

≈REVIEW PAPER≈

The potential role of sorghum in enhancing food security in semi-arid eastern Kenya: A review

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ABSTRACT

Successive droughts in Kenya compounded with other socio-economic constraints have led to persistently unstable and declining agricultural productivity in semi-arid eastern Kenya. This has given rise to the need to find coping strategies that would include growing alternative crops that are drought tolerant and thus suitable for the areas. Research in Kenya and elsewhere has shown that sorghum (*Sorghum bicolor* L. Moench) has the potential to end severe food insecurity in ASALs due to its tolerance to drought and ability to thrive under a wide range of soils. However, research and government policy in Kenya have shown a continual inclination to maize production in these areas though the crop is regarded a high risk option due to poor adaptation especially to the low rainfall. This paper reviews the potential of sorghum for improving food security in ASALs of Kenya with specific focus on semi-arid eastern Kenya. This will contribute to the ongoing debate to inform private and public sector policy and investments for increasing production of sorghum and other drought tolerant crops in the ASALs as a way of alleviating food insecurity and poverty.

Key words: ASALs, drought, sorghum, food security, poverty

INTRODUCTION

The agricultural sector is the largest contributor to the economies and livelihoods of many African countries. It accounts for 35 % of the continent's GDP, 40 % of export earnings and 70 % of employment (Nyage *et al.*, 2011). In Kenya, agriculture plays a vital role in development and is often referred to as the backbone of the economy. It is noted that agriculture is likely to remain the driver of the country's economic and social development for a long time (KV 2030, 2010). According to Miano *et al.* (2010), agriculture directly contributes 26% of GDP with a further 27% through linkages with agro-

based industries. The sector also accounts for 65 % of Kenya's total exports and provides more than 18 % of formal employment (GoK, 2009&2010). Recent estimates (GoK, 2010) show that the agricultural sector offers 70 percent of informal employment to Kenyans especially in the rural areas where most farming activities take place. In comparison, other sectors of the economy such as manufacturing, transport and communication contribute about 10 % to GDP (USAID, 2010). Considering the pivotal role that agriculture plays in the Kenyan economy, policies regarding development, food security and

agricultural enterprises including the type of crop to be produced should be guided appropriately. More focus should be directed on smallholder farmers who account for 75 % of total agricultural production and 70 % of marketed agricultural output in Kenya (FAO, 2007). Most of the smallholder farmers are found in areas considered arid or semi-arid. It is estimated that about 84 % of the country is arid or semi-arid and is not suitable for rainfed agriculture due to low and erratic rainfall. These areas also exhibit frequent crop failures and low crop and animal productivity (GoK, 2010). In addition to the declining parcels of land, smallholder farming is characterized by lack of markets for their products and weak representation in policy decision making processes. These make production and distribution of farm produce unreliable to meet consumer demands (KENPAF,

2009). Adeleke *et al.* (2010) categorizes African smallholder farmers on the basis of the agro-ecological zones in which they operate the type and composition of their farm portfolios and landholding and on the basis of annual revenue they generate from farming activities. In areas with high population densities, smallholder farmers usually cultivate less than one hectare of land, which may increase up to 10 hectares or more in sparsely populated areas, sometimes in combination with livestock of up to 10 animals. On the basis of farm revenue, smallholder farmers range from those producing crops only for family consumption to those who earn income from their farming enterprises. Table 1 show that the majority of farmers in Kenya can be categorized as smallholders with a land holding of less than two hectares.

Table 1: Categories of land holding in Kenya.

Attribute	Small holding		Medium holding		Large holdings	
Land size	0.2- 2 ha	2-10 ha	10-20 ha	20-60 ha	60-200 ha	200
No. holdings	2,928,240	599,740	41,040	27,360	1692	1908
% in sub-sector	83	17	60	40	47	53
Total holding	3,528,000		68,400		3600	
% in nation	81	17	12	12	0,05	0.06
Total area	3,200,000		1,040,000		2,700,000	
Average	0.9		15		750	

Source: GoK (2006)

Agro ecological conditions of Eastern Kenya: This review paper focuses on semi-arid eastern Kenya which includes Machakos, Makueni and Kitui counties (Fig. 1). The region is characterized by cyclical and persistent drought, sometimes going for two to three years at a stretch (Ongeko, 2011). Low agricultural productivity and erratic rains have also resulted in perennial food shortages in this region. For example in 2005 the average maize yield in Kitui was estimated at 0.06 ton/ha while the total cereal production was about 6661 metric tons as compared to the then annual cereal demand of 82,839

metric tonnes (FAO, 2007). During the same period, FAO estimated that the then Makueni district produced only 9 % of its annual cereal demand of 127,720 metric tonnes. With such low production, the poverty level in these areas is extremely high, increasing reliance on food relief for survival. It is estimated that 59.6% of the population in Machakos County live below the poverty line (GoK, 2011). Approximately 64% of the residents in Makueni County also live below the poverty line and this is attributed to low and unreliable rainfall. Poverty level in Kitui stands at 63.5 % (FAO, 2007; GoK, 2011).

