academicJournals

Vol. 10(30), pp. 2968-2978, 23 July, 2015
DOI: 10.5897/AJAR2014.8916
Article Number: DD672F054440
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Determinants of farm-level decisions regarding cereal crops and varieties in semi-arid central Tanzania

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Received 14 June, 2014; Accepted 16 July, 2015

We assess the potential and constraints of increased sorghum and pearl millet production to enhance food security and livelihoods in central Tanzania. These dryland cereals show a high potential to contribute to local food security. The study employed structured questionnaire survey as the main data collection method. Data analysis involved the use of Multinomial logit model (MNL) in combination with other descriptive statistics to determine the socio-economic and agro ecological variables influencing crop and variety choices and preferences. Empirical results revealed that age of the household head, farming experience, having plots on particular soil types and access to weather information significantly influence choices of cereal crops among sorghum, pearl millet and maize. On the same token, age, farming experience, farmer-extension contact and access to weather information were important factors on the choice of sorghum varieties viz. local landraces versus improved. Farmers' perception results show that harvest and post-harvest processes, consumer tastes and preferences, and market access and prices strongly influence farmers' decisions to grow sorghum. In conclusion the results show that although sorghum and pearl millet contribute to the food supply, perceptions, agro-ecological variables and socio-economic factors collectively constrain the realization of their potential in minimizing household food insecurity.

Key words: Drought tolerant cereals, agro-ecological, perception, multinomial logit, food security, livelihoods.

INTRODUCTION

It is estimated that in sub-Saharan Africa, sorghum and pearl millets account for 8% of the cultivable land area which support about 9% of the population mainly in the agro-pastoral millet/sorghum farming system (Dixon et al., 2001). There is perpetual food-insecurity among the people living in central regions of Tanzania due to existence of unfavourable agricultural conditions. In these regions, promotion of adoption of drought tolerant crops like cassava, millet or sorghum, despite their low market value, increase the potential to ensure households food sufficiency especially when crops like maize fail (Monyo et al., 2002). With the help from donors, Tanzania

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government using the Agricultural Sector Development Strategy (ASDS) (URT, 2001) and the recent initiative *Kilimo Kwanza* (2010), is promoting the use of small grain cereals to fight food insecurity in semi-arid areas of Tanzania. As a result of concerted efforts of government and donors, several new improved varieties of sorghum and millets have been released and are being disseminated to farmers (SADC/ICRISAT SMIP, 1998). Despite these efforts, adoption of these improved crop varieties by rural farmers, which would lead to increased crop production, is still limited.

Previous studies conducted to identify factors determining adoption of cereal crops in Tanzania, mainly maize (Kaliba et al., 2000) and sorghum (Mafuru et al., 2007; Bucheyeki et al., 2010) focused more on socio-economic variables than on agro-ecological and farmers' perceptions. Since the studies were conducted on a limited area it is not possible to apply them to other regions because they did not consider the role of all important indicators for agricultural water management.

Although applied at continental scales, Valipour (2014a,b, 2015a) underscores the importance of inclusion of socio-economic indices in water management aspects for food security. Moreover, Kafle (2010) suggests the consideration of all factors as they are equally important in the understanding of the determinants of adoption of agricultural innovations. Though it is strongly argued that farmers in semi-arid areas where sorghum and pearl millet are produced are reluctant to invest in new crop management practices such as improved varieties and manure application, reasons for the hesitancies remain unclear. Natural resource management practices that improve soil fertility do exist, but farmer adoption of the practices on sorghum and millets is continually declining (Ley et al., 2001). Some studies cite high production risks, limited incentives to increase productivity and limited access to markets for these small grains as the most important factors which deter smallholder farmers to adopt promising agricultural innovations (Rohrbach and Kiriwaggulu, 2007). Moreover, an over-reliance on a cultivar-alone strategy, such as the introduction of improved sorghum or millet varieties, seem to give limited gains (Ahmed et al., 2000), indicating that other driving factors may have a contributing role in determining cereals productivity.

Recent analyses have recommended some agricultural innovations to improve cereals productivity, for example, promotion of adoption of conservation agriculture technologies without considering whether they give immediate economic returns (Kahimba et al., 2014). Studies at the continental scale indicate that Africa needs governments' policy to provide an enabling environment for smallholder farmers to use irrigation systems and raise cropping intensity in the irrigated area in the future (Valipour, 2014c). Moreover, analyses by Valipour (2015b, c) and Valipour et al. (2015) using information from Food and Agriculture Organization (FAO) database show that appropriate policies are required which ensure accurate scheduling of water resources and designing of suitable cropping patterns for the irrigation systems to attain sustainable agriculture in future. Westengen and Brysting (2014) recommends maintenance of cereal crop and variety diversity through growing local landraces alongside improved varieties of maize and sorghum as a livelihood response strategy of crop adaptation to not only climatic stresses but also other abiotic stresses (e.g. pests and diseases) in central Tanzania. Though some empirical studies have attempted to analyse the impact of climate and factors affecting the choice of crop and cropping systems (Below et al., 2011; Waha et al., 2012), there is paucity in knowledge of determinants of farmers' choice of cereal crops and crop varieties encompassing agro-ecological and farmers' perception in the central semi-arid areas of Tanzania. A deeper analysis of the agro-ecological, farmers' perceptions and socio-economic factors determining production in the sorghum and pearl millet-based farming system is thus needed to elucidate their influence on the adaptive capacity of smallholder farmers to multifaceted challenges predominant in the system.

