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Markets, Institutions and Policies

# Sorghum and Millets in Eastern and Southern Africa

## Facts, Trends and Outlook

**A Orr, C Mwema, A Gierend and S Nedumaran**

ICRISAT Science with a human face
International Crops Research Institute for the Semi-Arid Tropics

CGIAR Research Program on Dryland Cereals

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# Sorghum and Millets in Eastern and Southern Africa: Facts, Trends and Outlook

**A Orr, C Mwema, A Gierend, and S Nedumaran**

This work has been undertaken as part of the

RESEARCH PROGRAM ON Dryland Cereals

RESEARCH PROGRAM ON Policies, Institutions, and Markets

International Crops Research Institute for the Semi-Arid Tropics

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## Abstract

This report analyses current and projected trends for sorghum and millets in Eastern and Southern Africa (ESA). Cereal production in this region is dominated by maize (70%) with sorghum accounting for 7% and millets 2% of total cereal production.

Between 1981 and 2012, trends in the area, production and yield of sorghum were negative for southern but positive for eastern Africa, where production doubled to reach 6 million tons. Production growth was led by Ethiopia and Somalia. Yields varied widely, from 5 t/ha in Botswana and 2 t/ha in Ethiopia to 0.3 t/ha in Zimbabwe. Sorghum was used primarily for food (64%) or food processing (14%) with 19% for other non-food uses and just 3% for animal feed. ESA was a net importer of sorghum, with Ethiopia and Sudan the largest importers, and Uganda the largest exporter. Domestic prices for sorghum were higher than world prices, which ranged from $100-200 USD per t. Despite its image as a poor man's crop, the price of sorghum was higher than for maize in Ethiopia and Kenya, although not in Zimbabwe.

Trends in the area, production and yield of millets over the same period showed weak but positive growth. Four countries – Ethiopia, Zimbabwe, Tanzania and Uganda – accounted for the bulk of production. Strong production growth in Ethiopia was offset by negative growth in Uganda due to civil unrest. Yields varied from 1.5 t/ha in Ethiopia to 0.2 t/ha in Zimbabwe. Millets were used primarily for food (68%) and food processing (20%), with just 3% for animal feed and none for non-food uses. World prices averaged $200-400 USD per t, or twice the price of sorghum. Domestic prices were above world prices, with the relative price of millet higher than maize in Ethiopia and Kenya, though not in Zimbabwe. Trade in millets was thinner than for sorghum, with Kenya being the biggest regional importer.

The East African Community allows free trade in cereals among member states but this is hindered by high transport costs and periodic export bans in drought years. Since 2004, the region has run a trade deficit in sorghum and millets. Nominal Rates of Protection between 2005 and 2012 were negative for sorghum and maize in Ethiopia, subsidizing domestic consumers, but positive or close to zero in Kenya, protecting domestic producers.

Projections using the IMPACT model (International Model for Policy Analysis of Agricultural Commodities and Trade) show production of sorghum in ESA rising from 6.6 million t in 2015 to 19.5 million t in 2050, and from 2.3 to 7 million t for millets. By 2050 ESA is projected to change from being a net importer to being a net exporter of sorghum (2.5 million t) and millets (1.8 million t). Scenarios were run to determine the impact of higher income growth, 25% faster yield increases for sorghum, millets and maize, and climate change using climate models GFDL (Geophysical Fluid Dynamics Laboratory) and MIROC (Model for Interdisciplinary Research on Climate). In combination, the effect is positive, increasing production of sorghum by 33% and of millets by 56% over the baseline scenario by 2050.These results suggest that in the future, sorghum and millets will play an increasingly important role in food security and trade.

***Keywords:*****JEL classification**: **Q10, Q11, Q16**

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## Acronyms

| | |
|---|---|
| AEZ | Agro-ecological zone |
| CET | Common External Tariff |
| COMESA | Common Market for Eastern and Southern Africa |
| DSSAT | Decision Support System for Agrotechnology Transfer |
| EAC | East African Community |
| ESA | Eastern and Southern Africa |
| FAO | Food and Agriculture Organization of the United Nations |
| FPU | Food Production Unit |
| GCM | General Circulation Models |
| GFDL | Geophysical Fluid Dynamics Laboratory |
| GNP | Gross National Product |
| GHG | Green House Gas |
| ICRISAT | International Centre for Research in the Semi-Arid Tropics |
| IFPRI | International Food Policy Research Institute |
| ILRI | International Livestock Research Institute |
| IMPACT | International Model for Policy Analysis of Agricultural Commodities and Trade |
| INTSORMIL | International Sorghum and Millet Research Support Program |
| IPR | Intrinsic Productivity Growth Rate |
| LGP | Length of Growing Period |
| MIC | Middle Income Country |
| MIROC | Model for Interdisciplinary Research on Climate |
| NCPB | National Cereals and Produce Board |
| NRP | Nominal Rate of Protection |
| PPP | Purchasing Power Parity |
| SADC | Southern Africa Development Community |
| SAT | Semi-Arid Tropics |
| SSA | Sub-Saharan Africa |
| USDA | United States Department of Agriculture |
| WCA | West and Central Africa |

# 1. Introduction

Sorghum and millets are widely perceived as crops in terminal decline. At the global level, production has shown either weak or negative growth. Between 1981 and 2012, worldwide production of sorghum fell by 0.8% per year while production of millets grew by 0.4% per year. However, these global trends are misleading. In Africa over the same period the production of sorghum grew by 2.2% per year and millets by 1.8% per year. The picture for these crops in Africa is therefore a positive one. Clearly, understanding the trends and outlook for sorghum and millets requires a regional approach.

This report focuses on Eastern and Southern Africa (ESA). This region accounts for a small share of the total production of sorghum and millets in Africa, while within ESA sorghum and millets account for a small share of total cereal production. However, the drought-prone areas in which these crops are grown contain 40 million of the region's poor (Walker 2010). This makes sorghum and millets important for household food security, while their resilience to drought can help offset the effects of climate change.

The general objective of this report is to provide an overview of current trends and the future outlook for sorghum and millets in the region. The specific objectives are to:

1. Describe the regional context;
2. Summarize past trends in production, consumption and prices;
3. Synthesize micro-level studies that help explain these macro-trends; and
4. Forecast future trends based on projections using the IMPACT model.

This report follows a regional approach following an earlier report for Asia (Bhagavatula et al. 2013). Both reports update an earlier publication that covered developments in the global sorghum and millet economies between 1979 and 1994 (ICRISAT/FAO 1996). In this report, the analysis of trends covers the period 1980-2012, which is the latest year for which data is available, while the outlook projections cover the period 2015-2050, which is the period covered by the IMPACT model.

The report is organized into six sections. The next section presents an overview of the region and the role of sorghum and millets. Sections 3 and 4 summarize recent trends in production, consumption, prices and trade. In Section 5 we discuss institutions and policy. Section 6 uses the IMPACT model to project future trends in production and consumption under alternative scenarios for climate change and growth in yields and income. The final section summarizes our conclusions.

# 2. Overview

## 2.1. The regional context

The ESA region as defined for this report comprises 17 countries that vary widely in terms of population and income per head (Table 2.1). In eastern Africa, Ethiopia has the largest population (94 m), equivalent to the combined population of Kenya (44 m) and Tanzania (49 m). Ethiopia also has the largest economy in eastern Africa ($44 billion) although Kenya with only half the population is not far behind ($41 billion). In terms of income per head, only two countries in eastern Africa qualify as a Middle Income Country (MIC) defined as those with income per head of over $1,000 per capita. Zambia and South Sudan qualify as MICs thanks to their natural resources (copper and oil). When income per head is measured in Purchasing Power Parity (PPP), however, Ethiopia also qualifies as an MIC.[1] By contrast, Southern Africa has a smaller population (61 m), but South Africa's economy ($ 381 billion) is bigger than the rest of ESA combined. In terms of income per head, all five countries in Southern Africa qualify as MICs.

**Table 2.1. Population, GNP and income per head in Eastern and Southern Africa.**

| Region/country | Population (million) | Gross National Product (GNP) ($ billion) | Income per head | |
|---|---|---|---|---|
| | | | Current US $ (2013) | Current US $ 2005 PPP (2009-2011) |
| **Southern Africa** | | | | |
| **South Africa** | 53 | 381.1 | 7,190 | 10,590 |
| **Namibia** | 2.3 | 13.4 | 5,840 | 6,462 |
| **Lesotho** | 2.1 | 3.2 | 1,550 | 1,606 |
| **Botswana** | 2 | 15.5 | 7,730 | 13,842 |
| **Swaziland** | 1.2 | 3.7 | 3,080 | 5,932 |
| ***Eastern Africa*** | | | | |
| **Ethiopia** | 94.1 | 44.2 | 470 | 1,032 |
| **Tanzania** | 49.3 | 31.1 | 630 | 1,395 |
| **Kenya** | 44.4 | 41.3 | 930 | 1,647 |
| **Uganda** | 37.6 | 19.2 | 510 | 1,284 |
| **Mozambique** | 25.8 | 15.2 | 590 | 918 |
| **Malawi** | 16.4 | 4.4 | 270 | 863 |
| **Zambia** | 14.5 | 21.5 | 1,480 | 1,543 |

[1] PPP is the ratio between the currency of two countries that will allow the same basket of goods and services to be purchased in one country and therefore gives a truer picture of the real cost of goods and services in that country than based simply on currency exchange rates. In this case, PPP shows income per head in ESA in relation to the cost of buying the same basket of goods and services in the US.

| | | | | |
|---|---|---|---|---|
| **Zimbabwe** | 14.1 | 11.6 | 820 | Na. |
| **Rwanda** | 11.8 | 7.3 | 620 | 1,205 |
| **South Sudan** | 11.3 | 12.7 | 1,120 | Na. |
| **Burundi** | 10.2 | 2.9 | 280 | 584 |
| **Eritrea** | 6.3 | 3.1 | 490 | 557 |
| **Median** | 11.8 | 11.6 | 620 | 1,340 |

Source: World Bank, Poverty and Equity Database. http://povertydata.worldbank.org/poverty/country/
World Bank, African Development Indicators. http://data.worldbank.org/data-catalog/africa-development-indicators

## 2.2. Poverty trends

Poverty is high. In 2000, Mozambique, Tanzania and Malawi all had poverty rates above 75%, compared to just 35% in Kenya (Figure 2.1). However, poverty rates are falling. The steepest fall has been in Ethiopia, where poverty has fallen by over 1% per year since 1981. By 2011, most countries in eastern Africa countries had poverty rates below 50%. Because of population growth, the absolute number of people living in poverty in the seven countries (shown in Figure 2.2) has increased from 74 million in 1981 to 126 million in 2002, but after 2002 the absolute number of people living in poverty has slowly started to decline, reaching 113 million in 2011.

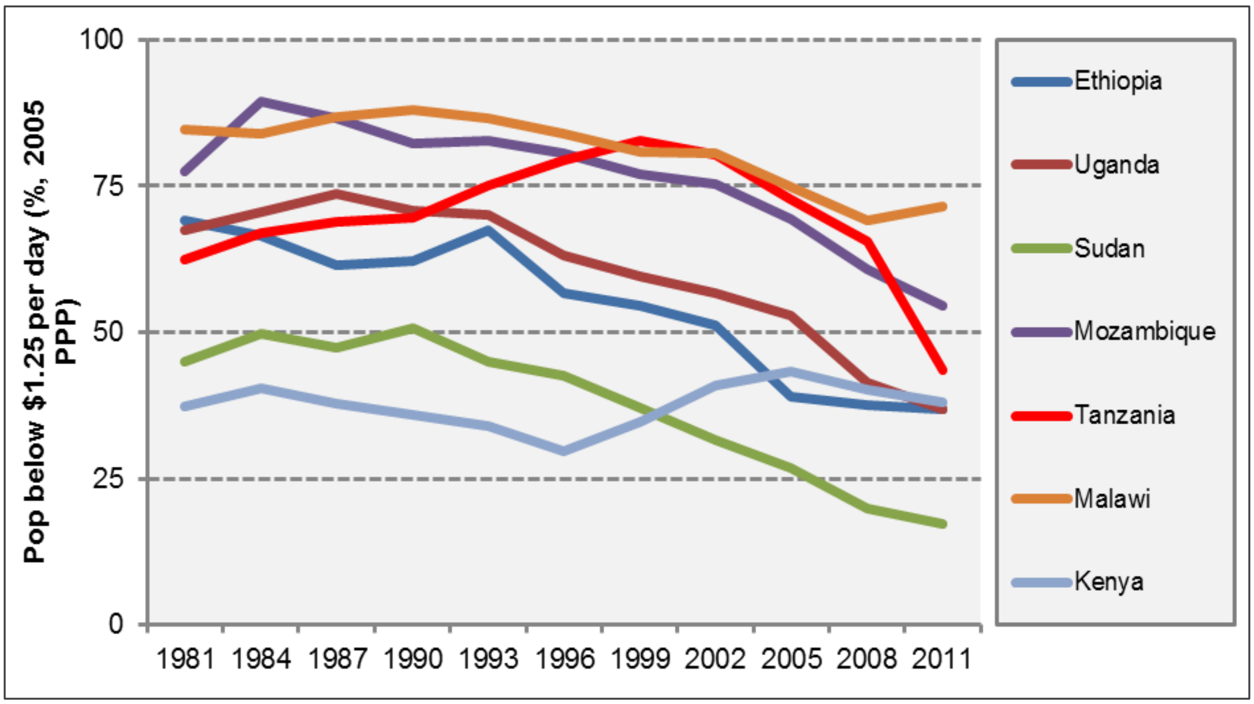



*Figure 2.1. Poverty rates in eastern Africa, 1981-2011.*

Source: World Bank, Poverty and Equity Database. http://povertydata.worldbank.org/ poverty/country/

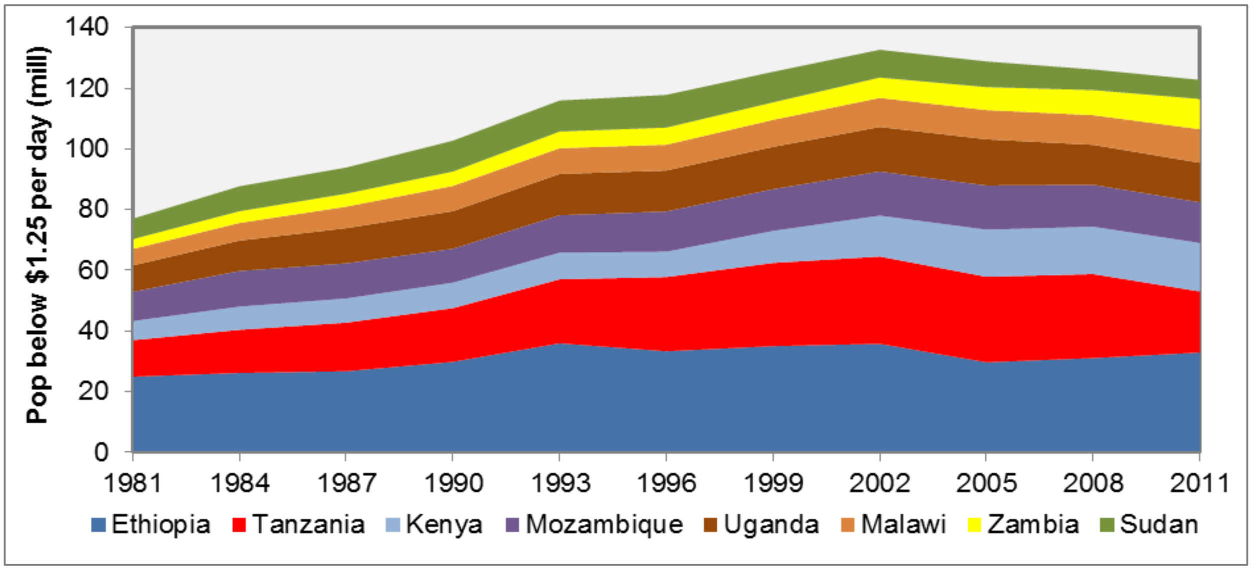



*Figure 2.2. Absolute number of poor people in eastern Africa, 1981-2011.*

Source: World Bank, Poverty and Equity Database. http://povertydata.worldbank.org/ poverty/country/

## 2.3. Farm size

Average farm size in ESA is small with the majority of farm households cultivating less than 1 ha (Figure 2.3). The high share of farms below 1 ha in Malawi (78%), Ethiopia (63%) and Uganda (49%) reflects population pressure on land. In Mozambique, where there is no shortage of arable land, the high share of farms below 1 ha may reflect a seasonal labor shortage for crop production. By comparison, the share of holdings below 1 ha in West Africa is relatively small, accounting for only 13% of total farms in Burkina Faso and 21% in Senegal. In ESA, only Namibia has such a low share of farms below 1 ha.