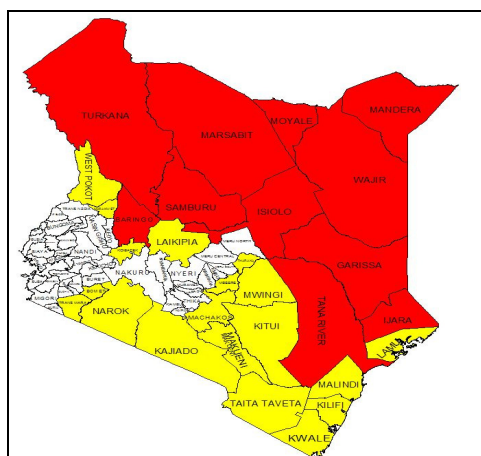


Figure 1: Map showing arid (red), semi-arid (yellow) and high potential (white) regions in Kenya.
Source: GoK (2004)

Table 2: Demographic data of Kitui, Makueni and Machakos counties.

Attribute	Kitui	Makueni	Machakos
Population	1,012,709	884,527	1,098,584
Surface area	30,496	8,009	6,208
Density (people per Km ²)	33	110	177
Poverty rate (%)	63.5	64.1	59.6
Annual rainfall	< 600mm	< 600mm	< 600mm

Source: Kenya Government, Commission on Revenue Allocation, (2011)

Food security challenges in Kenya: The world summit (1996) defined food security as existing when all people at all times have physical or economic access to sufficient and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 2009). FAO on the other hand defined food insecurity as a situation that exists when people do not have adequate

physical, social or economic access to food as it is the case in some parts of the world mainly in Africa (FAO, 2010). The food security situation in Kenya continues to deteriorate despite concerted attempts by stakeholders to address the situation.

Table 3: Extent of poverty in Kenya.

Year	Number of poor people (millions)	% of population
1990	11.3	48
1997	14.4	52
2000	16.9	56
2001	17.2	57

Source: GoK, 2006.

Food insecurity has been noted to be the main cause of the rising poverty levels in Kenya (Table 3; Kinyua, 2004). The number of the absolute poor increased from 10 million people in 1994 to 13.4 million in 1997 and by 2000

the overall poverty situation in Kenya was approximately 56 % of a population estimated at 30 million people. In 2011 the government of Kenya reported that about half of its estimated population of 38.5 million people were poor

and some 7.5 million people lived in extreme poverty while over 10 million people suffered from chronic food insecurity (GoK, 2011). It was also noted that communities in arid and semi-arid lands of the country were particularly vulnerable to food insecurity because of the recurring natural disasters of drought, livestock diseases, animal and crop pests and limited access to appropriate technologies, information, as well as credit and financial services (Kinyua, 2004). In common with the rest of the horn of Africa, drought is an inherent part of life in the ASALs of Kenya. It is reported that in the last decade drought episodes were experienced in 2001, 2003, 2006, 2009 and 2011 (Fitzgibbon, 2012). One dimension of the solution therefore lies in the adoption of indigenous crops that can withstand the harsh climatic conditions in the ASALs and thus improve food security in these regions (KARI, 2006; GoK, 2009).

Statistics by the Kenya Arid and Semi-Arid Lands programme (KASAL) indicate that between 2000 -2005, the Kenya government spent about £40-60 million annually on famine relief with NGOs spending an equal amount. In 2009 alone, approximately 10million Kenyans mainly in the ASAL areas needed food relief (KASAL, 2010). Increasing agricultural productivity would be the best long term solution towards poverty alleviation and enhanced food security in the ASALs. However this remains a major challenge especially due to the effect of climate change and variability that is likely to result in frequent and prolonged droughts with intermittent floods which are coupled with shorter recovery time. Despite persistent drought in the semi-arid parts of eastern Kenya, farmers have persisted on growing maize which is highly vulnerable to the harsh agro ecological conditions (Esipisu, 2011). In 2006 maize productivity in Machakos was estimated at 182.7 kg/ha which was much lower

compared to 299.6 kg/ha for sorghum (district planning unit Machakos, 2006). Even for sorghum, these yields are too low compared to the research potential of 4-5 tons/ha (KARI, 2006). This is due to low use of inputs by smallholder farmers as a result of high input prices among other factors (Muui *et al.*, 2013).

Current and past efforts to address food insecurity: It is noted that the first two decades after independence, the agricultural sector recorded the most impressive growth in sub-Saharan Africa averaging 6 % annually. This growth was underpinned by sustained government support to agricultural extension and research to support small-scale producers. The government also established and supported many agricultural institutions such as farmer cooperatives and agricultural inputs suppliers, marketing, credit and agro-processing industries. During that period the budgetary allocation to the agricultural sector averaged 3 % of the national budget (GoK, 2010). Currently, government support to the agricultural sector in terms of budgetary allocation is below 5 %.