We analyze factors that determine cereal crops and crop varieties choices among farming households, with the goal of understanding farmers' perceptions, and the socio-economic and agro-ecological factors influencing of the decision to produce sorghum or another cereal in a given cropping season and the choice between local landraces and improved varieties. Policy makers would be provided with additional insight into the relationship between sorghum production and the changing driving factors. We describe current yields, patterns and trends of sorghum production in relation to maize and pearl millet and we identify the determinant factors that impel patterns and trends in sorghum production, in relation to maize and millet production.

METHODOLOGY

Study area

The central zone (Dodoma and Singida) is located between latitudes 6° and 06°08' S and longitudes 34°30' and 35°45'E. The study was conducted in two villages of Bahi District, namely Makanda and Lamaiti, and two villages of Chamwino District, namely Mlowa Bwawani and Wiliko, Dodoma Region. Additionally, two villages of Iramba District, namely Kisiriri and Kisana and two villages of Singida rural District that is Ikhanoda and Ngamu, Singida region were involved. Both Regions are situated in semi-arid areas and have a dry savannah type of climate, which is characterized by long dry season, unimodal and erratic rainfall that falls between November/December and April. Dodoma Region has an annual average rainfall of about 500 to 700 mm and annual average temperature of about 22.6°C. Singida region has an annual average rainfall of about 500 to 800 mm and annual average temperature of about 20.4°C. The zone is one of the most sensitive to climate variability and change, but it account for three-quarters of Tanzania's 500,000 to 800,000 tonnes of annual sorghum harvest.

Table 1. Variables used in the MNL model and their expected signs.

Variable name	Variable description and measurement	Variable type	Expected sign
CRPTYPEchoice	Choice of a crop relative to other crops		
EDUC	Years of school completed by household head (number)	Continuous	+/-
AGE	Age of household head (years)	Continuous	+/-
FEXPERIENCE	Farming experience of household head (years)	Continuous	+/-
HSIZE	Household size (numbers)	Discrete	+/-
PLOTSIZE	Size of cultivated land in hectares	Continuous	+/-
SLTYPE1	Sandy reddish fine soils (*Isang'ha)*	Continuous	+/-
SLTYPE2	Red deep heavy soils (*Ng'uluhwi)*	Continuous	+/-
SLTYPE3	Whitish/Reddish soils (*Tifutifu)*	Continuous	+/-
SLTYPE4	Red sandy soils (*Sanghamanya)*	Continuous	+/-
SLTYPE5	Sandy soils along the sandy rivers *(Msawawa)*	Continuous	+/-
SLTYPE6	Black or grey alluvial cracking soils (*Mbuga)*	Continuous	+/-
DISMRKT	Distance to the nearest market (km)	Continuous	
EXTNCNT	Farmer received extension contact in 2011/12 (numbers)	Discrete	+/-
SUPPORT	Farmer obtained support (seed or fertilizer) in 2011/12 (dummy)	Continuous	+/-
CLIMINFO	Household head has access to weather information (dummy)	Dummy	+/-
TRAINING	Household head participate in training (dummy)	Dummy	+/-

Research design and methods of data collection

The study used both primary and secondary data. The study sample was obtained by using simple random sampling technique from a sampling frame of farming households who were producing cereal crops and raising livestock. A structured questionnaire was used to gather both qualitative and quantitative information covering aspects about patterns and trends, influence of biophysical (soil) and socio-economic factors on cereal crops production, discrete choices of cereals and ultimately the choices of sorghum varieties grown by farming households. The questionnaire was administered to a sample of 240 respondents. Secondary data were gathered from various reports relevant to the study and the web.

Data analysis

Likert type plot (diverging stacked bar chart) on socio-economic constraints on sorghum was generated from R using HH package (Heiberger and Robbins, 2014). The Multinomial Logit (MNL) model was used to analyse the factors influencing choice of growing one cereal crop among smallholder farmers in the two regions viz. Dodoma and Singida. The MNL parameter estimates are obtained using maximum likelihood estimation method given in MLOGIT routine for STATA version 11. Explanatory variables used to describe the choices of crop and crop varieties are shown in Table 1. The size of the plots (acreage) allocated for each cereal by the farmers during the season of 2011/2012 was used as a proxy for the preference of that particular farmer to choose a given cereal that is, the higher the acreage the higher the preference. The 2011/2012 season was chosen between the two previous seasons due to its relatively good rains in the study area compared to 2012/2013 season. The model was preferred because it permits the analysis of decisions across more than two categories in the dependent variable; hence it becomes possible to determine choice probabilities for the different cereals (Table 1).

To describe the MNL model, let y denote a random variable taking on the values {1,2….j} for choices j, a positive integer, and let ***x*** denote a set of conditioning variables. In the first case, y represents the cereal crop chosen by any farming household in the study area. We assume that each farmer faces a set of discrete, mutually exclusive choices of cereal crops (that means that a person chooses exactly one of the options, not more and not less) and these measures are assumed to depend on factors of x. Therefore, x represents a number of attributes, demographical, socio-economic characteristics of households and agro-ecological variables. The question is how, *ceteris paribus*, changes in the elements of ***x*** affect the response probabilities p(y=j/x), j = 1, 2…. J. Since the probabilities must sum to unity, p (y=j/x) is determined once we know the probabilities for j = 2…j. Let ***x*** be a 1x K vector with first element unity. The MNL model has response probabilities:

$$P\ (\gamma = j/X) = \frac{\exp\ (x\,\beta_j)}{1+\sum_{k-1}^{j}(x\,\beta_k)\ j=1,\ldots,\ J} \qquad (1)$$

Where is K × 1, j = 1……., J j β

Unbiased and consistent parameter estimates of the MNL model in equation-1 require the assumption of Independence of Irrelevant Alternatives (IIA) to hold (Deressa et al., 2008). More specifically, the IIA assumption requires that the probability of growing a certain cereal crop by a given household needs to be independent from the probability of choosing another cereal crop (that is, Pj/Pk is independent of the remaining probabilities). The parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent variable, but estimates do not represent either the actual magnitude of change nor probabilities (Greene, 2012). In the second case, MNL was used to regress on the sorghum variety choices, where y represent the sorghum variety chosen by any farming household in the study area. In order to understand the influence of the independent variables, marginal effects which measure the expected change in the probability of a particular choice were calculated in both cases as follows:

$$\partial p_i/_{\partial x_k} = P_j\left(\beta_{jk} - \sum_{j=1}^{j-1} P_j \beta_{jk}\right) \qquad (2)$$

Table 2. Distribution of respondents by education level, age, years in crop and livestock production.