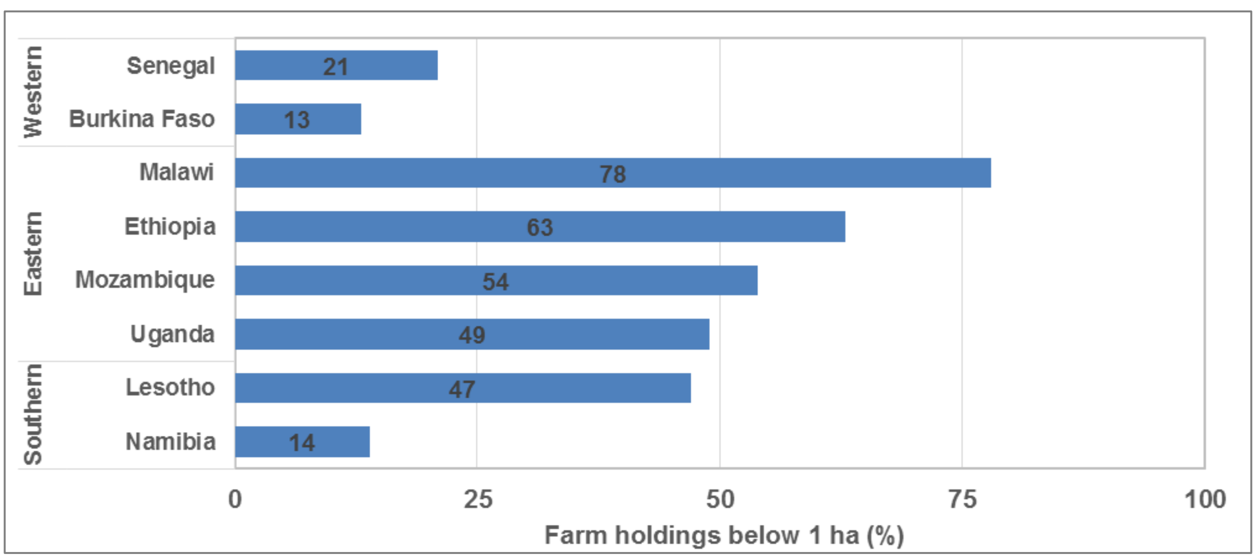



*Figure 2.3. Share of holdings below 1 ha for selected countries (%).*

Source: FAO (2014), Appendix Table A2.

## 2.4. Distribution of sorghum and millets

We used the AEZ zonation of Eastern and Southern Africa in accordance with the FAO Global AEZ project in which agro-ecological zones are defined by the length of the available growing period (LGP).[2] FAO and ICRISAT set the boundaries for the semi-arid areas between 75 and 179 days, and for the semi-humid areas between 180 and 269 days per year (Fischer et al. 2009). Areas with LGPs below 75 days are defined as arid, while areas with LGPs above 270 days are defined as humid and perhumid.

We used the LGP raster map developed by the International Livestock Research Institute (ILRI) because it covers the entire continent, which makes it possible to compare sub-regions and countries.

The ILRI map covers only the arid, semi-arid and semi-humid zones, omitting the humid and perhumid zones. LGP are not grouped in classes but each spatial cluster has an individual LGP value between 1 and 270. To estimate the distribution of zones by country, LGP zones were overlaid with the MapSpam 2005 crop map. The area planted to sorghum and millets in the MapSpam dataset were then adjusted to match with the average area reported by FAO in 2011-13. Some empty areas marked white on the ILRI map (indicated as a zero value) were allocated to arid or humid areas where this was plausible and could be validated by cross-checking maps of climate and rainfall.

Sorghum and millets are genetically adapted to the drylands. Water requirements over the growing period average 400 mm for sorghum and 300-350 mm for millet compared to 500 mm for maize. Sorghum and millet also have deeper roots than maize and can withstand higher temperatures without damage to the crop. Where the growing season is short (75-150 days), the crop that will give the highest relative yield is millet. Where the growing season is longer (150-240 days), sorghum and maize give higher yields than millet, with maize giving higher yields than sorghum (Frere 1984).

The conventional wisdom is that sorghum and millets are grown in the semi-arid tropics (SAT), or areas with an LGP between 75-179 days. However, Figure 2.4 shows that only 14% of the area planted to sorghum and millets in ESA can be classified as dry semi-arid (79-119 days). A high share of these crops is planted in the AEZ classified as moist semi-arid (120-179 days) and semi-humid (180-269 days). This suggests that sorghum and millets are planted in regions that are also suitable for maize, because of food preferences and the need to spread risk in the event of drought.

[2]According to FAO (http://www.fao.org/ag/againfo/programmes/en/lead/toolbox/Refer/AgroeZon.htm) LGP is defined as the period (in days) during the year when rainfed available soil moisture supply is greater than half potential evapotranspiration (PET). It includes the period required for evapotranspiration of up to 100 mm of available soil moisture stored in the soil profile. It excludes any time interval with daily mean temperatures less than 5°C.

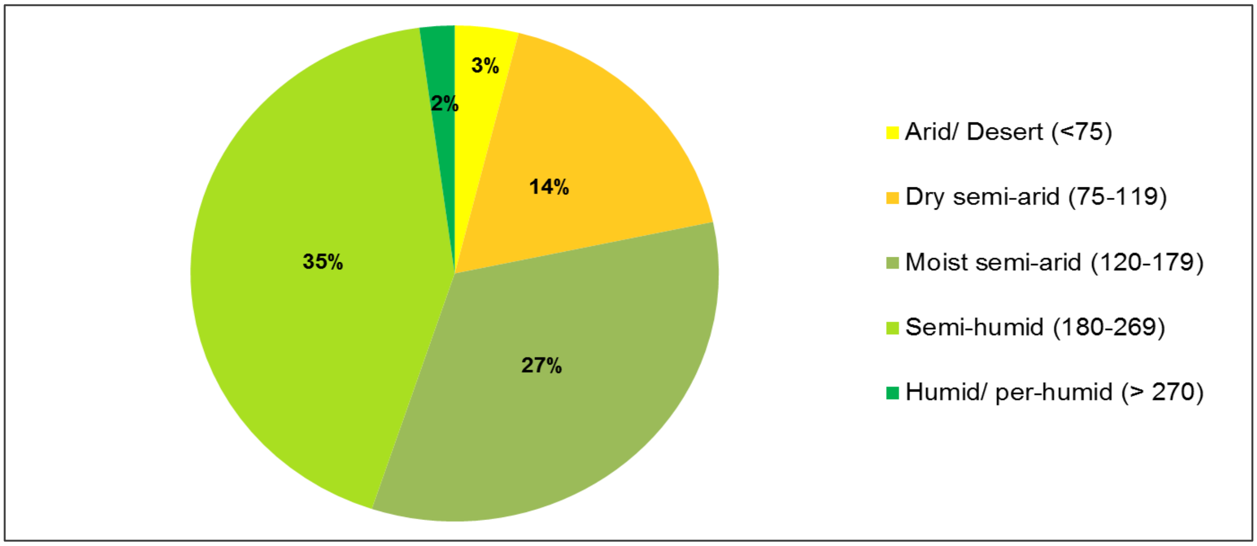



*Figure 2.4. Area planted to sorghum and millets, by agro-ecological zone (%).*

Millets in ESA can be divided into different species. The dominant species in ESA is finger millet (*Eleusinecoracana*), whereas pearl millet (*Pennissetumglaucum*, *P. typhoides*, *P. tyhpideum*, *P. americanum*) predominates in western Africa. Finger millet has a slightly higher water requirement than other millets and is found in cooler, higher regions up to 2,000 m asl. By contrast, pearl millet has the highest yield potential of all millets under drought and heat stress. Finger millet is grown exclusively in eastern Africa while pearl millet is grown in both eastern and in southern Africa (Figure 2.6).

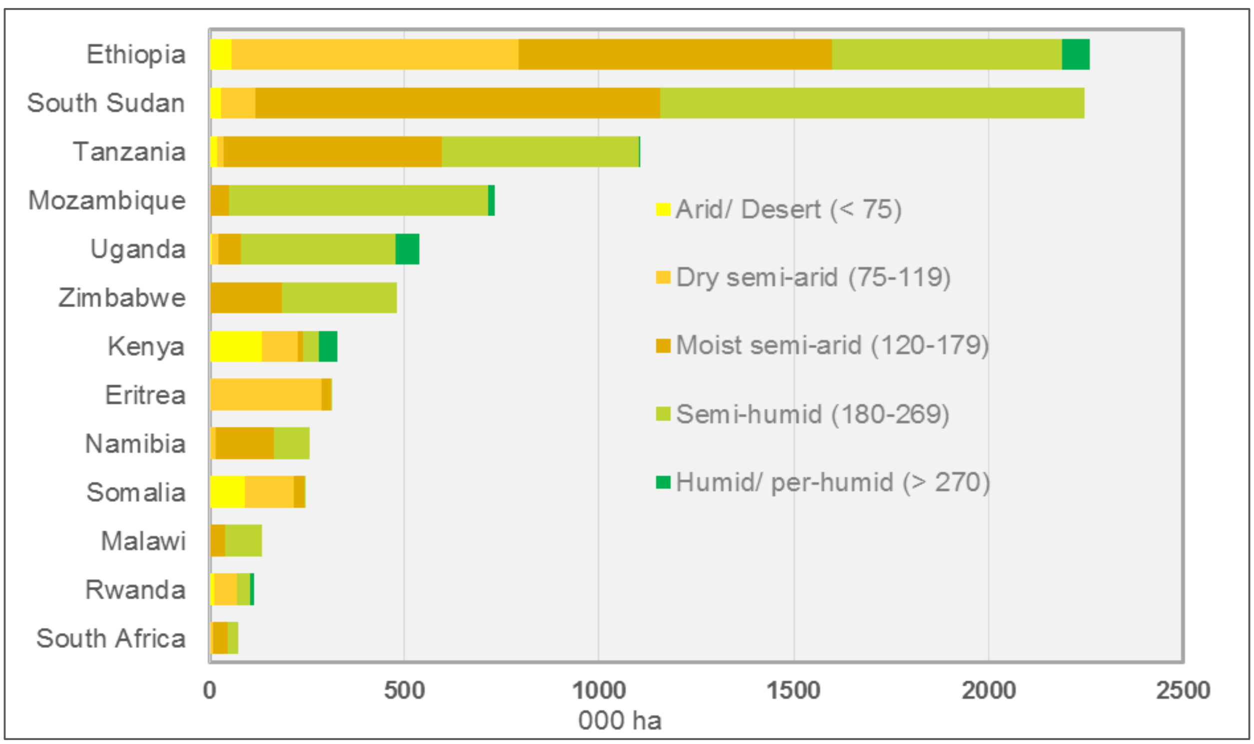



*Figure 2.5. Area planted to sorghum and millets, by length of growing period (LGP) and country.*

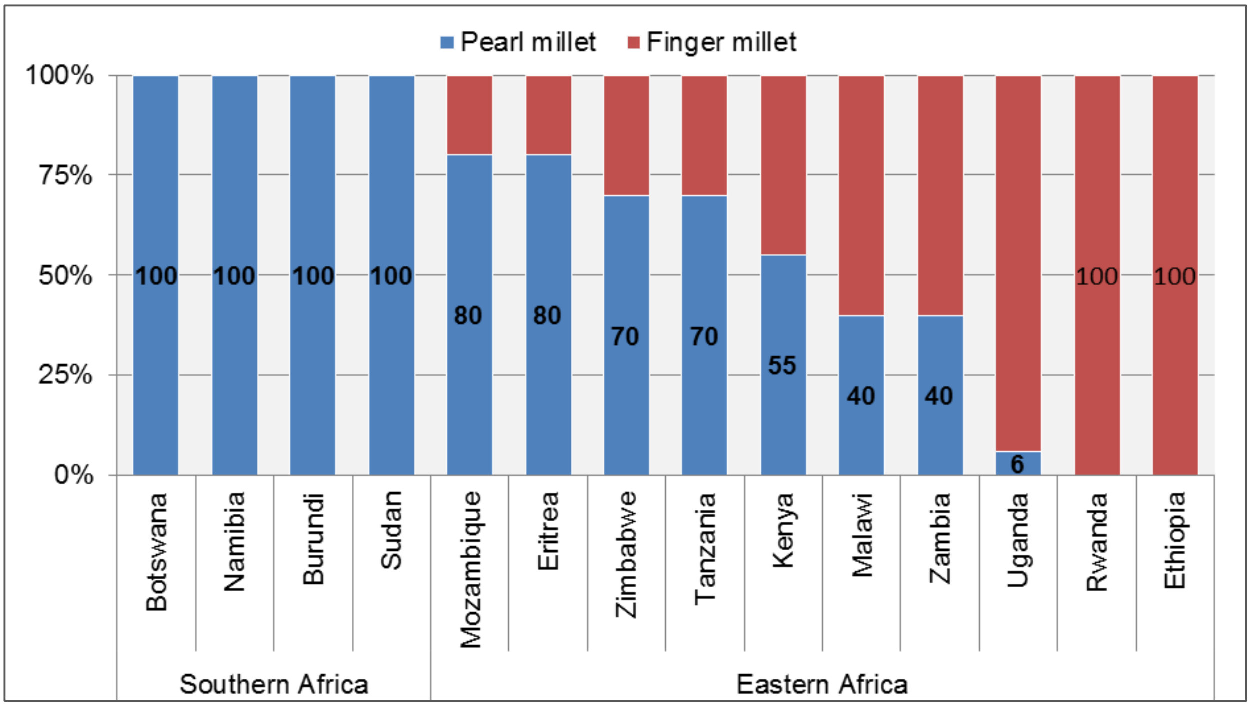



*Figure 2.6. Relative importance of finger and pearl millet species in ESA (%).*

Source: ICRISAT/FAO (1996),Annex II pp. 52-53.

Figures 2.7 and 2.8 show the area planted to sorghum and millets in ESA. The maps were developed from combining two different data sources. The first source is the International Food Policy Research Institute's (IFPRI) 'Spatial Production Allocation Model' (MapSPAM) in the 2000 version with the spatial crop data set from 2000. The other source was crop statistics from National Statistical Offices which were used to update the relatively old IFRPI data set with the newest regional crop information. The white areas on the maps indicate cloud cover over wetter regions, which prevented accurate estimation of the length of the growing period.

The results show that:

1. Sorghum and millets have a distinctive spatial distribution. They are not widely spread but cluster in specific areas. Millets has a larger number of clusters than sorghum.

