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DROUGHT RISK AND MAIZE PRODUCTION IN SOUTHERN AFRICA

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ABSTRACT

This paper discusses drought risk perception and management in five southern African countries. A sample of 1108 households was randomly drawn with different sample sizes across countries. Data generated were analyzed using descriptive statistics and non-parametric statistical models. Drought was reported to be the most important livelihood challenge 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 open pollinated and hybrid varieties in particular are being considered very risky in terms of predictability and reliability of yield levels. Given the importance of maize and the vulnerability of the farming communities in the region, this implies that drought and risks associated to it will have paramount and potentially irreversible consequences in the poor sections of the region. 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 drought tolerance, early maturity, and good performance under poor rainfall traits of maize implying to the need for targeted breeding schemes.

Keywords: Drought risk, Games-howell, Kruskal-wallis, Southern Africa, Trait preference.

JEL Classification: Q12, Q15, Q24, Q25, Q56

1. INTRODUCTION

The most important downside risk farmers in sub-Saharan Africa (SSA) face is production risk that is manifested through unpredictably variable agricultural yield. This risk is enormously enhanced in SSA due to the uncertainty surrounding the frequency, temporal and spatial distribution, and intensity of drought. Drought is generally defined as a normal part of climate for virtually every country. It is a slow-onset, creeping phenomenon with serious economic, environmental, and social impacts. It affects more people than any other natural hazard (Glantz and 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.

Across large areas of SSA, drought is a widespread phenomenon, with an estimated 22% of mid-altitude/subtropical and 25% of lowland tropical maize growing regions affected annually due to inadequate water supply during the growing season (Heisey and Edmeades, 1999). Climate change is likely to lead to increased temperature by an average of 2.1 °C in SSA and water scarcity, particularly in southern Africa, in the coming decades (Hendrix and Glaser, 2007; Lobell *et al.*, 2011). The immediate and in fact the profound impacts of drought risk in southern Africa are manifested through the low and declining performance of the agricultural sector in general and that of maize production in particular. Maize and its production define livelihoods of millions of people in southern Africa, part serving as the most important source of calorie for the poor (Lobell *et al.*, 2008). In all of the study countries; i.e., Angola, Malawi, Mozambique, Zambia and Zimbabwe, maize stands out as the primary crop both in terms of acreage and absolute yield levels. Maize production in SSA 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 (Kassie *et al.*, 2012).

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. The risk associated with drought is defined by a region’s exposure to the natural hazard and society’s vulnerability to it. Climate is a dynamic natural force, and hence exposure to drought varies over time. 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 (Wilhite *et al.*, 2000; ISDR., 2003; World Bank, 2006). Risk management is entrenched in the regular farm management activities of farmers manifested through selection of enterprises and allocation of their meager resources (Kassie *et al.*, 2012). The way farmers choose their enterprises and allocate their resources explain the intricacies of risk perception and risk efficient farm management smallholder farmers are dealing with. When faced with sources of negative risk, farmers tend to reduce the resources allocated to important enterprises undermining the sustenance of livelihoods.

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 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 *et al.* (2004) classified risk management strategies into two as 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), the 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.

Yield losses are quite high in tropical countries that rely on a relatively unpredictable rainy season for crop growth.

Past experience has demonstrated that the use of new varieties alongside improved management options can offset yield losses by up to 40% (Thornton *et al.*, 2009). Specifically, drought and heat tolerant crops will play an increasingly important part in adapting to this variation and to the long term underlying trend towards a hotter and probably drier production environment. So goes the argument that given the lack of water and its cardinal role in crop production, it follows that tolerance to drought and efficient water usage should be assigned the highest priority in developing future crops. Drought tolerance trait in maize is of enormous global importance, which virtually no crop or farmer in the world can afford to be without; using water at current rates when the world will have to support 9 billion people or more in 2050, is simply not sustainable (Edmeades, 2008).