Education level	N=240	%	Years in crop production	N=240	%
Primary school level	200	83.3	< 3 years	15	6.2
Secondary school level	15	6.2	3– 6 years	26	10.8
Post secondary level	0	0	Above 6 years	199	82.9
Adult education	3	1.7			
Non-formal education	22	8.8	Years in livestock keeping		
Respondent age (years)			< 3 years	35	16.1
15-20	7	3.1	3– 6 years	24	11.1
21-40	95	42.2	Above 6 years	158	72.8
41-60	103	45.8	Household size ++	8.4 (3.39)	-
Above 60	20	8.9	Plot size (hectares)++	5.1 (9.53)	-

Source: survey data 2013. Note: ++ denotes values are means and standard deviation in parentheses.

RESULTS AND DISCUSSION

Household and farm characteristics

Results in Table 2 show that the 83.3% of respondents attained primary school level of education, while the remaining had either secondary, adult education or non-formal education. None of the respondents had post-secondary education level. Age wise, 88% of respondents were in the range of 21 to 60 years. The lowest percentage of respondents was in the range of 15 to 20 years. The number of years of engagement in crop production was above six which was reported by 82.9% of the respondents while for the case of livestock keeping above six years was reported by 72.8%. It is further shown in Table 1 that the family size of respondents was 8.4 members. This family size is large and above the rural average household size of 5.0 (URT, 2013). Importance of large families in engagement to crop production activities is stressed especially when all of the household members take part in production and/or service provision to contribute to the economy of the household.

Cereal production patterns and trends

The findings in Table 3 show production patterns and trends in the two growing seasons in the study districts. Of the three cereal crops, the average area of maize fields is highest in the range of 3.32 to 3.71 ha, sorghum fields range from 3.27 to 3.66 ha and pearl millet with the lowest ranging from 2.09 to 2.72 ha. Table 4 show long term trends of cereal production for the two regions. In comparison with the current production trends, long term trends show a gradual increase in grain yields from 0.7 to 1.1 t/ha and 0.6 to 1.0 t/ha for sorghum and pearl millets, respectively. Similar results were reported by a previous study which has estimated an increase in sorghum productivity to 0.9 t/ha in 2005 (Mbwaga et al., 2006). With respect to cultivated area, it almost doubled for maize from those in 1991 to 2010 in both regions, while the area for sorghum decreased by one third during the same period in Dodoma region and by half in Singida region. However, long-term trends over ten year periods (that is, 1991-2001 and 2001-2010) show an increase by one third by both maize and sorghum and a decrease by two thirds for millets in Dodoma region. A striking feature, however, is observed for long-term trends for all three cereals in Singida region where the cultivated area has remained steady during both periods.

Determinant factors influencing patterns and trends in cereals

Soil type diversity

Responses of smallholder farmers on preferences of soil types where they would grow a given cereal are presented in Table 5. Frequencies (%) of plots reported by farmers where a given cereal was cultivated in the 2011/2012 season, indicated that for maize and sorghum, soil type preferences would follow the order: *Black or grey alluvial cracking soils<Red deep heavy soils <Whitish/Reddish soils<Sandy reddish fine soils<Red sandy soils<Sandy soils along the sandy rivers*. Whereas pearl millet would follow: *Sandy reddish fine soils<Red sandy soils< Red deep heavy soils < Whitish/Reddish soils <Sandy soils along the sandy rivers< Black or grey alluvial cracking soils.* On the other hand, when farmers were asked on the soil type where sorghum was actually grown in the 2011/2012 season, the frequencies (%) of plots reveal a slight different trend: *Sandy reddish fine soils=Red deep heavy soils < Black or grey alluvial cracking soils < Whitish/Reddish soils <Red sandy soils<Sandy soils along the sandy rivers.* Black or grey alluvial cracking soils are mainly located in lowland areas and positive relationship between adoption of improved maize varieties and location of fields in the low land areas

Table 3. Current production patterns and trend in cereal production and yield.

Growing season	Crop grown	Number of cultivating households	Mean area (ha)	Std.dev	Mean production (tons)	Std. dev	Mean yield (t/ha)
2011/2012	All	240					
	Sorghum	180	3.27	1.83	1.99	0.79	0.61
	Maize	201	3.32	1.61	2.18	1.12	0.66
	Pearl millet	54	2.09	1.06	1.33	0.50	0.64
2012/2013	Sorghum	153	3.66	2.05	1.89	0.80	0.52
	Maize	180	3.71	1.75	2.34	1.41	0.63
	Pearl millet	45	2.72	1.56	1.16	0.57	0.43

Source: survey data 2013, NB: Multiple responses.

Table 4. Trends in cropped area and yield (1991-2010).