2. Sorghum and millets are not confined to the SAT but grown across a wide range of AEZs. Whereas sorghum in Ethiopia is concentrated in the dry and moist semi-arid zones, sorghum in Zimbabwe is concentrated primarily in dry sub-humid zones. Similarly, millets are grown in dry and moist semi-arid zones in Namibia but in dry and moist semi-humid zones in Zambia.

3. Some regions that are suitable for sorghum and millets show limited concentrations of these crops. For example, large areas of South Africa are classified as dry or moist semi-arid, making them ideal for sorghum and millets. However, farmers in these zones prefer to plant maize rather than sorghum and millets, because of food preferences.

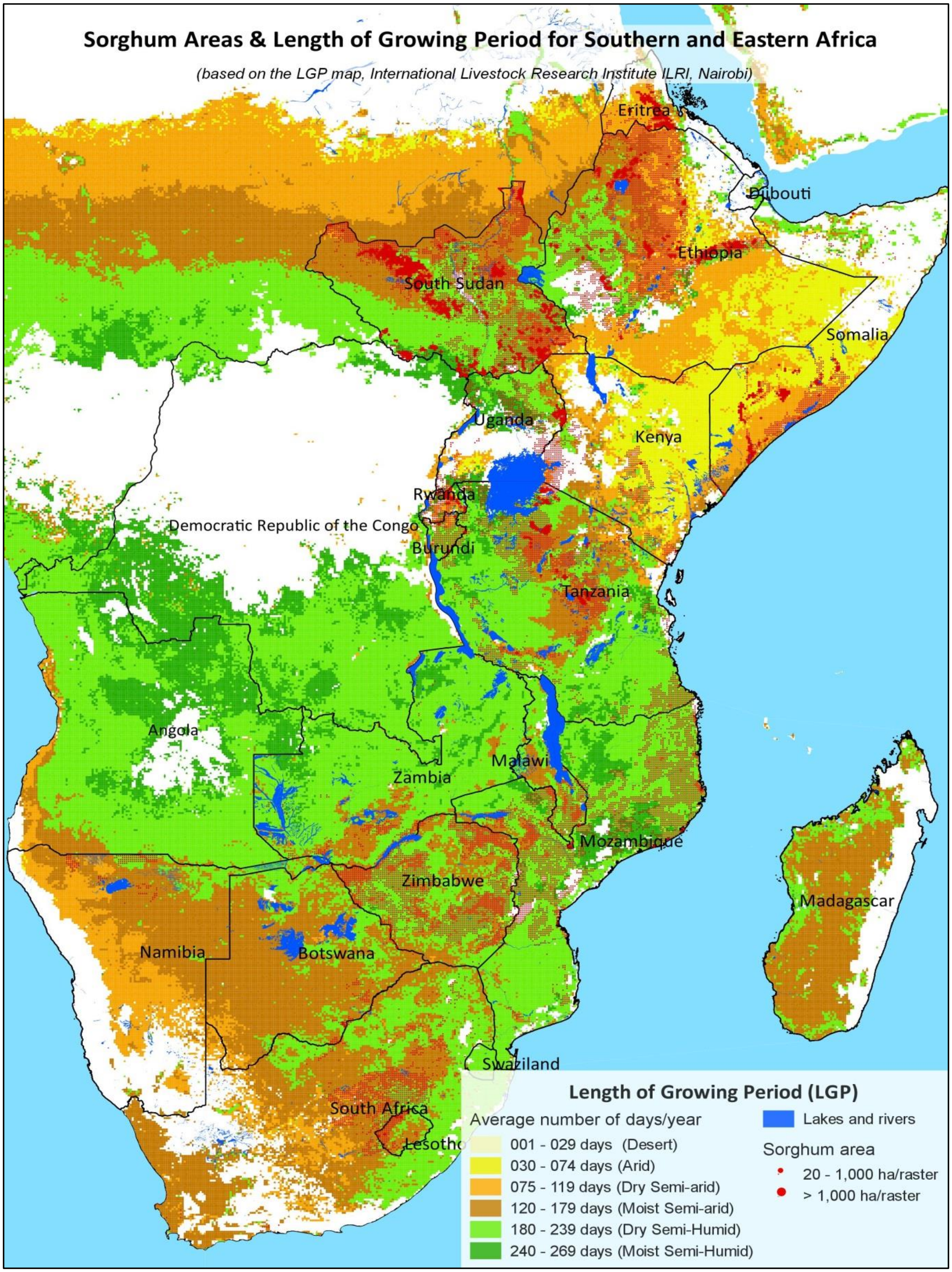



*Figure 2.7. Area planted to sorghum in ESA, showing length of growing period (LGP).*

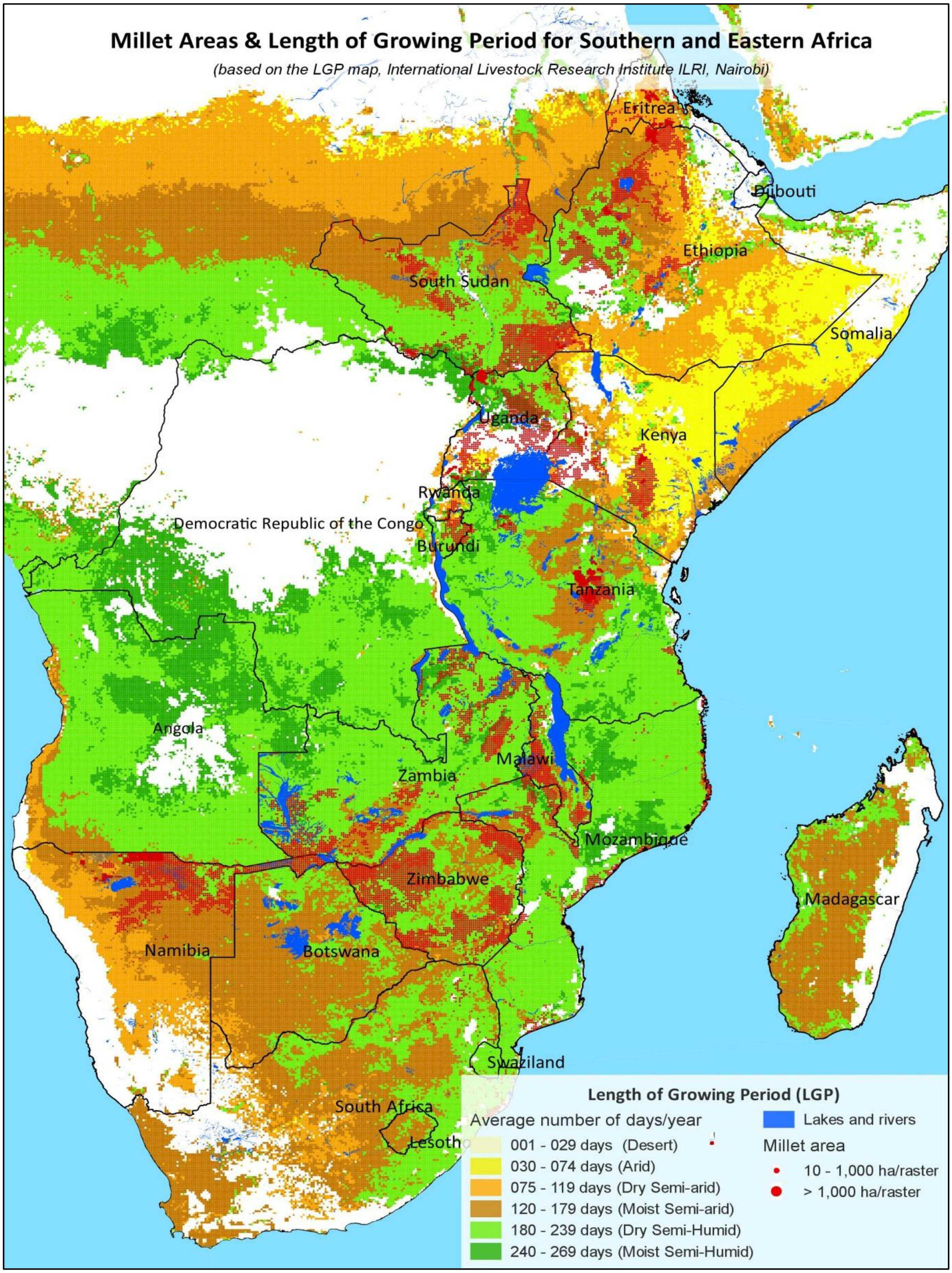



*Figure 2.8. Area planted to millets in ESA, showing length of growing period (LGP).*

## 2.5. Nutrition

Sorghum grain has moderately high levels of iron (> 40 ppm) and zinc (> 30 ppm) with considerable variability in landraces (iron > 70 ppm and zinc >50 ppm). Both micronutrients help reduce stunting. The protein and starch in grain sorghum are more slowly digested than other cereals, which is beneficial for diabetics. Millets are rich in fiber, iron and calcium, with as much as 40 times more calcium than maize and rice, and 10 times more than wheat. Finger millet has three times more calcium than milk, and 100 g provides one-third of the daily calcium requirement. Their high iron and calcium content explain why millets are widely used as a weaning food for children, and by lactating and pregnant women. Millets are also gluten-free, making them a good substitute for wheat flour for those unable to digest food made from wheat.

**Table 2.2. Typical nutrient values of African cereal grains compared to maize and wheat (data expressed on a 12% moisture basis).**

| Nutrient | Sorghum | Pearl millet | Finger millet | Teff | African rice | Wheat (hard red spring) | Maize (corn grain, yellow) |
|---|---|---|---|---|---|---|---|
| Protein (%, N x 6.25) | 11.6 | 11.5 | 7.3 | 9.5 | 7.1 | 15.9 | 9.42 |
| Carbohydrate (%) | 77 | 70 | 74 | 72 | 75 | 69 | 74 |
| Fat (%) | 3.4 | 4.7 | 1.3 | 2.0 | 1.8 | 1.9 | 4.7 |
| Dietary fibre (%) | 9.1-11.5 | 9.7 | 11.7 | NA | NA | 12.3 | 7.3 |
| Ash (%) | 1.6 | 2.3 | 2.6 | 2.9 | 3.5 | 1.9 | 1.2 |
| Calcium (mg/100 g) | 29 | 36 | 358[1] | 157[1] | 23 | 25 | 7 |
| Iron (mg/100 g) | 4.5 | 9.6 | 9.9 | 5.7 | 1.9 | 3.6 | 2.7 |
| Energy (kJ/100 g) | 1374 | 1443 | 1396 | 1390 | 1392 | 1389 | 365 |
| Vitamin A (ug Retinol equivalents) | 10-20 | 22 | 6 | 8 | Na. | 3 | 11 |
| Lysine (g/100 g protein) | 2.0 | 3.1 | 2.5 | 2.3 | 4.1 | 2.6 | 0.4 |

Source: Taylor and Emmambux (2007); Maize: USDA (2011). Notes: [1]Value questionable. NA = Not Available

## 2.6. The dominance of maize

Sorghum and millets in ESA are minor cereal crops compared to maize. In 2012, maize production in eastern Africa was 28 million t, compared to 6 million and 1.5 million t for sorghum and millets respectively (Figure 2.9). Since 1981, maize production has more than doubled. In comparison, sorghum production has also increased since 2000, doubling in volume from 3 to 6 million t over the past decade. By comparison, there has been no significant growth in the production of millets. Maize production per head has risen steadily since 2000, from 46 kg per head to 67 kg per head in 2012 (Figure 2.10). Sorghum production per capita has also risen from 9 to 14 kg per head over the same period, while production per head of millets remained constant at 4 kg per head. These trends suggest that the long-term decline in sorghum and millets in ESA has ended, and in the case of sorghum, may even have been reversed.

This decline began with the introduction of maize during the colonial period and continued in some regions until at least the 1970s (Box 1). However, the statistics suggest that the production of sorghum and millets has stabilized and that the future for these crops in ESA may be brighter than previously thought.

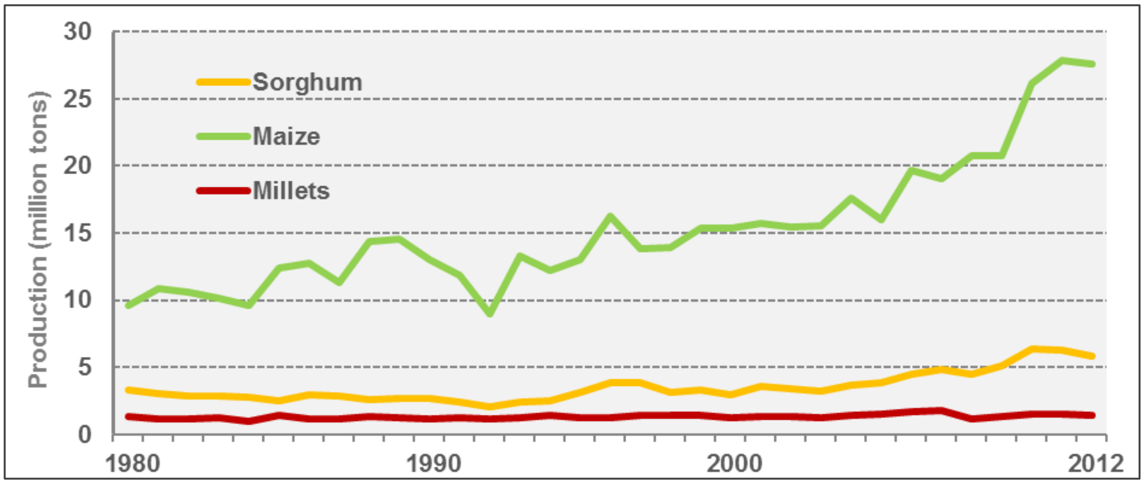



*Figure 2.9. Production of maize, sorghum and millets in eastern Africa, 1981-2012.*

Source: FAOSTAT

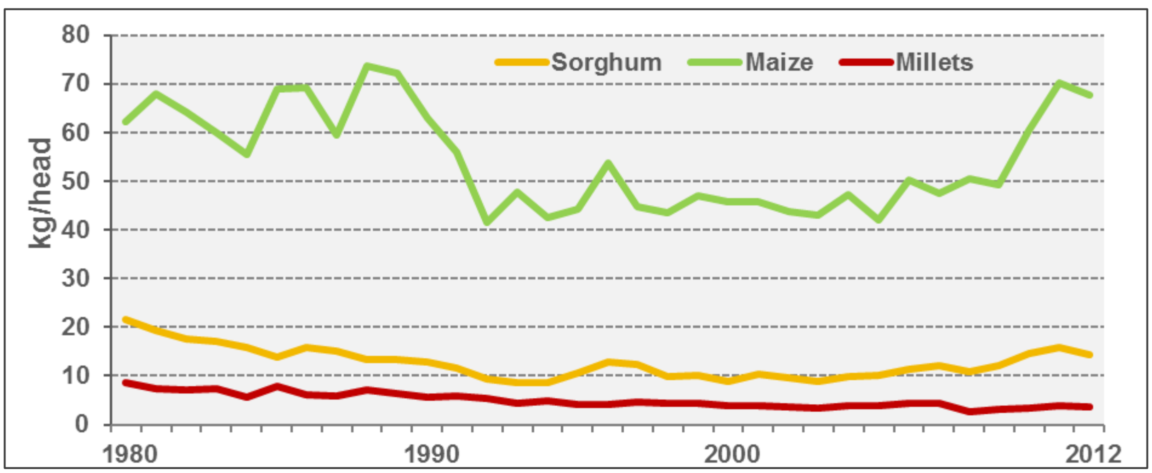



*Figure 2.10. Per capita production of maize, sorghum and millets in eastern Africa, 1981-2012.*

Source: FAOSTAT

Given the dominance of maize in the region, it is important to view sorghum and millets as components of maize-based farming systems. Figure 2.11 shows the share of sorghum and millets by country, arranged in descending order of importance for each country in a given region. For ESA as a whole, the share of sorghum (14%) and millets (4%) in total cereal production is under 20%. However, sorghum and millets remain important for individual countries. In southern Africa, sorghum accounts for 60% of total cereal production in Botswana, while millets account for 36% of cereal production in Namibia. In eastern Africa, sorghum and millets account for 85% of total cereal production in the former Sudan, while sorghum makes up 58% of cereal production in Somalia. However, for 12 of the 19 countries shown in Figure 2.11, sorghum and millets combined account for less than one-quarter of total cereal production.