Accordingly, the International Maize and Wheat Improvement Center (CIMMYT), in collaboration with partners, has been undertaking solid research to develop and disseminate drought tolerant maize for more than four decades. Since 2006, CIMMYT has been implementing a project called Drought Tolerant Maize for Africa (DTMA)[1] in 13 SSA countries. DTMA has made significant progress over the last 6 years (2006-2012) in terms of developing and delivering improved technologies. A total of 109 drought tolerant hybrid maize (55) and open pollinated (54) varieties were released and disseminated to smallholder farmers across the project countries. These improved varieties give 20-30% more yield in farmers' fields than current varieties available to smallholder farmers. The varieties developed by DTMA provide farmers with better yields than leading commercial varieties under moderate drought conditions, and have competitive or even better yield potential when rains are good. Improved seed production in target countries rose from 700 MT in 2009 to nearly 9,000 MT in 2011; it is planned to produce 70,000 MT annually by 2016. So far, some two million smallholder farmers have benefited from DTMA. The benefits from investment in DTMA were estimated in terms of economic gains from the increase in average maize yields and economic benefits from reduction in yield variability. The estimations show the largest gains to be in lower drought risk zones. With a potential full replacement of improved varieties with DTM by 2016, there would be economic gains of US$ 907 million over all 13 countries, assuming conservative yield gains, and US$ 1,535 million, assuming optimistic yield gains (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.

This paper discusses drought risk perception and management in the five southern African countries of the project to facilitate the efforts being exerted to reinforce the resilience of the farming communities. Despite the importance of drought and the agricultural risk associated to it, no comprehensive assessment of the farm household level management of drought risk has been documented in the region. We believe this paper enormously contributes in filling this glaring gap as maize has already been shown to be a very susceptible crop to drought and heat stresses (Cairns *et al.*, 2012). The paper is structured as follows. The next section discusses the research methodology in detail. The study areas, the sampling procedure, and the data collection and analysis are explained. The section that follows presents the results and discussion. The final section presents the conclusions and recommendations of the study.

2. METHODOLOGY

2.1. The Study Area

This study covered five southern Africa countries, namely, Angola, Malawi, Mozambique, Zambia and Zimbabwe (Figure 1). Angola has a surface area of 1.25 million Km^2 and an estimated human population of 19.1 million in 2010 (UNdata, 2012; World Bank, 2013). More than 48% of the population lives in the rural areas depending almost entirely on subsistence agriculture. Agriculture contributed 9% of the GDP in 2011 while the oil and mineral based industry sector contributed the grand share (World Bank, 2013). About 93% of the crop farming is conducted by small holder farmers and maize is the major staple food crop in the country.

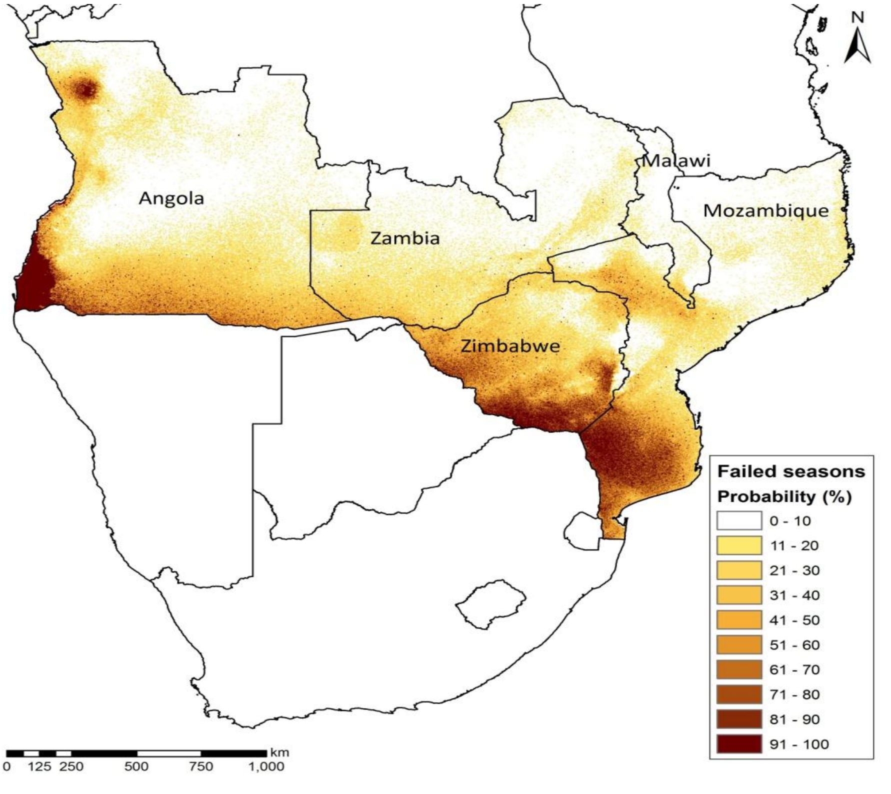
[1] DTMA is an award winning initiative (http://dtma.cimmyt.org) implemented by CIMMYT, IITA and national partners in 13 African countries. The initiative is funded by the Bill & Melinda Gates Foundation and Howard G. Buffet Foundation.