Region		1991	2010	1991-2010	2001-2010
Dodoma	Cropped area (ha)				
	(i) Sorghum	216,531	195,518	134,770	161,251
	(ii) maize	62,093	104,282	93,956	132,416
	(iii) Millets	72,177	92,362	61,911	22,577
	Grain yield (tons/ha)				
	(i) Sorghum	0.7	1.1	1.0	1.1
	(ii) Maize	0.7	0.6	0.8	0.7
	(iii) Millets	0.6	0.8	1.0	1.0
Singida	Cropped area (ha)				
	(i) sorghum	112,004	63,430	72,436	78,229
	(ii) maize	57,265	129,559	63,469	71,125
	(ii) Millets	37,335	43,291	37,207	32,199
	Grain yield (tons/ha)				
	(i) Sorghum	0.9	1.0	1.0	1.1
	(ii) Maize	1.0	0.6	0.8	0.7
	(iii) Millets	1.0	0.8	1.0	1.0

Source: MAFC 2010.

was reported by Kaliba et al. (2000). Other studies from the area have similarly found that soil diversity is an important factor in the strive to increase production and productivity of cereals as it allows smallholder farmers to explore a wide range of soils and soils management to ensure some crop is harvested during or beyond the main growing season of a crop (Liwenga, 2003, 2008). Elsewhere, Alumira and Rusike (2005) reported farmers' preference in Zimbabwe to grow hybrid maize seeds on clay soil type over sandy loams due to the perception that clay soil has high inherent soil fertility.

Local versus improved sorghum varieties

A total of 7 improved and 16 landrace sorghum varieties were reported across the surveyed households in the two regions of central Tanzania (Table 6). However, there were only few dominant varieties both for improved and landrace sorghum varieties. For example, *Macia*, *Pato* and *Tegemeo* were the most dominant improved sorghum varieties which were grown by 47.90, 20.36 and 17.96% of the farmers, respectively. In general, only five of the improved sorghum varieties were grown by more than 4% of the respondents. Similarly, among the most dominant landrace sorghum varieties grown by the households only three landrace varieties (*Lugugu*, *Langalanga* and *Gangisi*) were reported to be grown by more than 15% of the respondents. In general, landrace sorghum varieties were grown by a large proportion of the households. Similar results were reported by Westengen and Brysting (2014).

Table 5. Farmers crop preferences on soil types.

Soil description (Local name)	Predominant crops grown	Sorghum as main crop	
		Count	% of plots
Sandy reddish fine soils (*Isang'ha)*	Sorghum **(42.1)**, pearl millet(41.7), maize(21.2)	108	23.4
Red deep heavy soils (*Ng'uluhwi)*	Maize **(53.8),** sorghum(47.9), pearl millet(26.2)	105	22.7
Whitish/Reddish soils (*Tifutifu)*	Maize **(50.0),** sorghum(45.8), pearl millet(25.8)	79	17.1
Red sandy soils (*Sanghamanya)*	Pearl millet **(28.8),**sorghum(25.0), maize(21.7)	49	10.6
Sandy soils along the sandy rivers *(Msawawa)*	Pearl millet **(16.7),**sorghum(11.7), maize(9.6)	26	5.6
Black or grey alluvial soils (*Mbuga)*	Maize **(69.6),** sorghum(50.8), pearl millet(14.6)	95	20.6
Total		462	100

NB: Multiple responses; bold numbers in brackets next to crop name show a highest soil type preference reported, Source: survey data 2013.

Table 6. Name and frequency of distribution of improved and local sorghum varieties in 2011/2012 and 2012/2013.

Improved		Local	
Name of variety	% of growers	Name of variety	% of growers
Macia	47.90	Lugugu	30.88
Pato	20.36	Langalanga	24.88
Tegemeo	17.96	Gangisi	15.67
Serena	4.79	Bangala	7.37
Wahi	4.79	Mkombituna	5.53
KARI-Mtama	2.40	Sandala	4.15
Hakika	1.80	Nkolongo	2.76
		Wela	2.76

Source: survey data 2013.

There are three mutually exclusive sorghum variety choices for the sorghum producers: improved sorghum variety only, local landrace sorghum variety only and both improved and local landrace sorghum varieties (Table 7). The largest proportion (68%) of sample households was observed to grow both improved and local landrace sorghum varieties. About 24% of the sample households were observed to grow landrace sorghum varieties only (no adoption of improved sorghum varieties). On the other hand, the percentage of sample households growing landrace sorghum varieties only was about 8%. Among all districts, the highest percentage of farmers growing improved sorghum varieties only was observed for Chamwino district, Dodoma. Overall, more than 92% of the sample households were found to grow landrace sorghum varieties, either singularly (24%) or in combination with improved sorghum varieties (68%). Mafuru et al. (2007) observed that increased adoption of improved sorghum varieties by smallholder farmers depend not only on the production characteristics, but also the ultimate consumer preferences, thus signifying the existence of a combination of factors important in determining the constraints to adoption of improved varieties.

Socio-economic factors constraining sorghum production

Perceptions of farmers on the constraints of increasing sorghum production relative to other cereals reveal diverse opinions (Figure 1). The highest proportion of respondents, about 60%, strongly agree that birds scaring require extra labour, and that if care is not taken, crop damage becomes heavy thus leading to high crop losses at harvest. Threshing and winnowing drudgery as well as lack of machines or equipment to thresh sorghum were perceived by an almost equal number of respondents (~40%) as important constraints to increased sorghum production. Previous studies report lack of better threshing methods on the farm as one of the hindrances for sorghum to secure markets in the breweries even though farmers were advised to use mechanical threshers, which were mostly unavailable and difficult to manage, but alternatively, farmers could thresh their grain on tarpaulins or on cement floors (Rohrbach and Kiriwaggulu, 2007).

Moreover, from the market access and prices perspective, a big proportion of respondents (>30%) show that lack of established markets on sorghum is an

Table 7. Household sorghum variety adoption patterns by district.

