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Value Chains for Sorghum and Millets in Eastern and Southern Africa: Priorities for the CGIAR research program for Dryland Cereals

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Executive summary and recommendations for priority setting

A clearer understanding of commercial utilization of sorghum and millets is required so that the priorities for crop improvement can be based on market demand. This report was prepared to help the CGIAR Research Program on Dryland Cereals set research priorities for ESA. It complements an earlier report in the same series (No. 35) that identified research priorities based on household consumption of sorghum and millet grain (Gierend and Orr, 2015). This report extends the analysis to identify research priorities among the value chains for animal feed, flour, and beer. Utilization was analysed with specific reference to Kenya, Tanzania, Uganda and Ethiopia, for which information on these value chains was readily available. Unless otherwise stated, estimates of current and potential utilization in this report refer to the total for these four countries.

The evidence is based on both secondary and primary data. For evidence on utilization at national level, we used national statistics on the production of animal feed, flour, and beer. Where this was not available, utilization was estimated from secondary studies of individual value chains. Interviews with value chain actors (including flour processors, brewers, and feed companies) provided information on quality standards, pricing, and constraints to the utilization of sorghum and millets. Primary data from 18 household surveys conducted by ICRISAT and research partners was used to estimate the commercialization of sorghum and millets at the household level.

Current utilization

The FAO Commodity Balance sheets show that 91% of sorghum and 89% of millets in these four countries are used as food, with the balance used as seed, animal feed, and waste. 'Non-food' uses are therefore minimal. Of the total used for food, about 10% of sorghum and 23 % of millets are 'processed' into food by the formal sector, and the rest consumed on-farm. The higher share of millets in the formal processing sector reflects its status as a cash crop. Currently, therefore, the share of sorghum and millets in ESA used by the commercial sector is small, and utilization is dominated by a single value chain that processes grain into flour.

Commercialization

Commercialization of sorghum and millets in ESA varied by country and by region within the same country. In Kenya and northern Tanzania over 60% of sorghum was sold, with the same being true for millets in central Tanzania and Uganda. However, in Ethiopia, Eritrea, Mozambique and central Tanzania, sorghum remained a subsistence crop with 30% or less being sold, while in Ethiopia, Eritrea and Mozambique less than 15% of millets entered the market. Commercialization benefitted poorer smallholders. In Kenya, where sorghum was sold to make sorghum beer, the share of sorghum sold by the smallest 50% of farms ranged from 14% to 39%. In central Tanzania and Uganda, where millets were sold to flour millers, the share of finger millet sold by the smallest 50% of farms averaged 40%. However, the mean quantity sold by smallest 50% of farms was small, averaging 159 kg per household for sorghum and 45 kg per household for millets.

Sorghum and Millet Flour

In 2015 the total production of sorghum flour was estimated at 315,000 t/year, and the utilization of millets at 153,000 t/year. Ethiopia is the biggest producer of sorghum flour (175,000 t/year or 56% of the total) while the production of millet flour is more evenly divided with Ethiopia, Tanzania and Uganda each producing about 45,000 t/year.

Animal feed

In 2015 the total production of animal feed was estimated at 638,000 t/year. Kenya was the biggest producer of animal feed (520,000 t/year or 82% of the total). Most feed is for poultry (for layers), followed by cattle. The main by-products used for feed are maize and wheat bran. None of the companies interviewed in Kenya used sorghum grain or bran as a source of animal feed because its higher price made it uncompetitive with wheat and maize.

Wheat flour

In 2015 the production of wheat flour was estimated at 2,314,000 t/year. Kenya and Ethiopia are the biggest producers, at 856,000 t/year (37%) and 771,000 t/year (33%), respectively. Sorghum can be mixed with wheat flour to produce composite wheat flour. Consumer taste preferences restrict the ratio of sorghum used to 5%. At present, there is no production of composite wheat flour in ESA.

Maize meal

Maize meal is the most popular flour in ESA. In 2015 the total utilization of maize by the formal sector for producing maize meal was estimated at 1,887,000 t/year. Consumer taste preferences restrict the ratio of sorghum used to 5%. At present, there is no production of composite maize and sorghum meal in ESA.

Opaque beer

Only in Uganda does the formal sector brew opaque bee; elsewhere, it is brewed by the informal sector. In 2015 utilization of sorghum for opaque beer in the formal sector was estimated at 2,000 t/year.

Clear beer

In 2015 the total utilization of sorghum for clear (lager) beer was estimated at 39,000 t/year. Kenya was the biggest user of sorghum for beer (24,000 t/year or 62%) followed by Uganda (11,000 t/year or 28%). in order to compete with traditional brews from the informal sector, commercial production of sorghum beer requires a reduction in the excise duty on beer. The number of smallholders involved in this value chain is estimated at 13,000, or about 0.6 % of the total number of sorghum growers in Kenya, Kenya, Uganda, and Tanzania.

Recommendations for priority setting

Millets

1. The highest-priority value chain for millets is the value chain for millet flour, targeted at urban consumers. Based on current urban consumption in 2015, plus a conservative assumption of a 10 % growth in urban demand, we estimate potential utilization of millet flour will reach 169,000 t/year by 2025.
2. Research to meet this projected growth in demand for millet flour should focus on Ethiopia, Tanzania, and Uganda, where average utilization is projected to reach about 50,000 t/year by 2025. By contrast, demand in Kenya by 2025 will average only 21,000 t/year.
3. Demand for millet flour can be boosted by marketing millet as a Smart Food targeted at high-income urban consumers. Smart Food products include weaning foods, bread, and gluten-free flours. Middle-class consumers in ESA spend 32-41% of food expenditure on 'high-value' processed products. By 2040, demand for processed food products by middle-class consumers in ESA is projected to reach $53-67 billion per year.
4. The potential utilization of millet in value chains other than flour is limited by the high relative price of millet, which makes it uncompetitive with maize and wheat. This prevents the potential utilization of millets in the value chains for animal feed, wheat flour, and maize meal. Consequently, these value chains are a low priority for research on millets in ESA.

Sorghum

1. Based on current utilization, the highest-priority value chain for sorghum in ESA is the value chain for sorghum flour. Based on the level of consumption in 2015 and assuming a modest 10% growth in urban demand, the utilization of sorghum grain for flour was projected to reach 347,000 t/year by 2025. Research to meet this growth in demand for sorghum flour should focus on Ethiopia, where utilization is projected to reach 193,000 t/year by 2025 (56% of the total), followed by Tanzania with 95,000 t/year (27%). Utilization in Kenya is projected to reach 17,000 t/year.
2. The second highest-priority value chain for sorghum in ESA is the value chain for clear (lager) beer. Assuming that past growth in consumption can be sustained and a favourable tax regime, utilization of sorghum for clear (lager) beer is expected to reach 69,000 t/year by 2025. Research to meet this growth in demand should focus on Kenya (49,000 t/year or 71% of total utilization) and Uganda (17,000 t/year or 39%). The value chain for opaque sorghum beer is a low research priority because production by the formal sector exists only in Uganda and the projected utilization by 2025 is small (3,000 t/year).
3. Sorghum utilization (unlike millets) has the potential to expand into the value chains for animal feed, wheat flour, and maize meal. However, this expansion in utilization will require that the price of sorghum grain is 15-20% lower than the prices for maize and wheat. Provided that this pre-condition is met, the commercial utilization of sorghum in ESA can be significantly increased.
4. Assuming a price discount of 15-20% and that sorghum can substitute for 10% of the maize used, we estimate that by 2025 the potential demand for sorghum in the value chain for animal feed can reach 64,000 t/year. Research to meet this projected increase should focus on Kenya, where projected utilization can reach 52,000 t/year (81% of the total).

5. Assuming a price discount of 15-20% and that sorghum can substitute for 5% of wheat flour, we estimate that by 2025 the potential demand for sorghum in the value chain for wheat flour can reach 148,000 t/year. Research should focus on Kenya and Tanzania, where potential utilization is projected to reach about 50,000 t/year in each country (68% of the total).
6. Assuming a price discount of 15-20% and that sorghum can substitute for 5% of maize flour, we estimate that by 2025 the potential demand for sorghum in the value chain for maize meal can reach 94,000 t/year. Research should focus on Tanzania and Kenya, where potential utilization is projected to reach 37 and 38,000 t/year (80 % of the total).
7. Assuming a continued in increase in the price for teff in Ethopia, and that sorghum can substitute for 10% of teff flour, we estimate that by 2025 the potential demand for sorghum in the value chain for teff flour in Ethiopia can reach 98,000 t/year.
8. If sorghum utilization can be expanded to these new value chains, this will change the ordering of research priorities. The research priorities now become (1) sorghum flour (2) composite wheat flour (3) composite teff flour (4) composite maize meal (5) clear (lager) beer, and (6) animal feed.

The conventional wisdom is that sorghum and millets in ESA are stuck in a 'subsistence trap' where low yields limit supply which in turn limits market demand. In this view, the solution is to raise yields, which will in turn increase demand by improving supply and reducing prices. But this diagnosis does not fit the value chains for specialty flours, clear beer, and for teff, where demand for sorghum and millets has risen not because of higher yields but because of consumer preferences, changes in relative prices, and a favourable policy environment. This suggests the need to re-think ICRISAT's model of commercialization for dryland cereals in ESA.

Keywords: Sorghum; millets; value chains; Sub-Saharan Africa.

JEL classification: Q10, Q13.

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Acronyms

ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
BGI	Brasseries et Glacieres Internationale (BGI Ethiopia)
BMGF	Bill & Melinda Gates Foundation
CGIAR	Consultative Group for International Agricultural Research
EABL	East African Breweries Limited
EIAR	Ethiopian Institute of Agricultural Research
ESA	Eastern and Southern Africa
FAO	Food and Agriculture Organisation of the United Nations
FGD	Focus Group Discussion
KALRO	Kenya Agricultural and Livestock Research Organisation
KEBS	Kenya Bureau of Standards
HOPE	Harnessing Opportunities for Productivity Enhancement
ICDC	Industrial and Commercial Development Corporation
ICRISAT	International Crops Research Institute for the Semi Arid Tropics
MIC	Middle Income Country
NBA	National Biosafety Authority (Kenya)
PPP	Purchasing Power Parity
RATES	Regional Agriculture Trade Expansion Support Program
SSA	Sub-Saharan Africa
TBL	Tanzanian Breweries Limited
UFCL	Unga Farm Care Limited
VAT	Value Added Tax
QPM	Quality Protein Maize
WCA	West and Central Africa
WHO	World Health Organisation

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1. Introduction

Sorghum and millets are important cereal crops in Eastern and Southern Africa (ESA). Although in some areas a significant share of these crops is sold, they are primarily subsistence crops grown for home consumption. In India, sorghum and millets have increasingly become commercial crops that supply the grain milling and livestock feed industries. In ESA, only in South Africa is sorghum a commercial crop, grown on large farms for the milling industry. What are the prospects for the commercialization of sorghum and millets in ESA by smallholder farmers?

Opportunities for commercialization in ESA are driven by four factors (Jayne et al. 2013). The first is urbanization. ESA is urbanizing rapidly. Already by 2015, the share of the total population that was urban reached 32 % in Tanzania, 26 % in Kenya, 19 % in Ethiopia, and 16 % in Uganda. By 2050, the urban share of the population is projected to reach 53 % in Tanzania, 44 % in Kenya, 38 % in Ethiopia, and 32% in Uganda (United Nations, 2014). In ESA, between 2013 and 2050 the urban population will rise from 23% to 45 % (Orr et al., 2016). In ESA, between 2013 and 2050 the urban population will rise from 23% to 45 % (Orr et al., 2016). In terms of absolute numbers, in 2015 the combined urban population of Kenya, Ethiopia, Uganda and Tanzania was 54 million. This is projected to reach 86 million by 2025, and 215 million by 2050 (United Nations, 2014). Urbanization will increase the size of the domestic market for food, especially staple food grains.

The second driver is the rapid rise in food imports. Demand for food grains in ESA has outstripped domestic supply, creating a structural deficit that has been met by rising imports of rice and wheat. The region has a small trade surplus in millets but is a net importer of sorghum (Orr et. al., 2016). This trade deficit creates opportunities for local producers to fill the unmet demand for food grains currently met by imports. The third driver is rising incomes and changing food patterns. If current growth rates continue, by 2025 Kenya, Uganda, and Tanzania will be Middle-Income Countries (MICs) with average incomes of over $1000 per head (Fengler, 2013). Higher average incomes will increase demand not only for staple food grains but also for alcoholic beverages, meat and poultry. This will increase opportunities for new uses of sorghum, including clear beer and livestock feed. Finally, urbanization and ‘westernized’ diets will increase the health risks from obesity, heart disease, and diabetes, particularly among urban, middle-class consumers. This will create opportunities for the development of sorghum and millet health-foods (Smart Foods) that offer alternatives to diets based on maize, wheat and rice.

Sorghum and millets have been seen as victims of a ‘subsistence production trap’ (Rohrbach and Kiriwaggulu, 2001a). On the supply side, the lack of a commercial market for these crops discourages investment in new technology to increase yields. On the demand side, the development of a commercial market is discouraged by low yields and the lack of a consistent marketable surplus. The result is a low-level equilibrium trap for both sellers and buyers. To escape this trap, buyers must offer incentives to growers that will encourage them to expand production to meet this new market demand, while research and development (R & D) must be designed to meet the requirements of these new users. In order to prioritize R & D, the CGIAR research program on Dryland Cereals must identify the value chains for sorghum and millets that offer the greatest potential and highest return for its research investments.

The general objective of this report is to identify priorities for the CGIAR research program by reviewing the available information on the current and potential demand for sorghum and millets in the value chains for livestock feed, flour, and beer in ESA. The specific objectives of this report are to measure:

1. The commercialization for sorghum and millets at household level;
2. The current and potential scale of demand for sorghum and millets in the value chains for flour and beer; and
3. The potential scale of demand for sorghum and millets in the value chains for animal feed, teff flour, composite wheat flour, and maize meal.

In this report the value chain for biofuel is not considered, on the grounds that the shortage of arable land in ESA makes it more profitable to produce crops for food rather than for biofuel. Mozambique, which has a large land frontier, is a possible candidate for biofuels. However, a preliminary assessment concluded that the prospects for sorghum as source of biofuel in Mozambique were limited because the mandatory blending requirement was not yet in place and sugarcane was a more competitive source of biofuel than sorghum (Orr et al., 2013a). Mozambique and Tanzania suggests that biofuels can have a positive impact on economic growth but that expanded social protection programs will be needed to counter the negative impact of higher food prices (Arndt et. al., 2010). A recent ICRISAT analysis for India, where the mandatory blending requirement is 5%, suggests that the competitiveness of sweet sorghum with sugarcane depends critically on the price of ethanol and the recovery rate of ethanol from sweet sorghum (Basavaraj et. al., 2012). Currently, sweet sorghum in India is uncompetitive with sugarcane.[1]

The report focuses on four countries – Ethiopia, Kenya, Uganda, and Tanzania – for which information on chains for sorghum and millets was readily available. Sudan and Mozambique are also important producers of sorghum in the region, but information on the utilization of sorghum and millets in the value chains for these countries would require the collection of primary data on a scale that was beyond the scope of this report.

The report is organized as follows. The second section presents an overview of the results. Section 3 summarizes available information from household surveys on the commercialization of sorghum and millets at the household level. The next three sections provide information on the demand for sorghum and millets by the value chains for animal feed, flour, and beer. The final section concludes.

[1] Sweet sorghum is uncompetitive with sugarcane at the current recovery rate of 4.5% and at the current administered ethanol price of Rs 27 per liter. Ethanol production from sweet sorghum becomes profitable when the recovery rate rises to 4.9 % or the administered price for ethanol rises to Rs 36 per liter (Basavaraj et. al., 2012).

2. Overview

This section brings together the results from the analysis of individual value chains to present an overview that compares the utilization of sorghum and millets, by value chain and by country.

Table 1 summarizes the current and potential utilization for sorghum and millets as well as the assumptions on which the projections for potential utilization are based. The results show that:

1. At present, commercial utilization is confined to the value chains for flour (sorghum and millets) and beer (sorghum). Potentially, the utilization of sorghum could expand to include the value chains for animal feed, maize meal and wheat flour. However, this would depend on a sorghum price that was 15-20% lower than the price of maize or wheat and the continuation of a favourable tax regime for sorghum beer. Potential utilization of millets will remain confined to flour because its higher price prevents utilization in other value chains.
2. Current utilization of sorghum and millets in the value chains for flour, animal feed and beer in 2015 was estimated at 509,000 t, of which 356,000 t (70%) was sorghum and 153,000 t (30%) was millets. Potential utilization of sorghum and millets in these three value chains by 2025 was estimated at 992,000 t, or 95 % above the current level. The main potential increase was for sorghum, which rose by 130 % to reach 823,000 t, while millets rose by 11% to reach 169,000 t.
3. The value chain with the highest potential utilization of sorghum was the value chain for sorghum flour (347,000 t) followed by the substitution of sorghum for wheat flour (148,000 t) and for maize meal (94,000 t), and the value chains for clear beer (69,000 t), animal feed (64,000 t), and opaque beer (3,000 t). The value chain with the highest potential utilization of millets was the value chain for millet flour (169,000 t).

Table 2 shows current and potential utilization in the three value chains as a share of current supply. The results show that:

1. Current utilization (in 2013) accounted for just 6 % of the total current supply of sorghum and 11% of millets. When potential utilization is projected to 2025, utilization of sorghum increases to 15 % of current supply while utilization of millets increases to 12%. Despite potential growth in demand from these value chains, therefore, sorghum and millets in ESA will remain primarily subsistence crops.
2. Utilization by the value chains for flour, animal feed, and beer can be met from current supply. The exception is sorghum in Kenya, where utilization in 2025 is projected to reach 210,000 t per year, which is well above the current supply of 145,000 t. Meeting projected demand for sorghum in Kenya will require imports from neighbouring countries such as Uganda and Tanzania.

Table 1: Commercial grain demand and potential utilization of sorghum and millets, 2013, by value chain and country (000 t of grain)

Value Chain	Estimated annual utilization 2015			Potential utilization by 2025		Assumptions
	Total	Sorghum	Millets	Sorghum	Millets	
Sorghum and millet flour [1]						1. Current urban consumption, plus 10%. 2. Successful marketing of Smart Foods.
Ethiopia	218	175	43	193	47	
Kenya	37	16	21	17	23	
Tanzania	133	87	46	95	51	
Uganda	82	38	44	42	48	
Sub-total	468	315	153	347	169	
Maize meal [2]						1. 5% substitution of maize. 2. 15-20 % price discount.
Ethiopia	19	0	0	1	0	
Kenya	738	0	0	37	0	
Tanzania	745	0	0	38	0	
Uganda	365	0	0	18	0	
Sub-total	1887	0	0	94	0	
Wheat flour [2]						1. 5 % substitution of wheat. 2. 15-20 % price discount.
Ethiopia	987	0	0	49	0	
Kenya	1096	0	0	55	0	
Tanzania	576	0	0	29	0	
Uganda	303	0	0	15	0	
Sub-total	2962	0	0	148	0	
Teff flour						1. Teff prices rise 2. 10% substitution of teff.
Ethiopia	491	0	0	98	0	
Animal feed [2]						1. 100% substitution of maize. 2. 10 % of current feed production. 3. 15-20 % price discount.
Ethiopia	27	0	0	3	0	
Kenya	520	0	0	52	0	
Tanzania	60	0	0	6	0	
Uganda	31	0	0	3	0	
Sub-total	638	0	0	64	0	
Opaque beer [3]						1. Past growth in beer production is sustained.
Ethiopia	0	0	0	0	0	
Kenya	0	0	0	0	0	
Tanzania	2	2	0	3	0	
Uganda	0	0	0	0	0	
Sub-total	2	2	0	3	0	
Clear beer [3]						1. Past growth in beer production is sustained. 2. Favourable tax regime.
Ethiopia	0	0	0	0	0	
Kenya	24	24	0	49	0	
Tanzania	2	2	0	3	0	
Uganda	11	11	0	17	0	
Sub-total	39	39	0	69	0	
Grand total		356	153	823	169	

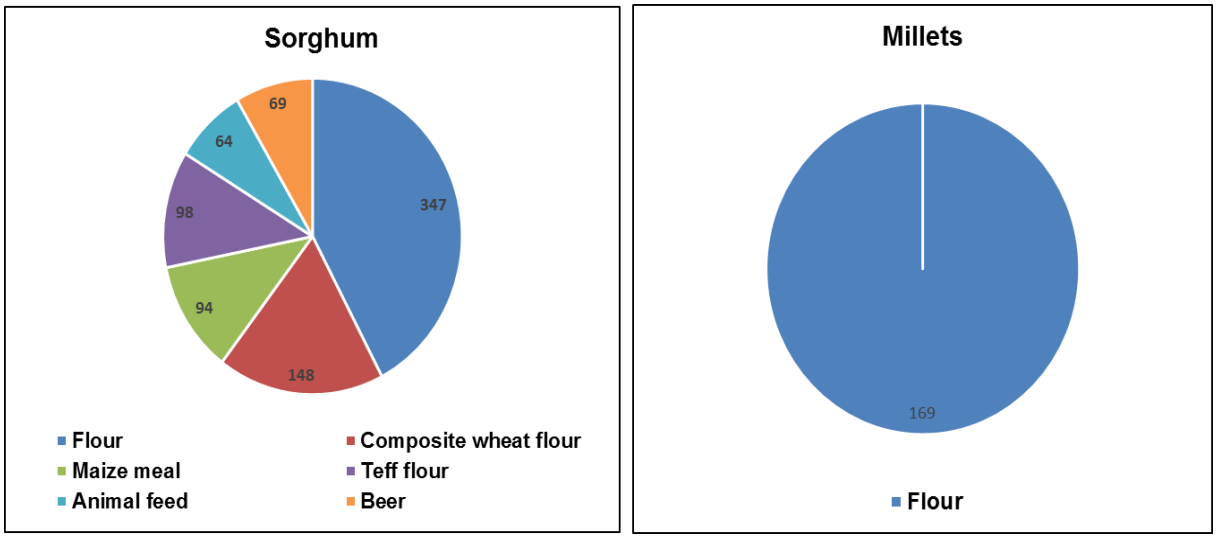
Sources: [1] Table 23 below [2] Table 20 below [3] Table Table 17 below; [4] Table 28 below.

Table 2: Current and potential utilization of sorghum and millets as a share of supply, ESA (000 t)

Country/ value chain		Utilization (000 t)		Utilization as share of supply (%)	
	Available supply	Current (2013)	Potential (2025)	Current (2013)	Potential (2025)
Sorghum					
Ethiopia	4,282	175	344	4	8
Kenya	145	40	210	28	145
Tanzania	832	89	174	11	21
Uganda	319	49	95	15	30
Total	5,578	353	823	6	15
Millets					
Ethiopia	807	43	47	5	6
Kenya	79	21	23	27	29
Tanzania	319	46	51	14	16
Uganda	227	44	48	19	21
Total	1,432	153	267	11	12

Source: Table 1.