Malawi is a landlocked country with a surface area of 118,484 Km^2 and human population of 14.9 million in 2010 (UNdata, 2012; World Bank, 2013). Majority of Malawi's population (>80%) lives in the rural areas. Agriculture is a very important sector contributing about 30% of the GDP in 2010 (World Bank, 2013). 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.

Mozambique has a surface area of about 0.8 million $Km^2$and human population of 23.4 million in 2010 (UNdata, 2012). Nearly 70% of Mozambicans live in the rural areas depending on traditional and subsistence agriculture. Agriculture contributed 30% of the GDP in 2011 (World Bank, 2013). 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.

Zambia is also a landlocked country with a surface area of about 0.75 million Km^2 and human population of 13.1 million in 2010 (UNdata, 2012; World Bank, 2013). About 60% of Zambians live in the rural areas depending mainly on agriculture which contributed 20% 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).

Figure-1. Failed season probability in the study countries



Zimbabwe is another land locked country with surface area of 390,757 Km^2 and estimated human population of 12.6 million in 2010 (UNdata, 2012). About 60% 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% 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 (Anseeuw *et al.*, 2012).

2.2. Sampling

The five study countries are among the 13 African countries where Drought Tolerant Maize for Africa (DTMA) is being implemented. A look into the perception and coping strategies of drought risk in the region will surely be helpful to understand the enterprise choice and resource allocation dynamics in the sub-region or the region in general. 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). 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 across countries. Table 1 summarizes names of districts and size of the random samples drawn from each of the countries.

Table-1. Parameters of the sampling procedure

Country	**Districts**	**Sample HH**
Angola	Cacuaco	150
	Lobito	
Malawi	Balaka	158
	Mangochi	
Mozambique	Mossurize	350
	Sussundenga	
Zambia	Monze	350
	Kalomo	
Zimbabwe	Bikita	100
	Masvingo	

2.3. Data Collection and Analysis

Comprehensive household survey was conducted in each of the countries to generate data on, *inter alia*, the perception and management of drought risk among maize growers. The focus was on the importance of drought as a challenge in the livelihoods of the communities, relative importance of drought as a constraint to the improvement of lives, maize trait preferences under hypothetical and actual scenarios, farmers' comparison of the riskiness – in terms of yield variability – of the different maize types, and pattern of land allocation to maize varieties vis-à-vis production risk.

Data generated were analyzed using descriptive statistics and non-parametric models. The descriptive statistics employed include both central measures of tendency and dispersion.

Summarizing variables which characterize the sample populations was the main purpose of using descriptive statistics. 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.

One of the important questions asked in the paper is whether drought is equally important as a challenge 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 and 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, given as $n_i - 1$.

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,

$$Q^{*}_{i,j} = \sqrt{\frac{s_i^2}{n_i} + \frac{s_j^2}{n_j}} \tag{4}$$

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

$$R_{\varepsilon,r,v} = s_{\varepsilon,k,v} \big/ \sqrt{2} \tag{5}$$

3. RESULTS AND DISCUSSION

3.1. Importance of Drought

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 2. 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. 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 despite the similar clustering following PFS. 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-2. Drought risk importance ranking in Southern Africa

Rank (1 high; 5 = low)	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

3.2. 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 eight years (Table 3).

Table-3. Descriptives of crop drought induced crop failure

Country	N	Mean	Std. Deviation
Angola	150	1.1267	1.49154
Malawi	148	3.0743	1.80736
Mozambique	344	2.3256	1.12943
Zambia	344	3.0349	1.33093

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 and Howell, 1976) to compare across the countries.

The results indicate that Angola has less and significantly different mean 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 of number of crop failures compared to Angola and significantly less mean number of crop failures than Malawi and Zambia (Table 4).

Table-4. Games-Howell Multiple Mean Comparison results (crop failure experience)

(I) Country	(J) Country	Mean Difference (I-J)	Std. Error	Sig
Angola	Malawi	-1.94766*	0.172	0.000
	Mozambique	-1.19891*	0.105	0.000
	Zambia	-1.90822*	0.112	0.000
Malawi	Angola	1.94766*	0.172	0.000
	Mozambique	.74874*	0.161	0.000
	Zambia	0.03944	0.165	0.995
Mozambique	Angola	1.19891*	0.105	0.000
	Malawi	-.74874*	0.161	0.000
	Zambia	-.70930*	0.094	0.000
Zambia	Angola	1.90822*	0.112	0.000
	Malawi	-0.03944	0.165	0.995
	Mozambique	.70930*	0.094	0.000

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

3.3. 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. 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 (OP) 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 OP varieties 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 5).