District	Sorghum variety choice (% of respondents)			
	Improved variety only	Local landraces only	Both improved and landrace variety	Whole sample
Bahi	6.68	13.32	80.0	25.0
Chamwino	15.00	0.00	85.0	25.0
Iramba	8.32	50.00	41.68	25.0
Singida rural	0.00	33.32	66.68	25.0
Whole sample	7.50	24.16	68.34	100.0

Source: survey data 2013.

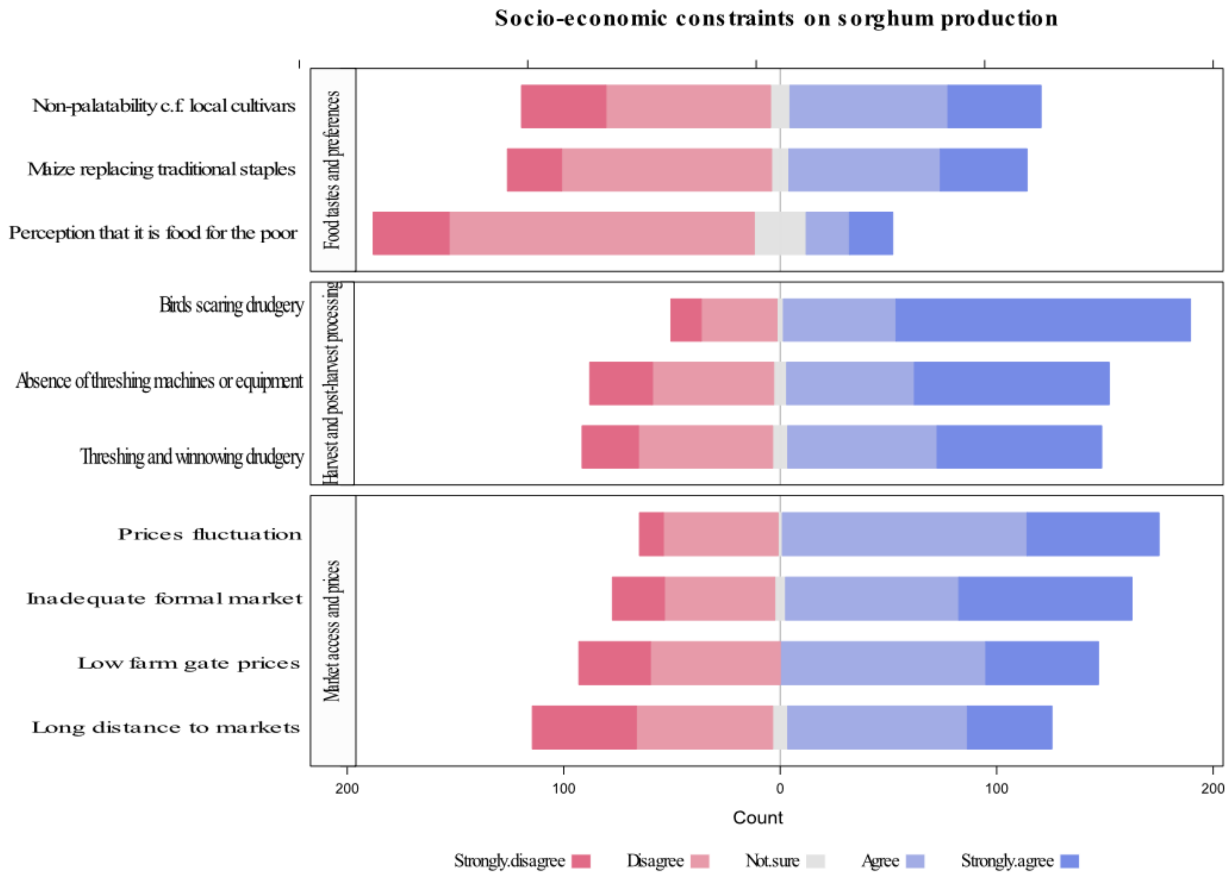

Figure 1. Socio-economic constraints on sorghum production.

important constraint to increased sorghum production. This was followed by prices fluctuations alternating between good and bad harvest years, low farm gate prices compared to maize and lastly long distances to the markets (e.g. "*minada*[1]*" and "*strategic grain reserves*"). On the other hand respondents seem to have equal opinions on the perception that maize is gradually replacing traditional staples viz. sorghum and millets and those new (improved) sorghum varieties are not palatable in comparison with local landraces/cultivars. This show that a good number of people in the study area still consume sorghum, and the declining percentage is probably due to lack of various processed products from sorghum flour such as bread or biscuits instead they rely only on stiff porridge "*Ugali*". Similar findings were reported by Kebakile et al. (2003) in Botswana where they observed increased desire for modern products derived from sorghum flour and that the ensuing

[1] These are weekly market gatherings rotating in selected villages where an assortment of commodities are traded and are considered as ready markets for cereal grains

Table 8. Marginal effects from the multinomial logit on the choice of cereal crop.