Figure 1: Potential utilization of sorghum and millets, ESA, 2025 (000 t)



Source: Table 2

Table 3 shows potential utilization of sorghum and millets by country. Ethiopia tops the list with a potential utilization of 297,000 t (32 % of the total), followed by Kenya (27%), Tanzania (25%) and Uganda (16%). Kenya was projected to have the largest utilization of sorghum and millets in the value chains for composite wheat flour, livestock feed, beer, and maize meal. In three countries – Ethiopia, Tanzania, and Uganda – the greatest demand for sorghum and millets was projected to lie in the value chain for flour.

Table 3: Potential utilization of sorghum and millets by 2025, by country (000 t)

Country	Animal feed	Flour	Composite wheat flour	Maize meal	Beer	Total	Total (%)
Ethiopia	3	240	49	1	0	297	32
Kenya	52	49	55	37	49	232	27
Tanzania	6	146	29	38	6	202	25
Uganda	3	90	15	18	17	141	16
Total	64	525	148	94	72	903	100

Source: Table 1.

By and large, the findings in this report echo those of earlier studies conducted by ICRISAT in the 1990s (Rohrbach, 1991a,b; Rohrbach and Kiriwaggulu, 2001a). The reason is simple. The structural conditions of smallholder agriculture remain unchanged. There are three main reasons for this:

1. Sorghum and millets remain low-yielding food grains. Even in favourable seasons, average yields are lower than the average yield for maize;
2. Lower yields for sorghum and millets translate into higher prices (particularly for millets) compared to maize and imported wheat. This makes them uncompetitive with maize as a source of animal feed and meal; and
3. The lower price of maize and the preference for imported wheat among higher-income consumers mean that the growth in urban markets has not resulted in a proportionate growth in demand for sorghum and millets.

Traditionally, therefore, the commercialization of sorghum and millets has been confined to specific market niches, such as opaque beer (sorghum or red pearl millet) or specialty products such as weaning foods for children (millets).

Recently, however, new opportunities have emerged for commercialization. One significant change has been the development of the value chain for sorghum clear (lager) beer, first in Uganda, then in Kenya and in Tanzania. Potentially, the value chains for composite wheat flour, teff flour, and maize meal offer larger markets than sorghum beer. The growth of Africa's middle class has increased consumer spending on processed and higher-value foods like millet flour. These developments suggest the need to re-examine the potential for the commercialization of sorghum and millets in ESA.

3. Commercialization

3.1. Introduction

The commercialization of sorghum and millets has the potential to benefit smallholders by increasing their cash income. However, smallholders are not a homogeneous group. The effectiveness of these new value chains in reducing poverty will depend on the distribution of benefits, and in particular on the share of benefits going to poorer smallholders. In this section, we review the available evidence to determine the distribution of cash income from the current pattern of sales of sorghum and millets.

3.2. Survey data

The evidence is based on data from 18 household surveys collected by ICRISAT, research partners, and other research centres in ESA (Table 4). The 18 surveys cover seven countries: Ethiopia (6 surveys), Eritrea (2), Kenya (2), Mozambique (1), Tanzania (3), Uganda (1) and Sudan (2). The surveys cover three crops: sorghum (10 surveys), pearl millet (4), finger millet (3), and teff (3). These surveys are not nationally representative, but special-purpose surveys conducted in areas where sorghum, millets or teff are widely grown. They cover a range of crop years (2004 to 2013), and vary in their sample size (70-1,200 households) and survey design. Further details on survey design and sampling may be found in the references to the survey reports given in Table 4. Unfortunately, no reports were available for the six surveys conducted by ICRISAT and national partners as part of a project funded by ASARECA, and no information was therefore available on their survey design. However, we included them in this analysis because they are the only surveys on these crops available for Sudan and Eritrea. All six surveys were conducted using the same questionnaire. ICRISAT obtained and cleaned the survey data to produce a set of tables that included information on crop utilization.

Table 4: Household surveys, sorghum, millets and teff, ESA 2008-2015

No.	Country	Districts	Crop Focus	Year of survey	Crop year	Sample size	Organisation	Source
1	Ethiopia	Miesso, Kobo	Sorghum	2011	2010	260	ICRISAT/ EIAR	Bekele et. al. (2012).
2	Ethiopia	Shalla	Finger millet	2011	2010	130	ICRISAT/ EIAR	Bekele et.al. (2012)
3	Ethiopia	Oromia, Amhara regions	Sorghum	2008	2007	220	AFRINT II (2008)	Djurfeldt et. al. (2011).
4	Ethiopia	Oromia, Amhara regions	Teff	2008	2007	70	AFRINT II (2008)	Djurfeldt et. al. (2011).
5	Ethiopia	Adaá-Liben, Alaba	Teff	2005	2004	170	ILRI	Gebremedhin and Hoekstra, (2008).
6	Ethiopia	'Five zones with highest commercial production'	Teff	2011	2012	1,200	IFPRI	Minten et. al,. (2013).

7	Eritrea	Gas Barka, Anseba	Pearl millet	2011	2010	300	ICRISAT/ ASARECA	None
8	Eritrea	Gash Barka	Sorghum	2011	2010	300	ICRISAT/ ASARECA	None
9	Kenya	Meru South, Tharaka South, Mwingi Central, Kibwezi	Sorghum	2013	2011-12	480	ICRISAT/ Africa Harvest	Marangu et. al. (2014).
10	Kenya	Kitui (Nzambani, Katulani, Lower Yatta)	Sorghum	2013	2012	297	ICRISAT	Orr et. al. (2013b).
11	Mozambique	Marara	Sorghum, Pearl millet	2014	2013	142	ICRISAT	Tsusaka et. al. (2015).
12	Tanzania	Kondoa, Singida Rural	Sorghum, millets	2011	2009	363	ICRISAT	Schipmann et. al. (2013).
13	Tanzania	Iramba, Singida Rural, Kongwa, Kondia, Serengeti, Moshi Rural, Mwanga, Same, Rambo	Sorghum	2012-13	2011	914	ICRISAT/ Sokoine University	Hella et. al. (2015).
14	Tanzania	Bahi Moshi Moshi Rural Mwanga Same Singida Rural	Sorghum	2012	2011	386	ICRISAT/ ASARECA	None
15	Tanzania	Singida, Kondoa, Kishapu	Pearl millet	2011	2010	360	ICRISAT/ ASARECA	None
16	Uganda	Lira, Kole, Serere	Finger millet	2015	2014	190	ICRISAT	Mwema et. al. (2017).
17	Uganda	Kumi, Katakwi, Abim	Sorghum	2011	2012	238	ICRISAT/ ASARECA	None
18	Sudan	Elnhood Elkhwie Shieken	Pearl millet	2011	2010	101	ICRISAT/ ASARECA	None

Source: own table

3.3. Utilization

Information on crop utilization was obtained from the original survey reports. Where this information was not contained in the survey report, it was calculated from the original data.

Sorghum

Table 5 summarises the utilization of sorghum revealed by the survey data. The data shows average utilization per household.

Table 5: Sorghum utilization from household surveys (kg/household)

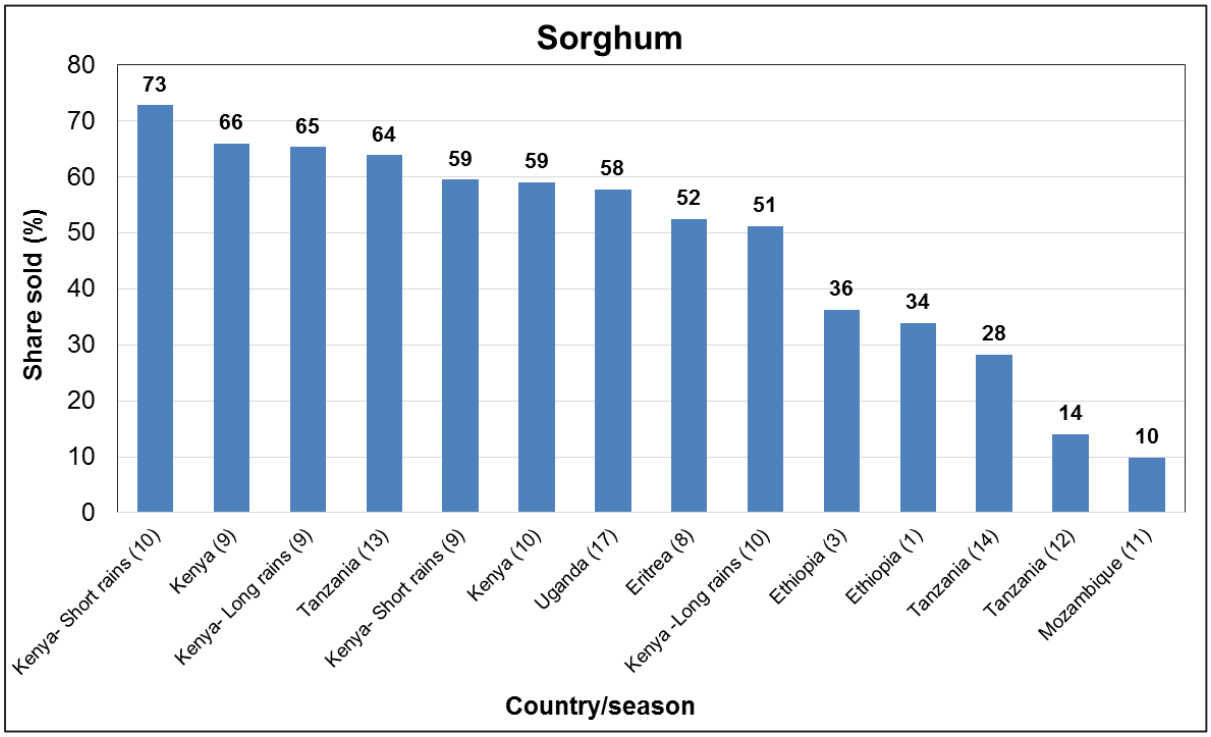
No.	Country	Total harvested	Sold	Seed	Gift/ Other	Home consumption	Source
1	Ethiopia	672	228 (33.9)	23 (3.4)	46 (6.9)	375 (55.8)	Bekele et. al. (2012).
3	Ethiopia	626	227 (36.3)	Na.	66 (10.5)	335 (53.5)	Djurfeldt et. al. (2011).
8	Eritrea	924	485 (52.5)	52 (5.6)	210 (22.7)	321 (34.7)	ICRISAT/ ASARECA
9	Kenya	340	226 (66.5)	73 (21.5)	0 (0.0)	16 (4.7)	Marangu et. al. (2015).
9	Kenya Long rains	386	252 (65.3)	21 (5.4)	30 (7.8)	83 (21.5)	Marangu et. al. (2015).
9	Kenya Short rains	316	188 (59.5)	15 (4.8)	32 (10.1)	71 (22.5)	Marangu et. al. (2015).
10	Kenya	442	259 (58.6)	Na.	Na.	Na.	Orr et. al. (2013b).
10	Kenya Long rains	295	151 (51.2)	Na.	Na.	Na.	Orr et. al. (2013b).
10	Kenya Short rains	147	107 (73.5)	Na.	Na.	Na.	Orr et. al. (2013b).
11	Mozambique	404	40 (9.9)	21 (5.2)	5 (1.2)	338 (83.7)	Tsusaka et al. (2015).
12	Tanzania	312	44 (14.1)	22 (7.1)	3 (1.0)	243 (77.9)	Schipmann et. al. (2013).
13	Tanzania	733	468 (63.8)	88 (12.0)	Na.	397 (54.2)	Hella et. al. (2015).
14	Tanzania	673	190 (28.2)	23 (3.4)	90 (13.4)	440 (65.4)	ICRISAT/ ASARECA
17	Uganda	369	213 (57.7)	33 (8.9)	187 (50.7)	154 (41.7)	ICRISAT/ ASARECA

Notes: numbers in the first column refer to the sources in Table 4. Numbers in parentheses are row percentages.

Figure 2 presents the information on sorghum sales as a share of the total harvest. The results show significant variation in sales between countries, ranging from 7 % in Mozambique to 73 % in Kenya. They also show significant variation within countries. For example, sales in the three surveys in Tanzania range from 14% to 34% to 64% while in Kenya sales range from 51% to 73 %. Only the two surveys in Ethiopia give a similar result (34% and 36 %). In general, the surveys show that sorghum is widely sold. In 7 of the 12 surveys (58%), half or more of the total sorghum harvested was sold. However, this level of crop sales was found in only four countries – in Kenya, Tanzania, Uganda and Eritrea. The highest share of sales (above 60%)

was found in Kenya and Tanzania. This reflects the high demand from breweries making sorghum beer (see Section 7, above). However, the average amount sold per household is small. In Tanzania and Kenya, the two countries with the highest level of sales, the average quantity sold was less than 0. 5 t/ha, at 468 kg/household in Tanzania and just 226 kg/household in Kenya.

Figure 2: Sorghum sales as a share of total harvest, ESA



Source: Table 5. Note: numbers refer to sources listed in Table 4.

Millets

Table 6 summarises the utilization of millets revealed by the survey data. The data shows average utilization per household.

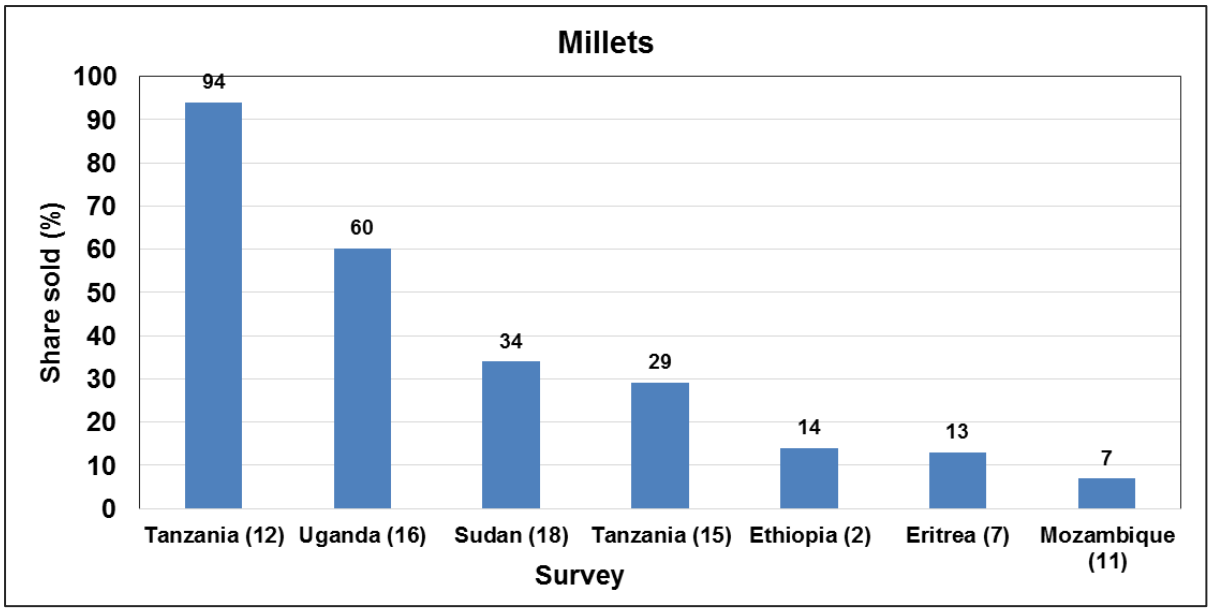
Figure 3 presents the information on the sale of millets as a share of the total harvest. As with sorghum, the results show significant variation in crop sales between countries, ranging from 94 % in Tanzania to just 7 % in Mozambique. Again, they also show significant variation within countries. For example, sales in the two surveys in Tanzania range from 16% to 94%. In general, millets are less widely sold than sorghum. In 5 of the 7 surveys (71%), millet sales accounted for less than half of the total harvest. The highest level of millet sales was found in Uganda (60%) and Tanzania (94%). This reflects the export of millets to Kenya, where the production of millets cannot meet consumer demand for millet flour (see Section 6, above). As with sorghum, the average amount of millets sold per household was small. In Tanzania and Uganda, the two countries with the highest share of sales, the average amount sold was 531 kg per household in Tanzania and 124 kg per household in Uganda.

Table 6: Millet utilization from household surveys (kg/household)

No.	Country	Total harvested	Sold	Seed	Gift/Other	Home consumption	Source
2	Ethiopia	370	52 (14.1)	10 (2.7)	5 (1.4)	302 (81.6)	Bekele et. al. (2012).
7	Eritrea	356	46 (12.9)	18 (5.1)	Na. (0.0)	292 (82.0)	ICRISAT/ ASARECA
11	Mozambique	459	32 (7.0)	22 (4.8)	5 (1.1)	401 (87.4)	Tsusaka et. al. (2015).
12	Tanzania	565	531 (94.0)	33 (5.8)	26 (4.6)	66 (11.7)	Schipmann et. al. (2013).
15	Tanzania	655	191 (29.2)	21 (3.27)	Na.	443 (67.6)	ICRISAT/ ASARECA
16	Uganda	206	124 (60.2)	8 (3.9)	29 (14.0)	45 (21.8)	Mwema et. al. (2017).
18	Sudan	579	198 (34.2)	62 (10.7)	0 (0.0)	380 (65.6)	ICRISAT/ ASARECA

Notes: numbers in the first column refer to the sources in Table 4. Numbers in parentheses are row percentages.

Figure 3: Millet sales as a share of total harvest, ESA



Source: Table 6. Note: numbers refer to sources listed in Table 4.

Teff

Table 7 summarises the utilization of teff revealed by the survey data. The data shows average utilization per household. Two of the three surveys show teff sales account for a high share (60% or more) of the total harvest. This reflects consumer preferences for teff for making the staple *injera* and the high demand for teff from urban markets (Minten et al., 2013). In the two surveys with the highest level of sales, the amount sold averaged just over 500 kg/household.

Table 7: Teff utilization, Ethiopia (kg/household)

No.	Country	Total harvested	Sold	Seed	Gift	Home consumption	Other	Source
4	Ethiopia	228	6 (2.6).	Na.	Na.	189 (82.9)	33 (14.5)	Djurfeldt et. al. (2011).
5	Ethiopia	900	540 (60.0)	Na.	Na.	Na.	Na.	Gebremedhin and Hoekstra, (2008).
6	Ethiopia	1120	520 (46.4)	Na.	Na.	Na.	Na.	Minten et. al. (2013).

Notes: numbers in the first column refer to the sources in Table 4. Numbers in parentheses are row percentages.

3.4. Crop sales by farm size

The distribution of crop sales by farm size provides information on the degree of commercialization among poorer smallholders. Smallholders with limited land may prioritize household food security which means that they will reserve a higher share of staple food crops for home consumption and have less available for sale. Conversely, smallholders with bigger farms are more likely to produce for the market and will account for the lions' share of crop sales. In Kenya, Mozambique and Zambia, for example, 1-2 % of farm households account for half the total volume of maize sold (Jayne, 2008). To compare crop sales by farm size, we divided farms into quartiles according to the area cultivated. This exercise was carried out only for the 16 household surveys for which the original data was available.

Sorghum

Table 8 shows the average quantity of sorghum sold for each farm size quartile. In general, the quantity of sorghum sold rises with farm size, with smaller farms in quartiles I and II selling smaller amounts than larger farms in quartiles III and IV. In some cases, however, the largest farms in quartile IV sell lower amounts of sorghum than farms in quartile III. The amount of sorghum sold by the two smallest farm size quartiles ranged from 538 kg/household in Eritrea to just 29 kg/household in Kenya in the short rains. The average quantity sold by the farms in the two lowest quintiles was 159 kg per household.

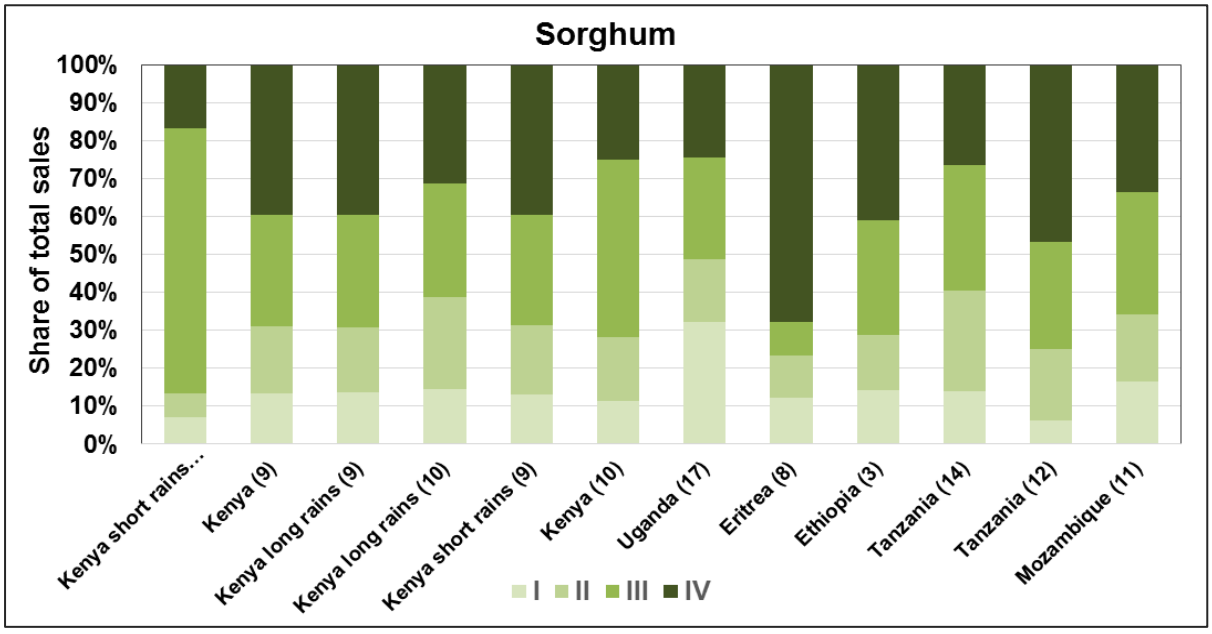
Figure 4 shows the share of total sorghum sales by farm size quartile. The 12 surveys in Figure 4 are ranked according to the degree of commercialization shown in Figure 2 starting with Kenya short rains (73 % of sorghum production sold) and ending with Mozambique (10% of sorghum production sold). The surveys show no relationship between the level of commercialization and the share of sales by smaller farmers – the share of sorghum sold by the first two quartiles does not change as the overall share of sorghum sold increases. The results show that smallholders with the smallest farms (quartiles I and II) accounted for less than 50 % of total sales. Uganda had the highest share of sales by the smallest farms (49%) and Kenya (short rains) the lowest (14%). Across the 12 surveys, the average share for the smallest farms was 31 %. This suggests that in ESA the poorest smallholders with the smallest farms accounted for roughly one-third of the total volume of sorghum sales.