As a means to curb food insecurity in Africa the Maputo declaration in 2003 saw every head of state commit to allocate 10 % of annual budget to agriculture. Unfortunately, by 2008, Kenya had managed to allocate only 4.5 % (GoK, 2010).The government of Kenya developed and launched the strategy for revitalizing agriculture in March 2004 in line with the economic recovery strategy. The strategy aims to transform Kenya's agriculture into profitable, commercially- oriented and internationally and regionally competitive economic activity that provides high-quality, gainful employment to Kenyans. The new approach represents a paradigm shift from subsistence to agriculture as a business that is profitable and commercially oriented (GoK, 2010)..

Table 4: Government of Kenya targets on poverty eradication by 2020.

Attribute	Year				
	2000	2005	2010	2015	2020
Population (million)	30.2	33.4	36.5	39.7	43.1
Poverty level (%)	56	60	26	10	0
No. of poor people (million)	16.9	20.1	9.5	4.0	0
Poverty level (%)	48.4	51.4	23.3	10	0
No. of hungry people (million)	14.6	17.2	8.5	4.0	0

Source: GoK (2006)

However, of concern was the fact that the strategy to revitalize agriculture did not put much emphasis on promotion of drought tolerant crop varieties for the arid and semi-arid regions in the country which accounts for over 80 % of the Kenyan land mass. As a way to curb food insecurity in Kenya, the government embarked on a special programme called njaa marufuku Kenya (NMK) that was intended to guide initiatives in improving food security of its 52 % food insecure population. This programme was developed in line with the millennium development goals (MDGs) whose objectives was to halve hunger and poverty in Kenya by 2015. It is however very important to note that even in this special programme, very little attention was given to drought tolerant crop varieties which have the potential to reduce food insecurity in the country (FAO, 2007). Table 4 presents the systematic plan to achieve these goals. In Kenya, it is estimated that 80 % of famine alarms are raised in the ASALs. KARI (2006) indicates that the semi-arid eastern Kenya is a major consumer of maize and the traditional maize varieties grown by the farmers are

poorly suited for the region. Growing of drought tolerant crops provides an opportunity for communities to better cope with climate change in the ASALs (Miano *et al.*, 2010). In support of this approach, the Ministry of Agriculture has been promoting adoption of “orphan crops” (such as sorghum and millets) to alleviate chronic food insecurity in ASALs as part of its strategy to revitalize agriculture (GoK, 2009). Falcon *et al.* (2010) describes “orphan crops” as those crops which are typically not traded internationally but which can play an important role in regional food security. The term has also been used to describe crops that receive little scientific research or funding despite their significance for food security in the world’s poorest regions. Research evidence shows that sorghum and millets are among the well adapted crops to the ASALs (Taylor, 2003). Unfortunately the response to the frequent famine alarms has not adequately exploited the available potential through increased production of these drought tolerant traditional food crops.

POTENTIAL OF SORGHUM FOR IMPROVING FOOD SECURITY IN KENYA

Sorghum (*Sorghum bicolor* L. Moench) is native to the tropical areas of Africa. The oldest cultivation records date back to 3000 B.C. in Egypt. Sorghum is produced throughout the tropical, semi-tropical and arid regions of the world. The crop is a self-pollinating plant and its drought tolerance is higher than that of corn. It is a member of the grass family graminea and can be categorized into four groups by application, i.e. grain, sweet, broom sorghum or grass sorghum. Grain sorghum is mainly used as a principal food in tropical areas and often used as raw material for alcoholic beverages, sweets and glucose. Broom sorghum on the other hand is for making brooms while sweet and grass sorghum is used to make sweetener syrup and green feed (U.S Grain Council, 2010). Sorghum is one of the most important drought tolerant crops and is often referred to as the camel of the plant kingdom (Fetene *et al.*, 2011). The plant has for a long time been noted to be the most important cereal for human consumption surpassed only by maize, wheat, rice and barley (Dicko *et al.*, 2006; Akram *et al.*, 2007). It is reported to be one of the main staple food crops for the world’s poorest and food insecure people (Timu *et al.*, 2012). Sorghum is a globally cultivated cereal unique due to its tolerance to drought, water logging and saline-alkali infertile soils and high temperature (Taylor, 2003). It has for a long time been

considered as a crop of the resource-poor small-scale farmers and is grown predominately in ASALs (USAID, 2010). In Kenya sorghum is ranked third after maize and wheat in terms of cereal production and has been noted to do well on a wide range of soils including those with very low fertility (Ashiono *et al.*, 2006; KIRDI, 2011). The potential of sorghum to catalyse regional development and improve food security is considerably high. Trade statistics from FAO indicate that in total Africa imports up to 1million tonnes of sorghum per year (USAID, 2010). Of concern, however, is the fact that despite the growing population in Kenya which mainly depend on cereal grains as their main diet, the sorghum sub-sector’s economic contribution at the micro and macro level is well below its potential. The reasons for the low performance include: low processing capacity, lack of ready market, low processing efficiency levels, and the crop being labour intensive. The crop is also vulnerable to attack by Quelea birds thus need daily scaring of birds, which increases the production costs (KIRDI, 2011). Farmers in the semi-arid areas often prefer to grow maize since it is less labour intensive and there is often a ready market even in the rural areas. There is also inadequate government support in promoting the production of sorghum inspite of its potential to improve food security and enhance economic development in the ASALs.