Explanatory variable	pearl millet	maize	sorghum
AGE	0.0050** (2.73)	-0.0011** (-0.39)	-0.0039** (-1.39)
EDUC	0.0054 (0.67)	0.0210 (1.54)	-0.0263 (-1.91)
PLOTSIZE	0.0025 (1.05)	-0.0088 (-2.27)	0.0063 (1.56)
HSIZE	-0.0082 (-1.34)	0.0127 (1.31)	-0.0046 (-0.45)
DISMRKT	-0.0033 (-0.56)	-0.0182 (-1.81)	0.0216 (2.05)
FEXPERIENCE	-0.1481 (-1.06)	0.2781* (1.85)	-0.1301 (-0.72)
SLTYPE1	0.1175** (2.78)	-0.2176*** (-3.06)	0.10005** (1.33)
SLTYPE2	-0.0348 (-0.91)	-0.1678 (-2.44)	0.1960 (2.86)
SLTYPE3	0.1428*** (3.04)	0.0246** (0.39)	-0.1674*** (-2.46)
SLTYPE4	0.1371*** (2.72)	-0.0044** (-0.07)	-0.1328*** (-1.88)
SLTYPE5	-0.0105 (-0.19)	-0.1493 (-1.01)	0.1465 (1.04)
SLTYPE6	-0.3616*** (-7.20)	0.2153*** (3.03)	0.1457*** (1.93)
EXTNCNT	-0.0394 (-0.98)	0.0471 (0.66)	-0.0031 (-0.05)
SUPPORT	-0.0641 (-1.46)	0.0825 (1.00)	-0.0212 (-0.24)
CLIMINFO	-0.0587* (-1.61)	-0.0354 (-0.42)	0.0869* (1.23)
TRAINING	-0.0302 (-0.61)	0.0167 (0.16)	0.0164 (0.18)

* denotes significance at 10%,; ** denotes significance at 5%,; *** denotes significance at 1%, Log likelihood = -154.41945; Prob(chi2)=0.0000; LR chi2(46)= 177.81; Pseudo R square = 0.2885; T-statistics in parentheses.

acceptability of the products depend on if they are nutritious, healthy, affordable and could maintain traditional flavours. However, when respondents were asked on their perception on if sorghum is considered as food for the poor, most (80%) disagreed with the assertion.

Empirical results on factors influencing cereal crop choice

Table 8 presents results of the multinomial logit model which indicated that 7 out of 16 explanatory variables used in the model were statistically significant at 10% level. The chi-square value of 173.113 show that likelihood ratio statistics are highly significant (p<0.0001) suggesting the model has high explanatory power. The pseudo R was 0.2885 indicating that the explanatory variable explained about 28.85% of the variation in choice of cereal crop. The results showed that age of the household head significantly influenced the likelihood of the choice of all cereals at 5% level in that for pearl millet the influence was positive, while for both sorghum and maize it was negative. They indicate that though by a small magnitude, the age of the household head increase the probability of choosing pearl millet and decrease the probability of choosing maize and sorghum. For instance a unit increase in age result in the 0.5% increase in probability of growing pearl millet, while a unit increase in age result in 0.1 and 0.4% decrease in the probability of growing maize and sorghum, respectively.

Farming experience is an important factor influencing decision to grow maize. Results show that households with farming experience of more than six years significantly (10% level) influenced the choice of growing maize in that a unit increases in the household with > 6 years farming experience result in the 27.81% increase in probability of growing maize. Four soil types out of the six existing in the area significantly influenced the choice of cereals though with different magnitudes. For example, a unit increase in households whose fields occupy sandy reddish fine soils (*Isang'ha*) (soil type1), result in the 12 and 10% increase the probability of growing pearl millet and sorghum, respectively. Contrastingly, soil type1 result in 22% decrease in the probability of growing maize. Whitish/Reddish soils (*Tifutifu*) (soil type 3) result in the 14 and 2% increase in the probability of growing pearl millet and maize, respectively; while it causes 17% decrease in the probability of growing sorghum. Red sandy soils (*Sanghamanya*) (soil type 4) cause 14% increase in the probability of growing pearl millet. On the contrary, it results in in the 0.4 and 13% decrease in the probability of growing maize and sorghum, respectively. Household owning fields with black or grey alluvial cracking soils (*Mbuga) (*soil type 6) faces a 36% decrease in the probability of growing pearl millet, while they realize an 22% and 15% increase in the probability of growing maize and sorghum, respectively. Thus, for example, when we want to promote sorghum and/or maize cultivation in the realm of soil diversity, targeting farmers with large land holding with clay soil type may be desirable. On the other hand when promoting the cultivation of pearl millet, the promoters should target farmers whose fields are dominated with sandy and

Table 9. Marginal effects from the multinomial logit on the choice of sorghum variety.

Explanatory variable	Landraces only		Improved variety only		Both improved and landrace	
AGE	-0.0038*	(-1.59)	-0.0023	(-1.36)	0.0061*	(2.31)
EDUC	0.0200	(1.34)	-0.0053	(-0.80)	-0.0148	(-0.99)
PLOTSIZE	0.0023	(0.62)	0.0017	(0.81)	-0.0041	(-1.04)
HSIZE	-0.0099	(-1.17)	-0.0042	(-0.81)	0.0141	(1.55)
FEXPERIENCE	0.3184**	(3.30)	0.0448	(1.84)	0.3632**	(3.80)
EXTNCNT	-0.0670	(-1.16)	0.0578*	(1.61)	0.1248	(1.97)
SUPPORT	0.0264	(0.32)	-0.0544	(-1.73)	0.0279	(0.33)
CLIMINFO	-0.1435**	(-2.72)	-0.0347	(-1.06)	0.1782**	(3.05)
TRAINING	0.0216	(0.28)	0.0870	(1.16)	-0.1087	(-1.25)

* denotes significance at 10%; ** denotes significance at 5%; *** denotes significance at 1%, Log likelihood = -147.42077; Prob(chi2)=0.0000; LR chi2(32)= 83.56;T-statistics in parentheses.

sandy loams.

The effect of access to weather forecasts/information prior to sowing was significant for pearl millet and sorghum in opposite directions. An increase in households with access to forecasted weather information result in decreased probability of growing pearl millet by 6% and increased the probability of growing sorghum by 9%.

