any linear or nonlinear monotonic transformation of $y$ as a consequence of this ordering property; that is, they are equivariant under monotonic transformation of *y* (Koenker & Machado, 1999) Thus it is possible to use a nonlinear transformation (eg logarithmic) of *y* to estimate linear regression quantiles and then back transform the estimates to the original scale (a nonlinear function) without any loss of information. Our dependent variable is ln $(y_i/Z_i)$, therefore in order to compute the marginal effects (ME) for the $y_i/z_i$ the equivariance property of QR is important. Following Cameron and Trivedi (2005), given, $Q_q(ln\ y|x) = x'\beta_q$, we have $Q_q(y|x) = \exp\{Q_q(ln\ y|x)\} = \exp(x'\beta_q)$. The ME on y in levels, given QR model $x'\beta_q$ in logs, is then

$$\frac{\delta Q_q(y|x)}{\delta x_j} = \exp(x'\beta_q)\beta_{qj} \qquad (4)$$

## Appendix 2. Non-parametric tests

One of the important questions asked in the paper is whether drought is equally important in the livelihood systems of the study countries. We compared the subjective rankings of drought as a constraint to livelihoods in Angola, Malawi, Mozambique and Zambia. Zimbabwe was dropped for lack of observations. As the countries are four, the samples independent and the measurement ordinal, we employed Kruskal-Wallis test. Kruskal-Wallis test is a non-parametric test used with *k*. independent groups, where *k* is equal to or greater than 3, and measurement is at least ordinal. The null hypothesis is that the *k* samples come from the same population, or from populations with identical medians. The alternative hypothesis states that not all population medians are equal (Siegel & Castellan, 1988).

The test statistic is computed as

$$H=\left[\frac{12}{N(N+1)}\sum_{i=1}^{k}\frac{R_i^2}{n_i}\right]-3(N+1) \qquad (1)$$

where $k$ = the number of countries; $n_i$ = the number of observations in sample '$i$'; $N$ = total number of observations; $R_i$ = the sum of the ranks in the $i^{th}$ sample

Another important question in this study is whether the frequency of drought related shocks or simply drought risk experience measured in terms of number of crop failures experienced over the last ten years is comparable across countries. This test was done using Games-Howell test as the sample sizes differ and the countries are more than two. More importantly, the sample populations were found to be generated from populations of different variance using Leven's homogeneity of variance test. Leven's statistic was computed to be 18.008 and was found to be highly significant ($p < 0.001$).

Games-Howell multiple mean comparison test is a pair wise comparison test based on the Studentized range test. This test can be applied in situations where the variances are unequal.

$$v=\frac{(s_i^2/n_i+s_j^2/n_j)^2}{s_i^4/n_i^2v_i+s_j^4/n_j^2v_j} \qquad (2)$$

Where $n_i$ is the number of observations at level $i$; $s_i$ is standard deviation of level $i$; and $v_i$ is degrees of freedom for level $i$, $n_i - 1$. Two means are significantly different if

$$\left|\bar{x}_i-\bar{x}_j\right| \geq Q_{i,j}^{*}R_{\varepsilon,r,v} \qquad (3)$$

where $\bar{x}_i$ is mean at level $i$,

$$Q_{i,j}^{*}=\sqrt{\frac{s_i^2}{n_i}+\frac{s_j^2}{n_j}} \qquad (4)$$

and $R_{\varepsilon,r,v}$ is given as

$$R_{\varepsilon,r,v}=s_{\varepsilon,k,v}/\sqrt{2} \qquad (5)$$

## Appendix 3. The Logit model

*Estimated to analyze determinants of adoption of improved maize variety in Angola*

The logit model is based on the plausible assumption that each decision maker selects adoption or non-adoption decision only if it maximizes its perceived utility. Utility is, however, latent and only the decision variable (adopting or not adopting) is observed. The decision of the respondent "y" takes on one of two values, 0 (not-adopting) or 1 (adopting). The probability that the respondent decides to adopt improved maize varieties can be formulated as

$$\Pr ob(\boldsymbol{Y_i} = 1) = \boldsymbol{F}(\boldsymbol{X_i \beta}) \tag{1}$$

where $X_i$ is a vector of explanatory variables and β is a conformable vector of coefficients to be estimated. By choosing F to be a logistic distribution, the probability can be estimated using the logit formulation as

$$\Pr ob(Y_i = 1) = \Lambda(X_i \beta) = \frac{\exp(X_i \beta)}{1 + \exp(X_i \beta)} \tag{2}$$