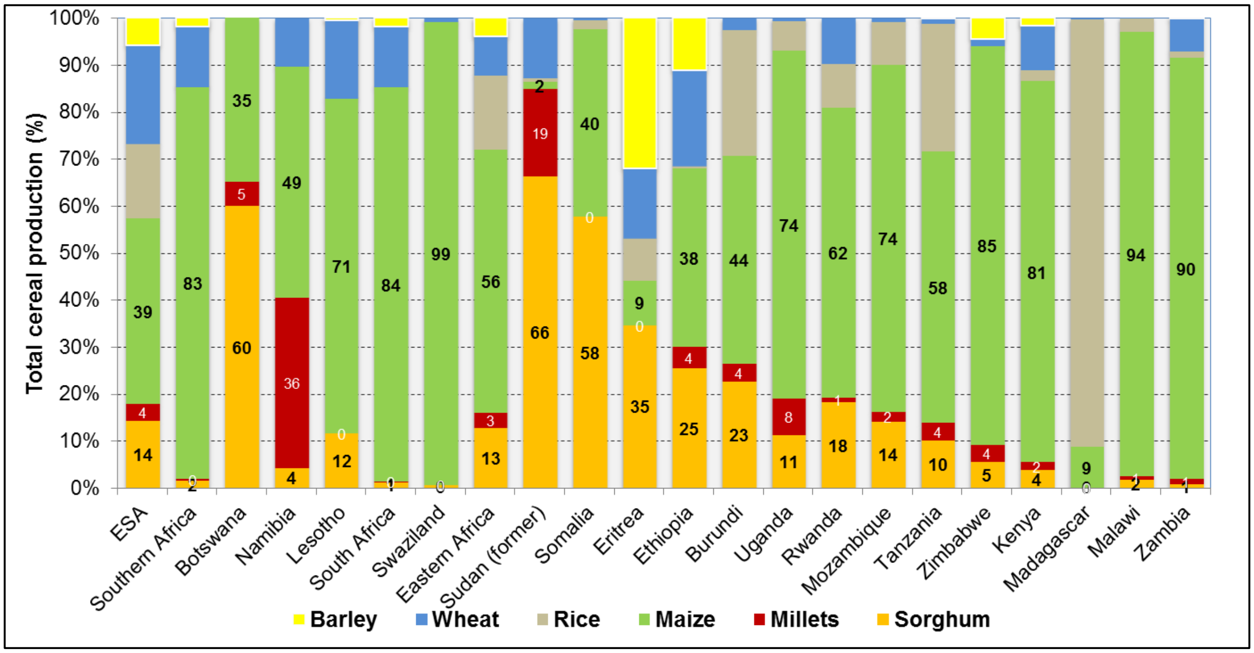



*Figure 2.11. Share of sorghum and millets in total cereal production, ESA (average 2010-12).*

Source: FAOSTAT

**Box 1. Why did maize replace sorghum and millets?**

The macro-data reveal a decline in the area planted to sorghum and millets in eastern Africa until the 1980s and continuing to the present day in southern Africa. To understand the reasons for this decline, the senior author reviewed evidence from micro-level studies conducted in four countries. Since these studies are diverse, using different methods and analytical tools, it is difficult to compare their findings directly. We therefore summarize the findings for each country and then draw some general conclusions.

**Malawi**

Finger millet was once widely grown in northern Malawi where it was planted on newly-cleared fields under shifting cultivation. The crop was grown primarily as insurance against the failure of maize and to provide cash for women who used it to brew beer. From the 1930s onwards, shifting cultivation and millet were discouraged for environmental reasons. With market liberalization in the 1990s, male labor was diverted into the production of burley tobacco. By 2010, only 9% of the households surveyed still grew finger millet, while another 13% had stopped growing it mainly because men were no longer available to burn and clear land. Sorghum was still being grown in the 1960s, but has now completely disappeared. The main reason is post-colonial government policy, which promoted subsidized maize seed and fertilizers to 'modernize' smallholder agriculture. Sorghum, by contrast, was identified with hunger, poverty and the colonial past. More schools also reduced the availability of children to scare birds and prevent crop losses.

*The results are based on interviews with 199 households and focus group discussions in the region surrounding Ekwendeni town, Mzimba district, northern Malawi, in 2010 (Bezner-Kerr2014).*

**Zimbabwe**

Between 1974 and 1985 the area planted to maize grew from 44% to 59% of the total area while the area planted to sorghum and millets fell from 33% to 19%. The area planted to sorghum and millets was determined by the previous maize harvest. In a drought year when maize failed, households ate their stocks of sorghum and millet then planted more the following year to build up their stocks again. Two factors explain the decline in area planted to sorghum and millets: the expansion of cultivation onto heavier soils more suitable for maize and the ease of pounding maize. Farmers recognized that millets were more drought-resistant than maize. Millets yielded well in 60% of years, rising to 82% with just 200 mm rainfall, compared to just 14% of years for maize. Yet in drought years it was men, not women, who were responsible for feeding the household. In the absence of small grain de-hullers, this encouraged women to replace sorghum and millets, which required hand-pounding, with maize which was processed by commercially operated hammer mills.

*The results are based on a survey of 84 farm households and focus group discussions in Chivi South, Masvingo Province, in 1987 (Balderrama et al. 1988).*

Households grew combinations of short-duration hybrid maize, sorghum and millets, with pearl millet as the major and finger millet as a minor cereal crop. Maize was popular for several reasons. First, in 'average' years maize yields were higher by 30%. Because of higher prices, sorghum and millets had higher gross margins and returns to labor, but this did not compensate for lower yields. Second, milling was easier. Although maize took longer to pound by hand than sorghum and millets, this was offset by the availability of commercial hammer mills for flour processing. Sorghum and millets can be processed by hammer mills, but the husks make the porridge rough and tasteless, while small grains milled with husks store for only a short period. Third, taste preferences, with the Shona preferring porridge made from maize, while the Ndebele and Kalanga preferred porridge made from pearl millet. Finally, market regulations restricted the sale of staple food to maize meal. Consequently, pearl millet was processed and traded as beer not as grain, but beer accounted for only 7% of total demand for cereals.

*The results are based on a survey of 192 farm households in four semi-arid Communal Areas in Matabaleland South and Midlands Provinces in 1988-89 (Hedden-Dunkorst 1993).*

**Ethiopia**

In 1970, maize was Ethiopia's fourth most important cereal crop, accounting for 15% of total cereal production. Fourteen years later, in 1984, maize had become the most important cereal crop in Ethiopia. By 2012, maize accounted for over 50% of national cereal production. Until the 1970s, maize was concentrated in the coffee-maize farming system in southern Ethiopia, where its labor profile fitted with coffee and provided food before the income from the coffee harvest. Maize also spread into the eastern highlands where it complemented the cultivation of *khat (Catha edulis*). During the revolution (1974-1991), maize production was promoted by the socialist military government that saw maize as a symbol of 'modernity', while farmers found maize to be 'expedient' because it required less labor and, unlike other marketable food crops, the marketing of maize was not controlled. The share of cereals planted to maize has increased steadily since, reaching 50% in 2012. Maize is valued for its high yield and early maturity, but for palatability is eaten mixed with wheat or teff. Low prices mean that maize is used primarily for home consumption.

*The results are based on historical research by McCann (2005) and participatory rural appraisal with 160 farmers in Oromia region (Abakemal et al 2013).*

**Kenya**

Semi-arid eastern Kenya has seen a long decline in the area planted to sorghum and millets. In the 1930s, they occupied twice the area planted to maize, but by the 1960s, the area planted to maize was more than four times greater. Farmers continue to rely on maize rather than sorghum for household food security, despite the greater risk of crop failure with maize, which fails 6 seasons in 10, producing 228 kg/ha in a poor year (Rao et al. 2011). This preference for maize over more drought-resistant sorghum and millets has puzzled researchers and frustrated attempts to improve household food security.

Farmers attributed the decline of sorghum to the introduction of primary schooling, which meant that children were no longer available for bird-scaring and the need for a cash crop in order to pay school fees. Another important reason was the spread of early-maturing, 'drought-escaping' varieties of maize in the early 1970s. The early-maturing variety Katumani Composite B (KCB) released in 1968, matured in two and a half months, a full month earlier than local maize varieties like Kikamba. By the mid-1970s, Katumani was being grown on more than half the area planted to maize, but adoption was never complete. Farmers continued to plant local varieties of maize because growing a range of varieties, rather than just one, reduces the risk of crop failure. Katumani is valued chiefly for its earlier maturity, which gives it a yield advantage in bad years, although it seems to have no yield advantage over local varieties in good years. Hence, Katumani extends the menu of options for coping with risk.

Another reason farmers continue to grow maize in preference to sorghum is that they cannot rely on the market to provide maize when they run out, and at a price they can afford. Thus, "*the political economy of maize as it plays out on the national stage locks farmers in this locality into a crop they feel they must plant (at huge cost to themselves) 'just in case' the national food system fails to deliver – as it has in recent years… attempts to promote alternative crops at the local level are undermined by national food system dynamics that neither assure access to affordable maize meal, nor provide reliable markets for crops that might otherwise have provided farmers in Sakai with viable alternatives to maize.. It is these* *cross-scale dynamics that lock farmers in areas like Sakai into maize cultivation*'' (Brooks et al. 2009: 20). What started as a cash crop in the 1930s has now become an insurance crop that farmers grow to safeguard their food security from high and fluctuating maize prices.

*Focus Group Discussions with farmers in Sakai Sub-location, Kisaudivision, Mboonidistrict, Eastern Province (Brooks et al. 2009). Tiffen et al. (1994): 77-84, 226-231.*

**Conclusions**

Despite the diverse locations, times and methods of these country studies, some common answers emerge as to why farmers in semi-arid regions have replaced sorghum and millets with maize:

- Farmers preferred maize for earlier maturity and higher yields. Any crop that shortened the hungry period before the next harvest was a welcome innovation. Where land became scarce, as among the Chagga on Kilimanjaro, higher yields were a priority (Bender 2011). Maize was not seen as a cash crop.
- Farmers preferred maize because it could not be processed by mechanical mills rather than being pounded by hand. This reduced drudgery for women. For the same reason, women have abandoned millet in south India (Finnis 2009).
- Maize was associated with modernity. Post-independence governments promoted maize to transform traditional agriculture into an image that matched their vision of the future. High maize yields also promised national food security, which increased their political legitimacy.
- Farmers in semi-arid areas can become 'locked' into the production of maize if they lack alternative cash crops and if they fear sudden increases in the price of maize that threaten household food security.

In combination, these factors help explain why food-deficit, risk-averse farmers in semi-arid regions are willing to grow a staple food crop that is less resistant to drought. However, farmers continue to grow sorghum and millets because they provide food security when maize fails, because they prefer the taste and because when processed into beer they provide women with a source of cash income that is outside their husband's control.

## 2.7. Trade deficit in cereals

ESA runs a large and growing trade deficit in wheat and rice, which are regarded as more desirable cereals by higher-income consumers (Figure 2.12). The trade deficits in these two crops have accelerated since the early 1990s, reaching 3 million t per year for rice and almost 8 million t per year for wheat. The trade balance for maize, the staple food grain, has fluctuated with a largely negative balance between 2000 and 2012. By comparison, the trade balance for sorghum and millets shows low fluctuations, reflecting relatively low levels of production. Generally, ESA has run a small trade surplus for millets but a growing trade deficit for sorghum, which reached 0.8 million t in 2010.

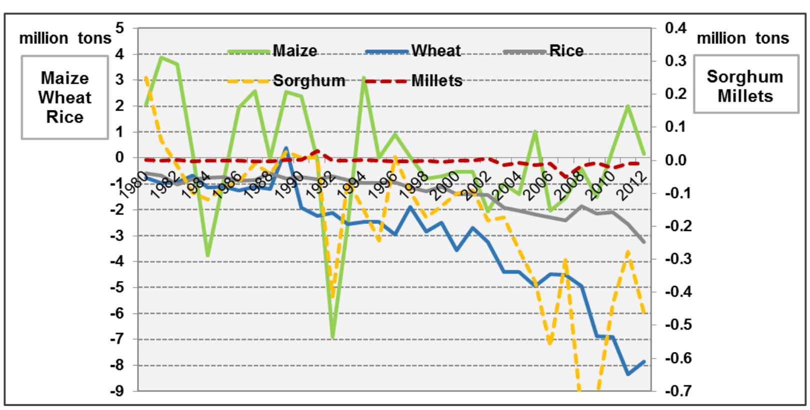



*Figure 2.12. Net trade in cereal crops, ESA, 1980-2012.*

Source: FAOSTAT

# 3. Sorghum: Facts and Trends

## 3.1. Overview

Sorghum is primarily an African cereal crop. Of the 44 million ha planted to sorghum worldwide, 27 million ha (62%) is planted in Africa (Figure 3.1). Within ESA, sorghum is the third most popular cereal crop after maize and rice, and is grown on 12% of the area planted to cereals (Figure 3.1).

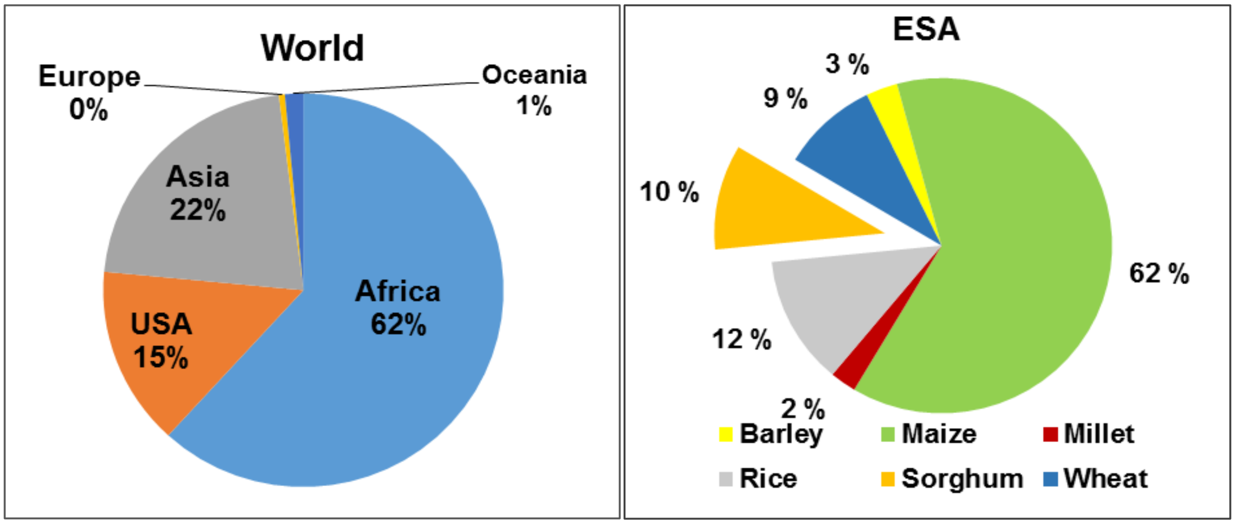



*Figure 3.1. Area planted to sorghum, 2010-2012.*

Source: FAOSTAT

Note: for the definition of the ESA region, see Appendix 1.