Comparatively more support is often given to maize and other “high value” crops like coffee and tea which earns

the country foreign currency.

Morphology, growth and development of sorghum in relation to ecological adaptation

Root system: The roots of the sorghum plant can be divided into a primary and secondary root system. The primary roots provide the seedling with water and nutrients from the soil. Primary roots have limited growth and their functions are soon taken over by the secondary roots. Secondary roots develop from nodes below the soil surface and constitute the permanent root system which branches freely and can reach a lateral distribution of 1m and a depth of up to 2 m early in the life of the plant. These roots are finer and branch approximately twice as

such as roots of maize plants and thus confer an advantage in access of water and nutrients from soils (Republic of South Africa, 2010). Roots distribution and root system structure are both affected by soil moisture and play an important role in the plants ability to survive drought situations. Plants having the ability to increase root growth into regions with more available soil water have better chances of survival under drought situations, since increased root growth re-establishes the soil-root contact and facilitates water uptake (Abdulai, 2005).



Figure 2: Photo showing secondary roots of sorghum. Source: Internet.

Leaves: Sorghum leaves are typically not as broad as maize leaves and also have a smaller leaf area. A unique characteristic of sorghum leaves is the rows of motor cells along the midrib on the upper surface of the leaf that can roll up leaves rapidly during moisture stress. Leaves are

covered by a thin wax layer and develop opposite one another on either side of the stem. Environmental conditions determine the number of leaves, which may vary from eight to 22 leaves per plant.



Figure 3: A photo showing sorghum leaves (source: Internet).

Stem: The stem of the sorghum plant is solid and dry, succulent and sweet. The internodes are covered by a thick waxy layer that reduces transpiration and increases

the drought tolerance of the plants. In adaptation to drought stress, the stem has no significant role such as that of leaves and roots. In many plants that grow in the

tropics (and in temperate-zone crops plants native to the tropics, such as maize, sugarcane and sorghum) a mechanism have evolved to circumvent the problem of wasteful photorespiration. The step in which CO₂ is incorporated into a three-carbon product, 3-phosphoglycerate, is preceded by several steps, one of which is a temporary fixation of CO₂ into a compound with four carbon atoms. These are referred to as C4 plants. These plants have high photosynthetic rates, high growth rates, low photorespiration rates, low water loss and unusual leaf structure. Photosynthesis in the C4 plants involves two cell types: mesophyll and bundle-sheath cells. It is from all these characteristics that make sorghum drought tolerant (Kakani *et al.*, 2011)

Sorghum varieties in Kenya; Drought events associated with climate change and climate variability have become more pronounced in Kenya in recent years adversely affecting the lives and livelihoods of smallholder farmers in ASALs (Miano *et al.*, 2010). Although there is great potential for development in the ASALs, the current picture is rather grim. However the future of ASALs need not to painted so bleak since these areas have enormous resources that can be harnessed not only to sustain themselves but also to contribute to national economic development. Focus on more drought tolerant crop varieties e.g. Sorghum has the potential to improve food security and contribute to economic growth. In terms of tonnage, sorghum has been reported to be Africa's 2nd

most important cereal. The continent produces about 20 million tonnes of sorghum per annum which accounts for a third of the total global sorghum production, (Taylor, 2003; KIRDI, 2011). In Kenya, sorghum is principally grown in the often drought-prone marginal agricultural areas of Eastern, Nyanza and Coast. USAID (2010) indicate that the major sorghum production areas are eastern province which accounts for 50.2 % of the total area of 104,041 hectares under sorghum production. The potential of sorghum to catalyse regional development and improve household food security is considerably high (USAID, 2010). Trials conducted in Kenya during the short rainy season showed that sorghum had the capacity to produce higher yields than maize due to its ability to produce grain even with minimal rainfall (Taylor, 2003). Dicko *et al.* (2006) indicated that the production of sorghum has been on the increase due to the introduction of improved sorghum varieties. Over the years, research institutions including KARI and ICRISAT have produced suitable dryland crops. This has resulted in the development of genetically superior cereal and legume crops in terms of yields, early maturity and drought tolerance or drought escaping and higher water use efficiency. Among the cereals, several varieties of sorghum have been developed and released. The common ones include KARI *Mtama 1*, *Gadam*, *Seredo* and *Serena* (Table 5) (KARI, 2006; Miano *et al.*, 2010).

Table 5: Sorghum varieties grown in Kenya.