An easier way of interpreting the estimated coefficients is considering the partial derivatives of the probability that $Y_i$ equals one with respect to a continuous variable or with respect to a change from the reference level to another of a discrete variable ($X_k$). The partial derivatives give the marginal effects and are formulated as

$$\frac{\partial E(Y_i = 1)}{\partial X_k} = \frac{\exp(X_i \beta)}{(1 + \exp(X_i \beta))^2} . \beta_k \tag{3}$$

The estimation of the logit model is done with the maximum likelihood (ML) approach. The general log likelihood function is specified as

$$\log \boldsymbol{L}(\boldsymbol{\beta}) = \sum_{i=1}^{N} \boldsymbol{Y_i} \log \boldsymbol{F}(\boldsymbol{X}_i' \boldsymbol{\beta}) + \sum_{i=1}^{N} (1 - \boldsymbol{Y_i}) \log(1 - \boldsymbol{F}(\boldsymbol{X}_i' \boldsymbol{\beta})) \tag{4}$$

The first order condition of the ML function is generated by differentiating the above equation with respect to β, which gives

$$\frac{\partial \log \boldsymbol{L}(\boldsymbol{\beta})}{\partial \boldsymbol{\beta}} = \sum_{i=1}^{N} \left[ \frac{\boldsymbol{Y_i} - \boldsymbol{F}(\boldsymbol{X}_i' \boldsymbol{\beta})}{\boldsymbol{F}(\boldsymbol{X}_i' \boldsymbol{\beta})(1 - \boldsymbol{F}(\boldsymbol{X}_i' \boldsymbol{\beta}))} \boldsymbol{f}(\boldsymbol{X}_i' \boldsymbol{\beta}) \right] \boldsymbol{X_i} = 0 \tag{5}$$

Where f is equal to F', denoting the density function. For the logistic function the above equation is simplified as

$$\frac{\partial \log \boldsymbol{L}(\boldsymbol{\beta})}{\partial \boldsymbol{\beta}} = \sum_{i=1}^{N} \left[ \boldsymbol{Y_i} - \frac{\exp(\boldsymbol{X}_i' \boldsymbol{\beta})}{1 + \exp(\boldsymbol{X}_i' \boldsymbol{\beta})} \right] \boldsymbol{X_i} = 0 \tag{6}$$

The solution for this equation is the maximum likelihood estimator $\hat{\boldsymbol{\beta}}$. This estimator can be used to estimate the probability that $Y_i$= 1 for a given $X_i$ as

$$\hat{\boldsymbol{P}}_i = \frac{\exp(\boldsymbol{X}_i' \hat{\boldsymbol{\beta}})}{1 + \exp(\boldsymbol{X}_i' \hat{\boldsymbol{\beta}})} \tag{7}$$

## Appendix 4. Tobit model

Almost all households in Zimbabwe do grow improved maize varieties. Therefore, the interest is in the intensity of use of improved maize varieties. We measure the intensity of adoption with the proportion of farm area allocated to improved maize varieties by each of the households. In this particular case, our formulation presumes that adopters will have greater than zero proportion of their land covered with improved maize. There are in fact few households who allocated no land to maize in the year of the survey. This results in observations with fully observed explanatory variables (x) and unobserved dependent variables (y). The implication is that our latent dependent variable (y*) – which denotes interest in improved maize varieties - is not observed until the interest in the varieties exceeds some known constant threshold (L) is passed; i.e., we observe y* only when y* > L.

Formulation of these data with ordinary least square will not generate any consistent information as the regression with zero values can hardly give results that can be inferred to the population. Therefore, tobit model censored only from the left side (L=0) is employed in this study.