In Zambia, more than 81% of the respondents (N = 336) believe that local maize varieties they are growing are riskier than other crops. Improved OP varieties were indicated to be even riskier by 90.2% of the respondents (N = 315) as compared to all other crops grown by farmers. Hybrid maize varieties 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 5). 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 can be concluded 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.

Table-5. 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

3.4. Land Allocation Pattern as a Response to Risk Expectation

Farmers have different ways of dealing with the different risks their agricultural activities are embedded with. Risk management is entrenched in the regular farm management activities of farmers manifested through selection of enterprises and allocation of their meager resources. 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; i.e., 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 6). 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 the 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 allocate as much land to local maize varieties or increase the allocation. Under better fertilizer and credit access, however, they tend to allocate more land to the local maize varieties they are growing. The land allocation follows the same pattern except the considerable tendency to increase the land allocated to these varieties when yield levels are expected to be lower than the normal average. For both local and improved OP varieties, farmers tend to maintain the current allocation of land 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 6).

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 OP varieties and hybrids, farmers tend to decrease the land allocated to such varieties when faced with negatives 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 6). 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 the livelihoods of people.

Table-6. 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

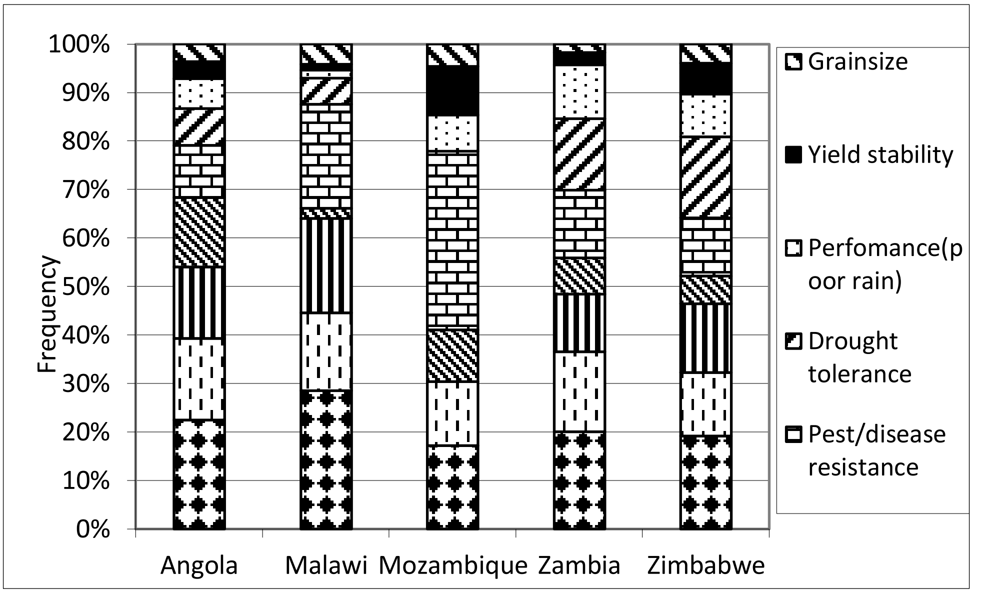
3.5. Maize Trait Preferences of Farmers: How Important is Drought Tolerance?

3.5.1. Traits of an Ideal Maize Variety

Crop trait preferences tacitly indicate the objectives and priorities of crop farming households. The preferences are also dictated by the opportunities and constraints farmers are facing 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 such that 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 2).

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 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 2).

Figure-2. Desirable Characteristics for Ideal Maize



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.