Table 8: Sorghum sales by farm size quartile (kg/household)

No.	Farm size quartile	I	II	III	IV	All farms	Source
3	Ethiopia	128	133	272	370	227	Djurfeldt et. al. (2011).
8	Eritrea	557	506	402	3063	755	ICRISAT/ ASARECA
9	Kenya	235	312	516	697	440	Marangu et. al. (2014).
9	Kenya Long rains	137	175	298	399	252	Marangu et. al. (2014).
9	Kenya Short rains	98	137	219	298	188	Marangu et. al. (2014).
10	Kenya	118	175	482	259	259	Orr et. al. (2013b).
10	Kenya Long rains	88	147	182	188	151	Orr et. al. (2013b).
10	Kenya Short rains	30	28	300	71	107	Orr et. al. (2013b).
11	Mozambique	22	24	43	45	33	Tsusaka et. al. (2015).
12	Tanzania	11	33	50	82	45	Schipmann et. al. (2013).
14	Tanzania	107	202	253	201	201	ICRISAT/ ASARECA
17	Uganda	272	139	228	205	196	ICRISAT/ ASARECA

Note: I = smallest, IV = largest. Numbers in the first column refer to the sources in Table 4.

Figure 4: Sorghum sales by farm size quartile, ESA (%)



Source: Table 8. Note: numbers in parentheses refer to the sources in Table 4

Millets: Table 9 shows the average quantity of millet sold for each farm size quartile. In general, the quantity of millet sold rises with farm size, with smaller farms in quartiles I and II selling smaller amounts than larger farms in quartiles III and IV. The average amount of sorghum sold by the two smallest farm size quartiles ranged from 191 kg/household in Tanzania to just 15 kg/household in Eritrea. The average quantity sold by the farms in the two lowest quintiles was 45 kg per household.

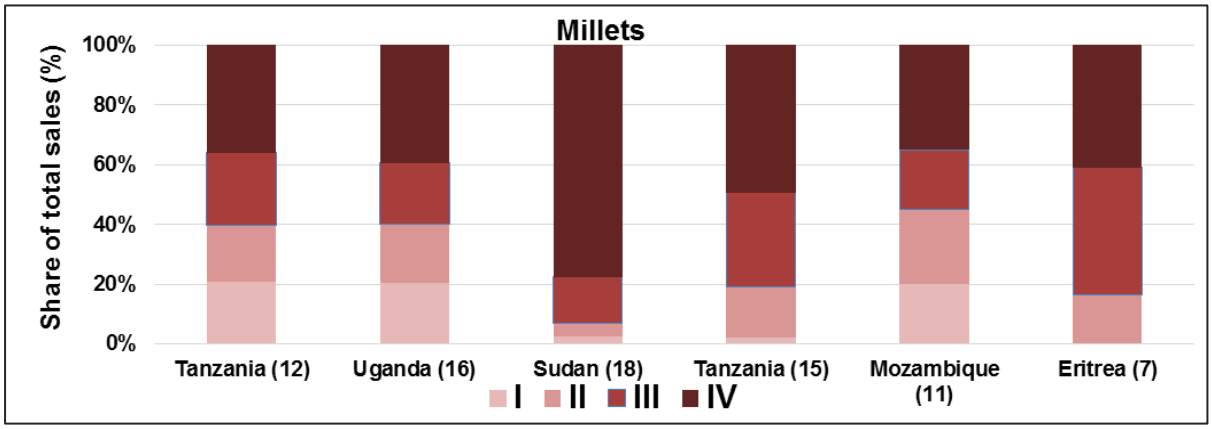
Table 9: Millet sales by farm size (kg/household)

No.	Farm size quartile	I	II	III	IV	All farms	Source
7	Eritrea	0	29	75	72	46	ICRISAT/ ASARECA
11	Mozambique	20	25	20	35	25	Tsusaka et. al. (2015).
12	Tanzania	199	183	234	346	241	Schipmann et al. (2013)
15	Tanzania	21	155	295	459	106	ICRISAT/ ASARECA
16	Uganda	104	100	105	201	124	Mwema et. al. (2017).
17	Sudan	113	180	650	3263	1763	ICRISAT/ ASARECA

Note: I = smallest, IV = largest. Numbers in the first column refer to the sources in Table 4.

Figure 5 shows the share of total millet sales by farm size quartile. The six surveys in Figure 5 were ranked according to the degree of sales shown in Figure 3.2, starting with Tanzania (94% of millet production sold) and ending with Mozambique (7% sold). The surveys show no relationship between the level of commercialization and the share of sales by smaller farmers – the share of millets sold by the first two quartiles does not change as the overall share of sorghum sold increases. On average, smallholders in the two lowest quintiles accounted for 14 % of total millet sales. Mozambique had the highest share of sales by the smallest farms (45%) and Sudan the lowest (7 %). On average, the share of millets sold by the smallest farms was 15 %. This suggests that in ESA the poorest smallholders with the smallest farms accounted for roughly one-fifth of the total volume of millet sales.

Figure 5: Millet sales by farm size quartile, ESA (%)



Source: Table 9. Note numbers in parentheses refer to the sources in Table 4.

Conclusion

Three conclusions emerge from this evidence on the sale and distribution of income from sorghum and millets. First, sorghum and millets in ESA cannot be defined in binary terms as 'subsistence' or 'commercial' crops. Instead, there is a continuum, with the share of sales or consumption varying by country. Thus, millets are clearly a commercial crop in central Tanzania, where 94 % is sold, but a subsistence crop in Mozambique where only 11 % of the crop is sold. Commercialization may also vary between different regions of the same country. Sorghum is clearly a commercial crop in Kilimanjaro region, northern Tanzania, where 64 % of the crop is sold, but a subsistence crop in central Tanzania where only 12-14% of the crop is sold. These contrasts suggest that while we should avoid generalizations about 'commercial' or 'subsistence' crops, both sorghum and millets have the potential to become commercial crops where market conditions are right. In regions that supply the brewing industry, such as Kenya or northern Tanzania, sorghum has become a commercial crop, while in regions that supply the milling industry, such as northern Uganda or central Tanzania, finger and pearl millet have become commercial crops. By contrast, teff is a commercial crop in most regions of Ethiopia. Again, this reflects favourable market conditions created by consumer preferences for *injera* made from teff and by rapid urbanization.

Second, while smaller farms do sell sorghum and millets, their share of crop sales is relatively small. On average, the two smallest farm quartiles (i.e. 50% of all farms) account for 31 % of the volume of sorghum sold and 14 % of the volume of millets sold. In countries or regions where the highest proportion of sorghum and millets are sold, the share of the two smallest farm quartiles does not change significantly. In Kenya, for example, where sorghum is sold to breweries to make sorghum beer, the share of sorghum sold by the two smallest quartiles ranges from 14% to 39%. In central Tanzania and Uganda, where millets are sold to flour millers, the share of finger millet sold by the two smallest quartiles averages 40%. Overall, the quantity of sorghum or millets sold by these smaller farms averages 159 kg per household for sorghum and 45 kg per household for millets. The good news, therefore, is that the commercialization of sorghum and millets does not exclude smaller farms; the bad news is that because the amount they sell is so small the benefits that they receive are limited.

Finally, the concept of 'commercialization' should be applied more critically. The word can be used to describe two processes: the transformation of a *crop* once grown for home consumption into one now grown primarily for sale, and the transformation of a *farmer* that once produced crops for subsistence into one that now produces crops for sale. We need to clearly distinguish between these two processes. As the evidence shows, it is possible to commercialize the sorghum and millets crops. However, transforming subsistence into commercial farmers is a different matter. Farmer groups in western Kenya selling finger millet differ significantly from each other in terms of their members, the quantity of crop sales, and the benefits received from group membership (Box 3.1). In western Kenya, the majority of farmer groups selling finger millet comprised women planting less than ½ acre, selling small amounts of grain and baked products, and relying on their co-members for labour. By no stretch of the imagination can they be described as 'commercial' farmers. In reality, the lion's share of crop sales are made by a tiny minority of commercial farmers, while the rest is made by an army of resource-poor smallholders selling whatever they can spare in order to generate cash income for consumption needs. Given the current agrarian structure in ESA with its

unequal distribution of land, the majority of smallholders will never become commercial farmers.

Box 3.1. What do we mean by 'commercialization'? Finger millet in Western Kenya

Finger millet was once grown throughout Kenya but is now largely confined to the Western region. Production centres on Teso district where it is important for food, beer, and cultural ceremonies. However, production is reviving in Busia and Mumias districts, where farmers now grow finger millet not for food security but as a cash crop replacing sugarcane. In Teso, for cultural reasons, finger millet plays a central role in household food security in preference to maize. In November 2011 we visited the region to select sites for socio-economic research (Handschuch, 2014). We held focus group discussions (FGDs) with seven farmer groups, all of which sold finger millet. These groups received technical support from the finger millet research program operated by the Kenya Agriculture and Livestock Research Organisation (KALRO) based at the research station at Kakamega.

Based on these FGDs, we developed a tentative typology of farmer groups according to their engagement with the market for finger millet (Table B.3.1).

Table B.3.1. Tentative typology of KALRO Finger Millet Groups

Indicator	Typology		
	Commercial	Pre-commercial	Income-generation
Motivation	Maximise profits	Get rich	Reduce/share poverty
Primary objective of the group	Cash	Cash/income	Reduced costs Access to loans Control over income Some income
Membership	Male	Both	Women
Area planted (acres)	1-2	½-1	¼ - ½
Labour-sharing	No	Some	Yes
Marketing	Individual	Collective	Collective
Buyers	Schools, traders, urban buyers	Schools KALRO Seed Unit	Villagers, KALRO Seed Unit
Value-added products	No	Some	Yes
Use of income from finger millet	Acquire assets (house-building, cows)	Want to acquire assets	School fees, Small expenses

The groups visited can be roughly divided into three types: commercial, pre-commercial, and income-generation:

1. '*Commercial' groups* comprised farmers where finger millet was the primary cash crop. They generally planted 1-2 acres and almost all of this was sold. Farmers grew other cash crops including sugarcane and cassava, but preferred finger millet because it gave the highest return. Since members produced large quantities marketing was done individually rather than collectively.
2. Finger millet was marketed as grain, not as seed or as products. Income from finger millet grain was invested in capital assets, including big-ticket items such as housing and cattle.

3. *'Pre-commercial' groups* comprised farmers who recognized the potential of finger millet as a cash crop but planted a smaller area of finger millet (less than 1 acre). The average production was small so marketing was done collectively through the group. The majority sold finger millet as grain but some members sold finger millet as seed or as bakery products. Generally, members of these groups had fewer assets and resources than the members of commercial groups, but were eager to expand production and increase cash income from millet sales.
4. *'Income-generation' groups* comprised poorer farmers that saw finger-millet as an additional way to generate cash income. Members of these groups were primarily women who planted small areas of finger millet (less than ½ acre) and relied on other members to share the labour required for millet. Since they produced only small quantities of grain, members of these groups were more likely to invest in value-addition, baking *mandazi* and biscuits for sale. The income from finger millet was not invested but used to meet consumption needs and help pay school fees. The majority of the groups visited fell into this third category.

ICRISAT sees commercialization as a continuum along which smallholders graduate from 'subsistence' to 'commercial' agriculture (ICRISAT, 2010). However, this was not the impression given by these FGDs. Instead, commercialization seemed to be a step-function in which graduation from one step to the next was limited by the average resources of group members, with groups occupying different rungs on the ladder but with limited ability to move higher up. Although all three types of group offered finger millet for sale, the function of crop sales differed between the groups. At the top of the ladder were commercial farmers who grew finger millet because it was more profitable than other cash crops, while at the bottom were resource-poor farmers (mostly women) who grew finger millet because it gave them another small source of cash income. For these farmers, the objective was not just crop sales. Group membership also offered access to loans and to cheap labour from other group members. Collective marketing of finger millet was not a stepping stone to becoming commercial farmers but a way of sharing poverty.

4. Utilization

4.1. Introduction

This section provides an overview of utilization of sorghum and millets for our four selected ESA countries, based on data from the FAO. We first define the concept of the commodity balance, and present a set of re-worked figures according to four types of utilization. We then compare differences in food and non-food uses between countries,

4.2. Commodity balance

The FAO commodity balance sheets provide a comprehensive picture of the pattern of a country's commodity supply and utilization for a specific period and a specific commodity. The most recent commodity balances available in the FAOSTAT database is for 2011, while crop statistics are available for 2014.

Commodity balances are useful to: (1) distinguish food and non-food utilization of a commodity (2) assess the scale of further processing of a commodity by the commercial (formal) sector, for example through large scale feed and flour mills in case of cereals, and (3) approximate the available domestic supply for food use as a base to update and extrapolate food consumption estimates. The FAO webpage provides a detailed description of all elements in a commodity balance. Extracts of the description are provided in the footnote below: [2]

[2] **1. Production**. For primary commodities, production should relate to the total domestic production whether inside or outside the agricultural sector, i.e. including non-commercial production and production in kitchen gardens. Unless otherwise indicated, production is reported at the farm level for primary crops (i.e. excluding harvesting losses for crops) and livestock items and in terms of live weight (i.e. the actual ex-water weight of the catch at the time of capture) for primary fish items. Production of processed commodities relates to the total output of the commodity at the manufacture level (i.e. it comprises output from domestic and imported raw materials of originating products).

2. Changes in Stocks. In principle, this comprises changes in stocks occurring during the reference period at all levels from production to the retail stage, i.e. it comprises changes in government stocks, in stocks with manufacturers, importers, exporters, other wholesale and retail merchants, transport and storage enterprises, and in stocks on farms. In practice, though, the information available often relates only to stocks held by governments, and even this is, for a variety of reasons, not available for a number of countries and important commodities. Increases in stocks of a commodity reduce the availability for domestic utilization. They are therefore indicated by the - sign and decreases in stocks by the + sign since they increase the available supply. In the absence of information on opening and closing stocks, changes in stocks are also used for shifting production from the calendar year in which it is harvested to the year in which it enters domestic utilization or is exported.

3. Gross Imports. In principle, this covers all movements of the commodity in question into the country as well as of commodities derived therefrom and not separately included in the food balance sheet. It, therefore, includes commercial trade, food aid granted on specific terms, donated quantities, and estimates of unrecorded trade.

4. Supply. There are various possible ways to define "supply" and, in fact, various concepts are in use. The elements involved are production, imports, exports and changes in stocks (increases or decreases). There is no doubt that production, imports, and decreases in stocks are genuine supply elements. Exports and increases in stocks might, however, be considered to be utilization elements. Accordingly, the following possibilities exist for defining "supply".

(a) Production + imports + decrease in stocks = total supply. (b) Production + imports + changes in stocks (decrease or increase) = supply available for export and domestic utilization.

(c) Production + imports - exports + changes in stocks (decrease or increase) =

5. Gross Exports. In principle, this covers all movements of the commodity in question out of the country during the reference period. The conditions specified for gross imports, under 3. above, apply also to exports by analogy. A number of commodities are processed into food and feed items. Therefore, there is a need to identify the components of the processed material exported in order to arrive at a correct picture of supplies for food and feed in a given time-reference period.

6. Feed. This comprises amounts of the commodity in question and of edible commodities derived therefrom not shown separately in the food balance sheet (e.g. dried cassava, but excluding by-products, such as bran and oilcakes) that are fed to livestock during the reference period, whether domestically produced or imported.

7. Seed. In principle, this comprises all amounts of the commodity in question used during the reference period for reproductive purposes, such as seed, sugar cane planted, eggs for hatching and fish for bait, whether domestically produced or imported.

Table 10 shows the commodity balances for sorghum, millets and maize. The left-hand side shows sources of domestic supply including domestic production, change in stocks (usually public strategic reserves), imports and exports. Exports are commonly included in the supply side of the balance although they may rather be considered as a form of utilization as being exported to other countries. Changes in stocks enter with a negative sign if stocks are replenished since they lower the availability for domestic utilization and enter with a positive sign if stocks are released onto the market. Production, change in stocks and imports minus exports determine the available supply in a given year. The right-hand side comprises components of utilization, subdivided into feed, seed, waste, processing and other uses. The category 'processing' (in the FAO explanation labelled as 'food manufacture') only takes account of processing activities for food purposes, e.g. flour, and various types of convenience food containing cereals. Quantities of the commodity used for manufacture for non-food purposes, e.g. industrial starch, are shown under the category 'other uses'. According to FAO, the category 'other uses' has two components: (1) manufactures for non-food purposes and (2) corrections of statistical discrepancies between the supply and utilization side, presumably caused by unreported quantities in the informal sector on the utilization side. We used the FAO commodity balance to estimate the supply going to food and non-food uses. The only categories that clearly indicate non-food use are feed, seed and waste. It is less clear for 'other uses'. Based on our knowledge of the food sector in ESA and the evidence of limited use of cereals for industrial purposes, we assume that the category 'other uses' primarily captures statistical differences caused by unreported quantities in the informal sector. Based on this assumption, we have included 'other uses' in the category of 'food use', though it is defined otherwise by FAO.

Our study therefore assumes the following functional relationships:

Non-food use = feed + seed + waste

Food supply = available supply – non-food use

Food supply – processing = unreported processed and unprocessed food

Food supply = domestic food consumption

Whenever official data are not available, seed figures can be estimated either as a percentage of production (e.g. eggs for hatching) or by multiplying a seed rate with the area under the crop of the subsequent year.

8. **Food Manufacture.** The amounts of the commodity in question used during the reference period for manufacture of processed commodities for which separate entries are provided in the food balance sheet either in the same or in another food group (e.g. sugar, fats and oils, alcoholic beverages) are shown under the column Food Manufacture. ***Quantities of the commodity in question used for manufacture for non-food purposes, e.g. oil for soap, are shown under the element Other Uses.***
9. **Waste.** This comprises the amounts of the commodity in question and of the commodities derived therefrom not further pursued in the food balance sheets, lost at all stages between the level at which production is recorded and the household, i.e. losses during storage and transportation. Losses occurring during the pre-harvest and harvesting stages are excluded.
10. **Other uses**. In order not to distort the picture of the national food pattern, quantities of the commodity in question, consumed mainly by tourists, are included here (see also "12. Per Caput Supply") as well as the amounts of the commodity in question used during the reference period for the manufacture for non-food purposes (e.g. oil for soap). Also statistical discrepancies are included here. They are defined as an inequality between supply and utilization statistics.
11. **Food**. This comprises the amounts of the commodity in question and of any commodities derived therefrom not further pursued in the food balance sheet that are available for human consumption during the reference period. The element food of maize, for example, comprises the amount of maize, maize meal and any other products derived therefrom, like cornflakes, available for human consumption.

Non-food use is defined as the sum of feed, seed and waste. *Food supply* is measured as the difference between available supply and non-food use and includes all types of consumption, whether processed or not. By definition, food supply is equivalent to domestic food consumption because all other forms of utilization, foreign trade and stock holdings are factored out. The actual quantity of food consumed by the household may be slightly lower than the quantity shown by 'food supply' depending on the degree of losses of edible food and nutrients during storage, in preparation and cooking.

The FAO category 'processing' most likely refers to the commercial food processing sector (larger flour mills or food manufacturers) while the quantity processed by the informal and small-scale sector is subsumed in the category 'food supply'. However, the interpretation of FAO commodity balances for our commodities and for ESA countries is subject to a fair amount of ambiguity. Fortunately, the quantities reported in the categories 'other uses' and 'processing' are relatively small and mistakes in interpretation have a limited effect on the actual magnitude of 'food supply'.

Table 10: FAO commodity balances for cereals in ESA countries (000 tons)

2013	Production	Change in stocks	Imports	Exports	Available Supply	Feed	Seed	Waste	Other uses	Processing	Food supply
	Kenya										
Sorghum	139	0	29	23	145	17	4	18	0	32	105
Millets	64	0	15	0	79	6	2	9	0	16	63
Maize	3,391	-61	596	34	3,893	106	68	83	3	18	3,636
Wheat	486	50	1,092	16	1,512		11	31	34		1,436
	Ethiopia										
Sorghum	4,338	-301	258	13	4,282	*na*	48	230	1,149	0	4,005
Millets	807	0	0	0	807	*na*	12	40	0	113	754
Maize	6,674	-529	69	29	6,185	414	72	338	0	9	5,359
Wheat	4,039	3	868	3	4,901		119	245	1,600		2,937
	Tanzania										
Sorghum	832	0	2	2	832	17	12	85	0	359	718
Millets	323	0	0	4	319	6	5	32	0	138	275
Maize	5,356	-253	35	37	5,102	1,034	87	760	10	24	3,222
Wheat	104		817	107	814		11	19			785
	Uganda										
Sorghum	299	0	25	5	319	32	8	32	0	148	246
Millets	228	0	0	1	227	23	3	16	0	28	186
Maize	2,748	-203	35	143	2,438	276	38	312	1	313	1,812
Wheat	*na*.	*na*	*na*	*na*	*na*	*na*	*na*	*na*	*na*	*na*	*na*

Source: own calculation, based on FAO commodity balances

Table 10 shows the commodity balance for the year 2013. Since the FAOSTAT database provided information only up to 2011, these figures were adjusted based on the newest 2013 production statistics and a five year average (2008-2012) utilization pattern for each category.

Table 10 reveals the heterogeneous composition of supply and utilization for each country and crop. Ethiopia is the largest cereal producer with a total production of 12 million t of maize, sorghum and finger millet in 2013. Ethiopia is relatively active in foreign trade and adjusting its strategic cereal stock reserve to safeguard against famines. Most of the sorghum and maize imports in 2013, as in previous years, came from bi- and multilateral food aid programs. On the export side, Ethiopia trades small volumes with Sudan, South Sudan and Somalia. Available market supply is almost the same as domestic production because stocks for the strategic grain reserve are sourced primarily from foreign food aid. On the utilization side, very little sorghum and maize is used by the feed industry, or at least by the formal and larger-scale feed mills captured by the FAO statistics.

Tanzania is the second largest grain producer among the four. Some of the figures on the supply side do not reflect the fact that Tanzania has been exporting significant amounts of sorghum and maize to Kenya. By the same token, the high share of feed use for maize (1 million t) and high share of sorghum and millets used for food processing share are somewhat surprising and require confirmation by first-hand evidence from the Tanzania feed and milling industry.

Uganda's commodity balance shows remarkable similarities with Tanzania, though at a much lower level of turnover. These include replenishment of the strategic reserve with maize during the recent years, limited trade with neighbouring countries (export of finger millet to Kenya does not appear in the balance), and significant quantities entering the animal feed and grain milling industries.