Attribute	Variety			
	Serena	Seredo	Kari Mtama1	Gadam
Plant height	150-160cm	150-160cm	50-170cm	100-130cm
Flowering	69-78 days	65-77days	58-65 days	45-52 days
Maturity	110-120 days	110-120 days	95-100 days	85-95 days
Grain colour	Brown	Brown	White	Grey
Potential yield (kg/ha)	1800-2300	4000	1800-4000	1700-4500
Tolerance	Striga , drought	Drought	Drought	Pests, low rainfall
Pests	-	-	Quelea birds	Quelea birds

Source: KARI (2006)

Gadam sorghum variety was introduced by KARI to semi-arid Eastern Kenya in 2009 as a way for farmers to improve their food security and earn income. The hard-high yielding variety has not only thrived in harsh conditions, it has also won a place in the hearts of farmers in the region. The grain is high in starch and low

in protein, which makes it suitable for malting. It also offers a good alternative source of starch (Esipisu, 2011). In 2010 KARI estimated the demand for this variety of sorghum to be 60,000 metric tons due to the demand from East African Breweries Limited (EABL), the region's brewing giant but its production was estimated to be only

2,000 metric tons which was way below its potential. This shows there exists huge untapped potential. Production of Gadam sorghum, which is the most recommended in semi-arid eastern Kenya, could be important for improving food security as well. It is short, early maturing and is reported to survive and produce grain with

approximately 200mm rainfall (Esipisu, 2011). The low current production is due to the low adoption of these improved varieties, low use of fertilizers to boost soil fertility, dietary preferences, and low prices (Miano *et al*, 2010).



Figure 4: A photo showing Gadam sorghum, (left) (Photo source: M. Mwangi, KU) and KARI Mtama 1 (right) (photo source: Internet).



Figure 5: sorghum heads of the four most common sorghum varieties in Kenya, (photo source: KARI, 2006).

Government policies: The arid and semi-arid lands of the world make up to over 40 % of the earth's surface on which over one billion people depend for their livelihood (GoK, 2004). The arid and semi-arid lands in Kenya, which account for approximately 84 % of Kenya's land mass, are characterized by low and erratic rainfall thus leading to massive crop failures when non-drought tolerant crops are grown (FAO, 2007; GoK, 2010). Acknowledging that 60 % of the ASALs inhabitants live below the poverty line (GoK, 2004), MoA (2009) called for the urgent need to diversify livelihoods by adopting traditional crops that are known to do well in the areas. Kenya's agricultural sector is guided by the Agricultural Sector Development Strategy (ASDS), 2010-2020, which aims to increase agricultural productivity, commercialization and competitiveness of the sectors' commodities and enterprises to achieve national food security, increase exports for foreign exchange earnings and create employment opportunities (Kilambya and Witwer, 2013). The ASDS classifies sorghum as one of Kenya's main food crops, along with maize, rice, wheat, potatoes, cassava, vegetables and beans and puts forth several broad based strategies for increasing productivity and marketability of these crops. Before ASDS was developed, agricultural policy focussed on cash crops rather than staple food crops and even among food crops, more attention was paid to maize than other cereals.

Market initiatives: Sorghum is thinly traded due to low production volumes and poor marketing channels; only an estimated 30% of domestic production is marketed. Most farmers produce enough sorghum to meet their domestic requirements with little surplus to sell. In recent years, KARI in collaboration with East African Breweries Ltd (EABL) has been promoting the use of high quality sorghum varieties such as Gadam in beer production. This development has spurred renewed interest in the commercial production of sorghum, as it offers farmers prospects for higher returns (Kilambya and Witwer, 2013). In response to the brewing industry's demand for sorghum, KARI and Kenya's MoA have been promoting the production of high quality Gadam sorghum through the bulking and distribution of seeds to farmers under the Traditional High Value Crops (THVC) program, (MoA, 2012). The program aims to increase production and consumption of drought tolerant crops in the country's ASALs. It was initiated in 2006/07 financial year, mainly implemented through government funding of 150 million Kenya shillings per year. Though the trade is limited in Kenya, this is likely to change in the near future. Due to increased health concerns and awareness, the use of sorghum products has seen a gradual increase as reflected by the quantity and range of processed sorghum products sold in local supermarkets (Kilambya and Witwer, 2013).

Table 6: Sorghum trade and production in Kenya, 2005-2011 (tonnes).

Parameter	Year						
	2005	2006	2007	2008	2009	2010	2011
Production	150,127	131,188	147,365	54,262	94,955	164,066	159,877
Imports	10,948	16,691	5,105	3,301	58,822	10,035	37,613
Exports	734	97	919	892	1,503	49,706	276
Trade balance	-10,213	-16,594	-4,186	-57,320	-57,320	39,674	-37,337
Self-sufficiency ratio (%)	94	89	97	96	62	132	81

Source: MoA-ERA, 2009 & 2012

Current status of sorghum production and consumption in Kenya: According to USAID (2010) consumption of sorghum in Kenya increased from 1.1 million bags in 2004 to 1.5 million bags in 2008. The per capita consumption also increased from 2.6 to 3.8kg/ca within the same period. This increase in consumption is an indication that people in the ASALs are now realizing the potential of sorghum as a food security crop although

the adoption of improved sorghum varieties is still very low. Contrary to Dicko *et al.* (2006) report that the production of sorghum has been on the increase, the production in Kenya is low despite the introduction of new improved sorghum varieties which are high yielding. Taylor (2003) estimates that despite the potential of sorghum for improving household food security in the semi-arid tropics, Kenya produces only 0.6 % of the total

production in Africa. The yields of sorghum have been on the decline since 2006 due to several problems partly related to the post-election violence of 2007/08 and the low use of fertilizers to replenish soil fertility (GoK, 2010).