Empirical results on factors influencing sorghum variety choice

Table 9 presents results of the multinomial logit model on sorghum variety choice. Age of household head significantly (10% level) influence the choice of sorghum varieties by farming households. It tends to decrease the probability of growing landraces and improved sorghum varieties but increases the probability of growing both improved and landrace sorghum varieties. For instance, a unit increase in age result in 0.4 and 0.2% decrease in the probability of growing landraces and improved variety, respectively. While a unit increase in age causes a 0.6% increase in the probability of growing both landrace and improved sorghum varieties. Farming experience significantly influences the decision to grow landraces only and both landraces and improved variety. Results show that households with farming experience of more than six years significantly (5% level) influenced the choice of growing landraces in that a unit increases in the household with > 6 years farming experience result in the 32 and 36% increase in probability of growing landrace and both improved and landrace sorghum varieties, respectively. The results may be prompted by the feeling that in drought prone areas such as central semi-arid Tanzania, growing improved varieties only may prove too risky, thus variety combination may be the best option. Elsewhere, similar findings show that sorghum landraces are more likely to produce under severe drought than improved early maturing sorghum variety (Cavatassi et al., 2011). Moreover, planting of different crop varieties is identified as an important means of combating crop losses from pests and diseases hence increasing productivity (Di Falco et al., 2007).

Farmers' reception of agricultural extension services in the previous two seasons significantly (10% level) influenced the probability of growing improved variety only. For instance a unit increase in number of household receiving extension services result in increase of probability of growing improved variety by 6%. Similarly, Abdulai and Huffman (2005) observed that the number of contacts with extension officers which is a proxy measure for access to agricultural information positively contributes to awareness and the subsequent adoption of new technologies. Access to weather forecasts/information prior to sowing was significant for households choosing to grow landrace only and households which grow both improved and landrace varieties in opposite directions. An increase in households with access to forecasted weather information result in decreased probability of growing landraces only by 14% and increased the probability of growing both improved and landrace by 18%.

CONCLUSION AND POLICY RECOMMENDATIONS

The multinomial logit model results indicated that farmers' choice or not of growing a particular cereal or sorghum variety during a growing season are dependent on different socio-economic factors and agro-ecological characteristics, of which the major ones were included for this study. Farmers' ownership of land with particular soil types, age, farming experience and access to weather forecast information significantly influences the choice of a crop. On the other hand, age, farming experience, extension contact and access to weather forecast information influences sorghum variety choices. In both scenarios of choices, other factors namely household size, education of household head, agricultural support, plot size and farmers' attaining training in the past two seasons had no significant influence on the crop and/or variety choices.

Results show that harvest and post-harvest processing losses, perceptions on food tastes and preferences, and problems with market access and prices variably and strongly influence farmers' decisions to grow sorghum. Moreover, agro-ecological alongside socio-economic factors and preferences have a significant influence on choices of growing drought tolerant cereals such as sorghum and pearl millet rather than maize. Findings indicate that crop variety combination is likely the best option in cushioning the production risks. Policies in support of promoting the cultivation of improved varieties alone need to be revisited as they do not seem to guarantee increased production and productivity of the three cereals in central semi-arid Tanzania.

Based on the analyses of farmers' perceptions and empirical results, different policy options could be suggested. These include, devising simple methods to ease bird scaring drudgery, promoting fortification of sorghum and pearl millet meals to enhance palatability and tastes, facilitating the availability of ready markets and means of cushioning prices to reduce prices fluctuations. Additionally, awareness creation is required on the use of threshing machines to ease the labour burden, improved neatness of the grain for emerging markets such as breweries and increased research on the potential of growing local landraces alongside improved crop varieties rather than relying only on improved varieties.

Conflict of Interest

The authors have not declared any conflict of interest.

ACKNOWLEDGEMENTS

Thanks are due to the Enhancing Climate Change Adaptation in Agriculture and Water Resources in the Greater Horn of Africa (ECAW) and The Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) project for funding the study.

REFERENCES

Abdulai A, Huffman WE (2005). The diffusion of new agricultural technologies: The case of crossbred-cow technology in Tanzania. American J. Agric. Econ. 87:645-659. http://dx.doi.org/10.1111/j.1467-8276.2005.00753.x

Ahmed MM, Sanders JH, Nell WT (2000). New sorghum and millet cultivar introduction in Sub-Saharan Africa: Impacts and research agenda. Agric. Syst. 64:55-65. http://dx.doi.org/10.1016/S0308-521X(00)00013-5

Alumira J, Rusike J (2005). The Green Revolution in Zimbabwe. Electronic. J. Agric. Dev. Econ. 2:50-66.

Bucheyeki TL, Shenkalwa EM, Mapunda TX, Matata LW (2010). Yield performance and adaptation of four sorghum cultivars in Igunga and Nzega districts of Tanzania. Comm. Biometry Crop Sci. 5:4-10.

Below TB, Mutabazi KD, Kirschke D, Franke C, Sieber S, Siebert R, Tscherning K (2011). Can farmers' adaptation to climate change be explained by socio-economic household-level variables? Gl. Env. Change 22:223-235. http://dx.doi.org/10.1016/j.gloenvcha.2011.11.012

Cavatassi R, Lipper L, Narloch U (2011). Modern variety adoption and risk management in drought prone areas; insight from the sorghum farmers of eastern Ethiopia: Agric. Econ. 42:279-292 http://dx.doi.org/10.1111/j.1574-0862.2010.00514.x.

Deressa T, Hassan RM, Alemu T, Yesuf M, Ringler C (2008). An Analysis of Determinants of farmer's choice of adaptation methods and perceptions. International Food Policy Research Institute (IFPRI), Washington, D.C. P. 2.