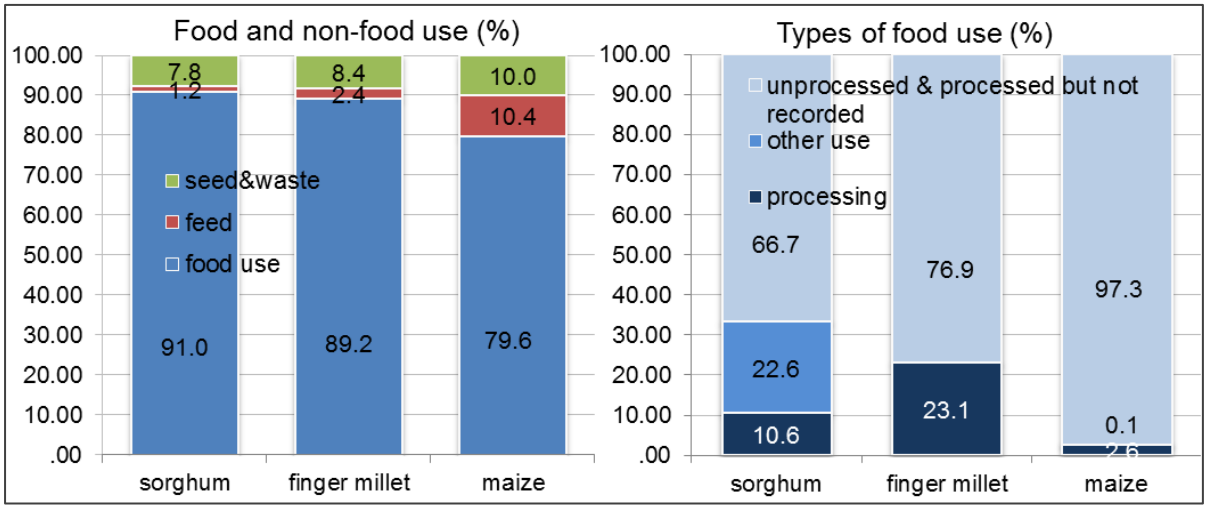
Kenya has the lowest level of production. Imports and exports and public stockholding are small. While the feed industry processes a significant quantity of maize, the aggregate quantity of maize, sorghum, and millets processed by the formal commercial sector is low.

4.3. Food and non-food use

Non-food use is defined as the quantities allocated to the livestock feed industry plus use for seed production and waste. The FAO category 'other use' is assumed to be a residual that takes account of any statistical mismatch between quantities reported on the utilization side and available supply. However, since some quantities are hard to explain, the figures should be treated cautiously.

Figure 6 shows the aggregate results for all four countries. The left hand side depicts the share of food use which is highest for sorghum (91%), with 89% for millets and 79% for maize. This confirms two known facts. The first is that the use of locally produced grains in ESA is predominantly for food use, and that the capacity of the feed industry is still low and that it sources raw materials to a large extent from the internal market. The second is that maize is the preferred raw material in the feed industry due it its cost advantage and widespread availability.

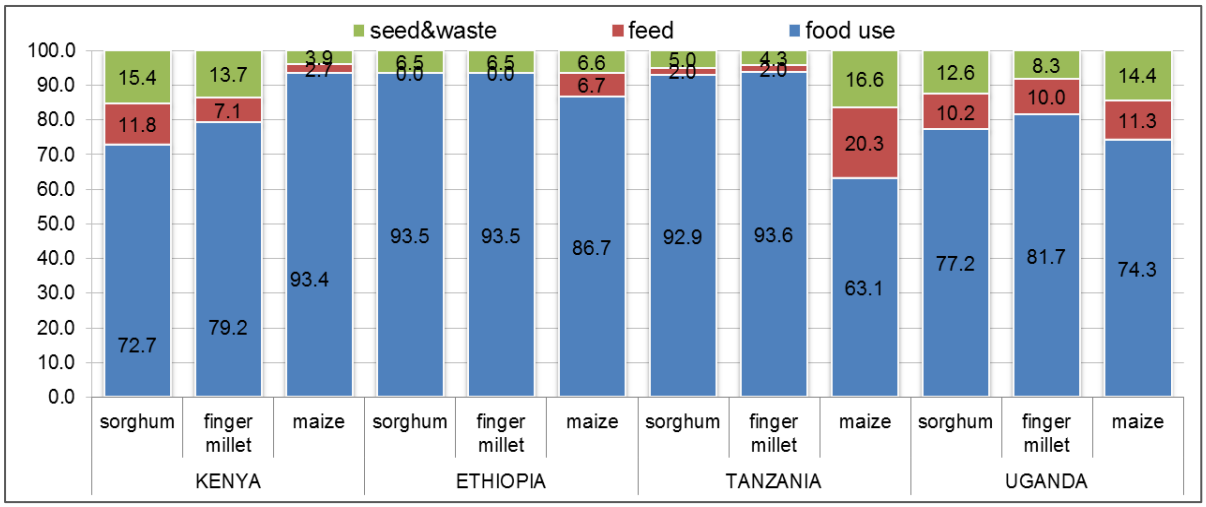
Figure 6: Food and non-food use ESA in 2013 (%)



Source. Own calculation, based on FAO commodity balances

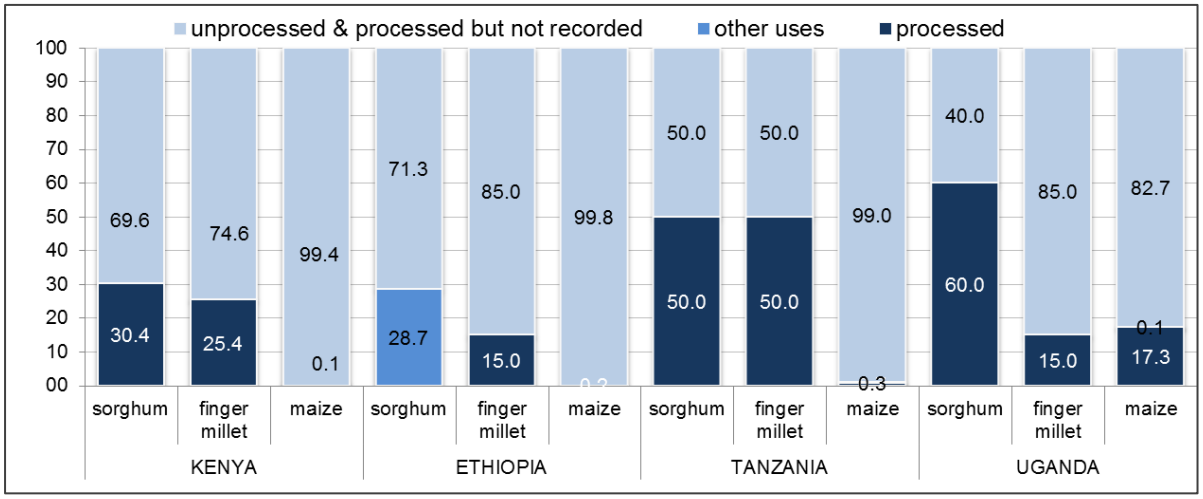
The right hand side in Figure 6 breaks down food use into different segments according to the FAO commodity balances: (1) 'processing' with reported quantities of food manufacturing, (2) 'other use' and (3) 'unprocessed and processed but not recorded' which takes up the difference between total food use minus (1) and (2). A breakdown of food use into these three segments helps understand the relative share of the informal and formal sectors in the food sector. Across ESA over 10% of sorghum seems to be processed by the formal food processing sector, with 23 % for finger millet and a surprisingly low 2.6% for maize. The high share of finger millet processed by the formal sector reflects the status of finger millet as a cash crop. Figure 7 and Figure 8 highlight the differences in food and non-food use between crops and between countries. A few observations are worth mentioning. One is the relatively high share of livestock feed in Uganda (Figure 7) and the high share of food processing in Tanzania (Figure 4.3). These differences between countries are hard to explain, and reinforce the need for caution in the use of these figures.

Figure 7: Food and non-food use for ESA countries in 2013 (%)



Source: own calculations, based on FAO commodity balances

Figure 8: Type of food use in ESA countries in 2013 (%)



Source: own calculations, based on FAO commodity balances

The pattern of utilization did not experience major structural changes over the last two decades. (See Appendix 1, which contains the entire set of commodity balances for the period 2000 to 2013). The magnitude of food supply in the sorghum, millets and maize sub-sectors in ESA countries is basically driven by production factors. There have been gradual changes in cross border trade, strategic reserve policies, and capacities in the food and feed industry but food supply remains largely determined by developments in national production. Table 11 presents annual growth rates in national production, available domestic supply and food supply for the period between 2000 and 2013.

Table 11: Annual growth rates in production, available supply and food supply for selected ESA countries, 2003 – 2013 (%)

	Production	Available Supply	Food supply
	Sorghum		
Kenya	3.9	4.2	3.9
Ethiopia	9.7	7.5	7.5
Tanzania	2.4	2.4	2.4
Uganda	-1.3	-1.1	-1.1
	Millets		
Kenya	2.6	4.0	4.3
Ethiopia	6.8	6.8	6.9
Tanzania	2.8	2.6	2.5
Uganda	-5.9	-6.7	-6.7
	Maize		
Kenya	3.3	2.2	2.1
Ethiopia	6.7	5.2	4.8
Tanzania	7.4	4.8	2.2
Uganda	6.8	5.8	5.6

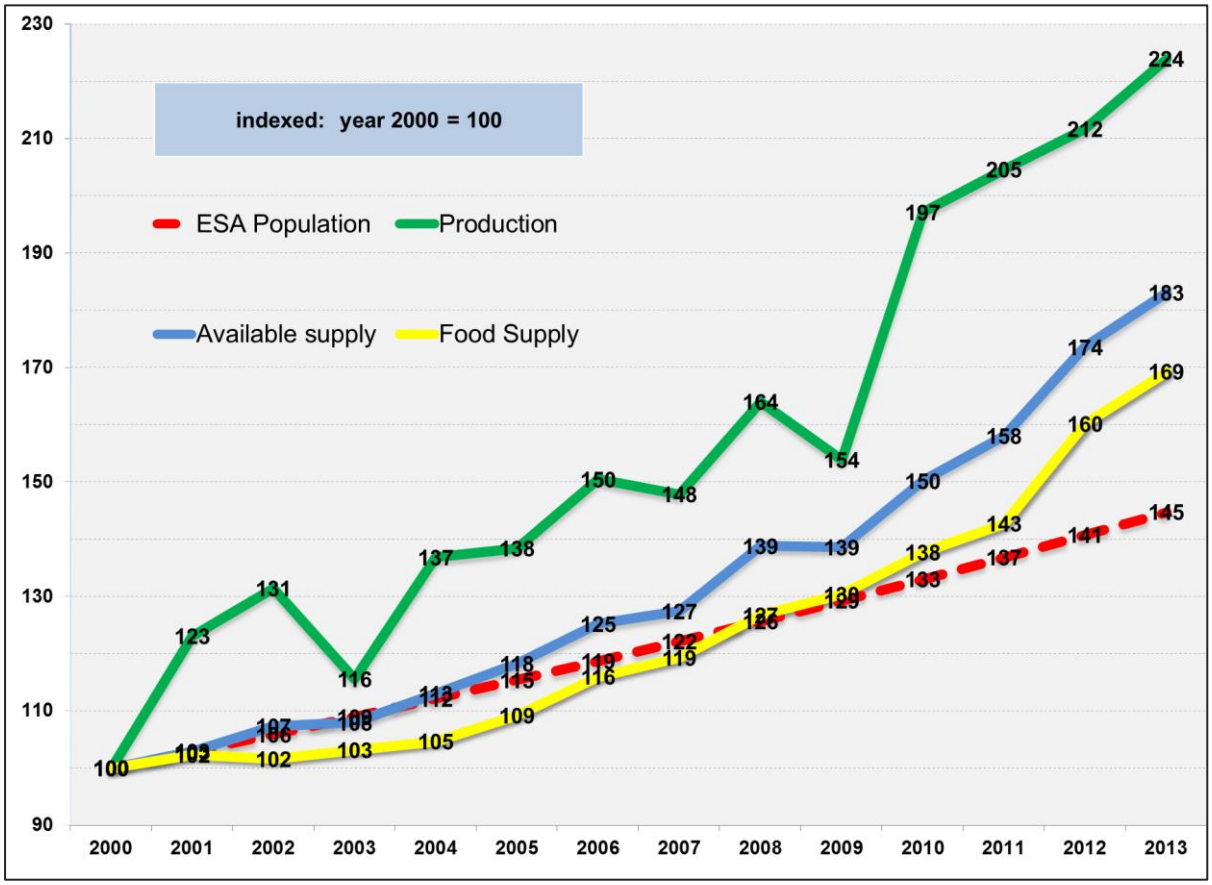
Source: own calculation, based on FAO commodity balances.

Ethiopia has the highest growth rates in production, available supply and food supply. Uganda ranks last as the country experienced a sharp decline in sorghum and finger millet production starting in 2008. Growth rates for all three indicators indicate that production is the main driver determining food supply.

To place long term trends of production and supply of sorghum, millets and maize in the context of population growth we can study how the general food situation of the three cereals changed between 2000 and 2013. Population growth in ESA countries remained very high – between 2.5% and 3% annually over the last decade.

Figure 9 shows that since the year 2000 production and available supply outpaced population growth by a small margin increasing per capita availability of food and with a positive effect on food security in the staple food sector. Food supply lagged behind population growth between 2001 and 2007 but then recovered with a steep increase in food supply.

Figure 9: Population, production, available supply and food supply in cereals (aggregated over ESA countries and indexed, 2000-2013)



Source: own calculation.

5. Animal Feed

5.1. Introduction

In many countries sorghum and millets are primarily used as animal feed. Rising incomes increase the demand for meat and dairy products. Reflecting this, China has recently overtaken the United States as the world's biggest consumer of sorghum. In ESA, however, the use of sorghum and millets for animal feed remains limited. This reflects the low income of the majority of consumers in ESA, with a high share living below the poverty line (Orr et. al., 2016).[3]

Interviews with feed manufacturers in Kenya identified several reasons for the lack of demand for sorghum and millets as a source of animal feed:

1. Supply is inconsistent. Supplies may be available after a particularly favourable rainy season, but may then be limited when rains are poor. While feed manufacturers will commonly switch ingredients as relative input prices change, this practice is less common among the many smaller-scale feed manufacturers in ESA, many of whom seem to prefer a consistent formula

2. Sorghum and pearl millet are heavily discounted by the industry, ranging from 70% to 80% of the price offered for maize (see also Rohrbach, undated).

3. Feed manufacturers are skeptical about the feed value of sorghum and pearl millet. Some argue that sorghum has low levels of protein, or that tannins (believed to be in all sorghum) unacceptably reduce the digestibility of sorghum-based feeds. Related questions arise about the risks of mycotoxins. Some argue that sorghum lacks essential amino acids that are necessary, and otherwise unavailable, for feeding poultry. When feed data are provided to manufacturers they argue that they need proof of the value of these grains from other feed manufacturers, and discount data from university laboratories and research trials.

4. Feed manufacturers complain that sorghum does not mill well. Whereas maize can be cracked in a hammer mill, the softer sorghum grains turn into powder. This is claimed to reduce feed efficiency. Few feed manufacturers besides the larger companies use feed extruders, where ingredients are forced through a die into a specific shape.

These objections are identical to those reported by a survey of feed manufacturers in Tanzania conducted by ICRISAT in 1999 (Rohrbach and Kiriwaggulu, 2001a).

Table 12 shows the present scale of utilization for animal feed industry in the four selected countries in ESA. In total, utilization as a share of total supply accounted for just 1 % for millets and 2 % for sorghum, compared to 10 % for maize. The share of utilization of sorghum for

[3] In 2011, headcount poverty was 32 % in Kenya, 37 % in Uganda and in Ethiopia, and 44 % in Tanzania (Orr et. al., 2016).

feed was highest in Kenya (12%) while the share of utilization for millets was highest in Uganda (10%). Tanzania had the largest share of utilization of maize for animal feed (20%).

Table 12: Animal Feed Use from FAO Commodity Balance Sheet, 2013 (000 tons)

	Crop	Kenya	Ethiopia	Uganda	Tanzania	Total
Supply	Sorghum	145	4,282	319	832	5,578
	Millets	79	807	227	319	1,432
	Maize	3,893	6,185	2,438	5,102	17,618
	Total	4,117	11,274	2,984	6,253	24,628
Feed	Sorghum	17	Na.	32	17	66
	Millets	6	Na.	23	6	35
	Maize	106	414	276	1,034	1,830
	Total	129	414	331	1,057	1,931
Feed (%)	Sorghum	12	Na.	10	2	1
	Millets	8	Na.	10	2	2
	Maize	3	7	11	20	10
	Total	3	4	11	17	8

Source: Table 10

Alternative estimates of livestock feed production are provided by national statistics for the countries concerned, some of which are summarized in the United Nations' Yearbook of Industrial Statistics (UN 1996, UNIDO, 2015). Table 13 provides estimates of livestock feed production from national statistics between 1990 and 2014. These show major discrepancies with the FAO statistics for all four countries:

1. The FAO commodity balance sheet for Tanzania shows feed production of over 1 million t while the national statistics give a figure of just 3,500 t. By comparison, an ICRISAT survey of Tanzanian feed manufacturers in 1999 estimated total feed production at 60,000 t (Rohrbach and Kiriwaggulu, 2001a). A recent study of the maize value chain in Tanzania estimated that 10% of total maize production (500-600,000 t) was processed each year into animal feed, primarily for poultry (BMGF, 2014b).
2. The FAO commodity balance sheet for Uganda shows feed production of 331,000 t, while the national statistics give a figure of just 31,000 t. A recent study of the maize value chain in Uganda estimated that 11% of total maize production (302,000 t) was processed each year into animal feed, primarily for poultry (BMGF, 2014a).
3. The FAO commodity balance sheet for Ethiopia provides no figure for feed production. A recent study of the value chain for maize suggests that 10% of total production is used for seed and animal feed (RATES, 2003).
4. The national statistics for feed production in Kenya give a figure (464,000 t) that is four times higher than that shown by the FAO commodity balance sheet (129,000 t).

National statistics for production of animal feed are usually based on a sample of firms, which do not capture total production within the country.[4] Typically, these are large, commercial firms where production is relatively easy to monitor. By contrast, value chain studies estimate feed production based on the total number of firms in the country, including small enterprises. However, potential demand for sorghum as a substitute for maize in the production of animal feed is more likely to come from large, commercial feed companies that source sorghum from centres of production.

Consequently, we have based our estimate of the potential utilization of sorghum for animal feed on the national statistics (Table 13). Table 13 suggests that the production of animal feeds in ESA has grown rapidly since 2000, albeit from a low base. Between 2005 and 2012, animal feed production rose by 232 % in Kenya, 167 % in Ethiopia, 62 % in Uganda, but with zero growth in Tanzania. These figures suggest that Kenya is the biggest feed producer in the region. Based on the scale of the industry and the rate of growth, therefore, the prospects for sorghum as raw material for animal feed seem brightest in Kenya.

Table 13: Animal feed production, selected countries, 1990-2014 (000 tons)

	1990-94	2000-04	2010-14
Ethiopia	15	6	27
Kenya	130	147	464
Uganda	22	23	31
Tanzania	8	0.2	3.5
Total	175	176	526

Sources: 1990-94: UN (1996); 2000-04, 2010-14: Statistical Abstracts, various years.

Note: These figures show production in the formal sector.

5.2. The feed industry in Kenya

The use of manufactured animal feeds and feed supplements in Kenya has increased steadily since 2000 (Table 14). Kenya's State Department of Livestock estimates that annual demand for feeds and supplements in 2014 is about 650,000 t. Registered feed manufacturers account for about 60 % of supply, while unregistered small scale manufacturers, home/community-based formulators, and importers account for the balance. UNGA Farm Care Limited (UFCL) and Pembe are the market leaders in the feed sector in Kenya. The informal feed sector in Kenya has emerged in the last two years and now commands over 15 % of the market share. The growth in the informal feed sector began in May 2014, after the Government of Kenya levied a Value Added Tax (VAT) of 16% on feeds, making feed more expensive.[5] This has led to the emergence of unregulated companies around Nairobi and Nakuru that are not

[4] For example, the Statistical Abstracts for Uganda cover only 7 companies producing livestock feed and 8 grain milling companies. (Statistical Abstract, Uganda, 2007). Similarly, figures for the production of animal feeds in Tanzania are based on a sample of 6 manufacturers (Statistical Abstract, Tanzania, 2012), but it is estimated that there are over 60 feed manufacturers in the country (Mgaya, 2010).

[5] Personal Communication, Dr. Patrick Karanja, Jubilee Feed Industries Ltd, May 2015.

regulated by the Kenya Bureau of Standards (KEBS) and the Directorate of Veterinary Services.

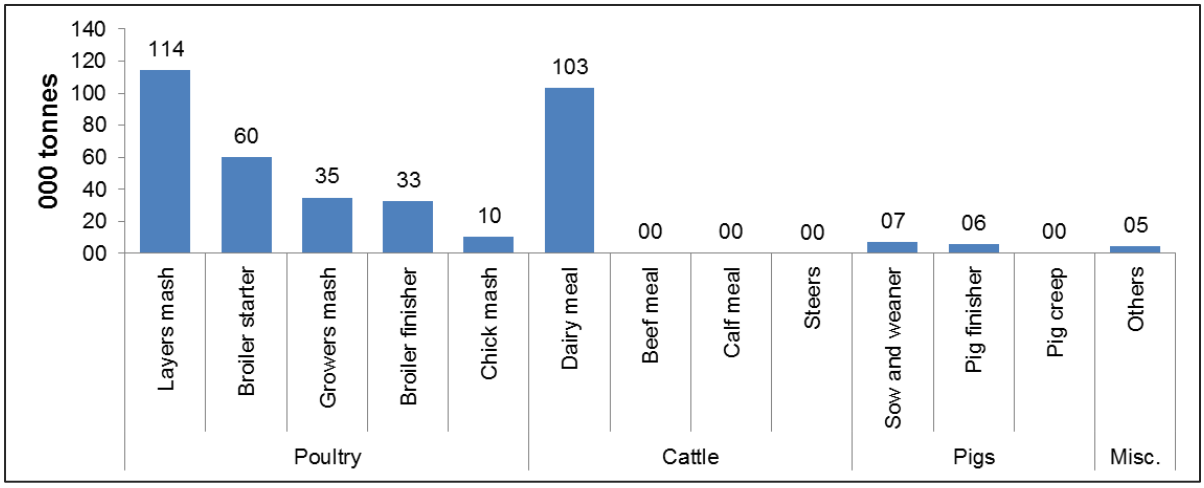
Table 14: Animal feed production by type, Kenya 2000-2014 (000 tons)

Year	Poultry	Cattle	Other	Pigs	Total	Poultry (%)
2000	485	138	76	49	748	65
2001	728	207	115	73	1,123	65
2002	1,224	348	193	122	1,887	65
2003	1,167	332	184	117	1,799	65
2004	1,380	392	217	138	2,128	65
2005	1,711	486	269	171	2,638	65
2006	1,454	413	229	146	2,242	65
2007	1,322	376	208	132	2,038	65
2008	3,145	894	495	315	4,849	65
2009	3,596	1,022	566	360	5,544	65
2010	2,888	821	455	289	4,453	65
2011	2,537	721	399	254	3,911	65
2012	2,980	847	469	298	4,595	65
2013	3,377	960	532	338	5,207	65

Source: Statistical Abstracts, Kenya, various years.