Unlike West Africa, where sorghum is grown as a sole crop, most sorghum in ESA is intercropped. The most important sorghum intercrops are maize, cowpea and common bean (Wortmann et al. 2009). Intercropping sorghum with maize is especially common in central Mozambique, and to a lesser extent in western Kenya, eastern Tanzania and the southern highlands of Tanzania. Intercropping with cowpea is most important to the Coast and Eastern Provinces of Kenya, southern Mozambique and in much of Tanzania, Zambia and Zimbabwe. Intercrop production of sorghum and common bean is common in: southwestern, central and western Uganda; the Eastern and Rift Valley Provinces of Kenya; Rwanda; Malawi; and in the southern highlands of Tanzania. The sorghum and groundnut intercrop association is common in several regions of Tanzania and Rwanda. Intercropping with pigeonpea is important in eastern Tanzania. Significant intercrop production with cassava and pearl millet occurs in the Coast and Eastern Provinces of Kenya, respectively.

## 3.2. Trends in area, production and yield

### Area

Worldwide, the area planted to sorghum in the last three decades has shown a declining trend. Area planted fell from 45 million ha in 1981-83 to 41 million ha in 2010-12 (Table 3.1). In Africa, however, the area planted to sorghum rose by 84%, from 13.7 million ha in 1981-83 to 25.2 million ha in 2010-12. This represents an annual growth rate of 1.7% (Table 3.2). Most of this growth in area occurred in western Africa. ESA presents a mixed picture. In eastern Africa, the area planted to sorghum rose from 3.0 to 4.9 million ha, or by 2.1% per year (Table 3.2). In southern Africa, however, the area planted to sorghum fell from 0.4 to 0.2 million ha, or by -3.94% per year (Table 3.2). Within ESA, Ethiopia and Eritrea showed the strongest growth in the area planted to sorghum, increasing more than threefold between 1991-93 and 2010-13.

### Production

Global production of sorghum fell by 15% from 68 million t in 1981-83 to 58 million t in 2010-12 (Table 3.1). In Africa, however, production rose by 90%, from 12.5 to 23.7 million t. Western Africa showed the strongest increase, from 5.5 million t in 1981-83 to 11.4 million t in 2010-12.Within ESA, the picture was mixed. In southern Africa, sorghum production fell steeply from 0.4 million to only 0.2 million t, whereas in eastern Africa production rose from 3 to 6 million t. Within eastern Africa, the strongest performer was Ethiopia where production rose from 0.2 million t in 1991-93 to 4 million t in 2010-12. By 2012, Ethiopia had overtaken Sudan to become the region's biggest sorghum producer. Box 3 explores the reasons for this rapid expansion in Ethiopia.

### Yield

Over the three-year period 2010-2012, the global yield of sorghum averaged 1,420 kg/ha (Table 3.1). In Africa, yields over the same period averaged 908 kg/ha. Over the period 1981-2012 the global trend in yields was downwards at -0.21% per year, while in Africa yields rose by 0.11% per year (Table 3.2). Within Africa, yields in western Africa were stable and showed a weak upward trend, growing at only 0.08% per year. By contrast, yields in eastern Africa grew strongly by 0.8% per year. In southern Africa, however, yields fell by -0.5% per year and this downward trend accelerated over time. Within eastern Africa, the rate of growth in sorghum yields varied by country. In the period 2000-2012, Somalia (8.90%) and Ethiopia (4.98%) showed the strongest growth in yield.

Average yields varied widely between individual countries within the region. In 2010-12, only Somalia and Ethiopia had average yields above 2,000 kg/ha in 2010-12. In Sudan, the second largest producer in eastern Africa, the average yield was only 521 kg/ha. The trend in sorghum yields also varied between countries, with both Somalia and Ethiopia showing strong growth in yields, while yields in Sudan, Uganda and Zimbabwe actually declined. Over the region as a whole, yields rose from 778 to 1,243 kg/ha, driven primarily by increased yields in Ethiopia.

**Table 3.1. Sorghum production, area and yield, 1981-2012.**

| | Production ('000 tons) | | | Area harvested ('000 ha) | | | Yield (kg/ha) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Country/ region** | **1981-1983** | **1991-1993** | **2010-2012** | **1981-1983** | **1991-1993** | **2010-2012** | **1981-1983** | **1991-1993** | **2010-2012** |
| World | 67,960 | 61,065 | 57,860 | 45,333 | 44,129 | 40,794 | 1,498 | 1,380 | 1,420 |
| Africa | 12,466 | 16,423 | 23,677 | 13,729 | 20,965 | 25,210 | 908 | 784 | 940 |
| Eastern Africa | 2,964 | 2,311 | 6,171 | 3,009 | 3,052 | 4,962 | 987 | 778 | 1,243 |
| Southern Africa | 413 | 375 | 214 | 377 | 331 | 177 | 1,074 | 1,091 | 1,208 |
| Western Africa | 5,522 | 8,920 | 11,435 | 5639 | 11,030 | 12,251 | 979 | 809 | 932 |
| ***Southern Africa*** | | | | | | | | | |
| Botswana | 12 | 29 | 34 | 66 | 73 | 67 | 1,618 | 3,936 | 5,070 |
| Lesotho | 35 | 27 | 12 | 52 | 30 | 22 | 666 | 808 | 454 |
| Namibia | 7 | 7 | 6 | 31 | 29 | 18 | 2,152 | 2,249 | 3,306 |
| South Africa | 359 | 312 | 162 | 227 | 199 | 68 | 1,608 | 1,531 | 2,421 |
| Swaziland | 1 | 0 | 0 | 2 | 1 | 1 | 488 | 500 | 395 |
| ***Eastern Africa*** | | | | | | | | | |
| Burundi | 53 | 66 | 67 | 53 | 58 | 62 | 1,000 | 1,134 | 1,054 |
| Eritrea | NA | 15 | 73 | NA | 140 | 256 | NA | 320 | 284 |
| Ethiopia | NA | 209 | 3,838 | NA | 448 | 1844 | NA | 1,402 | 2,082 |
| Kenya | 61 | 109 | 164 | 97 | 117 | 235 | 683 | 941 | 700 |
| Madagascar | 1 | 1 | 1 | 3 | 2 | 3 | 460 | 592 | 540 |
| Malawi | 16 | 15 | 65 | 28 | 34 | 86 | 545 | 411 | 754 |
| Mozambique | 197 | 123 | 346 | 333 | 408 | 632 | 594 | 306 | 545 |
| Rwanda | 198 | 149 | 151 | 179 | 137 | 117 | 1,112 | 1,104 | 1,303 |
| Somalia | 192 | 106 | 165 | 464 | 310 | 328 | 408 | 336 | 536 |
| Sudan | 2,408 | 3,336 | 2,408 | 3,720 | 5,328 | 5,658 | 642 | 621 | 521 |
| Tanzania | 493 | 639 | 815 | 500 | 642 | 756 | 1,133 | 1,000 | 1,095 |
| Uganda | 332 | 374 | 388 | 192 | 250 | 77 | 1,733 | 1,495 | 1,067 |
| Zambia | 14 | 23 | 21 | 20 | 40 | 22 | 685 | 581 | 920 |
| Zimbabwe | 81 | 62 | 78 | 235 | 112 | 258 | 367 | 531 | 302 |
| Source: FAOSTAT | | | | | | | | | |

NA = Not Available

**Table 3.2. Annual compound growth rates of sorghum production, area and yield, 1981-2012 (%).**

| | Production ('000 tons) | | | Area harvested ('000 ha) | | | Yield (kg/ha) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Country/ region** | **1981-2012** | **1981-1999** | **2000-2012** | **1981-2012** | **1981-1999** | **2000-2012** | **1981-2012** | **1981 - 1999** | **2000-2012** |
| **World** | -0.81 | -1.10 | 0.17 | -0.59 | -0.51 | -0.64 | -0.21 | -0.59 | 0.82 |
| **Africa** | 1.78 | 1.75 | 1.99 | 1.66 | 2.43 | 0.70 | 0.11 | -0.67 | 1.29 |
| **Eastern Africa** | 2.07 | 0.43 | 5.69 | 1.23 | 0.45 | 2.60 | 0.83 | -0.02 | 3.01 |
| **Southern Africa** | -3.94 | -4.57 | -8.34 | -3.46 | -4.26 | -5.63 | -0.50 | -0.32 | -2.88 |
| **Western Africa** | 2.75 | 4.00 | 1.29 | 2.67 | 4.55 | 0.11 | 0.08 | -0.53 | 1.18 |
| ***Southern Africa*** | | | | | | | | | |
| **Botswana** | 0.96 | -4.23 | 10.62 | -2.00 | -4.99 | -3.50 | 3.01 | 0.80 | 14.63 |
| **Lesotho** | -9.88 | -1.97 | -19.79 | -4.55 | -3.77 | -4.89 | -5.58 | 1.86 | -15.67 |
| **Namibia** | 0.60 | -2.71 | -1.29 | -2.01 | -2.56 | -2.62 | 2.66 | -0.16 | 1.36 |
| **South Africa** | -4.45 | -4.91 | -9.92 | -4.72 | -4.32 | -8.50 | 0.28 | -0.61 | -1.55 |
| **Swaziland** | -3.76 | -3.54 | -3.62 | -1.96 | -1.37 | -2.22 | -1.84 | -2.20 | -1.43 |
| ***Eastern Africa*** | | | | | | | | | |
| **Burundi** | -1.66 | 0.69 | -5.35 | 0.03 | -0.32 | 0.41 | -1.69 | 1.02 | -5.73 |
| **Eritrea** | NA | NA | 2.15 | NA | NA | 4.66 | NA | NA | -2.40 |
| **Ethiopia** | NA | NA | 9.69 | NA | NA | 4.48 | NA | NA | 4.98 |
| **Kenya** | 1.88 | 0.90 | 6.14 | 3.21 | 2.93 | 5.15 | -1.29 | -1.97 | 0.94 |
| **Madagascar** | 0.17 | -0.87 | 3.44 | -0.51 | -1.23 | 0.51 | 0.69 | 0.36 | 2.91 |
| **Malawi** | 3.95 | 4.12 | 5.05 | 3.21 | 3.86 | 3.14 | 0.72 | 0.26 | 1.85 |
| **Mozambique** | 0.58 | 1.25 | 1.79 | 2.37 | 1.97 | 5.31 | -1.75 | -0.71 | -3.34 |
| **Rwanda** | -1.05 | -3.18 | -0.93 | -2.03 | -1.93 | -4.75 | 1.00 | -1.28 | 4.01 |
| **Somalia** | 0.17 | -2.93 | 5.46 | -2.47 | -3.39 | -3.15 | 2.70 | 0.48 | 8.90 |
| **Sudan** | -1.83 | -1.93 | -2.30 | 0.15 | 0.81 | -0.18 | -1.98 | -2.72 | -2.12 |
| **Tanzania** | 0.16 | 1.43 | -0.60 | 2.57 | 2.71 | 2.42 | -2.35 | -1.25 | -2.94 |
| **Uganda** | 2.22 | 1.55 | 2.86 | 0.59 | -0.33 | 1.10 | 1.62 | 1.89 | 1.74 |
| **Zambia** | 0.32 | 3.41 | -5.48 | -1.01 | 3.01 | -7.35 | 1.33 | 0.39 | 2.02 |
| **Zimbabwe** | -2.09 | -2.09 | -3.79 | 0.16 | -1.83 | 1.91 | -2.25 | -0.27 | -5.60 |

Source: FAOSTAT
NA = Not Available

## 3.3. Variability in production and area planted

Figure 3.2 shows the variation in production for sorghum, millets and maize in ESA for the period under review. Since production over this period showed a positive trend, we subtracted the annual increase due to the trend and based our estimates on the de-trended production values. Figure 3.2 shows that for the 29 years between 1981 and 2009, average production in ESA were below the average in 12 years. Low production was concentrated in the 1990s. Sorghum production in the region was below average in 7 out of 10 years. By contrast, since 2000, the variation in production has generally been positive.

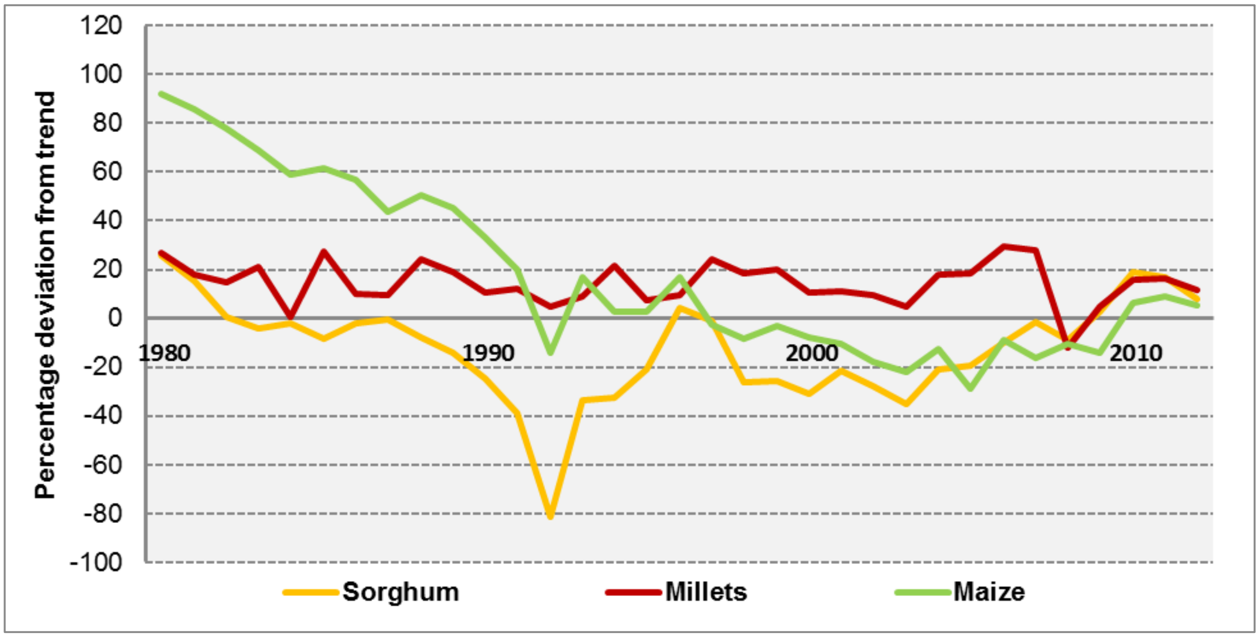



*Figure 3.2. Fluctuations in the production of sorghum, maize and millets, ESA, 1981-2012.*

Source: FAOSTAT

Variations in the area planted to sorghum may reflect its importance as an insurance crop in drought years. Consequently, we might expect that variations in the production of maize would be reflected in changes in the area planted to sorghum. We explored this relationship using time-series data for Zimbabwe and Eastern Province, Kenya.

In Figure 3.3, Panel 1 charts the production of maize against the area planted to sorghum in Zimbabwe for the period 1970-2010. For most of the period, maize production and the area planted to sorghum move in parallel, except for years like 1983, where farmers compensated for a sudden drop in maize production by increasing the area planted to sorghum.

However, the prolonged drop in maize production between 2004 and 2010 was accompanied by an increase in the area planted to sorghum, which rose from 228,000 ha in 2004 to reach 330,000 in 2007, a jump of 45% in just six years. This sudden drop in maize production was not the result of drought but of land reform policy that reduced production on commercial farms. In response, smallholders in communal areas increased the area planted to sorghum, which requires fewer purchased inputs than maize.