Di Falco J, Chavas P, Smale M (2007). Farmer management of production risk on degraded lands: the role of wheat variety diversity in the Tigray region, Ethiopia. Agric. Econ. 36(2):147-156. http://dx.doi.org/10.1111/j.1574-0862.2007.00194.x

Dixon J, Gulliver A, Gibbon D (2001). Farming systems and poverty: Improving farmers livelihoods in a changing world. FAO and World Bank, Rome and Washington, DC

Greene WH (2012). Econometric Analysis. Seventh edition. Prentice Hall, New Jersey.

Heiberger RM, Robbins NB (2014). Design of diverging stacked bar charts for likert scales and other applications. J. Stat. Soft. 57:1-32

Kahimba FC, Mutabazi KD, Tumbo, SD, Masuki, KF, Mbungu, FD (2014). Adoption and Scaling-Up of Conservation Agriculture in Tanzania: Case of Arusha and Dodoma Regions. Nat. Resour. 5:161-176. http://dx.doi.org/10.4236/nr.2014.54016 .

Kafle B (2010) Determinants of adoption of improved maize varieties in developing countries: A review. Int. Res. J. Appl. Basic Sci. 1:1-7.

Kaliba RMA, Verkuijl H, Mwangi W (2000). Factors affecting adoption of improved maize seeds and use of inorganic fertilizer for maize production in the intermediate and lowland zones of Tanzania. J. Agric. Appl. Econ. 32:35-47.

Kebakile MM, Mpotokwane SM, Motswagole BS, Lima de Faria M, Santo P, Domingues M, Saraiva C (2003*).* Consumer attitudes to sorghum foods in botswana.http://www.afripro.org.uk/papers/Paper12Kebakile.pdf cited 03/06/2014.

Ley GJ, Myaka FA, Heinrich GM, Nyaki AS (2001). Review of soil fertility and water management research, and farmers' production practices for sorghum and pearlmillet-based systems in Tanzania. International Crops Research Institute for the Semi-Arid Tropics. Bulawayo, Zimbabwe.

Liwenga ET (2003). Food Insecurity and Coping Strategies in Semiarid Areas: the Case of Mvumi in Central Tanzania, Stockholm Studies in Human Geography No. 11, PhD Dissertation, Stockholm University: Department of Human Geography. 186 pp.

Liwenga ET (2008). Adaptive livelihood strategies for coping with water scarcity in the drylands of central Tanzania. Phy. and Chem. of the Earth 33:775-779. http://dx.doi.org/10.1016/j.pce.2008.06.031.

MAFC (2010). Statistics Unit-Ministry of Agriculture, Food Security and Cooperatives. National Sample Census of Agriculture 2007/2008.

Mafuru JM, Norman DW, Langemeir MM (2007). Ex-Ante adoption analysis for improved sorghum varieties in the Lake Zone Tanzania. Afr. Crop Sci. Conf. Proc. 8:1215-1219.

Mbwaga AM, Riches CR, Gebissa E (2006). Integrated Striga management to meet sorghum demand in Tanzania. www.agry.purdue.edu/strigaconference/pdf/25-mbwaga.pdf accessed 4th June, 2014.

Monyo ES, Ngereza JA, Mgonja, MA, Rohrbach DD (2002). Adoption of improved sorghum and pearl millet technologies in Tanzania. International Sorghum Millets Newsletter 43:12-14.

SADC/ICRISAT SMIP (Southern African Development Community/ International Crop Research Institute for the Semi- Arid Tropics Sorghum and Millet Improvement Programme). (1998). Sorghum cultivars released in the SADC Region: Description and potential *uses*. Bulawayo, Zimbabwe: SADC/ICRISAT SMIP (Semiformal publication).

URT (2001). Agricultural Sector Development Strategy*.* United Republic

of Tanzania 70 pp.
URT (2013). Key Findings Household Budget Survey 2011/12 Tanzania Mainland. Final Report National Bureau of Statistics Tanzania. Colour printing Dar es Salaam Tanzania Limited.
Valipour M (2014a). Variations of irrigated agriculture indicators in different continents from 1962 to 2011. Adv. Water Sci. Technol. 01:01-14.
Valipour M (2014b). Future of agricultural water management in Europe based on socioeconomic indices. Acta Adv. Agric. Sci. 2(7):1-18.
Valipour M (2014c). Land use policy and agricultural water management of the previous half of century in Africa. Appl. Water Sci. DOI 10.1007/s13201-014-0199-1
Valipour M (2015a). Assessment of Important Factors for Water Resources Management in European Agriculture. J. Water Resour. Hydraulic Eng. 4(2):169-178.
Valipour M (2015b). What is the tendency to cultivate plants for designing cropping intensity in irrigated area?. Adv. Water Sci. Technol. 2(1):1-12.
Valipour M (2015c). Future of agricultural water management in Africa. Arch. Agron. Soil Sci. 61(7):907-927. DOI: 10.1080/03650340.2014.961433
Valipour M, Ziatabar AM, Raeini-Sarjaz M, Gholami SMA, Shahnazari A, Fazlola R, Darzi-Naftchali A, (2015). Agricultural water management in the world during past half century. Arch. Agron. Soil Sci. 61(5):657-678.
Waha K, Müller C, Bondeau A, Dietrich JP, Kurukulasuriya P, Heinke J, Lotze-Campen H (2012). Adaptation to climate change through the choice of cropping system and sowing date in sub-Saharan Africa. – Gl. Environ. Change.
Westengen OT, Brysting AK (2014). Crop adaptation to climate change in the semi-arid zone in Tanzania: The role of genetic resources and seed systems. Agric. Food Secu. 3:1-12.