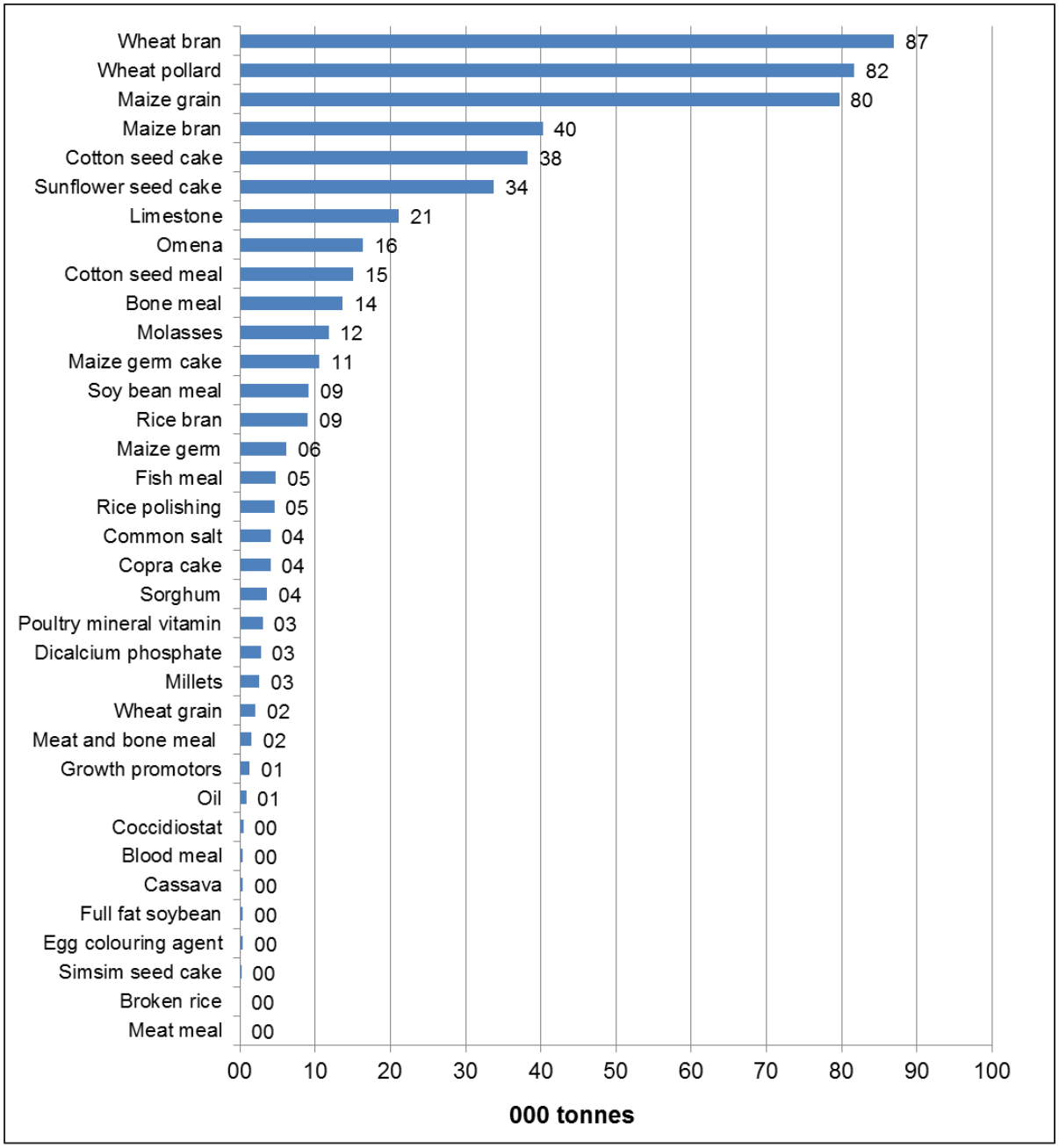
A survey by the Ministry of Livestock Development provides a snapshot of the industry (Githinji et. al., 2009). The survey was conducted in 2008 and covered 82 feed manufacturers in eight regions of Kenya, of which 27 (33 %) were located in Nairobi, and 20 (24%) in Kiambu and Thika close to Nairobi. Among the 82 firms surveyed, the total installed capacity was 843,567 tons/year, while actual production in 2008 was 374,967 tons/year or 45 % of capacity. Most animal feed is for poultry and dairy cattle, with pigs a distant third (Table 14). In 2013, 65 % of animal feed in Kenya was produced for poultry, 18 % for cattle, and 7 % for pigs, with 10 % unspecified. The bulk of poultry feed is produced for layers, or egg production. Figure 10 shows the type of feed produced by the industry in Kenya in 2008, while Figure 11 shows the materials used to make feed.

Figure 10: Type of feed produced, Kenya 2008



Source: Githinji et. al., (2009), Table 5.

Figure 11: Raw materials used in animal feed production, Kenya 2008



Source: Githinji et. al., (2009), Table 6.

5.3. Case studies

To assess the opportunities for sorghum in animal feed, we interviewed three feed manufacturers in Nairobi, using a pre-tested questionnaire (Choudhary, 2015). The companies varied in structure and nature of their operations (Table 15). While Jubilee Feeds Industries sold mainly through the dealer distributor network in the open market, UFCL produced feed for Kenchick, a large poultry firm under the group's corporate conglomerate. Nguku Products Ltd was not a stand-alone feed manufacturer but produced feeds for their own chicken farm. The information obtained was not consistent or detailed enough to allow comparisons between firms. This was mainly due to the low and relatively recent use of sorghum in the manufacture of animal feed, the lack of records on the quantity of sorghum used (managers mainly provided approximate percentage figures), as well as managers' understandable reluctance to share information about costs and prices. The information obtained was grouped into three themes: company information and products; the use of sorghum in feed; and the feed supply chain.

Table 15: Case Studies of Animal Feed Manufacturers, Nairobi, Kenya, 2015

	UNGA Farm Care (UFCL)	Jubilee Feed Industries	Nguku Products Limited
Year established	1949	2000	2001
Installed capacity (t)	207,692	165,000	220
Operating capacity 2015 (%)	65	60	100
Feed produced 2015 (t)	135,000	99,000	220
- Poultry	101,250	79,200	220
- Cattle	29,700	11,880	
- Pigs	4,050	7,920	
Raw material used for feed in 2015 (t)	54,720 [1]	69,300 [2]	154 [3]
- Maize	60,000	48,510	108
- Wheat	500	17,325	26
- Sorghum	300	2,079	20
Price at which sorghum is competitive with maize (KES/kg)	19	23	21
Price of maize (KES/kg)	21	26	27
Difference with maize price (%)	0.09	12	22
Maximum share of sorghum in poultry feed (%)	0.01	3	13

Source: own table
Notes: [1] Calculated based on 90% of the feed from cereal-based raw materials, from a total of 60,800 tons of raw materials used in 2015. [2] Calculated based on 70% use of cereal-based raw materials. [3] Calculated based on the total figures provided.

5.3.1. Unga Farm Care Ltd

Company information: Unga Farm Care Limited (UFCL) was founded in 1949 and is the largest manufacturer of animal feed in Kenya with 25-30 % of the market. UFCL manufacturers 135,000 tons of feed per year, of which 100,000 is for poultry, 30,000 for cattle, and 5,000 for

pigs. The feed unit operates at 65% of its installed capacity. UFCL's main competitors are Pembe Feeds and Insinya – Sigma Feeds. The largest buyers are Kenchick and Farmers' World. In the past five years, sales of feed have increased by 9% mainly driven by the growth in the poultry sector which is estimated at more than 10% per year. UFCL uses maize, wheat and sorghum as the main ingredients for feed with estimated quantities of 60,000 tons, 500 tons and 300 tons respectively in 2014.

Use of sorghum in animal feed: Previously, UFCL did not use sorghum to make animal feed. This was due to the high cost of sorghum at 33 KES/kg. However, UFCL will use sorghum as raw material for feed if its price is 10-20 % less than maize. In 2014 UFCL used sorghum as raw material for the first time, buying 300 t to make poultry feed. They did not buy any specific variety of sorghum but believed it might have been an Australian variety. The company estimates that use of sorghum in feed can increase up to 50 % in the near future, provided that the price of sorghum is competitive with maize. Although the company knew that animal feed in the United States is made entirely with sorghum, UFCL cannot replace maize completely with sorghum due to the anticipated weight loss of chickens from inadequate nutrition.

Feed supply chain: The requirements of the feed industry are seasonal and the peak period for procuring raw material is November, December and March. Supply of raw materials is scarce from May to October. UFCL procures raw materials at the farmgate, from traders and from manufacturers. Contractual arrangements are made with one large farmer growing sorghum, finger millet and wheat on 800 acres. Quality and volumes are the major problems in sourcing raw materials and hence the company prefers to purchase quality assured raw materials from this farmer who follows good post-harvest practices for grains. The high price of sorghum relative to maize is the major constraint to increase the uses of sorghum in animal feed.

5.3.2. Jubilee Feed Industries Limited

Company information: Jubilee Feeds produces 16,500 tons of feed per year, of which 80% percent is for poultry, 12 % for cattle and 8 % for pigs. The poultry feed sector has increased by 20 % over the last 5 years and the company's sales have also increased by a similar percentage. In 2014 it operated at 60 % of capacity. The company sells 80 % of its feed through a stockist network across the country and 20 % directly to farmers. In terms of raw material for feed, the company uses 35% maize, 25% wheat, 15% sorghum and 7% rice. The remaining 18% constitute other ingredients such as fish meal, maize by-products, sunflower seed cakes, soya bean meal cakes, cotton seed cake, minerals and vitamins. While sorghum was mainly sourced from Kenya, maize, wheat and rice based products were also imported from Uganda and Tanzania.

Use of sorghum in animal feed: Sorghum is mainly used for poultry feed. Feed manufacturers prefer sorghum varieties with low tannin, white colour, and large grain size. The use of sorghum in the feed sector in Kenya is recent. In 2014 after the government imposed excise duty on sorghum beer, demand dropped and prices fell due to oversupply. Many feed manufacturers then started using sorghum, up to 10% of the raw materials requirements for producing feed. The main factors behind this increase were sorghum's low cost and

availability. Maize is purchased at KES 2,500 per 90 kg bag which is approximately 28 KES/kg. In 2015, the price of maize ranged from KES 3000 to KES 2,600 per 90 kg bag, while sorghum was available for KES 2,300 per 90 kg bag. The fall in price led to the use of sorghum in feed. In 2014, the company used 15% sorghum, estimated at 1,980 tons. Feed manufacturers prefer to buy sorghum if the price of sorghum is 10% less than that of maize. The company is unaware of the differences between sorghum varieties and purchases sorghum based on visual inspection. Apart from the cost of raw materials, the costs of other operations such as cleaning, grading, storage and transportation are the same as for maize. However, the company observed that the labour cost for milling sorghum is 5 % higher because sorghum's harder shell and its smaller grain makes it harder to grind than maize. The company foresees an increase in the demand of sorghum for feed, due mainly to high consumption of chicken meat, growing awareness among farmers about the use of improved feed, and as an alternative to maize in the event of falling maize productivity. The company also believed that sorghum can replace up to 60—70% of maize in animal feeds. Sorghum cannot entirely replace maize as the quality of feed value for sorghum is lower than for maize. However, the manager believed that cost also played an important role in the use of raw materials. If in future the price of sorghum was lower than for maize, 100% replacement could be possible and the loss in tannins/proteins could be replaced by supplements of amino acids. However, this suggestion may be impractical in terms of maintaining the quality of feed.

Feed supply chain: October, November and December are the peak months for the broiler market. There is a shortage of grains, both maize and sorghum, from January to March. Most of the sorghum is purchased from their own preferred grain dealers and the company does not make direct purchases from farmers or from farmer groups.

5.3.3. Nguku Products Limited

Company information: Established in 2001 Nguku Products is a producer of broiler chicken and chicken feed. In 2014 the company produced 220 tons of feed. It mainly uses maize and wheat by-products to manufacture feed. They estimate the size of the poultry feed industry to be 500,000 tons in Kenya. The company does not sell feed in the markets and is distributed to their contracted farmers producing chicken.

Use of sorghum in feed: Sorghum is difficult to source due to its unavailability and also commands a higher price than maize. It estimates that in poultry feed a mix of 60 % maize and 40 % sorghum could be a good proportion because if sorghum is increased to much the palatability of feed decreases. Sorghum also has less fibre content as compared to maize. They estimate that 2 kg of feed should lead to production of 1 kg meat. They are unaware of the sorghum varieties that are available but use white varieties. The company is also of the opinion that sorghum needs to be competitive in its pricing for increased use in the feed industry. Broken maize and off-colour maize is available at KES 15 and KES 18/kg while the price of sorghum is around KES 27/kg. A sorghum price between KES 21-24/kg would be ideal for its use in feed and the company could use 100 tons of sorghum each year.

Feed supply chain: The company purchased sorghum in 2014 from Smart Logistics an aggregator based in Kitui. The company prefers to deal with one credible and reliable company to source their sorghum. They are open to developing contractual relationships with such

suppliers if the farmers are organized and trained to produce sorghum of the desired quantity and quality.

5.4. Potential utilization

The potential utilization of sorghum for livestock feed in ESA was determined based on the substitution of sorghum for maize. Table 16 shows that white sorghum can replace 100% of the maize used in poultry and ruminant diets, and pearl millet can replace 50% of maize in these same diets. Brown or red sorghums are less suitable for livestock feed based on their low levels of substitution with maize. Based on these limits, we assumed a substitution rate of 100 % of white sorghum for maize in the current level of demand for livestock feed.

Table 16: Limits on the use of sorghum and pearl millet for livestock feed (% maximum inclusion)

Type of livestock	Brown sorghum	White sorghum	Pearl millet
Poultry			
Broiler	12	No limit	50
Layer	15	No limit	55
Pigs			
Growing	20	No limit	No limit
Breeding	20	No limit	0 (not suitable)
Ruminants	30	No limit	No limit

Source: Rohrbach and Kiriwqggulu (2001a): 12.

In view of the differences between the FAO commodity balance sheet, national statistics and estimates from ICRISAT surveys, we have had to use our own judgement in estimating current utilization for livestock feed production. Table 17 shows our estimate and the sources for the figures we have used. The results show current utilization of 638,000 t, dominated by Kenya (82%). Assuming a rate of substitution of 100 % between white sorghum and maize, and a target of 10 % of current utilization, gives a potential utilization of 64,000 t of sorghum in livestock feed.

Table 17: Potential utilization of white sorghum for livestock feed in ESA, 2013 (000 tons)

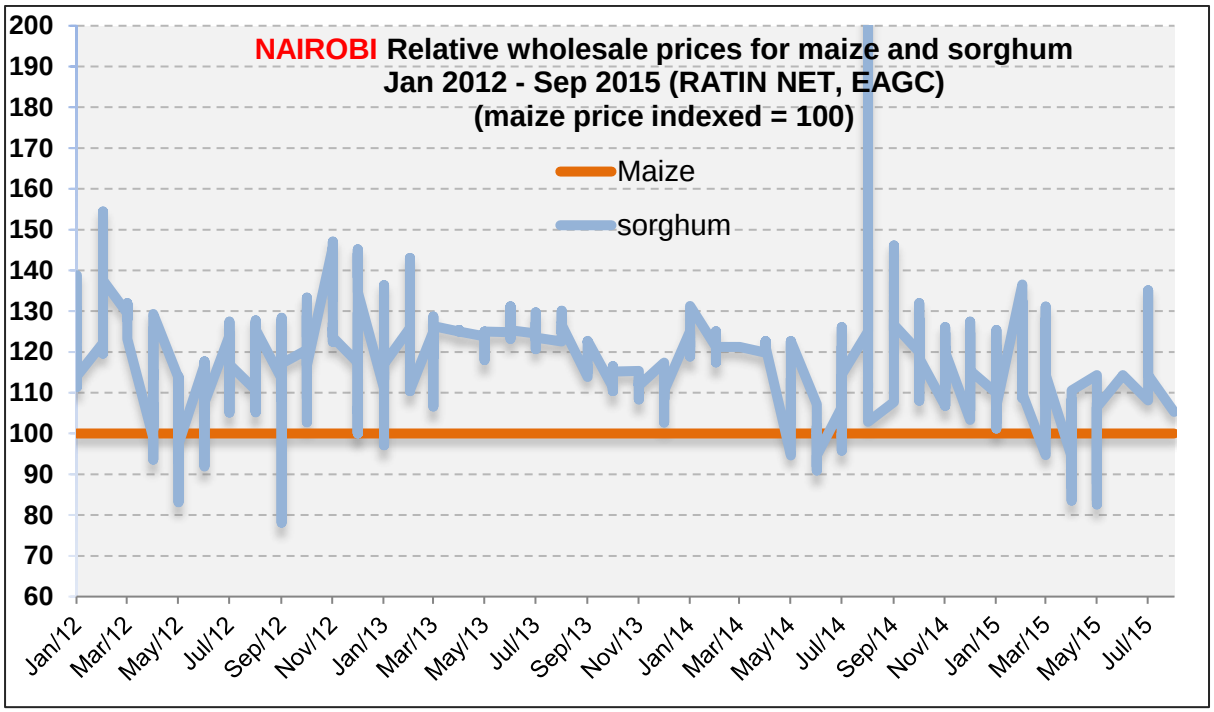
Country	Current annual utilization			Estimated current feed production	Potential utilization of white sorghum
	FAO utilization [1]	UN Abstracts feed production [2]	Other, feed production		
Ethiopia	414	27		27	3
Kenya	106	520 [4]		520	52
Tanzania	1,034	3.5	60 [3]	60	6
Uganda	276	31		31	3
Total	1830	526		638	64

[1] FAO Commodity balance sheets (Table 10 above). [2] UN Statistical Abstracts of Manufacturing (2010-14). (Table 13 above), [3] Rohrbach and Kiriwaggulu (2001a). [4] Table 14 above.

Of course, this potential will only be realized if sorghum can compete with maize on price. The feed manufacturers that we interviewed in Kenya reported that sorghum can increase its share to about 60-70 % in the feed industry only if the price of sorghum relative to maize is discounted by about 10-20%. (The replacement of regular maize as a source of raw material for livestock feed with quality protein maize (QPM), which has higher levels of amino acids like lysine, would reduce feed manufacturing costs by an estimated 5 % (De Groote, et. al., 2010). The use of QPM maize would raise the price discount for sorghum required by feed manufacturers to 25 %) Similarly, feed manufacturers in Tanzania were willing to substitute sorghum and pearl millet for maize if they were priced 15-20 % less than maize (Rohrbach and Kiriwaggulu, 2001a).

However, Figure 12 shows that the price ratio of sorghum/maize in Kenya between 2012 and 2015 was above 120%. The price ratio became favourable in late 2014 and in early 2015, which led to some utilization of sorghum by the feed industry. This reflected a sudden reduction in demand for sorghum from the brewing industry in response to an increase in the excise duty on sorghum beer. In general, however, reducing the sorghum/maize price ratio to the level required by the feed industry would require significant growth in the supply of sorghum to drive down prices.

Figure 12: Price ratios for sorghum and maize in Kenya, 2012-15



6. Flour

6.1. Introduction

The grain milling industry is an important potential source of demand for sorghum and millets. The flour processing sector in ESA operates through two parallel systems: either consumers buy grain and take it to milling shops to be ground into flour, or they buy ready-packed flour supplied by formal processing companies and sold in retail shops and supermarkets. However, retail shops and supermarkets serve only a minority of urban, middle-class consumers, and most sorghum and finger millet flour is still processed by informal-sector milling shops (Schipmann-Schwarze et. al., 2013). Urbanization is expected to increase the share of sorghum and millets processed by the formal sector. As average income rises, the number of African consumers that are able to afford ready-packed flour is expected to increase. The growth of the African middle-class is expected to fuel consumer demand for processed food, including processed sorghum and millet products.

6.2. The milling industry

Table 18 summarizes information from FAO on the quantity of cereals used for 'food processing'. This category includes cereals used for processing into beer as well as into flour. The statistics are based on food processing by the formal sector, or large-scale breweries and grain mills, and excludes processing by the informal sector, or by small-scale firms located primarily in rural areas.

The formal food processing sector is relatively small. In the four countries under review, the share of available domestic food supply that enters the formal processing sector is 10% for sorghum and 21% for millets. Hence, most of the available food supply for these crops never enters the formal sector but is processed either on the farm by the growers themselves or by the informal sector. The higher share of millets entering the formal sector reflects its status as a 'cash crop' and the use of millets for making traditional beers as well as nutritious flour used as a weaning food.

For sorghum, Uganda (46%) and Tanzania (43%) have the highest share of domestic sorghum supply entering the formal food processing sector, followed by Kenya (20%). Although Ethiopia has by far the biggest available supply of sorghum, none is processed by the formal food processing sector. This reflects the preference of Ethiopian consumers for buying whole grain and processing through the informal sector. This preference is shared even by urban, middle-class consumers. Consequently, Ethiopia has no formal food processing sector for sorghum.

For millets, Tanzania (43%) and Kenya (20%) have the highest share domestic of domestic supply entering the formal food processing sector, followed by Ethiopia (14%) and Uganda (12%). The high share of food processing for millets in Tanzania is hard to explain. However, the evidence from household surveys in central Tanzania (Table 6 above) confirms that a relatively high share of millets is sold. The food processing industry in Kenya also imports millets from Tanzania, which increases competition between buyers and contributes to the high share entering the market.

Remarkably, although Ethiopia is the largest producer of sorghum and millets, the share of total production that is processed is small (0% for sorghum, 14 % for millets). A survey of 57 processing companies conducted in 2013 showed that the main raw materials for flour were teff (for *injera*) and wheat and maize (bread) (Kassa et al. 2014). Of the processors making injera, about 80 % blended teff flour with sorghum, which was a cheaper ingredient. Thus, the potential demand for sorghum flour is high, since it can be blended with teff to make *injera*, which is the staple cereal dish.