Figure 3.3 Panel 2 plots the trend in maize production in Eastern Province, Kenya, against the area planted to sorghum at national level, for the period 1970-2005. During the 1980s, the area planted to sorghum collapsed from 500,000 to just over 100,000 ha, largely due to the release in 1967 of Katumani, an early-maturing variety of maize with a field duration of three to four months.

Subsequently, maize production and the area planted to sorghum have moved in parallel. From the mid-1990s, however, the area planted to sorghum has increased, from 30,000 ha in 1996 to 50,000 ha in 2010, reflecting the improved price of sorghum relative to maize in Kenya (Figure 3.8).

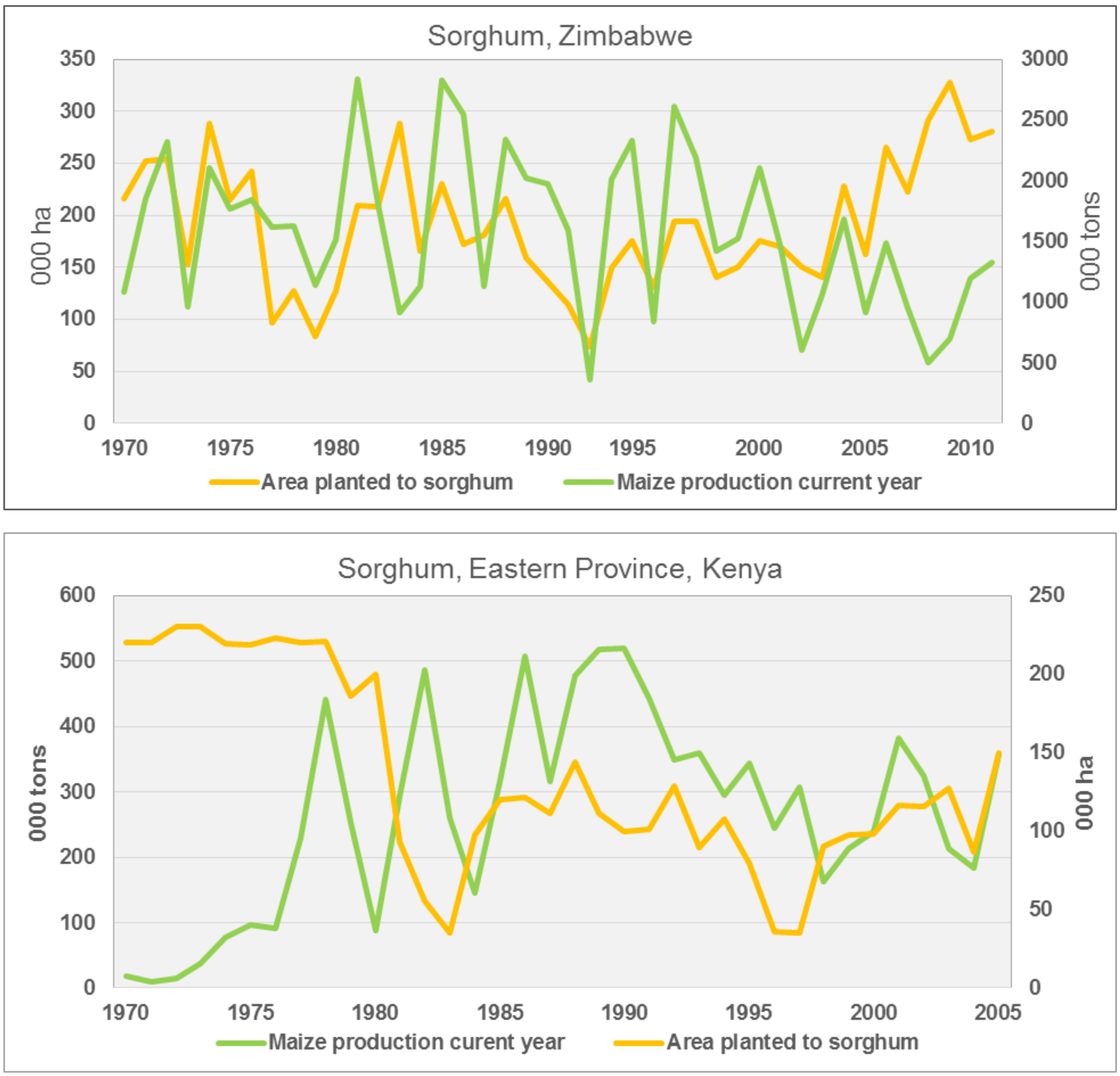



*Figure 3.3. Changes in the area planted to sorghum in Zimbabwe and Kenya, 1970-2010.*

Source: World Bank (2015), African Development Indicators (Zimbabwe); Ministry of Agriculture, Kenya (2007).

Of course, the area planted to sorghum also responds to other factors. In Zimbabwe, the production of sorghum between 1980 and 2011 was also determined by price, the price of maize and rainfall (Vincent et al. 2013). A 10% rise in the price of sorghum increased the production of sorghum by only 4%, a relatively low price response. By contrast, a 10% rise in the price of maize reduced the production of sorghum by only 3%, while a 10% increase in average rainfall in the previous year reduced production by by 5%. These results suggest that smallholders grow sorghum primarily as a food crop, responding slowly to changes in market prices or the price of maize, but reducing the production of sorghum after a year of good rains when, we assume, they had experienced a bumper harvest of maize.

## 3.4. Production constraints

Sorghum production is affected by both biotic and abiotic constraints, including numerous pests and diseases, low soil fertility and water stress. Together these may significantly reduce yields. *Striga*, a parasitic weed, is considered a major pest of sorghum in Africa. Information on sources of crop loss is available for selected countries in ESA. Figure 3.4 shows crop losses by country, arranged in descending order of total sorghum production. Overall, the three major constraints on production are water deficit, nutrient deficiency and birds, which together account for 70% of crop losses. *Striga* is estimated to account for only 10% of aggregate crop loss. Sources of crop loss vary significantly between countries. In Ethiopia, the largest sorghum producer in ESA, an estimated 35% of crop loss is attributed to pests and diseases (particularly smut and shootfly). These results suggest that improved crop management and new varieties with increased resistance to pests and diseases can significantly increase sorghum yields.

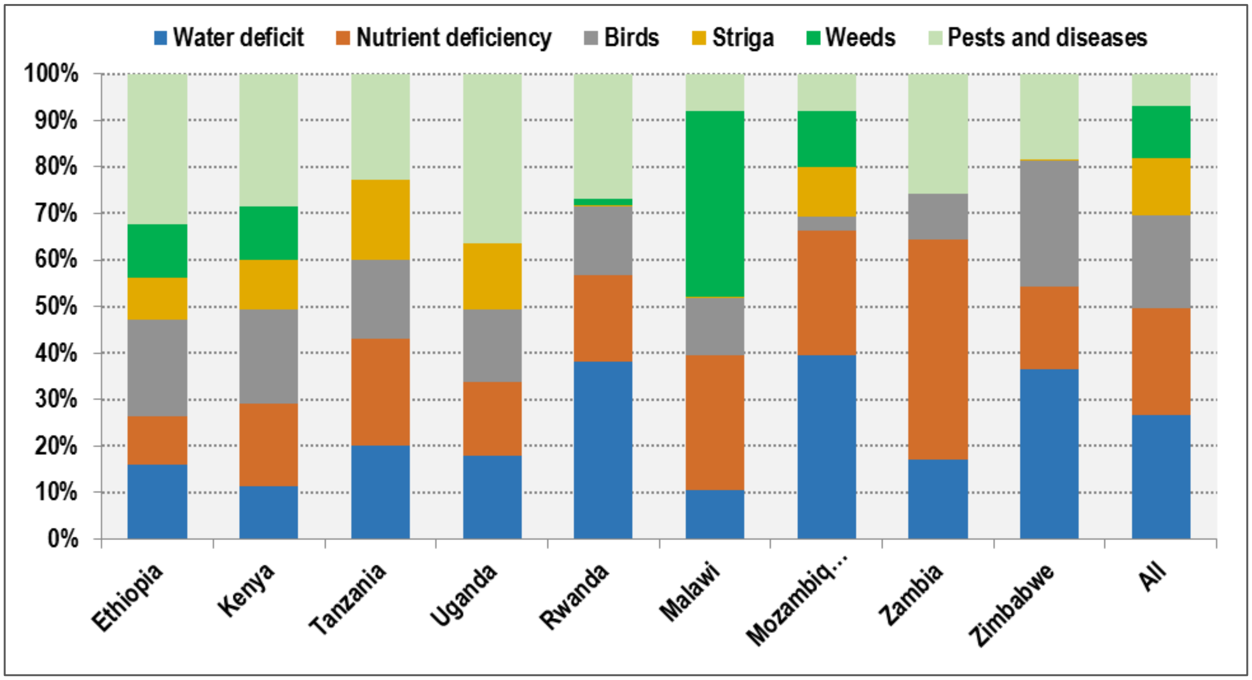



*Figure 3.4. Source of crop losses for sorghum in eastern Africa, 2009 (% of crop lost).*

Source: Wortmann et al. (2009), p. 19 Table 3.1

**Box 2. Why are sorghum yields so low?**

Although the average yield of sorghum in eastern Africa rose between 1981-2012 (Table 3.2), it remains low by international standards. The evidence shows significant yield gaps for sorghum and millets in ESA. Crop simulation models for ESA show that differences of 80-90% between actual and potential yields of sorghum and millets are common across the region (Global Yield Gap Atlas 2015). Similarly, household surveys for five countries show that the top 5% of sorghum growers regularly achieve yields 50-80% above the rest (Table B2.1). In this section we explore three possible explanations for the yield gap for sorghum in ESA.

**Table B2.1. Sorghum yield gap (tons/ha) in ESA.**

| Country | Sorghum yields 2000-2002 | | | Sorghum yields 2006-2008 | | |
|---|---|---|---|---|---|---|
| | Top 5% of farmers | The rest | Yield gap (%) | Top 5% of farmers | The rest | Yield gap (%) |
| Ethiopia | 2.34 | 1.05 | 55 | 2.04 | 0.72 | 65 |
| Kenya | 1.23 | 0.56 | 54 | 0.45 | 0.29 | 36 |
| Malawi | 1.57 | 0.14 | 91 | 1.37 | 0.25 | 82 |
| Mozambique | 1.37 | 0.33 | 76 | 1.37 | 0.68 | 50 |
| Zambia | 0.95 | 0.51 | 46 | 0.83 | 0.43 | 48 |

Source: Jirstrom et al. (2011), p. 89 Table 4.8.

**Limited adoption of improved varieties and crop management practices**

One reason for this yield gap is that sorghum growers generally use traditional varieties and management practices. In Ethiopia, Kenya, Uganda and Mozambique, less than 5% of sorghum growers planted improved varieties in contrast to maize, where improved varieties have been widely adopted (Table B2.2). Similarly, fewer farmers used inorganic fertilizer for sorghum than for maize. The difference for pesticides/herbicides was minimal. The exception to this pattern was Mozambique, where the adoption of improved varieties and crop management practices was low for both crops.

**Table B2.2. Adoption and crop management for sorghum and maize, 2008 crop season (% of growers).**

| Country | Ethiopia (n=225) | Kenya (n=22) | Uganda (n=105) | Mozambique (n=146) |
|---|---|---|---|---|
| Growing improved/hybrid variety | | | | |
| Sorghum | 2 | 3 | 2 | 4 |
| Maize | 42 | 90 | 50 | 4 |
| Applying inorganic fertilizer in 2002 | | | | |
| Sorghum | 4 | 26 | 0 | 1 |
| Maize | 36 | 72 | 2 | 1 |
| Applying pesticides/herbicides | | | | |
| Sorghum | 26 | 9 | 1 | 0 |
| Maize | 20 | 12 | 5 | 2 |

Source: Djurfeldt et al. (2015), Afrintdatabase

**Under-investment in agricultural research**

A second reason for limited adoption may be under-investment in agricultural research. Although Ethiopia, Kenya and Uganda have large national agricultural research systems, until 1990-2000 the supply of improved sorghum varieties was limited. At the end of the 1990s, only three improved sorghum varieties had been released in Ethiopia, the largest producer in the region (Figure B2.1). The period 2000-2010 saw increased investment in agricultural research. Public agricultural R&D spending in SSA increased by more than one-third in real terms, from $1.2 billion in 2000 to $1.7 billion in 2011, measured in constant 2005 PPP dollars (Beintama and Stads 2014). By 2011, Ethiopia, Uganda and Kenya were among the top six highest investors in publicsector agricultural research, while Ethiopia had the highest number of full-time agricultural researchers, second only to Nigeria (Beintama and Stads 2014). In Ethiopia, the number of improved sorghum varieties more than doubled over the decade, while the supply of improved varieties also rose in Uganda, Kenya and Mozambique.

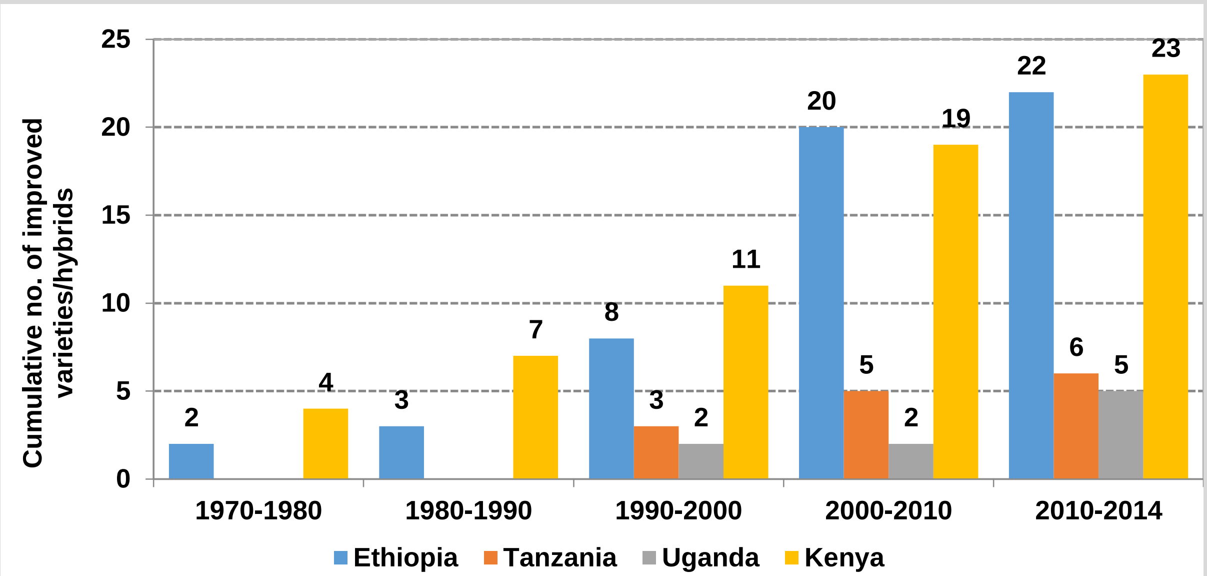



**Figure B2.1. Supply of improved sorghum varieties/hybrids, 1980-2014.**

Source: Gierend et al. (2014a, 2014b, 2014c) (Ethiopia, Uganda, Tanzania); KEPHIS (2015)

**Lack of economic incentives**

A third reason for limited adoption may be low market demand, since farmers generally invest in crops that they can sell. The evidence shows a mixed picture. In Ethiopia and Uganda, sorghum is widely sold, while this is not the case in Kenya and Mozambique (Table B2.2). Similarly, the share of sorghum production that is sold is high in Ethiopia and Uganda, but minimal in Kenya and Mozambique. Despite these differences, prices for sorghum across all four countries are competitive with maize. Thus, even in countries with strong market demand, the adoption of improved varieties and crop management practices for sorghum remains low.