CONSTRAINTS TO SORGHUM PRODUCTION

Despite the potential of sorghum to improve household food security and promote regional development, the sorghum sub-sector is faced with numerous challenges. Findings by KIRDI in 2011 indicate that despite the growing population in Kenya which mainly depend on cereal grain as their main staple diet, the contribution of sorghum is well below potential. The problems are further compounded by inefficiencies in input and output marketing including poor market infrastructure, lack of marketing support services and limited market information (USAID, 2010; KIRDI, 2011). ReSAKSS synthesis report (2011) indicated that despite the significance of the agricultural sector as a primary source of livelihood, the sector is afflicted by several challenges which are especially predominant in the arid and semi-arid areas. The report pointed out that crop productivity has been below potential in recent years especially for sorghum. From this report it is evident that very little attention has been given to the sorghum sub-sector. In Kenya, the report indicated that only 18 hybrids of sorghum had been

However, with appropriate government policy, the full potential of sorghum in improving food security in the ASALs and catalyse regional development can become a reality.

released as compared to 164 improved maize varieties up to the year 2011.

Seed systems and markets: The agricultural sector development strategy, 2010-2020 also noted that the decline in productivity of orphaned crops was partly arising from low use of improved seeds due to poor distribution systems and the monopoly of the Kenya seed company which concentrates its operations in high rainfall areas (GoK, 2010). The other major problem facing the sorghum subsector is the dominant position of the single market provided by East African breweries for the Gadam sorghum which is widely grown by farmers in the semi-arid eastern Kenya. Although EABL has helped to address the problem of marketing, it has led to a situation where farmers do not have an alternative market to sell their surplus produce or grains that do not meet the standards set by EABL. Cases of grains below standard have been encountered due to seed impurities especially mixing of varieties common with commercially supplied seed lots (Miano *et al.*, 2010).



Figure 6: A sorghum Gadam field with stands of other sorghum varieties which were packed with the Gadam seeds. The plants (marked red) are of disproportionate height, (photo source: R. Mwadalu KU).

The other problem facing the sorghum sub-sector is an image problem where it is considered to be a food crop for the poor and vulnerable communities in the ASALs. As such its consumption in the urban areas is extremely low and many urban dwellers prefer maize thus lowering the market potential of sorghum. Interventions are necessary

to expand the market and increase acceptance of sorghum among the more financially endowed middle class residing in urban areas.

Diseases and pests: The frequent invasion by *Quelea* birds makes sorghum production more labour intensive which makes many smallholder farmers in the ASALs opt

for maize production, which has higher risk (Miano *et al.*, 2010). The red-billed Quelea, also called “pest bird” is a famous bird of the Sub-Saharan Africa with high populations which can devastate cereal fields and an

important criterion for farmers to reject white sorghum varieties without tannin (Habindavyi, 2009). Other biotic constraints that cause high losses in sorghum cultivation include stem borer and Cercosporiosis.



Figure 7: Red-beaked Quelea birds which feed on sorghum at the milking stage (left); Photo on the right shows Gadam sorghum head whose grain has been destroyed by Quelea birds.

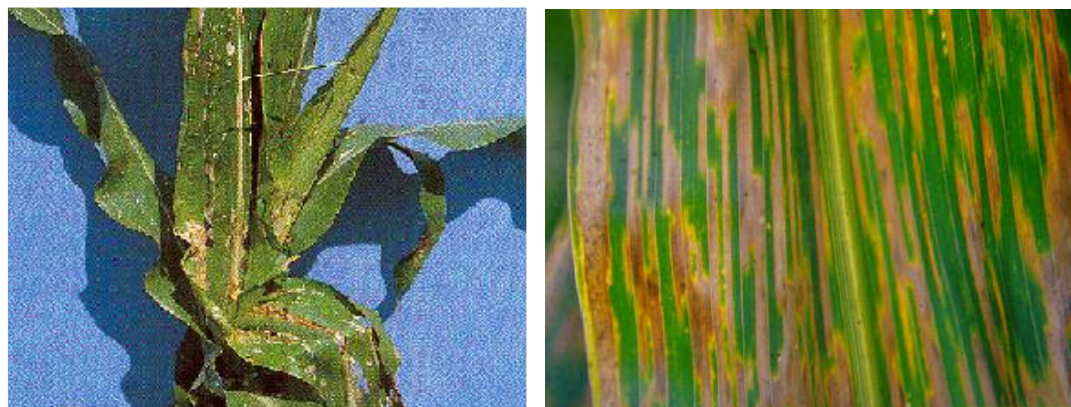


Figure 8: photos of stem borer in sorghum stem (left) and Cercosporiosis in sorghum leaves: Internet source.