Table 18: 'Processing' Use from FAO Commodity Balance Sheet, 2013 (000 tons)

	Crop	Kenya	Ethiopia	Uganda	Tanzania	Total
Supply	Sorghum	145	4,282	319	832	5,578
	Millets	79	807	227	319	1,432
	Maize	3,893	6,185	2,438	5,102	17,618
	Total	4,117	11,274	2,984	6,253	24,628
'Processing'	Sorghum	32	0	148	359	539
	Millets	16	113	28	138	295
	Maize	18	9	313	24	364
	Total	66	122	489	521	1,198
'Processing' (%)	Sorghum	22	0	46	43	10
	Millets	20	14	12	43	21
	Maize	1	0	13	1	2
	Total	2	1	16	8	5

Source: Table 10

In ESA the two most common milling products are maize meal and wheat flour. The FAO commodity balance sheets for ESA estimate the quantity of maize used for 'processing' but give no information for wheat (Table 10). Estimates of the production of wheat flour are available from national statistics. According to these data, Kenya is the biggest producer of wheat flour, followed by Ethiopia, Tanzania, and Uganda (Table 19).

The national statistics for Uganda, Ethiopia, and Tanzania give no information on the production of maize flour. A recent study of the value chain for maize in Uganda estimated that commercial production of maize flour accounted for 15% of total maize production (BMGF, 2014a). Applying this ratio to the 2,438,000 t harvested in 2013 gives 366,000 t of maize. Converting thi**s** to flour production using an extraction rate of 72 %, which is normal for white flour (Bender, 2005), gives 263,000 t of maize flour. A recent study of the value chain for maize in Ethiopia estimated that production of wheat and maize flour accounted for 57% and 1% of commercial flour production (RATES, 2003). Applying this ratio to the average production of wheat flour in 2010-14 gives a total of 14,000 t for the production of maize flour. Finally, a recent study for Tanzania estimated that 15% of total maize production was processed into maize flour, mostly by small rural mills (BMGF, 2014b). Applying this ratio to the 5,102,000 t harvested in 2013 and converting to flour using an extraction rate of 72% gives 551,000 t of maize flour.

Table 19: Flour production, ESA, 1990-2014 (000 tons)

Country/type	1990-94	2000-04	2010-14
Ethiopia			
- Maize	Na.	3	14
- Wheat	112	150	771
- Other	28	1	96
Kenya			
- Maize	202	166	531
- Wheat	188	233	856
Uganda			
- Maize	Na.	Na.	263
- Wheat	11	37	237
- Other	Na.	Na.	Na.
Tanzania			
- Maize	Na.	Na.	551
- Wheat	24	338	450
- Other	*na.*	10	15

Sources: 1990-94: UN (1996); 2000-04, 2010-14: Statistical Abstracts, various years. Uganda maize, 2010-14: BMGF (2014a). Tanzania maize, 2010-14: BMGF (2014b); Ethiopia maize: RATES (2003).

6.3. Case studies

We investigated the processing of sorghum and finger millet flour in Tanzania, Kenya, and Uganda (Schipmann-Schwarze et. al., 2015). Fifty-three companies processing these crops were interviewed in 2011-2012. Here we present the results that are most relevant for the potential development of this value chain.

6.3.1. Company profiles

Except in Kenya, the processing sector was dominated by small- and medium-scale companies with 8-10 employees and an annual demand of below 50 t per year (Table 20). Annual demand was highest for finger millet in Kenya (600+ t). The main products were pure sorghum or millet flours or various blends, mixing sorghum and millets with other cereals or with soya. These products were used as weaning foods. Most firms operated below capacity because of demand constraints, inconsistent supply of raw material, and fluctuating prices for grain.

Table 20: Company profiles, demand and major products

Structure	Tanzania (n=25)	Kenya (n=13)	Uganda (n=15)
Average employees (no).	9	56	16
Yeas in business (no.)	8	21	14
Years processing sorghum or millets (no.)	6	10	9
Finger millet demand (mt/year)	32	663	30 (processors) 273 (millers)
Sorghum demand (mt/year)	36	95	32
Major products (% sorghum or millets in product)	Pure flour (100%) *Lishe* (30%) Other blended flours (20%)	Pure flour (100%) *Uji* flour (30%) Other blended flours (40-50%)	Pure flour (100%) Millet-soya flour (80%)
Companies reporting spare capacity (%)	80	80	90

Source: Schipmann-Schwarze et. al., (2015).

6.3.2. Quality, grades and prices

Although 62 % of processors in Tanzania claimed they were satisfied with the quality of grain they purchased, only a minority of firms in Kenya (42 %) and Uganda (31%) were satisfied with grain quality (Table 21). Cleanliness was the single most important quality required by over 80 % of processors in all three countries, followed by grain colour (white or red), and freedom from damage by pests (20-30%). Hand threshing of sorghum and millets results in contamination by sand and stones, which require cleaning by grain washing to prevent damaging expensive milling equipment. Over 70% of processors in all three countries were willing to pay a price premium for grain quality. Few processors in Kenya (22 %) or in Uganda (20 %) graded the grain they bought from suppliers, implying that they paid the same price irrespective of grade, whereas 64 % of processors in Tanzania claimed to use grades, paying different prices for the first and second grades. Grain prices for millets were higher than for sorghum in Kenya and Uganda, though not in Tanzania. Price fluctuations for grain between high and low seasons varied from 30 – 48 % in Tanzania and Kenya but only by 18 % for millet in Uganda. By contrast, the price of sorghum and millet flour was usually the same, with higher prices charged for blends rather than pure flour.

Table 21: Quality, grades and prices for sorghum and millet flour

	Tanzania (n=25)		Kenya (n=13)		Uganda (n=15)
Satisfied with grain quality (%)					
Yes	62		42		31
Quality requirements (%)					
Cleanliness	98		79		85
Colour	26		46		46
Free from pest damage	34		25		-
Maturity	14		-		15
Moisture	9		79		-
Size of grains	-		-		23
Willing to pay price premium? (%)					
Yes	72		75		90
Premium (%)	25		Na.		Na.
Applying grades (%)					
Yes	64		22		20
Mean grain prices (USD/kg)	Sorghum	Finger millet	Sorghum	Finger millet	Finger millet
Low season	0.60	0.50	0.58	0.66	0.79
High season	0.42	0.30	0.30	0.43	0.65
Difference (%)	30	40	48	35	18
Mean flour prices(USD/kg)					
Pure flour	1.12	1.12	1.13	1.06	1.0
Lishe flour	1.30	1.30	0.98	-	-
Uji flour	-	-	-	1.31	-
Millet-soya flour	-	-	-	-	1.1

Source: Schipmann-Schwarze et al. (2015).

Although the company profile of finger millet and sorghum processors differed between the three countries, they faced some of the same challenges (Table 22). On the supply side, the biggest reported challenge was the lack of reliable supply. This reflects the use of sorghum and millets as insurance crops in drought years, which reduces the supply available for sale. Processors, on the other hand, require a steady supply of grain to minimize their production costs and to meet consumer demand. A second challenge on the supply side was the lack of capital to invest in de-hullers and hammer mills. This reflects the structure of the milling industry, with the majority being small firms. However, capital for investment does not appear to be a major constraint, since most firms do not operate at full-capacity and existing equipment is under-used.

On the demand side, the major challenge found in all three countries was a lack of consumer demand, viewed as reflecting lack of consumer awareness on the nutrition and health benefits of sorghum and millet flour. Only large companies can afford to spend on advertising. However, consumption can be promoted by external actors that provide consumers with relevant information about the health benefits of finger millet and sorghum. Given the

predominance of small- and medium-scale producers in the processing sector outside Kenya, this would require an externally-funded marketing campaign.

Table 22: Challenges facing processors (% reporting)

Major challenges (%)	Tanzania (n=25)	Kenya (n=13)	Uganda (n=15)
Main business challenge	Lack of capital (56%) Unreliable demand (20%) Lack of machines (20%	Unreliable demand (40%) Insufficient supply (30%)	Unreliable demand (54%) Lack of capital (31%) Unreliable supply (31%)

Source: Schipmann-Schwarze et. al., (2015).

6.3.3. Prospects

Most of the processors we interviewed reported increasing demand. In Tanzania, 95 % of sample processors reported increasing demand, while in Kenya 69% of processors reported increased demand for finger millet and 64 % for sorghum. In Uganda, all finger millet processors stated that demand had increased over the past five years. Looking to the future, all the sample processors in Tanzania and Uganda expected demand for their products to increase, while in Kenya 92 % of finger millet processors and 82 % of sorghum processors also expected growth in demand. The processors we interviewed were primarily targeting retail shops and supermarkets. Urbanization and increasing health consciousness among consumers are expected to increase demand for finger millet and sorghum flour in these market outlets. Box 6.1 explores the potential role of middle-class demand for ICRISAT's Smart Foods.

6.4. Potential demand

Based on evidence of rising income and middle-class demand, we estimated a 10% increase in demand for sorghum and millet flours by 2025 (Table 23). At current price levels, millets provide a specialty market for middle-class consumers and include both pure and blended flours (Table 21). Therefore, millets are not a substitute for wheat flour or maize meal.

Table 23: Current and potential demand for sorghum and millet flour in ESA, 2013 (tons of grain)

	Current utilization as flour (t) [1]		Potential utilization as flour (t) (+10%)	
	Sorghum	Millets	Sorghum	Millets
Ethiopia	175,172	42,479	192,689	46,727
Kenya	15,500 [2]	20,560	17,050	22,616
Tanzania	86,661	46,276	95,327	50,904
Uganda	37,842	43,895	41,626	48,285
Total	315,175	153,210	346,693	168,532

Sources: [1] Gierend and Orr (2015) Table 12 (urban consumption); [2] Table 20 above for average annual demand by processors (95 t) multiplied by the number of mills in Kenya (163).

In Ethiopia, sorghum flour is mixed with teff flour to make *injera*. Higher prices for teff have led to a higher ratio of sorghum being used to make injera (Deribe et. al., 2014). The urban consumption of teff in Ethiopia averages 61.4 kg per head (Berhane et. al., 2011). In 2013 the total urban population of Ethiopia was 8 million (adult equivalents) (Gierend and Orr, 2015). This gives a total consumption of 491,000 t of teff in urban areas in 2013. Processors in Ethiopia were not willing to reveal the share of sorghum they used to make *injera* since consumers prefer to buy pure teff flour (Kassa et. al., 2014). We have assumed that sorghum can substitute for 10 % of the current consumption of teff flour, which gives an additional potential demand of 98,000 t.

The potential utilization of sorghum was determined based on the substitution of sorghum for wheat flour and maize meal (see Table 24). Consumer testing of sorghum maize meal in Tanzania showed a strong preference for whiter sorghum meal, of the type produced by improved varieties like Macia and Pato, together with clear plastic packaging so that consumers can see the colour and quality of the meal they are buying (Rohrbach and Kiriwaggulu, 2001b). For wheat flour, white sorghum would make a superior composite flour at substitution levels up to 30% (Dendy, 1992). Industry tests in Zimbabwe suggested a viable substitution rate of 7% and Rohrbach and Kiriwaggulu (2001a) used a substitution rate of 5 % for Tanzania. To estimate potential utilization, we used the conservative figure of 5 % as the rate of substitution of white sorghum for both wheat flour and maize meal.

Again, this potential will only be realized if sorghum can compete with wheat and maize on price. Figure 13 shows that, in the case of wheat, the price ratio of sorghum in Ethiopia has been consistently below 1. The same was true of Kenya, except for the price spike in 1992, but since 2002 the price ratio of sorghum to wheat has been above 1, reflecting the increased demand for sorghum from Kenyan breweries. The story for maize is similar to wheat. In Ethiopia, sorghum has been consistently cheaper than maize while in Kenya the price ratio of sorghum to maize has been more erratic, and since 1998 the price ratio has been above 1. The substitution of sorghum for wheat flour and maize meal in Kenya would therefore depend on the availability of imports from other countries in the region.

Table 24: Potential utilization of sorghum for wheat flour and maize meal in ESA, 2013 (000 tons)

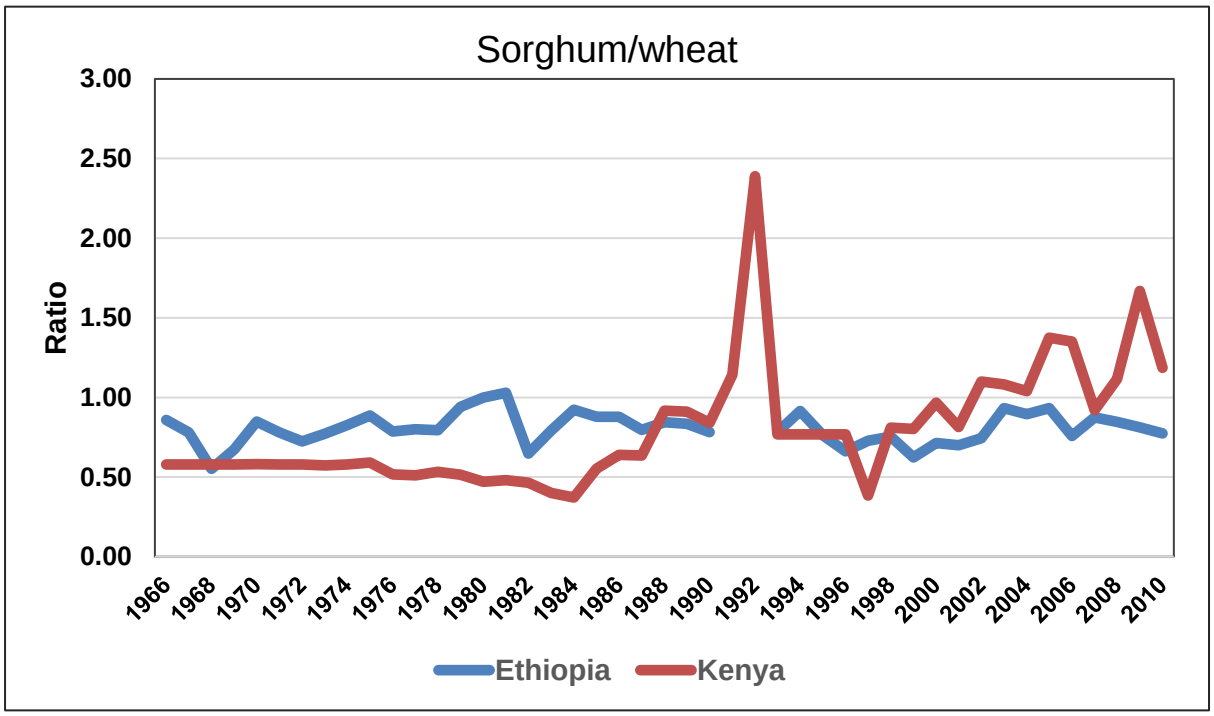
	National Statistics	Value chain studies	Utilization	
			Current [2]	Potential sorghum (5%) [3]
Maize meal	Flour [1]	Flour [1]	Grain	Grain
Ethiopia	Na.	14	19	1
Kenya	531	Na.	738	37
Tanzania	Na.	551	765	38
Uganda	Na.	263	365	18
Total	1359		1887	94
Wheat flour	Flour [1]		Grain	Grain
Ethiopia	771		987	49
Kenya	856		1096	55
Tanzania	450		576	29
Uganda	237		303	15
Total	2314		2962	148

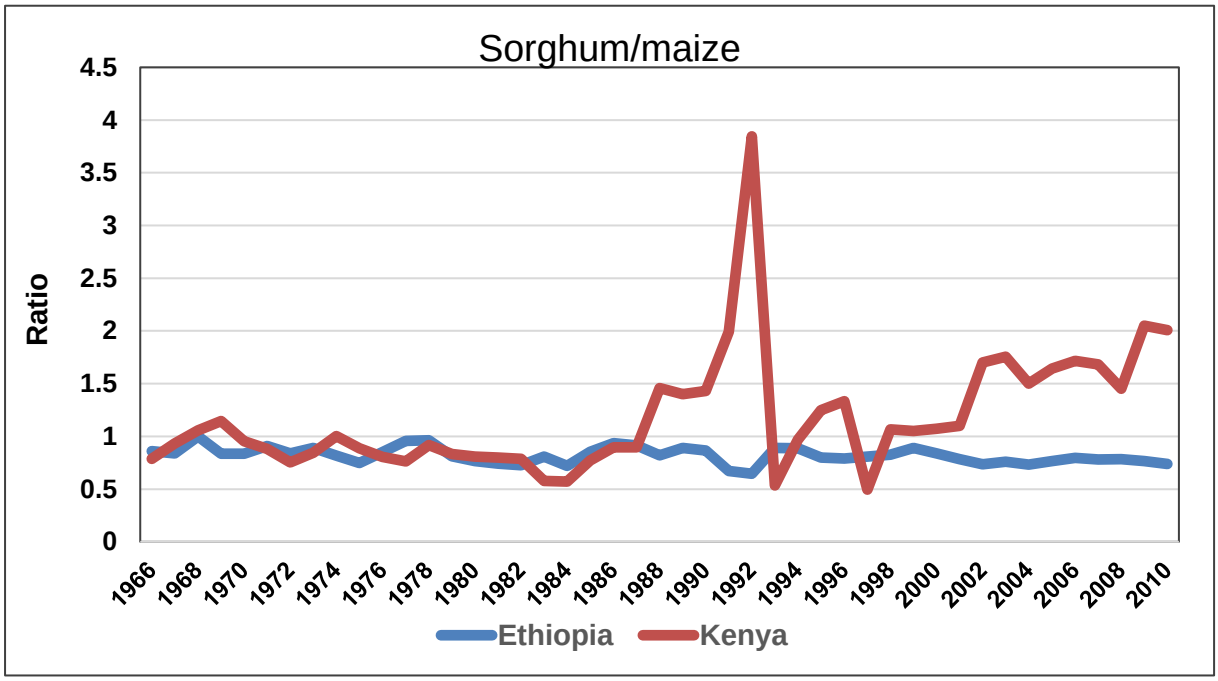
Source:

Notes: [1] Flour production: Table 19; [2] Current grain utilization: W**e** converted flour production to demand for wheat grain using an extraction rate of 72 %, which is normal white flour (Bender, 2005). **[3]** Potential grain utilization (sorghum) Rohrbach and Kiriwaggulu (2001a).

Sorghum also has higher processing costs than maize. Cleanliness was a top priority for buyers (Table 21). In Tanzania, the retail price of sorghum meal is 50-100% higher than for maize meal largely because of higher processing costs for de-hulling and cleaning (Rohrbach and Kiriwaggulu, 2001a). Millets and sorghum are usually threshed on the ground, which allows sand and grit to mix with the grain. Reducing the cost of processing for buyers would require improved post-harvest management of sorghum, including the use of tarpaulins or threshing machines. Without such improvements, higher processing costs would significantly reduce any price advantage that sorghum had over wheat or maize.

Figure 13: Ratio of producer price of sorghum to wheat and maize in Kenya and Ethiopia, 1966-2010





Source: World Bank (2015), African Development Indicators

Box 6.1 Can the middle class drive demand for Smart Foods in ESA?

ICRISAT promotes sorghum and millets as Smart Foods that can improve health and nutrition (ICRISAT 2015). Sorghum and millets already enjoy a reputation as health foods for weaning children, diabetics, and the elderly. Millets have a low glycemic index which helps manage blood glucose levels and prevents diabetes. Demand for Smart Foods is assumed to be highest among urban, middle-class consumers that are at risk from lifestyle diseases and that have sufficient disposable income to afford processed and specialty food products. Targeting Smart Foods at 'the middle of the pyramid' is intended to tap this demand for an improved diet among health-conscious consumers. But what is the size of the market? How many consumers are there and what is their spending power? Recent research has highlighted the role of Africa's emerging middle class in economic development (Ncube and Lufumpa, 2015). In this box, we explore the potential of middle class consumer demand for Smart Foods in ESA.

How big is the middle class?

Recent estimates based on household expenditure suggest that Africa's middle class grew by almost 60 % between 2000 and 2010, from 220 to 350 million (Ncube et. al., 2011). However, these numbers include those living on just $2-4 per day. This segment has been called the 'floating' middle class since it is barely above the poverty line. A more realistic definition based on expenditure of $4-20 per day gives a middle-class of 44 million, or 13.4 % of Africa's total population (Ncube et. al., 2011). For ESA, this translates into a middle class of 16.8 million or 8.7 % of the total population (Table B.6.1).

Table B6.1: 'Middle class' populations, 2008 (millions)

Country	Poor (<$2)	Floating ($2-4)	Lower-middle ($4-10)	Upper-middle ($10-20)	Total ($2-20)	Middle with floating ($2-20)	Middle without floating ($4-20)
Kenya	21.3	10.8	5.9	0.6	38.6	17.3	6.5
%	55.1	28.1	15.2	1.6	100.0	44.9	16.8
Ethiopia	63.2	10.7	4.2	2.4	80.5	17.3	6.6
%	78.5	13.3	5.2	3.0	100.0	21.5	8.2
Tanzania	37.1	3.9	0.6	0.6	42.2	5.1	1.2
%	87.9	9.3	1.4	1.4	100.0	12.1	2.8
Uganda	25.7	3.4	1.5	1.0	31.6	5.9	2.5
%	81.3	10.8	4.8	3.2	100.0	18.7	7.9
Combined	147.1	28.8	12.2	4.6	192.7	45.6	16.8
%	76.3	15.0	6.3	2.4	100.0	23.7	8.7

Source: Ncube et al (2011).

How much spending power does the middle class have?

Tschirley et. al., (2015) provide estimates of the food expenditure of middle-class consumers in ESA (Table B6.2). Their figures are based on five countries: Ethiopia, Uganda, Tanzania, Mozambique and Malawi, and do not include Kenya. They show a middle-class population with spending power of $4-20 per day of 17 m in 2010, which is projected to grow (if the current pattern of growth, in level and distribution, continues), to 224 m by 2040. By 2040, this consumer segment is projected to account for 47 % of the total population. Currently, this group accounts for 19.6 % of total annual expenditure on food. Assuming that the share of food expenditure stays constant within income classes, we can project the share of total food expenditure for each class. By 2040 the middle class will account for 46.1 % of total annual food expenditure. In monetary terms, this will be equivalent to $164 billion. Combined with spending on food by the upper class (($20>) this gives a total annual expenditure on food of $259 billion. For the ESA population as a whole, expenditure on processed food is projected to reach 79 % of total food expenditure by 2040, with 49 % on high-value processed products. Every additional $1 of expenditure results in an additional $1.05 of expenditure on 'high-value' processed products.