Our model is specified as an unobserved latent variable, y*,

$$y_i^* = x_i^{'}\beta + \varepsilon_i, \; i = 1, \ldots, N. \qquad (1)$$

where $\varepsilon_i \sim N(0, \delta^2)$. $y^*$ is a latent variable that is observed for values greater than $L$ and censored otherwise, whereas $x_i$ denotes (K x 1) vector of exogenous and fully observed regressors.

The observed y is defined by the following measurement equation

$$y = \begin{cases} y^* \text{ if } y^* > L \\ L \text{ if } y^* \leq L \end{cases} \qquad (2)$$

In our case, L=0 as the proportion of land allocated to improved maize is censored at 0. Thus, we have

$$y = \begin{cases} y^* \text{ if } y^* > 0 \\ 0 \text{ if } y^* \leq 0 \end{cases} \qquad (3)$$

With the assumption of homoskedastic and normally distributed error term and L=0 the likelihood function for the tobit model can be given as

$$L = \prod_i^N \left[ \frac{1}{\sigma} \phi\left( \frac{y_i - X_i\beta}{\sigma} \right) \right]^{d_i} \left[ 1 - \Phi\left( \frac{X_i\beta}{\sigma} \right) \right]^{1-d_i} \qquad (4)$$

Where $\phi(.)$ is the standard normal density, $\Phi(.)$ is the standard normal cumulative distribution function, $X_i\beta$ is the expected value of the observed dependent value for the non-censored observations, and $d_i$ is a dummy (i = 0, 1) indicator of censoring of an observation.

## Appendix 5. Double Hurdle Model

The double-hurdle model is due to (Cragg, 1971) and is a parametric generalization of the Tobit model whereby two sequential decisions are assumed to follow two separate stochastic processes. In our case, the two decisions are the decision to adopt and the decision on the intensity of adoption. The first decision variable (D) takes the value 1 for farmers who have grown improved maize variety and takes the value zero otherwise. The expected utility of adopting a technology ($D_i^*$) is latent, however. Therefore, the first decision (adoption hurdle) of the households is formulated as

$$D_i^* = z_i'\alpha + \varepsilon_i$$
$$D = \begin{cases} 1 \text{ if } D^* > 0 \\ 0 \text{ otherwise} \end{cases} \quad (1)$$

Not all improved maize adopters do grow improved maize at the same level of intensity. Intensity of adoption is measured in terms of the proportion of farm area allocated to improved maize varieties. The intensity of adoption (intensity hurdle) of improved maize varieties is given as in a tobit like function:

$$y_i^* = x_i'\beta + \upsilon_i$$
$$y^{**} = \begin{cases} y^{**} \text{ if } y^* > 0 \\ 0 \ \text{ otherwise} \end{cases} \quad (2)$$

The observed value of the proportion of land allocated to improved maize is therefore given by:

$$y_i = D_i y_i^* \quad (3)$$

Models of both decisions (hurdles) are assumed to be linear in parameters and the random terms are assumed to be independently and normally distributed:

$$\begin{pmatrix} \varepsilon_i \\ \upsilon_i \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & 0 \\ 0 & \sigma^2 \end{pmatrix}\right] \quad (4)$$

The matrices x and z are overlapping sets of explanatory variables for the two decisions. The double-hurdle model is estimated with the maximum likelihood procedure that maximizes the log of the following likelihood function:

$$L = \prod_0 \left(1 - \Phi\left(\frac{x_i\beta}{\sigma_{\varepsilon_1}}\right).1 - \Phi(z_i\alpha)\right) \prod_+ \left(\Phi(z_i\alpha)\frac{1}{\sigma_{\varepsilon_1}}\phi\left(\frac{y_i - x_i\beta}{\sigma_{\varepsilon_1}}\right)\right) \quad (5)$$

where $\Phi(.)$ is the standard normal cumulative density function and $\phi(.)$ is the standard normal probability density function. The two processes are non-separable and thus both parts of the likelihood function must be maximized simultaneously.

Given the cross sectional nature of our data and hence the possibility of conditional heteroscedasticity, we estimated the double hurdle model with robust option to generate the Huber-White-Sandwich standard errors (Cameron & Trivedi, 2009).