**Table B2.2. Marketing of sorghum and maize, 2008 crop season (% of growers).**

| Country | Ethiopia (n=225) | Kenya (n=22) | Uganda (n=105) | Mozambique (n=146) |
|---|---|---|---|---|
| **Households selling** | | | | |
| Sorghum | 76 | 0 | 46 | 3 |
| Maize | 20 | 18 | Na. | 18 |
| **Share of crop sold** | | | | |
| Sorghum | 36 | 0 | 80 | 5 |
| Maize | 50 | 30 | 61 | 16 |
| **Highest price received (USD per 100 kg)** | | | | |
| Sorghum | 14 | na | 22 | 12 |
| Maize | 12 | 23 | 14 | 16 |

Source: Djurfeldt et al.(2015), Afrint database

**Conclusions**

The large gap between average and potential yields demonstrates the scope for raising yields of sorghum and millets. Despite increased investment in agricultural research since 2000, the adoption of improved varieties remains low. Even where improved varieties have been adopted, adoption has not necessarily resulted in higher productivity. And even where there has been strong market demand, farmers have been slow to invest in crop management practices that will increase yields. However, the top 5% of growers achieve yields that are at least 50% higher than those achieved by the other 95%. This suggests that it is possible to increase the current yield of dryland cereals under farmers' field conditions.

## 3.5. Utilization

Sorghum has a wide variety of uses. The grain is eaten after boiling the flour to produce foods such as *ugali*, *sadza* and *uji*. In Ethiopia, sorghum flour is used to make *injera*, a traditional bread made from fermented dough. Sorghum grain is also used for brewing. Varieties of sorghum suitable for brewing have low tannin content since consumers prefer beer with this taste. Although sorghum grain is not usually fed to livestock, sorghum stover is used for fodder as well as fuel and material for building and roofing houses.

**Table 3.3. Trends in sorghum utilization, by region and country, 1981-2012 ('000 t)[3].**

| | 1980-82 | | | | | 2009-2011 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Country/ region | Available supply[a] | Food[b] | Feed | Food pro-cessing[c] | Other uses[d] | Available supply *(for domestic utilization*[a] | Food[b] | Feed | Food pro-cessing[c] | Other uses[d] |
| World | 63,826 | 23,372 | 35,332 | 1,251 | 32 | 60,991 | 25,032 | 26,475 | 3,677 | 1,696 |
| Africa | 11,748 | 8,036 | 1,336 | 1,026 | 0 | 25,460 | 16,794 | 2,455 | 1,926 | 1,575 |
| Eastern Africa | 2,586 | 1,817 | 61 | 468 | 0 | 5,505 | 3,296 | 91 | 647 | 1,017 |
| Southern Africa | 433 | 163 | 123 | 101 | 0 | 345 | 147 | 58 | 118 | 0 |
| Western Africa | 5,539 | 3,836 | 631 | 334 | 0 | 12,532 | 8,756 | 1,207 | 895 | 0 |
| ***Southern Africa*** | | | | | | | | | | |
| Botswana | 30 | 21 | 0 | 4 | 0 | 61 | 46 | 0 | 8 | 0 |
| Namibia | 6 | 5 | 0 | 1 | 0 | 5 | 4 | 0 | 1 | 0 |
| South Africa | 343 | 100 | 122 | 90 | 0 | 253 | 78 | 57 | 105 | 0 |
| Swaziland | 3 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Eastern Africa*** | | | | | | | | | | |
| Ethiopia | 0 | 0 | 0 | 0 | 0 | 3,471 | 2,225 | 0 | 0 | 1,017 |
| Kenya | 116 | 62 | 12 | 27 | 0 | 150 | 75 | 18 | 33 | 0 |
| Malawi | 20 | 14 | 2 | 12 | 0 | 67 | 31 | 3 | 26 | 0 |
| Mozambique | 193 | 170 | 6 | 2 | 0 | 306 | 262 | 12 | 3 | 0 |
| Rwanda | 183 | 137 | 0 | 37 | 0 | 168 | 127 | 0 | 34 | 0 |
| Sudan (former) | 1,941 | 1,567 | 88 | 83 | 0 | 4,357 | 3,135 | 277 | 167 | 558 |
| Tanzania | 505 | 219 | 10 | 219 | 0 | 783 | 339 | 16 | 339 | 0 |
| Uganda | 310 | 96 | 32 | 144 | 0 | 399 | 123 | 41 | 184 | 0 |
| Zambia | 15 | 10 | 0 | 3 | 0 | 30 | 20 | 0 | 7 | 0 |
| Zimbabwe | 91 | 57 | 1 | 24 | 0 | 124 | 89 | 2 | 22 | 0 |

Source: FAO STAT commodity balances

[1]Category ***'Available supply for domestic utilization'*** is defined as production + imports + changes in stocks (decrease or increase) – exports
[2]Category ***'Food'*** is defined as available supply for domestic utilization – feed – seed – waste – food processing and – other uses.
[3]Category ***'Food Processing'***. 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 FAO food balance sheet either in the same or in another food group (eg, 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, eg, oil for soap, are shown under 'Other Uses'.
[4] Category ***'Other Uses'*** representsthe amounts of the commodity in question used during the reference period for the manufacture for *non-food purposes* (eg, oil for soap). Also statistical discrepancies are included here. They are defined as an inequality between supply and utilization statistics.

[3]Available supply also contains seed use which is not included in Table 3.3

Table 3.3 shows the trends in the utilization of sorghum for the period 1980-2011. Worldwide, more sorghum was used for feed in 2009-11 (26 million t or 43%) than for food (25 million t or 41%). This reflects sorghum's primary use as livestock feed in the United States. However, the share of sorghum used for feed has declined from 45% in 1980-82 to 29% in 2009-11. This shift reflects the growing importance of Africa in the utilization of sorghum. In Africa in 2009-11, sorghum was still primarily used for food (17 million t, or 66%), compared to just 2 million t or 10%) for feed. Most utilization for feed is in western Africa, with minimal use as feed in ESA (2.5%).

Within ESA, the utilization of sorghum as food is dominated by Sudan and Ethiopia, where consumption in 2009-11 averaged 3 and 2 million t, respectively. Elsewhere in ESA, utilization for food was rivaled by utilization for beer. Opaque beer manufactured by modern breweries (eg, Chibuku shake-shake) is a popular alcoholic drink. In Uganda and Tanzania, the use of sorghum for 'food processing' (mostly opaque beer) equals or exceeds the use of sorghum for food. Generally, sorghum that is not used for food is used to make beer rather than used as feed for livestock or poultry. The only country that seemingly uses sorghum as feed on a significant scale is Sudan, where hybrid sorghum is widely grown with irrigation, maize is not a staple crop and meat is exported to the Middle East.

## 3.6. International trade

International trade in sorghum is thin. In 2009-11, world exports averaged 5.7 million t, which was only 9% of world sorghum production (Table 3.4). In 1981-83, exports averaged 13.3 m t, or 20% of sorghum production. Thus, world exports of sorghum have halved over the past 25 years. Africa shared this decline in sorghum exports, where volumes fell from 456 million t in 1981-82 to just 83 million t in 2009-11. Over the same period, imports of sorghum to Africa grew from 173 to 1,075 million t. Africa, therefore, is a net importer of sorghum. Imports are highest in eastern Africa (476 million t in 2009-11) with Sudan and Ethiopia accounting for the bulk of these imports, probably as food aid.

Cross-border trade in sorghum is often unrecorded and is underestimated in official statistics. Informal trade in staple food grew by 10% in eastern Africa between 2012 and 2013. The increase in informal sorghum trade in 2013 was due to the trade ban imposed by Sudan in 2012. Uganda met this gap by supplying sorghum to South Sudan. Uganda is the region's biggest informal exporter of staple food crop (329,000 t of informal exports in 2013, 95% of total informal sorghum exports in 2013). South Sudan is the region's biggest informal importer (317,000 t in 2013 or 92% of informal sorghum imports) (Food Security & Nutrition Working Group 2014). Informal sorghum imports to Kenya in 2013 were only 14,000 t, or 4% of total informal imports. Ethiopia also exported sorghum but mostly to Eritrea, Djibouti and Somalia.

**Table 3.4. Trends in sorghum trade by region and country, 1981-2012 ('000 t).**

| | Exports | | | | Imports | | | |
|---|---|---|---|---|---|---|---|---|
| **Country/ Region** | **1980-1982** | **1990-1992** | **2000-2002** | **2009-2011** | **1980-1982** | **1990-1992** | **2000-2002** | **2009-2011** |
| **World** | 13,129 | 9,018 | 7,003 | 5,713 | 12,793 | 8,808 | 8,157 | 6,759 |
| **Africa** | 456 | 579 | 37 | 83 | 173 | 491 | 455 | 1075 |
| **Southern Africa** | 124 | 7 | 2 | 5 | 19 | 87 | 78 | 60 |
| **Western Africa** | 3 | 0 | 5 | 6 | 92 | 90 | 17 | 28 |
| **Eastern Africa** | 15 | 18 | 5 | • 56 | 14 | 69 | 54 | 476 |
| ***Southern Africa*** | | | | | | | | |
| **Botswana** | 0 | 3 | 1 | 2 | 10 | 6 | 47 | 37 |
| **Lesotho** | 0 | 0 | 0 | 0 | 6 | 4 | 3 | 11 |
| **Namibia** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **South Africa** | 124 | 4 | 1 | 3 | 2 | 77 | 25 | 12 |
| **Swaziland** | 0 | 0 | 0 | 0 | 2 | 0 | 4 | 0 |
| ***Eastern Africa*** | | | | | | | | |
| **Burundi** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Eritrea** | 0 | 0 | 1 | 15 | 0 | 0 | 0 | 0 |
| **Ethiopia** | 0 | 0 | 1 | 15 | 0 | 0 | 9 | 225 |
| **Kenya** | 0 | 0 | 0 | 0 | 0 | 6 | 1 | 42 |
| **Malawi** | 0 | 0 | 0 | 1 | 1 | .0 | 1 | 0 |
| **Mozambique** | 13 | 0 | 0 | 0 | 0 | 9 | 0 | 2 |
| **Rwanda** | 0 | 0 | 0. | 4.7 | 0 | 0 | 1 | 13 |
| **Somalia** | 0 | 0 | 0 | 0 | 5 | 13 | 12 | 80 |
| **Sudan** | 322 | 33 | 24 | 11 | 0 | 154 | 21 | 343 |
| **Uganda** | 0 | 0 | 1.0 | 6 | 0 | 0 | 1 | 5 |
| **Tanzania** | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 |
| **Zambia** | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| **Zimbabwe** | 0 | 4 | 3 | 0 | 0 | 17 | 1 | 44 |

Source: FAOSTAT

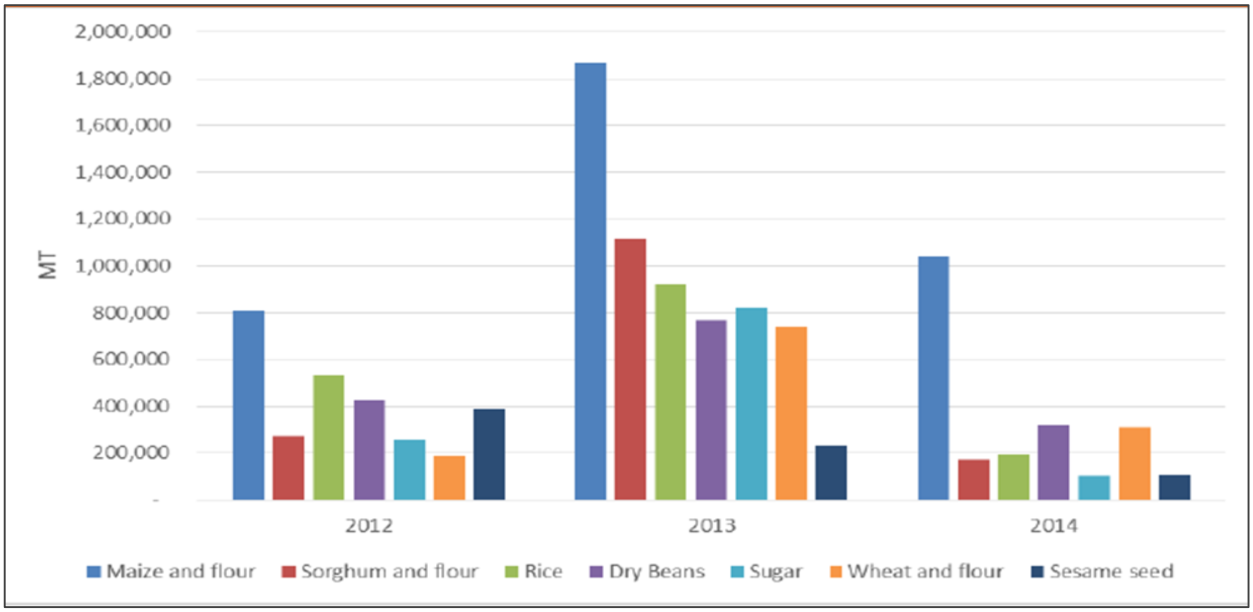



*Figure 3.5. Cross-border trade in selected markets in eastern Africa, 2011-2014.*

Source: Food Security & Nutrition Working Group (2014)

Figure 3.6 shows the trend in sorghum imports for the period 1980-2011. Imports increased sharply in the early 2000s, from about 2003,reaching 708,000 t in 2008, when prices for staple food grains spiked. High imports reflect the use of sorghum as food aid in Sudan and Ethiopia (Food Security & Nutrition Working Group, 2015).

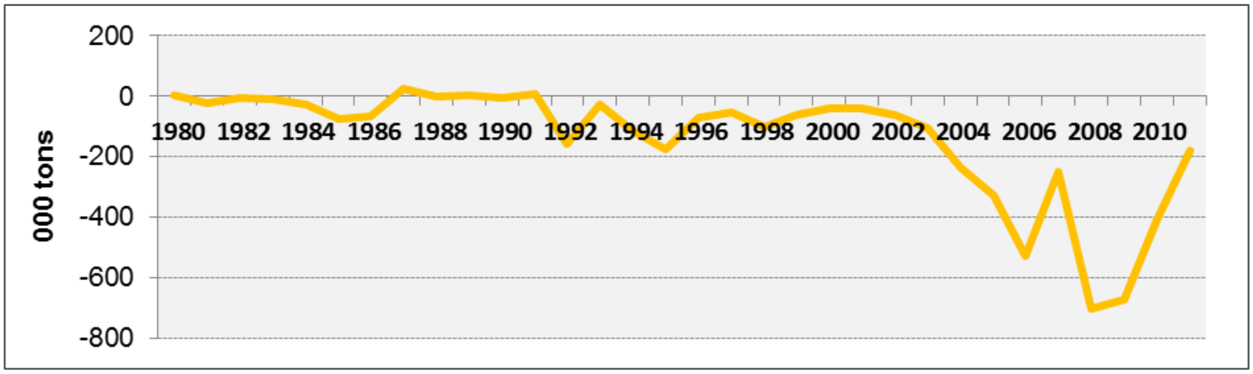



*Figure 3.6. Net trade in sorghum, ESA, 1981-2011.*

Source: FAOSTAT

## 3.7. Prices

World prices for sorghum between 1991 and 2010 ranged between $100 and $200 per t (Figure 3.7). World prices were lower than national prices in Ethiopia, the largest regional producer, and much lower than in Kenya, where prices were the highest in the region. The price spike for food grains in 2007 and 2008 also affected sorghum, with the world price peaking at $ 229 per t in 2008. In Kenya, sorghum reached $634 per t. In 2010, prices in Ethiopia and Kenya were still well above historical levels.