Table B6.2. Middle-class spending power in five ESA countries, 2010-2040

Income class	Population		Population		Annual food expenditure		Food expenditure (%)		Processed food	
	2010	2040	2010	2040	2010	2040			Low value	High value
	(mill)	(mill)	(%)	(%)	($bn)	($bn)	2010	2040	(%)	(%)
Poor (<$2)	170	90	72.3	18.7	44.5	23.6	50.4	6.6	16.6	14.9
Middle class ($2-20)	64	363	27.4	75.3	42.0	237.0	47.6	66.7	20.8	25.6
Floating ($2-4)	47	139	20.0	28.8	24.7	73.1	28.0	20.6	19.8	22.9
Lower middle ($4-10)	15	166	6.5	34.4	17.3	164.0	19.6	46.1	23.4	31.8
Upper middle ($10-20)	2	59	0.9	12.1					24.8	41.4
Upper ($20>)	0.6	29	0.2	6.1	1.8	94.8	2.0	26.7	21.9	56.4
Total	235	483	100.0	100.0	88.3	355.4	100.0	100.0	19.0	21.7

Source: Tschirley et. al., (2015), Tables 4 and 5; Figures for share of food expenditure in 2040 are our own projections.

How much might they spend on Smart Foods?

Middle-class consumers spend a higher proportion of their income on 'processed' food. These include 'low-value' processed products like maize flour and milled rice. 'High-value' processed products include breads and bakery products, industrially-produced vegetable oils, and food eaten away from home. The average ESA consumer spends about 41% of total food expenditure on processed products, divided equally between 'low' and 'high' value products (Table B6.2). By contrast, lower-middle and upper-middle-class consumers spend 55-62 % of their total food expenditure on processed products, with 32-41 % of food expenditure on 'high-value' processed products. Given a total expenditure of $164 billion by middle class consumers in 2040, this suggests a potential expenditure of between $53 – 67 billion on processed food products by 2040.

Conclusions

We do not know the size of the potential market for Smart Foods, or what specific products will generate the highest demand. However, if current trends continue, we know that: (1) ESA will see a rapid growth in the number and share of middle-class consumers (2) they will account for most of the expenditure on food and (3) over one-half of their food expenditure will be on processed products. Even if demand for Smart Foods was confined to upper-class consumers spending $20> per day, this would still represent a significant consumer market, accounting for over 25 % of the total expenditure on food, and with 78 % of their expenditure on processed products. The size and growth of this market offers incentives for value-addition by local firms producing a range of Smart Foods to suit different customers. These will range from 'low-value' composite flours for weaning children to 'high-value' breads, sushi and other products for upper-class consumers. With clever marketing Smart Foods can win a share of this growing market in ESA. Nissin Food Holdings, a Japanses transnational, recently launched instant noodles made from sorghum on the Kenyan market (Eagle, 2014). Other manufacturers may also be conducting their own market studies to identify the most promising product lines.

7. Beer

7.1. Introduction

Sorghum and millets in Africa have traditionally been used as ingredients for beer. Traditional opaque beers are made by cooking the grain, souring, mashing, straining and alcoholic fermentation. Opaque beer is generally home-brewed as a source of cash income for rural women. In Zimbabwe, virtually all sales of finger millet are in the form of beer and ICRISAT economists have concluded that the market for traditional beer offers the greatest potential for expanding utilization (Rohrbach and Mazvimavi, 1993). SAB Miller has successfully commercialised the manufacture of opaque sorghum beers in southern Africa (including Zimbabwe, Zambia, and Malawi). However, only one of the four countries covered in the present report – Tanzania – produces opaque beer on an industrial scale. Total demand for sorghum by DarBrew, the major manufacturer, was 2,200 t in 2010 (Makindara, 2012). Since demand for commercially-produced opaque beer in ESA is limited, this value chain is not considered further in this report.

Since 2002, ESA has seen the emergence of a value chain for clear (lager) beer. Commercial production of sorghum beer began in Nigeria in 1991, when a foreign exchange crisis led to a government ban on the import of barley malt. All breweries and malt-based industries were required to convert to the use of sorghum or other local cereal substitutes (Koleoso and Olatunji, 1992).

In ESA, the first commercial sorghum beer (Eagle Lager) was developed by Nile Breweries in Uganda, followed in 2004 by Senator keg developed by East African Breweries Limited (EABL) in Kenya and in 2008 by the launch of Eagle Lager in Tanzania by Tanzanian Breweries (Mackintosh and Higgins, 2004; Makindara, 2012; Orr et. al., 2013b). Only Ethiopia has no commercially-produced sorghum beer. Demand for malt barley in Ethiopia is estimated at 72,000 t per year, of which only 35 % is supplied by Ethiopian growers, the rest being imported from Europe (Deribe et. al., 2014).

7.2. The brewing industry

The brewing industry in ESA is dominated by multinational firms, including SABMiller (South Africa), Diageo (UK/Eire), and Heineken (the Netherlands) (Table 25). The exception is Kenya, where EABL is 50% locally owned. Typically, national markets are dominated by a single company. EABL has a market share of 50 % in Kenya, while SABMiller has market shares of 58 % in Uganda and 70% in Tanzania. Faced with stagnant markets for beer in developed countries, multinationals have invested in Africa, where demand is growing. In Ethiopia, privatization has led to the sale of state-owned breweries and their acquisition by Diageo, Heineken and SabMiller. This inward investment suggests that the market for clear beer is expected to grow significantly in the near future. Currently, beer consumption per head is highest in Kenya (12 litres/capita) which is three times higher than Ethiopia, the next highest consumer.

Table 25: The brewing industry in ESA, 2013

	Kenya	Uganda	Ethiopia	Tanzania
Multi-national companies	EABL (50 % owned by Diageo)	SABMiller EABL	SABMiller Diageo Heineken France owns BGI Ethiopia	SABMiller EABL
Local Name	Tanzanian Breweries Ltd (SAB imports) Kenya Breweries Ltd (EABL) Keroche Breweries	Nile Breweries Ltd.(SAB) Uganda Breweries (EABL)	BGI Meta Brewery (Diageo) Harrar, Bedele (Heineken)	Tanzanian Breweries Ltd. (SAB) Serengeti Breweries (EABL)
Production (hl)	2,500,000 (Kenya Breweries Ltd)	2,408,000 (SAB) 750,000 (EABL)	BGI (1,900,000)	2,749,000
Beer consumption (per capita)	12	9	4	7
Total beer market (hectolitres)	5,000,000	2,800,000	4,000,000	3,077,000
Share of beer market (%)	50 % (EABL) 5 % (Keroche)	58 %	15 % (Meta) BGI+Raya (50 %)	70 % (SAB) 17 % (Serengeti) 12 % (EABL)
Sorghum beer	Senator Keg	Eagle Senator Keg	Nil.	Eagle
Foreign direct investment ($ m)		$29(SAB, 2009) $16 (SAB, 2009) Ks 1.6 billion (EABL, 2011)	$225 (Diageo, 2011) $263 (Heineken) $60 (SAB)	
Year of investment	1922 (EABL) 1998 (Keroche)	1993 (SABMiller) 1946 (EABL)		1993

Sources: various web-based sources.

Demand for beer in ESA has increased since the 1990s. In the four countries under review, the production of beer has tripled in two decades, rising from 4600 hl in the early 1990s to 14,000 hl in 2010-14 (Table 26). The biggest beer markets are Kenya and Ethiopia, which account for 61 % of production.

Table 26: Beer production, 1990-2014 (000 hectolitres)

	1990-94	2000-04	2010-14
Ethiopia	504	1,650	4,233
Kenya	3,395	2,080	4,290
Uganda	225	1,240 [1]	2,460 [1]
Tanzania	503	2,130	3,060
Total	4,627	7,100	14,043

Source: own table
Notes: [1] includes opaque beer. Sources: 1990-94: UN (1996); 2000-04, 2010-14: Statistical Abstracts, various years

Since sorghum in eastern Africa is grown by smallholders rather than on commercial farms, the development of clear sorghum beer offers smallholders the opportunity to benefit from the growth of this value chain. Although breweries producing sorghum beer have tried to source sorghum directly from smallholders, the results have been mixed. Experience shows that the

best business model is for breweries to sub-contract production and delivery to an intermediary. In Uganda, Nile Breweries contracted Afro-Kai Limited, a commodity broker, which contracts farmers and provides seeds and training, collects and aggregates the sorghum, cleans and re-bags, before delivering to the brewery (Balya, 2007). In Kenya, EABL relied initially on Africa Harvest, then contracted a range of intermediaries (including Smart Logistics Solutions) (Orr et. al., 2013b). In Tanzania, Tanzanian Breweries Limited (TBL) contracted with smallholders through farmer cooperatives. The brewery contracted both smallholder and commercial farmers, with half in each category (Makindara, 2012). In all three countries, therefore, breweries have not relied exclusively on smallholders but have also sourced sorghum from wholesale traders.

While these initiatives have brought real benefits to smallholders, the scale of direct involvement by smallholders is low (Table 27). In Kenya, where the demand for sorghum has been highest, the number of smallholders that have benefitted directly is about 3,000. In Uganda, the number is about 9,000. We were unable to find any estimate of the number of smallholders involved in Tanzania, and the figure of 1,000 is our own estimate. In total, the number of smallholders contracted and selling directly to breweries is about 13,000.[6] This is only a tiny fraction (0.6 %) of the smallholders growing sorghum in these three countries. Similarly, in some countries in West and Central Africa (WCA), the number of smallholders involved does not exceed 15,000. [7]

Table 27: Smallholder participation in the value chain for clear sorghum beer in ESA

Country	Company	Brand	Annual demand (t)	Growers supplying (no.)	Total sorghum growers (no.)	Growers supplying (%)
Kenya	East African Breweries Limited	Senator keg	24,000	3,000	240,000 [1]	1.0
Uganda	Nile Breweries	Eagle Lager	11,000	9,000	620,596	0.1
Tanzania	Tanzanian Breweries Limited	Eagle Lager	2,000	c. 1,000.	1,459,649	0.0
Total			37,000	13,000	2,320,245	0.6

Sources: Kenya: Orr et. al., (2013b); Uganda: Kapstein et. al., (2009); Tanzania: Makindara (2012).
Notes: [1] Chemonics (2014). [2],[3]: Total supply (2013) from Table 4 above, divided by mean household production of sorghum from household survey data (Table 5 above), 369 kg/household for Uganda (survey no. 17) and 570 kg/household for Tanzania (mean of survey nos. 12, 13, and 14).

[6] In other countries the numbers are also small. Zambia, SABMiller contracts about 2,000 smallholders to produce sorghum. SABMiller (2015), Annual Report. http://www.sabmiller.com/docs/default-source/sustainability-documents/sabmiller-sustainable-development-report-2015.pdf?sfvrsn=6. . Sorghum is aggregated using an intermediary, CHC Commodities, based in Kabwe district, Central Province. (Chimai, 2011).

[7] In Ghana, the number of farmers supplying sorghum to breweries in 2008-09 was estimated at 11,800, while in Sierra Leone the number in 2009 was 2,000. Van Wijk and Kwakkenbos (2012).

7.3. Case study [8]

The market for beer in Kenya is dominated by Kenya Breweries Ltd, a subsidiary of East African Breweries (EABL), which has an estimated market share of 93%. EABL is a subsidiary of Diageo plc, which has a 50% stake, while 50 % is state-owned through the Industrial and Commercial Development Corporation (ICDC). EABL produced its first bottled sorghum beer, called Senator, in 2003. Disappointing sales led to the rebranding of Senator as Senator keg. As the name suggests this was an un-bottled sorghum beer targeted at 'aspirational' consumers who wanted to 'trade up' from home-brewed drinks but could not afford bottled beers made from more expensive malted barley. Senator keg was marketed as an 'intermediate' product that did not compete with EABL's flagship brands. By 2011, Senator keg had become the second-most popular beer in Kenya, commanding 15.3 per cent of the beer market by volume and earning EABL an estimated $380 million in net sales. In the 2012 financial year, the demand for sorghum by EABL reached 24,000 t, of which Kenyan growers supplied 8,000 t, with the balance met by imports.

Several factors explain the remarkable success of sorghum beer in Kenya. First, EABL had a virtual monopoly. After independence in 1963 EABL swiftly bought out smaller breweries and enjoyed a virtual monopoly over the market for beer until 1998, when SAB Miller bought Castle Brewing in Thika. This sparked a 'Beer War' between EABL and SABMiller. The 'Beer War' ended with a truce in 2002 when SABMiller sold Castle Brewing to EABL, which promptly closed it down. In return, EABL closed Kibo Breweries in Moshi, Tanzania, with SABMiller agreeing to distribute EABL beers in Tanzania and EABL agreeing to distribute SABMiller beers in Kenya. Competition between EABL and SABMiller intensified the pressure on EABL to make a cheaper beer. Victory in the 'Beer War' left EABL free to set prices according to what the market could bear without fear of competition.

Second, the substitution of sorghum for barley malt significantly reduced EABL's production costs for EABL. Devaluation of the Kenya shilling in the 1990s raised the cost of imported malt, while the price of barley also rose sharply in the 1990s relative to the price of sorghum. Although barley is produced in Kenya, price fluctuations encouraged EABL to search for cheaper alternatives. In addition, sorghum can be used to produce beer directly without the added cost of malting. According to EABL, replacing barley with sorghum cut production costs by 20-30 %.

Third, EABL received a tax break on sorghum beer. Market research by EABL revealed that 56 % of alcohol consumption consisted of traditional fermented brews (*busaa*) or distilled spirits (*chang'aa),* which were illegal and therefore untaxed. Eliminating excise duty would encourage consumers to switch to Senator keg, boost sales of legal beer, and allow government to collect some of the tax lost from the sale of illicit brews. In 2004 the government granted a remission of 30 % on excise duty, increased to 100 % in 2006. This allowed Senator keg to be sold at $0.20 per 300 ml glass, the same price as most illicit brews.

[8] This case study is based on Orr et. Al. (2013), which gives full references.

The importance of this tax break was revealed in 2013, when the government re-imposed an excise duty of 50 %, on the grounds that 'it has been difficult administratively to differentiate between various beer products and Senator keg, thereby posing a threat to revenue collection'. Beer made from sorghum, millet and cassava continued to enjoy full remission in excise duty, however. As a result, the price of Senator keg rose from KES 20 to between KES 45-50 per 300 ml glass. According to EABL, the price increase cut sales of Senator keg by 80 %. Falling sales forced EABL to reduce production at its main Nairobi plant in Ruaraka from seven to five days a week. The loss to the value chain resulting from the government's decision was estimated at KES 6.4 billion (Opiyo, 2015).

In 2015, however, the government reversed its decision and the Alcoholic Drinks Control (Amendment) Bill 2015, granted remission of excise duty at 90% for beer made from sorghum, millet or cassava grown in Kenya. The brewer must make beer that has at least 75 % of sorghum, millet and cassava.[9] Although this is less than the 100% remission of excise duty before 2013, it is obviously a significant concession that is expected to revive the value chain for sorghum beer in Kenya. The re-introduction of the tax break saw EABL triple its demand for sorghum to 22,000 t. [10]

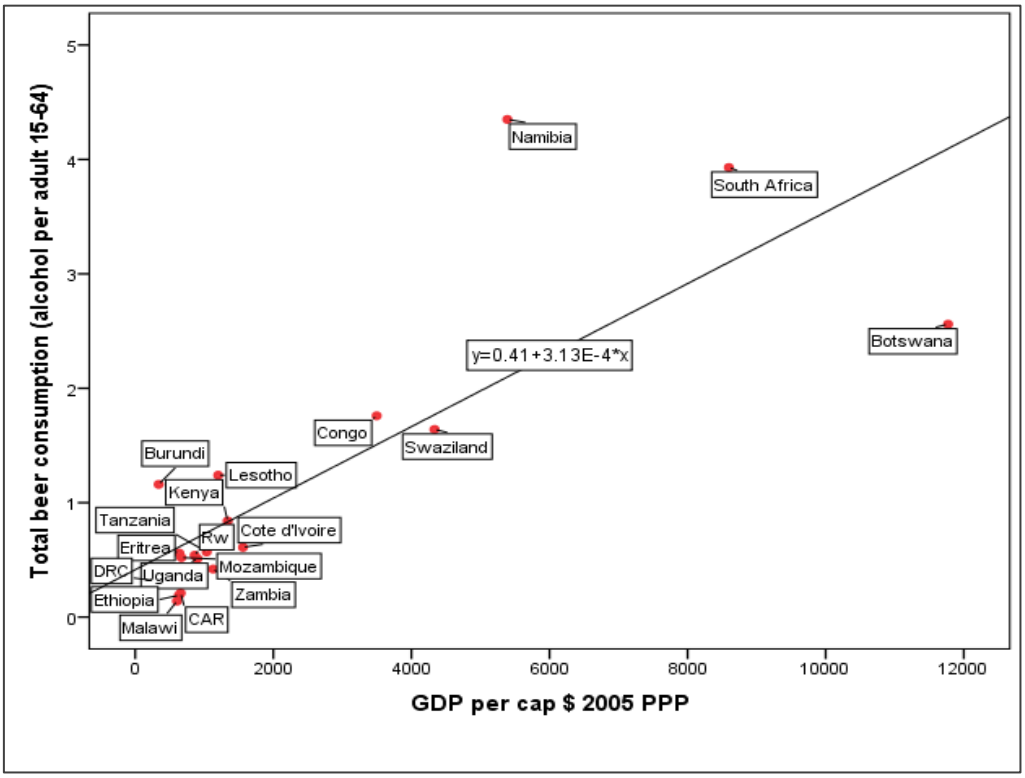
7.4. Potential demand

Demand for beer rises with income. In southern Africa, South Africa, Namibia and Botswana qualify as a Middle Income Country (MIC), defined as those with income per head of over $1,000 per capita. In eastern Africa, however, only Zambia and South Sudan qualify as MICs, although Ethiopia also qualifies if income per head is measured in terms of Purchasing Power Parity (PPP). Lower average income results in lower beer consumption per head in eastern Africa. Beer consumption per adult in Kenya, Ethiopia, Uganda, Tanzania and Uganda is below 1 litre of pure alcohol, compared to 2.5 litres in Botswana and 4 litres in South Africa and Namibia (Figure 14). The regression estimate suggests that additional $1 in income at PPP increases alcohol consumption per head by 0.000313 beer per adult, or that each $1000 in income increases beer consumption by 0.3 litres of pure alcohol per adult. This shows the potential increase in demand for clear beer in eastern Africa as average incomes grow.

[9] The New Nation, 16 May 2016. http://www.nation.co.ke/business/Brewer-farmers-win-big-in-new-tax-on-beer-/-/996/2717994/-/6oxn60/-/index.html

[10] The Daily Nation, 24 November 2015. http://www.nation.co.ke/business/Tax-reduction-boosts-demand-for-sorghum/-/996/2963218/-/vi9w47z/-/index.html

Figure 14: Beer consumption and GDP per capita in Eastern and Southern Africa, 2005



Sources: Beer consumption: WHO (2011) Appendix III; GDP per capita: Source: World Bank (2015), Poverty and Equity Database. http://povertydata.worldbank.org/poverty/country/

Table 28: Potential increase in demand for sorghum from value chain for beer, ESA, 2015-2025

Country	Current utilization of sorghum		Increase 2000-04 to 201-14 (%)	Potential utilization [3]	
	Opaque beer	Clear beer [2]		Opaque beer	Clear beer
Ethiopia		Nil			Nil
Kenya		24,000	106		49,440
Tanzania	2,000 [1]	2,000	44	2,880	2,880
Uganda		11,000	50		16,500
Total		37,000			68,820

Notes: [1] Makindara (2012); [2] Table 27 above; [3] based on national growth rate in beer production 2000-04 and 2010-14 from Table 26 above.

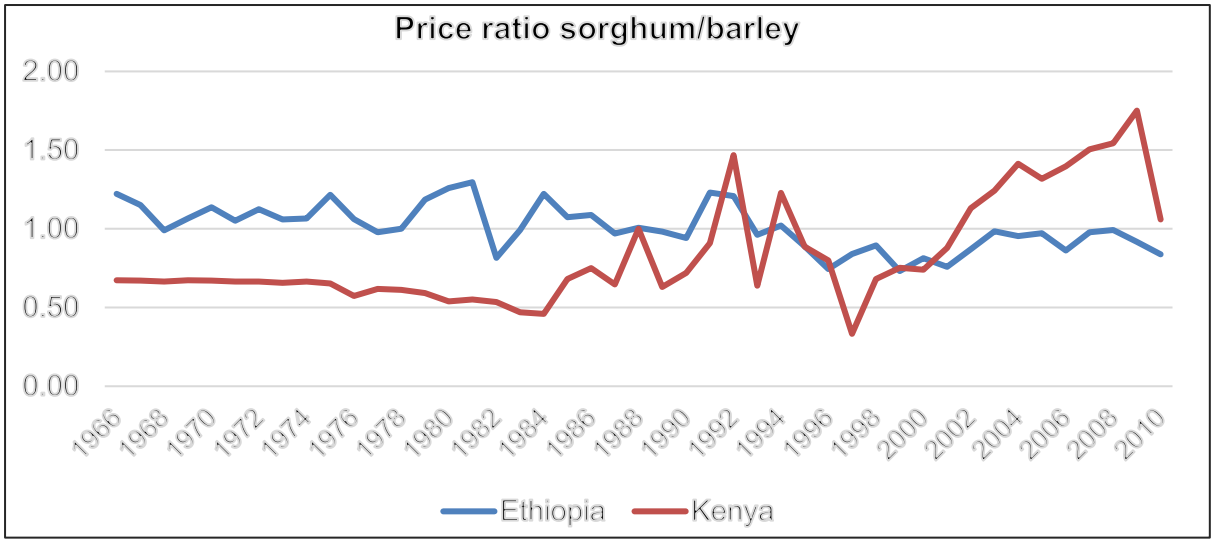
Two pre-conditions must be met in order to realise this potential. First, a favourable tax policy. The experience with sorghum beer in Kenya illustrates the dependence of the value chain for sorghum beer on government tax breaks and its vulnerability sudden reversals in fiscal policy. As in Kenya, the success of sorghum beer in Uganda also hinged on a favourable tax regime: "*Raw material inputs represent only about 15% of the retail selling price of beer and it is thus clear that even a drastic reduction in the cost of raw materials will not have a significant impact*

on the retail selling price if margins are to be maintained. The key success factor in a project of this nature, therefore, is to obtain a reduction in excise duty applicable to a product made from predominantly local raw materials and which could demonstrably contribute to economic development within the country."(Mackintosh and Higgins, 2004: 238).

In Uganda in 2002, the government granted a 100% remission on excise for a limited (but unspecified) period for products using a minimum 75 % of local brewing materials. Only once this was granted did Nile Breweries proceed to develop Eagle Lager, which quickly captured 15 % of the market for bottled beer (Mackintosh and Higgins, 2004). Thus, ‘*'while sorghum lager is slightly more expensive to produce than other beers, its retail price is one-third less than the price of lagers that use imported barley, thanks to a favourable excise structure*" (Inspiris Limited, 2006).