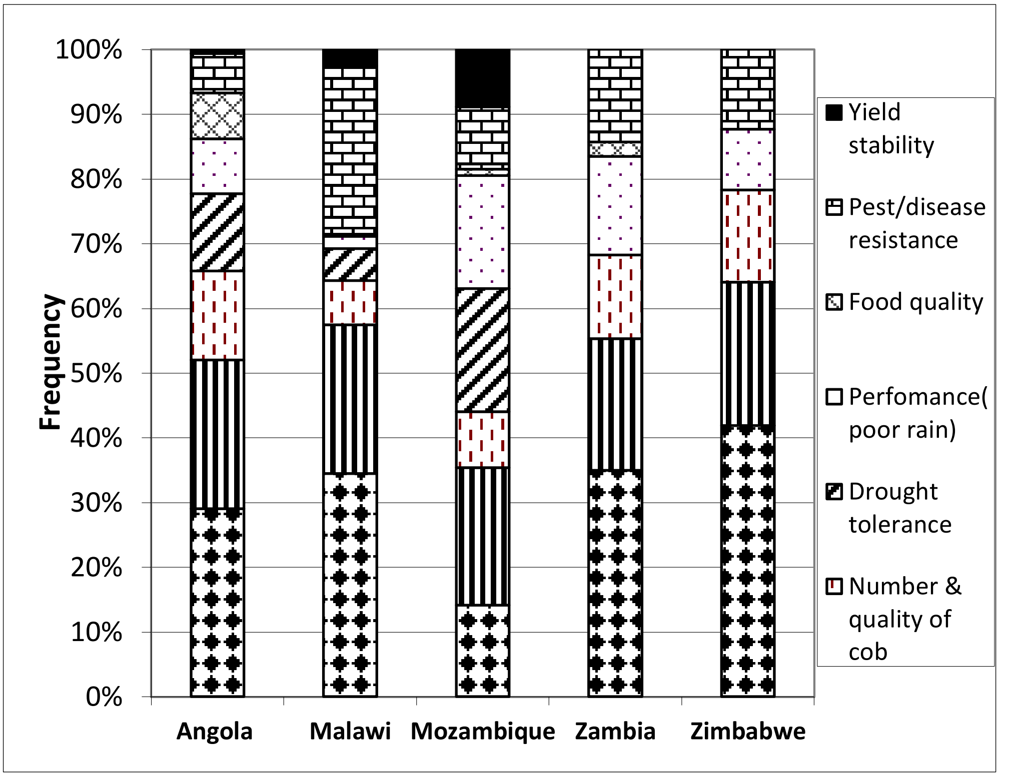
Yield potential is a composite trait explained by different specific traits which can include tolerance to drought, pests and diseases, and erratic rainfall pattern. Nonetheless, the fact that farmers are mentioning these traits as important considerations when selecting maize varieties implies the importance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

3.5.2. Preferred Traits of the Maize being grown

Poor farmers hardly have access to the ideal varieties of maize or of any other crop. More important is, therefore, 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 3). 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 3).

Figure-3. Attributes considered in selecting maize variety to grow



4. CONCLUSION

Drought and the negative risk associated to it will always be a bottleneck to agriculture in general and maize production in particular in Southern Africa. The frequency and intensity of drought would be increasing so long as the climatic change the globe is experiencing continues. Drought is therefore unavoidable part of the farming systems and the focus shall be on adapting to the patterns in moisture level and coping mechanisms for erratic scenarios. Farmers will benefit more from technological options that help them diversify their agricultural portfolio.

Given the importance of maize and the vulnerability of the farming communities in the region, it can easily be concluded that drought and risks associated to it will have paramount and potentially irreversible consequences in the poor sections of the region. The effort DTMA/CIMMYT is putting into generating drought tolerant maize germplasms is an important step in re-enforcing the resilience of the farming communities. 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 farming communities in Malawi and Zambia were, for instance, found to be suffering more than the other countries from drought-induced crop failures and thus deliberate focus on maize growers of these countries will apparently be worthwhile. Given the importance of maize and the poverty of Mozambicans, targeting, maize growers here will also be important to make them more insulated to the negative consequences of drought.

Looking at production risk from variability of yield level angle, all types of maize (local, improved OP, and hybrids) were indicated to be very risky, making maize production a risky enterprise all along. This entails as much focus on yield stability as yield level. Despite the fact that yield size is among the most preferred traits, farmers' strong implication of maize as a risky crop urges refocusing breeding activities to generation of germplasms with reliable yield distribution.

The way farmers choose their enterprises and allocate their resources explain the intricacies of risk perception and risk efficient farm management smallholder farmers are dealing with. When faced with sources of negative risk, farmers tend to reduce the resources allocated to important enterprises undermining the sustenance of livelihoods. Comprehensive understanding of risk perceptions and the resultant decisions will be crucially important to make effective contribution at grassroots level.

Farmers have also shown strong interest in drought tolerance, early maturity, and good performance under poor rainfall attributes of maize. This clearly shows the importance of drought and erratic moisture level in maize production. Eliciting the trait preferences of maize growers will be crucial not only for understanding the challenges and opportunities farmers' are focusing on but also to sharpen and make the contributions or research and development more efficient.

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