Other problems facing the sorghum sector include reduced effectiveness of extension services. Total extension staff in agricultural ministries stood at 23,605 in 1983, and increased to 40,753 in 1994 then declined to 26,645 in 2002 and further down to 13,986 in 2005. Service delivery has been hampered by inadequate staff as the current staff to farmer ratio is 1:978 as compared to the FAO recommended ratio of 1:400 (GoK, 2006). As a result many smallholder farmers especially in the ASALs do not access important information on how to improve their crop productivity, which also contributes to the low crop production in the region. The effectiveness of Kenya's extension service system, specifically in regard to sorghum production, has declined due to low technology adoption rates caused by high poverty

indices, weak research-extension-farmer linkages and inappropriate technologies. Although a number of other stakeholders, particularly NGOs are now providing agricultural extension they are thinly spread and in some cases provide non-standardized messages, (GoK, 2006). While the intensity of fertilizer use has rapidly increased in other parts of the world, it has remained at a low level in SSA. For instance while it has increased from 38kg/ha in 1982 to 101kg/ha in 2002 in South Asia, it increased only from 7 to 8kg/ha during the same period in SSA. In Kenya, the withdrawal by the government from the fertilizer market and abandonment of price controls to encourage private investors increased the distribution of fertilizer in the market but led to an increase in the prices of inputs which are currently unaffordable to the

smallholder farmers in the country. The increase in fertilizer prices is largely affected by the prices in the international markets (Yamano & Arai, 2010), which limits government ability to intervene. In addition, sorghum

farmers have not benefited from the subsidized fertilizer scheme operated by the government compared to maize farmers.

Table 7: Trend of domestic fertilizer prices from 2000- 2008 in Kenya.

Fertilizer type	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
SSP	825	825	850	1100	1100	1100	1075	1650
TSP	1125	1150	1150	1500	1600	1680	1680	3400
DAP	1250	1125	1125	1500	1680	1700	1730	3800
CAN	875	850	900	1250	1350	1350	1375	2000
UREA	780	750	900	1250	1400	1450	1600	3100
NPK 20:20:0	1100	1075	1100	1350	1600	1600	1630	3000
NPK 17:17:17	1200	1200	980	1250	1400	1450	1620	3150
NPK 20:20:0	1050	1075	1100	1250	1350	1400	1450	3000
NPK 23:23:0	1100	1075	1065	1400	1600	1600	1630	3050

Source: Ministry of Agriculture, (2009)

Research shows that there is a positive relationship between the level of adoption of new technologies and the availability of credit (Ndambiri *et al.*, 2012). Availability of credit eases the cash constraints and allows farmers to purchase inputs such as fertilizer, improved varieties and irrigation facilities. Access to credit for Kenya's smallholder sorghum farmers from financial institutions is however limited by the fact that most farmers lack collateral to obtain loans and financial institutions also perceive farming in ASALs as a high risk undertaking.

CONCLUSION

The foregoing shows that sorghum has the potential to enhance food security in semi-arid areas where maize performs poorly. It is demonstrated that not enough is being done to tap into the potential of this crop in terms of government support to research, dissemination of research findings and promoting sorghum markets in Kenya and beyond. Lessons on improving food security

Agricultural policy in Kenya revolves around the main goals of increasing productivity and income growth especially for smallholders; enhanced food security and equity, emphasis on irrigation to introduce stability in agricultural output, commercialization and intensification of production especially among small scale farmers. There is no specific legal or regulatory framework for sorghum production, unlike other agricultural sub-sectors that have their own policy documents (Alila & Otieno, 2006).

through increased sorghum production can be drawn from India where the government launched the vision 2030 for sorghum. As a way forward, policies promoting sorghum production should be viewed beyond just enhancing household food security to also include other benefits that accrue to the economy at large.

REFERENCES

- Abdulai A L, 2005. Morphological and physiological responses of sorghum (*sorghum bicolor* L. Moench) to different patterns of drought, Rheinische Friedrich- Wilhelms Universitat zu Bonn, Ghana.
- Adeleke S, Kamara BA, Brixiova Z, 2010. Smallholder agriculture in east Africa: trends constraints and opportunities. Working paper No. 05. African development bank group.
- Agriculture, forestry and fisheries Department, republic of South Africa, 2010. Sorghum production guidelines.
- Akram A, Fatima M, Ali S, Jilani G, Asghar R, 2007. Growth, yield and nutrient uptake of sorghum in response to integrated phosphorus and potassium management. Pakistan Journal of Botany 39(4): 1083-1087.