Second, the price of sorghum must be competitive with barley and barley malt. In Kenya, this price ratio has been in favour of sorghum, but from 2002 the ratio has moved sharply in favour of barley (Figure 15). This reflects pressure on the supply of sorghum in Kenya due to increasing demand from EABL. Supply shortages have been met by imports from neighbouring Tanzania and Uganda. In Ethiopia, the price ratio has been in favour of sorghum since the early 1990s. This suggests that sorghum is competitive with barley as a raw material for clear beer. The market for beer in Ethiopia increased by over 150 % in the last decade (Table 26). Recent investments by multinational breweries suggest that the sector will see rapid growth in the future. These companies already produce clear sorghum beer elsewhere in the region. However, since Ethiopia grows its own barley and produces its own barley malt, there is no strong incentive for the government to provide a tax break to encourage production of sorghum beer. Consequently, the potential for the development of this value chain in Ethiopia seems limited.

Figure 15: Ratio of producer price of sorghum to barley in Kenya and Ethiopia, 1966-2010



Source: World Bank (2015), African Development Indicators.

8. Conclusions

In conclusion, we return to the problem of the commercialization of sorghum and millets. The conventional wisdom is that sorghum and millets in ESA are caught in a “subsistence production trap”, which keeps productivity low and prices high (Rohrbach and Kiriwaggulu, 2001). To break out of this trap, R & D is required to boost yields which will increase supply, lower prices, increase competitiveness, and thus stimulate commercial demand for these crops.

Our analysis confirms the relevance of this ‘subsistence production trap” for specific value chains. Except for Ethiopia, prices for sorghum in ESA are higher than for maize and wheat. This limits the current utilization of sorghum in the value chains for livestock feed, wheat flour and maize meal. To increase the utilization of sorghum as livestock feed, manufacturers in Kenya reported that sorghum would have to be 10-20% cheaper than maize. Similarly, to compete with wheat and maize as raw material for flour, sorghum would require a price discount. A second factor limiting utilization of sorghum in these value chains is lack of information about the nutrient composition of sorghum. White sorghum can replace maize for livestock feed without any loss of feed quality. However, some manufacturers believe otherwise. Similarly, sorghum can substitute for wheat in wheat flour and for maize in maize meal. Although the ratio of sorghum in composite wheat flour can reach 30%, processors use ratios of 10 % or below. This highlights the need to provide the feed and flour industries with better information on the quality of sorghum grain.

A 20 % reduction in price is therefore required to increase the utilization of sorghum in the value chains for livestock feed, composite wheat flour, and maize meal. This level of price reduction can only be achieved by increasing yields and boosting supply. This suggests that crop improvement to increase utilization by the livestock feed and flour industries should focus primarily on increasing sorghum yields, and on white sorghum varieties suitable for composite flour.

However, the model of the “subsistence production trap” seems inappropriate for other potential value chains. These include the value chains for specialty sorghum and millet flour, for composite teff flour, and for sorghum beer. In each case, there is evidence of growing commercial demand for sorghum and millets, but without any prior rise in productivity to reduce prices.

In the value chain for specialty sorghum and millet flour, demand is being driven by consumer preferences. The growing share of middle-class consumers will increase demand for processed food. Annual expenditure on processed food by middle-class consumers in five ESA countries is expected to top $53 billion by 2040. This will include demand for nutrient-dense sorghum and millet flour by health-conscious consumers. Smart Foods targeted at this consumer segment can significantly increase utilization of sorghum and millets in this value chain. Sorghum and particularly millets already enjoy a reputation as a health ‘brand’ of flour. Marketing campaigns that highlight the health benefits of these flours for young children, and adults at risk of lifestyle diseases should find a growing demand. As specialty products, they do not need to compete on price with other flours.

In the value chain for composite teff flour, demand for sorghum is being driven by the higher relative price of teff. Teff is the preferred grain for making *injera*, but supply has failed to keep pace with growing urban demand, which has led to a rapid rise in the price of teff. In order to make *injera* affordable for consumers, processors use sorghum to make composite teff flour. Again, this market opportunity is not the result of increasing the productivity of sorghum but of a change in relative prices that has made it profitable for processors to increase their utilization of sorghum.

Finally, in the value chain for sorghum beer, demand is facilitated by fiscal policy. Governments in Kenya, Tanzania and Uganda have encouraged domestic production of sorghum by reducing the excise duty on beer made from locally-sourced materials. This tax break has been critical in creating demand from low-income consumers trading-up to from traditional home-brews to clear beer. Demand for beer in ESA is expected to grow with rising income, and this has attracted investment from multinational breweries. Once again, this market opportunity is independent of any prior increase in the productivity of sorghum, but is the result of favourable government policy and competition within the industry to win new customers.

In conclusion, the argument that increasing the utilization of dryland cereals first depends on raising yields is not true for all value chains. New market opportunities in the value chains for sorghum, millet, and teff flour and for sorghum beer were the result of changes in relative prices, consumer preferences, and fiscal policy that were independent of changes in productivity. Thus, the rising price of teff offers scope to substitute sorghum for teff flour, rising middle-class income and preferences for a healthier diet offer scope for millet flours, while tax breaks have increased demand for sorghum beer. These value chains offer a potential escape route from the subsistence production trap. They also suggest the need to re-think the rationale for growth in productivity as the key driver for the commercialization of sorghum and millets in the region.

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Appendix 1. FAO Commodity Sheets, 2000-2013

Table A1. FAO Commodity balance sheets for cereals in Kenya

Kenya	SUPPLY (in tons)					DOMESTIC UTILIZATION (in tons)					
	Pro-duction	Change in stocks	Imports	Exports	Available Supply	Feed	Seed	Waste	Other uses	Pro-cessing	Food supply
SORGHUM											
Annual growth	3.9%				4.2%						3.9%
2013	139	0	29	23	145	17	4	18	0	32	105
2012	167	0	35	27	174	21	5	22	0	39	127
2011	160	0	58	50	168	22	4	23	0	36	119
2010	164	0	10	50	124	17	5	19	0	25	83
2009	99	0	59	2	156	15	3	17	0	37	121
2008	54	0	3	1	57	7	3	6	0	12	40
2007	147	0	1	1	147	16	3	16	0	34	112
2006	131	0	38	0	169	17	3	19	0	40	130
2005	150	0	17	0	167	16	3	19	0	39	129
2004	70	0	0	0	69	7	2	8	0	16	52
2003	127	0	0	0	127	13	2	14	0	30	98
2002	116	0	0	0	115	12	3	13	0	27	88
2001	117	0	0	1	116	12	3	13	0	27	89
2000	82	0	2	1	82	8	3	9	0	19	62
FINGER MILLET											
Annual growth	2.6%				4.0%						4.3%
2013	64	0	15	0	79	6	2	9	0	16	63
2012	75	0	18	0	93	7	2	10	0	19	74
2011	73	0	2	0	76	6	2	8	0	15	59
2010	54	0	17	0	71	6	2	8	0	14	55
2009	54	0	12	0	66	5	2	7	0	13	52
2008	38	0	11	0	50	3	2	6	0	10	39
2007	120	0	39	0	158	10	2	18	0	33	128
2006	79	0	1	0	80	6	3	9	0	16	62
2005	53	0	4	0	57	5	3	6	0	11	43
2004	50	0	2	0	53	4	2	6	0	10	41
2003	64	0	3	1	65	5	2	7	0	13	50
2002	72	0	2	0	74	6	2	8	0	14	58
2001	45	0	1	0	45	4	2	5	0	9	34
2000	45	0	1	0	46	4	2	5	0	9	35
MAIZE											
Annual growth	3.3%				2.2%						2.1%
2013	3,391	-61	596	34	3,893	106	68	83	3	18	3,636
2012	3,600	-65	633	36	4,133	112	73	88	3	19	3,860
2011	3,377	-160	314	15	3,516	120	65	73	8	11	3,258
2010	3,465	-250	259	18	3,456	95	64	74	2	12	3,223
2009	2,439	-700	1,554	17	3,276	80	57	79	1	12	3,061
2008	2,367	701	263	34	3,297	80	54	66	1	36	3,097
2007	2,929	147	173	61	3,188	80	54	64	0	8	2,990
2006	3,247	-167	160	30	3,211	76	48	68	1	12	3,018
2005	2,906	131	133	20	3,149	57	53	63	0	19	2,977
2004	2,607	219	265	23	3,067	58	53	61	1	12	2,895
2003	2,711	225	108	35	3,009	55	41	61	0	22	2,853

2002	2,409	418	19	35	2,811	50	50	57	1	0	2,654
2001	2,790	-206	324	6	2,902	62	48	62	1	0	2,730
2000	2,160	292	418	7	2,862	49	49	57	2	8	2,706

Source: FAOSTAT

Table A2. FAO Commodity balance sheets for cereals in Ethiopia

Ethiopia	SUPPLY (in tons)					DOMESTIC UTILIZATION (in tons)					
	Pro-duction	Change in stocks	Imports	Exports	Available Supply	Feed	Seed	Waste	Other uses	Pro-cessing	Food supply
SORGHUM											
Annual growth	9.7%				7.6%						8.1%
2013	4,338	0	0	0	4,338	0	0	0	0	0	4,338
2012	3,604	0	0	0	3,604	0	0	0	0	0	3,604
2011	3,951	-400	53	22	3,583	0	34	200	1,100	0	3,349
2010	3,960	-700	352	22	3,590	0	38	216	1,100	0	3,336
2009	2,971	0	269	0	3,240	0	38	162	850	0	3,040
2008	2,659	0	253	2	2,910	0	32	146	800	0	2,732
2007	2,316	0	16	2	2,330	0	31	117	350	0	2,183
2006	2,174	0	1	1	2,173	0	29	109	160	0	2,035
2005	1,716	0	3	13	1,705	0	29	86	0	0	1,590
2004	1,742	40	5	2	1,785	0	25	89	0	0	1,671
2003	1,784	0	24	1	1,807	0	26	90	0	0	1,691
2002	1,546	140	10	1	1,695	0	27	85	0	0	1,584
2001	1,549	100	9	0	1,657	0	23	83	0	0	1,552
2000	1,188	370	7	1	1,564	0	27	78	0	0	1,459
FINGER MILLET											
Annual growth	6.8%				6.8%						6.9%
2013	807	0	0	0	807	0	12	40	0	113	754
2012	742	0	0	0	742	0	11	37	0	104	694
2011	652	0	0	0	652	0	9	33	0	92	611
2010	635	0	0	0	635	0	9	32	0	89	594
2009	524	0	0	0	524	0	8	26	0	73	490
2008	484	0	0	0	484	0	7	24	0	68	453
2007	397	0	0	0	397	0	8	20	0	55	369
2006	500	0	0	0	500	0	7	25	0	70	468
2005	397	0	0	0	397	0	8	20	0	55	370
2004	333	0	0	0	333	0	7	17	0	46	310
2003	305	0	0	1	304	0	6	15	0	42	283
2002	306	0	0	9	297	0	6	15	0	41	276
2001	316	0	0	0	316	0	6	16	0	44	295
2000	320	0	0	0	320	0	7	16	0	45	297
MAIZE											
Annual growth	6.7%				5.2%						4.8%
2013	6,674	-529	69	29	6,185	414	72	338	0	9	5,359
2012	6,158	-488	64	27	5,707	382	67	312	0	8	4,945
2011	6,069	-1,250	31	60	4,790	600	50	304	0	0	3,836
2010	4,986	-650	32	36	4,332	350	51	251	0	1	3,680
2009	3,897	0	57	0	3,954	200	49	198	0	0	3,508
2008	3,776	0	73	0	3,850	120	44	191	0	28	3,495
2007	3,337	150	34	0	3,521	100	44	176	0	0	3,201
2006	4,030	-500	62	1	3,591	120	42	204	0	0	3,224
2005	3,912	-500	31	3	3,440	120	38	197	0	0	3,085
2004	2,906	50	36	11	2,981	90	49	148	0	0	2,694
2003	2,744	240	88	1	3,071	80	45	150	0	1	2,797
2002	2,826	240	6	13	3,059	70	45	153	0	0	2,791
2001	3,298	-300	32	1	3,029	70	38	166	0	0	2,755
2000	2,683	320	29	0	3,031	70	47	151	0	0	2,763

Table A3. FAO Commodity balance sheets for cereals in Tanzania

Tanzania	SUPPLY (in tons)					DOMESTIC UTILIZATION (in tons)					
	Pro-duction	Change in stocks	Imports	Exports	Available Supply	Feed	Seed	Waste	Other uses	Pro-cessing	Food supply
SORGHUM											
Annual growth	2.4%				2.4%						2.4%
2013	832	0	2	2	832	17	12	85	0	359	718
2012	839	0	2	2	839	17	12	86	0	362	724
2011	807	0	1	2	805	16	13	81	0	348	695
2010	799	0	1	1	799	16	12	80	0	345	691
2009	709	30	5	0	744	15	9	74	0	322	645
2008	551	40	2	4	589	12	13	59	0	252	505
2007	971	-70	0	0	901	19	9	97	0	388	776
2006	712	0	1	0	713	71	12	71	0	279	558
2005	730	0	0	2	728	73	13	73	0	284	569
2004	649	0	1	0	649	65	11	65	0	254	508
2003	199	150	0	0	349	17	10	35	0	143	286
2002	636	-150	0	0	486	13	7	64	0	201	403
2001	692	0	0	0	691	14	10	69	0	299	599
2000	598	0	0	1	598	12	9	60	0	258	517
FINGER MILLET											
Annual growth	2.8%				2.6%						2.5%
2013	323	0	0	4	319	6	5	32	0	138	275
2012	214	0	0	2	212	4	3	21	0	91	182
2011	312	0	0	1	311	6	4	31	0	135	270
2010	351	0	0	1	350	7	5	35	0	151	303
2009	312	0	0	12	300	6	5	31	0	129	258
2008	150	0	2	2	150	3	6	15	0	63	126
2007	308	0	0	1	307	6	3	31	0	133	267
2006	247	0	0	0	246	5	6	25	0	105	211
2005	219	0	0	2	217	4	4	22	0	93	187
2004	246	0	0	2	244	5	4	25	0	105	210
2003	91	21	0	0	112	2	5	9	0	37	96
2002	233	11	0	0	244	5	3	23	0	101	213
2001	207	5	0	1	211	4	5	21	0	88	181
2000	219	5	0	0	224	4	3	22	0	95	195
MAIZE											
Annual growth	7.4%				4.8%						2.2%
2013	5,356	-253	35	37	5,102	1,034	87	760	10	24	3,222
2012	5,104	-241	34	35	4,862	985	83	724	9	23	3,070
2011	4,341	0	30	18	4,352	700	82	898	4	21	2,672
2010	4,733	-750	31	15	3,999	850	66	625	8	21	2,458
2009	3,326	400	24	8	3,742	700	61	426	7	18	2,555
2008	5,441	-800	38	18	4,662	1,100	59	678	11	18	2,824
2007	3,659	135	19	88	3,725	800	80	424	10	18	2,421
2006	3,423	30	304	24	3,734	870	52	424	8	18	2,387
2005	3,132	500	57	103	3,586	820	51	423	7	12	2,292
2004	4,651	-1,095	221	54	3,724	650	62	574	9	17	2,437
2003	2,614	830	88	169	3,363	540	63	275	9	12	2,485
2002	4,408	-900	95	169	3,435	550	69	375	6	12	2,441
2001	2,653	0	94	29	2,718	110	34	164	4	12	2,409
2000	1,965	630	67	17	2,645	100	17	144	6	12	2,384

Source: FAO commodity balances

Table A4. FAO Commodity balance sheets for cereals in Uganda

Uganda	SUPPLY (in tons)					DOMESTIC UTILIZATION (in tons)					
	Pro-duction	Change in stocks	Imports	Exports	Available Supply	Feed	Seed	Waste	Other uses	Pro-cessing	Food supply
SORGHUM											
Annual growth	-1.3%				-1.1%						-1.1%
2013	299	0	25	5	319	32	8	32	0	148	246
2012	336	0	28	6	358	36	9	36	0	166	277
2011	437	0	2	1	438	44	11	44	0	203	339
2010	391	0	6	7	390	40	11	40	0	180	300
2009	374	0	8	11	371	38	11	38	0	170	284
2008	342	0	74	16	401	42	10	42	0	185	308
2007	458	0	78	0	535	54	10	54	0	251	418
2006	440	0	101	0	540	54	9	54	0	254	423
2005	449	0	73	0	521	52	9	52	0	245	408
2004	399	0	38	0	436	44	9	44	0	204	340
2003	421	0	2	0	423	42	9	42	0	198	330
2002	427	0	3	0	430	43	9	43	0	201	335
2001	423	0	0	0	423	42	9	42	0	198	330
2000	361	10	0	1	370	37	8	37	0	172	287
FINGER MILLET											
Annual growth	-5.9%				-6.7%						-6.7%
2013	228	0	0	1	227	23	3	16	0	28	186
2012	244	0	0	1	243	24	3	17	0	30	199
2011	292	0	0	2	290	29	4	20	0	35	236
2010	268	0	0	2	266	27	4	19	0	32	217
2009	250	0	0	0	249	25	4	17	0	30	203
2008	275	0	0	2	273	27	5	19	0	33	222
2007	732	0	0	1	731	73	5	51	0	90	602
2006	687	0	0	2	685	69	11	48	0	84	557
2005	672	0	0	0	672	67	11	47	0	82	547
2004	659	0	0	2	657	66	11	46	0	80	534
2003	640	0	0	1	639	64	10	45	0	78	520
2002	590	0	0	1	589	59	10	41	0	72	479
2001	584	0	0	0	584	58	10	41	0	71	475
2000	534	70	0	0	604	60	10	42	0	74	492
MAIZE											
Annual growth	6.8%				5.8%						5.6%
2013	2,748	-203	35	143	2,438	276	38	312	1	313	1,812
2012	2,734	-201	35	142	2,426	275	38	311	1	311	1,802
2011	2,551	-200	22	92	2,280	257	33	252	1	309	1,739
2010	2,374	0	7	193	2,188	237	32	282	1	295	1,636
2009	2,355	-250	13	100	2,018	236	31	276	1	244	1,475
2008	2,315	-350	55	72	1,948	234	28	272	2	233	1,414
2007	1,262	0	43	107	1,197	127	26	152	1	155	892
2006	1,258	0	60	118	1,199	130	25	154	1	150	890
2005	1,237	40	79	90	1,265	133	25	158	1	159	950
2004	1,080	60	153	89	1,204	124	23	148	1	143	908
2003	1,300	-100	89	41	1,248	135	23	160	1	145	930
2002	1,217	0	48	62	1,203	125	21	149	0	140	908
2001	1,174	0	15	39	1,149	118	20	141	0	135	870
2000	1,096	0	19	9	1,106	111	20	133	0	130	842

Source: FAO commodity balances

Appendix 2. Time series data on value chains 1990-2014

Table A1. Animal feed production, 1990-2014 (000 metric tons).

Year	**Ethiopia**	**Kenya**	**Uganda**	**Tanzania**
1990	28	146	15	12
1991	21	151	22	10
1992	11	153	20	6
1993	7	102	18	2
1994	7	96	35	
1995	11	143		
1996		181		
1997		202		
1998		178	17	
1999	7	207	14	
2000	8	197	32	
2001	5	201	13	
2002	7	109	30	
2003	6	114	21	1
2004	11	114	20	5
2005	13	142	17	5
2006	8	141	39	2
2007	6	156	50	2
2008	17	242	42	2
2009	19	339	36	2
2010	20	349	34	4
2011	26	433	28	5
2012	35	471	28	
2013		528	34	
2014		540		

Sources: 1990-94: UN (1996); 2000-04, 2010-14: Statistical Abstracts, various years.

Note: These figures show production in the formal sector. Figures for Tanzania are based on a sample of six feed manufacturers.

Table A2. Beer production, 1990-2014 (000 hectolitres).

Year	**Ethiopia**	**Kenya**	**Uganda**	**Tanzania**	
				Bottled beer	Chibuku
1990	500	3311	194	450	
1991	435	3140	195	498	
1992	428	3686	187	493	
1993	522	3492	239	570	
1994	634	3250	308		
1995	724	3470			
1996		2832			
1997		2704			
1998		2630	1088		
1999	1111	1885	1064		
2000	1605	2029	1261		
2001	1812	1843	1079		
2002	2123	1919	989		
2003	1247	2223	1391		
2004	1463	2375	1485	2026	101
2005	1561	2663	1355	2166	111
2006	1734	3116	1414	2990	116
2007	2137	3934	1958	3176	103
2008	2513	4249	2176	2935	103
2009	2938	3968	1958	2889	161
2010	4016	3986	2186	2423	210
2011	4553	4537	2671	2697	235
2012	4130	5037	2651	3387	220
2013		4218	2334		
2014		3671			

Sources: 1990-94: UN (1996); 2000-04, 2010-14: Statistical Abstracts, various years.

Note: 1 hectolitre = 100 litres.

Table A3. Wheat flour production, 1990-2014 (000 metric tons).

Year	**Ethiopia**	**Kenya**	**Uganda**	**Tanzania**
1990	177	172	13	12
1991	158	186	11	3
1992	88	222	12	16
1993	62	143	10	7
1994	75	191	8	82
1995	116	237	11	72
1996	185	227	11	120
1997		245		
1998		230	18	
1999	185	225	14	
2000	165	189	12	
2001	143	227	52	
2002	137	240	53	
2003	156	246	42	
2004	149	262	26	338
2005	174	374	20	368
2006	140	387	187	422
2007	152	375	168	296
2008	261	565	165	307
2009	314	620	211	368
2010	351	757	188	468
2011	578	815	224	439
2012	1384	845	273	444
2013		884	263	
2014		977		

Sources: 1990-94: UN (1996); 2000-04, 2010-14: Statistical Abstracts, various years.

Table A4. Other flour production, 1990-2014 (000 metric tons).

Year	**Ethiopia ('Óther')**	**Kenya ('Maize')**	**Uganda (Na.)**	**Tanzania ('Maize')**
1990	49	241		
1991	57	227		
1992	21	120		
1993	4	168		
1994	9	233		
1995	11	314		
1996		267		
1997		273		
1998		266		
1999	1	205		
2000	0	154		
2001	1	135		
2002	1	143		
2003	0	193		
2004	0	207		10
2005	0	283		19
2006	8	322		12
2007	6	288		7
2008	9	351		15
2009	14	458		14
2010	14	473		14
2011	127	509		14
2012	147	524		16
2013		563		
2014		587		

Sources: 1990-94: UN (1996); 2000-04, 2010-14: Statistical Abstracts, various years.