- Alila P A and Atieno R, 2006. Agricultural policy in Kenya: Issues and Processes. Institute for Development Studies, Nairobi, Kenya.
- Ashiono G B, Ouma J P, Gatwiku, 2006. Farmyard manure as an alternative source in production of cold tolerant sorghum in the dry highlands of Kenya. *Journal of agronomy* 5(2):201-204.
- Commission on Revenue Allocation (CRA), 2011. Kenya county fact sheets. <https://www.opendata.go.ke>
- Dicko M H, Gruppen, Traore A S, Voragen A T, Berkel W H, 2006. Sorghum grain as human feed in Africa: relevance of content of starch and amylase activities. *African journal of biotechnology* 5(5): 384-395.
- District planning unit Machakos, 2006. Statistics on cereal production in Machakos district
- Espisu I, 2011. Gadam sorghum in semi-arid Eastern Kenya. <http://ipsnews.net/news.asp?idnews=55737> *Sorghum Proving Popular with Kenyan Farmers.*
- Falcon W P, Naylor R L, Fowler C, 2010. Studies at Stanford University. www.fsi.stanford.edu/research/orphancrops
- FAO Kenya, 2007. Food security profiles. District profiles for 23 districts, (pp. 28-34).
- Fetene M, Okori P, Mneney E, Tesfaye K 2011. Delivering new sorghum and finger millet innovations for food security and improving livelihoods in eastern Africa, Nairobi, Kenya.
- Fitzgibbon C, 2012. Economics of resilience study-Kenya country report
- Food and Agriculture Organization of the United Nations, (FAO, 2009. Food security and agricultural mitigation in developing countries: options for capturing synergies.
- Food and Agriculture Organization of the United Nations, 2010. The state of food security in the world: addressing food security in protracted crises
- Government of Kenya, 2004, National draft policy for the sustainable development of arid and Semi- Arid lands of Kenya
- Government of Kenya, 2006. Millennium Development Goals needs assessment report. Requirements for goal No. 1: Eradication of extreme poverty and hunger.
- Government of Kenya, 2009^a, national irrigation policy
- Government of Kenya, 2009^b. 10 years of fight against poverty (1999-2009). A report of the poverty eradication commission.
- Government of Kenya, 2010, National emerging crop policy
- Government of Kenya, 2011, National food and nutrition security policy
- Habindavi E, 2009. Morphological characterization of sorghum (sorghum bicolor) diversity in Burundi, CBM Swedish Biodiversity Centre, Uppsala University.
- Kenya Agricultural Research Institute, 2006. Variety, Characteristics and Production Guidelines of Traditional Food Crops
- Kenya Arid and Semi-Arid Land Programme (KASAL) 2010. Gadam sorghum production
- Kenya Industrial Research and Development Institute, 2011. Increasing sorghum utilization and marketability through food diversification.
- Kenya Ministry of Agriculture (MoA), 2012. *Economic Review of Agriculture (ERA)*.
- Kenya Ministry of Agriculture (MoA), 2012. *Traditional High Value Crops Program*. Journal of the Agricultural Industry in Africa. Agricultural Review Online. Retrieved from <http://www.agriculturalreviewonline.com/index.php/featured/68-featured/122-traditional-high-value-crop.html>.
- Kenya National Federation of Agricultural Producers (KENFAP), 2009. Report on sorghum Production in Kenya.
- Kenya vision 2030 online
- Kilambya D and Witwer M, 2013. Analysis of incentives and disincentives for sorghum in Kenya. Technical notes series, MAFAP, FAO, Rome.
- Kinyua J, 2004. Towards achieving food security in Kenya
- Miano M D, Karanja D, Mutuku R, Maina L, 2010. The role of the market in addressing climate change in arid and semi-arid lands of Kenya: the case of Gadam sorghum
- Ministry of Agriculture (MoA), 2009. Republic of Kenya. www.kilimo.go.ke
- Ministry of Agriculture (MoA), 2009. Food security in Kenya
- Muui C W, Muasya R M, Kirubi D T, 2013. Baseline survey on factors affecting sorghum production and use in Eastern Kenya. *African journal of food, agriculture, nutrition and development*: 13(1). African journal online.
- Ndambiri H K, Ritho C, Mbogoh S G, Ng'ang'a S J, Muiruri E J, Cherotwo F H, 2012. Assessment of

- farmers' adaptation to effects of climate change in Kenya. *Journal of economic and sustainable development*: 3(12). ISSN 2222-2855 (online).
- Nyage N E, Kingamkono R R, Kullaya A K Mneney E E, 2011. Biotechnology for sustainable agriculture, food security and poverty reduction in Africa.
- Ongeko T, 2011. Farmers in Makueni turn to drought tolerant crops, (source: coast week news)
- Regional strategic analysis and knowledge support system, (ReSAKSS). 2011. Technologies for enhancing the productivity of cereals, pulses, roots and tubers in the arid and semi-arid parts of Kenya.
- Taylor J R N, 2003. Overview: importance of sorghum in Africa
- Timu A G, Mulwa M R, Okello J, Kamau M, 2012. The role of varietal attributes on adoption of improved seed varieties. The case of sorghum in Kenya. Tegemeo institute of agricultural policy development, Nairobi, Kenya.
- U.S Grain council, 2010. White sorghum, the new food grain. Sorghum handbook: All about white sorghum.
- USAID, 2010. State of food value chain analysis. Country report Kenya
- Yamano T and Arai A, 2010. Fertilizer policies, price and application in east Africa. National Graduate Institute for policy Studies. Discussion paper 10-24.