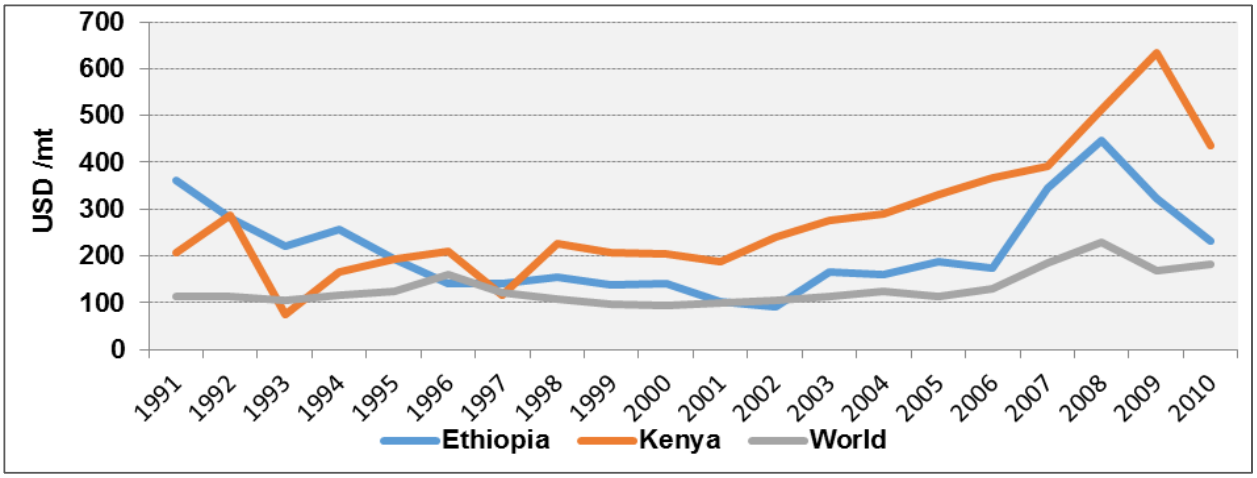



*Figure 3.7. Trends in sorghum wholesale prices, 1991-2010.*

Source: FAOSTAT

Sorghum has a reputation as a 'poor man's crop' for which demand declines as income rises. Figure 3.8 shows the price ratio for sorghum and maize for three countries in ESA for the period 1981-2010. The results reveal three stories about sorghum. In Zimbabwe, the ratio of the price of sorghum to maize was consistently below 1, ie, the value of one unit of sorghum was always below the value of one unit of maize. Thus, sorghum in Zimbabwe fits the stereotype of sorghum as a poor man's crop. In Ethiopia, by contrast, the price ratio for sorghum/maize has been consistently above 1 throughout the period. Hence, in Ethiopia, sorghum has never been a poor man's crop. Finally, in Kenya, the price ratio of sorghum/maize has changed significantly over time. In the early 1980s, the ratio was below 1, in the early 1990s the ratio fluctuated above and below 1, and since the late 1990s the ratio has been consistently above 1, reaching 2 by 2010. Thus, sorghum in Kenya is no longer a poor man's crop. The high price ratio for sorghum in Ethiopia reflects taste preferences while the change in Kenya reflects the growing demand for food processing, namely sorghum beer. In sum, the stereotype of sorghum as a poor man's crop is not true for the region as a whole. Sorghum may be a poor man's crop in terms of food preferences, but not in terms of price.

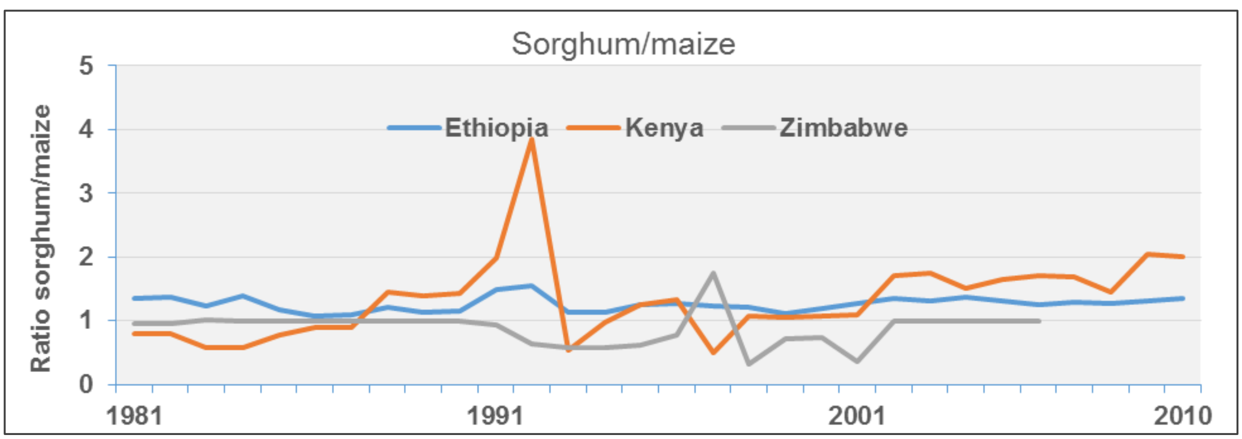



*Figure 3.8. Producer price ratios for sorghum and maize, 1981-2010.*

Source: World Bank, African Development Indicators (based on current prices in local currency).

**Box 3. Ethiopia's Success Story**

Ethiopia is a centre of diversity for sorghum and biggest producer of sorghum in the region. Sorghum accounts for one-fifth of the country's total cereal production, alongside teff, maize, wheat and barley. Sorghum production has trebled since the early 1990s, making Ethiopia the fastest-growing sorghum producer in the region. What are the reasons for such rapid growth in production?

*Area expansion:* Overall, nearly 70% of the increase in production is accounted for by expansion in the area planted. The area planted to sorghum virtually doubled from 0.71 million ha in the 1980s to 1.35 million ha in the 2000s. Unlike teff, whose share of the area planted to cereals declined, sorghum maintained and even increased its share to 18% of the cereals mix (Taffesse et al. 2012). Rapid population growth (from 36 million in 1981 to 91 million in 2011) and consequent growth in the number of smallholder farms help explain the increase in area planted.

*Yield increases:* About 30% of the growth in sorghum production was due to increase in yield. Average yields rose from 1,197 kg/ha in 1981-83 to 1,577 kg/ha in 2007-2009. In the main Meher growing season sorghum gave the highest yield of 1,730 kg/ha second only to maize (Taffesse et al. 2012).

*New technology:* Nineteen improved varieties of sorghum were released or registered in Ethiopia between 1986 and 2005 (Adugna 2007). However, by 2007 less than 1% of the area planted to sorghum was planted to improved varieties and only 5% was fertilized (Tafesse et al. 2012). By contrast, improved varieties covered 20% of the area planted to maize and 33% of the area planted to maize was fertilized. Thus, growth in yields was not the result of adoption of improved varieties or chemical fertilizer. One reason for low adoption is that growers lacked access to new sorghum technology. Another is that the new technology did not meet farmers' needs. Sorghum growers prefer local varieties because they are better-adapted and gave more stable yields (Asrat et al. 2009; Cavatassi et al. 2010), because their longer duration means higher yields in good years, because taller local varieties give more fodder, and because they perform better under low-input management (McGuire 2007). Farmers select local varieties with specific traits, with the average farmer growing four different varieties of sorghum (McGuire 2007).

*Price incentives:* Higher prices for sorghum explained 25-41% of the change in revenue from sorghum in the period 2001-2007 (Tafesse et al. 2012). White sorghum fetches a higher price than maize (Figure B3.1). However, the relative price of sorghum did not change and the contribution of prices to change in crop revenue was lower for sorghum than the average for cereals as a whole (Tafesse et al. 2012).

*Markets:* Sorghum in Ethiopia has a wide range of uses, including food (mixed with teff to make *injera*), animal feed, fuel, house construction and fencing. In Kenya, Uganda and Tanzania, a new market for sorghum has been from commercial brewers as a substitute for barley, but this market has not yet developed in Ethiopia. Recently, rising prices for teff have led to consumers mixing teff with sorghum to make '*injera*', an unleavened bread that forms part of the staple diet.

*Conclusion*: In sum, the expansion of sorghum in Ethiopia seems to have been driven primarily by the needs of a growing rural population for a robust, low-cost cereal crop that provides a basic level of household food security under challenging climatic conditions.

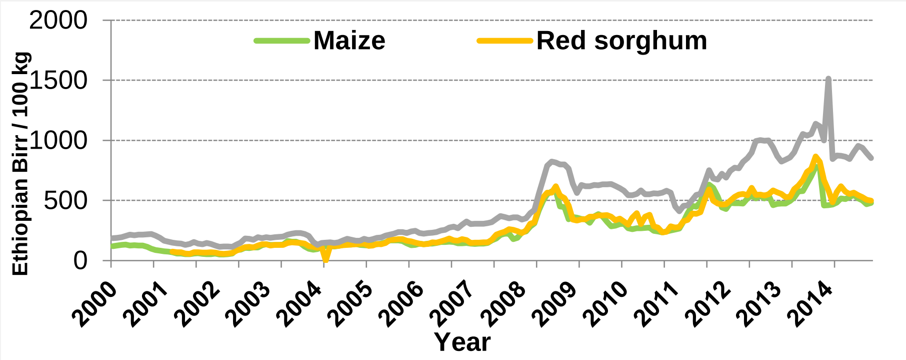



**Figure B3.1 Wholesale price of maize and sorghum, Addis Ababa, 2000-2014.**

Source: http://www.fao.org/giews/pricetool/http://www.fao.org/giews/pricetool/

# 4. Millets: Facts and Trends

## 4.1. Overview

Like sorghum, millets are primarily an African cereal crop. Of the 33 million ha planted to millets worldwide, 19 million ha (60%) are grown in Africa, compared to 38% in Asia (Figure 4.1). Within ESA, millets are the least widely grown cereal crop, planted on only 2% of the area planted to cereals. In ESA, 85% of the area planted to millets lies in eastern Africa and only 15% in southern Africa.

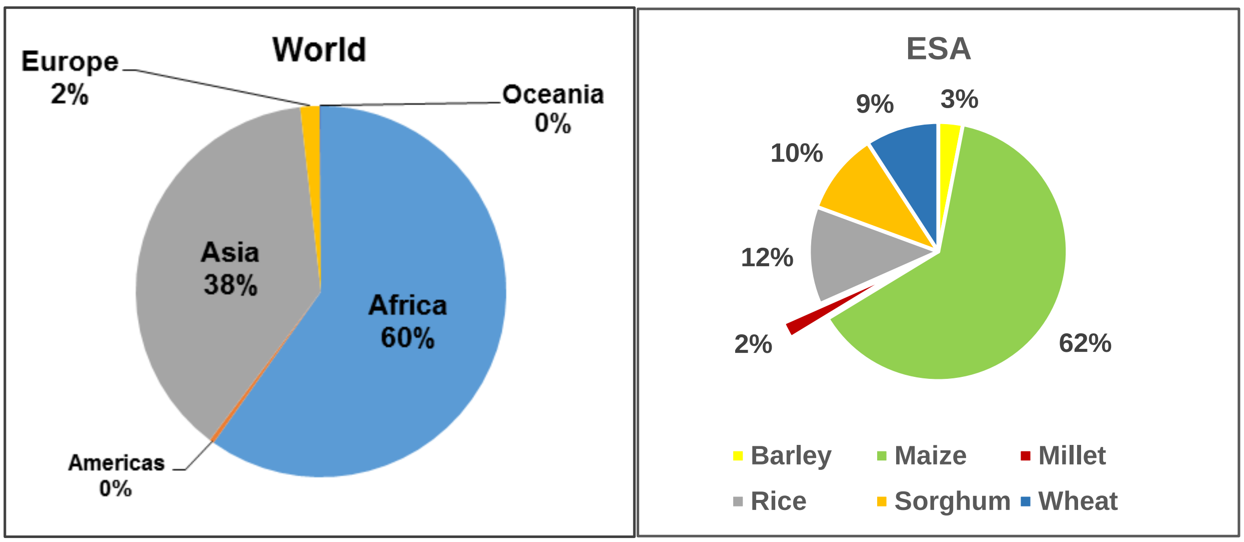



*Figure 4.1. Area planted to millets, 2010-2012.*

Source: FAOSTAT

## 4.2. Trends in area, production and yield

### Area

Unlike sorghum, the global production of millets (28 million t) has stayed constant over the period 1981-2012 (Table 4.1). However, millet production is increasingly concentrated in Africa, whose share of world production rose from 28% in 1981-83 to 45% in 2010-12. Over the past three decades, the production of millets in Africa grew by 2.21% per year from 7.7 million t in 1981-83 to 12.9 million t in 2010-12. Most of this growth in area occurred in western Africa. In ESA, the combined area planted to millets in 2010-12 was only 12% of that in western Africa. Within ESA, millets are concentrated in eastern Africa, where the area planted rose only slightly, from 1.2 to 1.5 million ha, or by 0.14% per year (Table 4.1).

**Table 4.1. Trends in millet area, production and yield, 1981-2012.**

| | Production ('000 tons) | | | Area harvested ('000 ha) | | | Yield (kg/ha) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Country/ region** | **1981-1983** | **1991-1993** | **2010-2012** | **1981-1983** | **1991-1993** | **2010-2012** | **1981-1983** | **1991-1993** | **2010-2012** |
| **World** | 28,059 | 26,892 | 28,840 | 36,861 | 36,694 | 33,089 | 761 | 732 | 872 |
| **Africa** | 7,762 | 10,766 | 12,925 | 10,875 | 16,780 | 19,804 | 714 | 642 | 652 |
| **Eastern Africa** | 1,205 | 1,205 | 1,542 | 1,233 | 1,341 | 1,529 | 987 | 902 | 1,001 |
| **Southern Africa** | 53 | 45 | 61 | 175 | 172 | 271 | 305 | 267 | 217 |
| **Western Africa** | 5,848 | 8,780 | 10,029 | 7,800 | 13,198 | 14,762 | 750 | 666 | 676 |
| ***Southern Africa*** | | | | | | | | | |
| **Botswana** | 1 | 1 | 3 | 8 | 7 | 6 | 116 | 150 | 435 |
| **Namibia** | 37 | 33 | 51 | 145 | 144 | 250 | 257 | 232 | 202 |
| **South Africa** | 15 | 11 | 7 | 22 | 20 | 14 | 682 | 562 | 490 |
| ***Eastern Africa*** | | | | | | | | | |
| **Burundi** | 11 | 14 | 12 | 11 | 130 | 11 | 1000 | 1,081 | 1,045 |
| **Eritrea** | NA | 19 | 19 | NA | 80 | 56 | NA | 238 | 341 |
| **Ethiopia** | NA | 135 | 676 | NA | 176 | 424 | NA | 768 | 1,594 |
| **Kenya** | 37 | 53 | 67 | 58 | 92 | 110 | 644 | 580 | 612 |
| **Malawi** | 6 | 9 | 31 | 13 | 18 | 47 | 439 | 460 | 662 |
| **Mozambique** | 5 | 11 | 49 | 20 | 33 | 108 | 250 | 301 | 457 |
| **Rwanda** | 2 | 1 | 8 | 3 | 2 | 6 | 642 | 625 | 1,513 |
| **Tanzania** | 33 | 224 | 321 | 293 | 294 | 320 | 1,325 | 760 | 987 |
| **Uganda** | 475 | 607 | 268 | 324 | 395 | 171 | 1,471 | 1,537 | 1,566 |
| **Zambia** | 135 | 370 | 39 | 205 | 55 | 40 | 673 | 665 | 992 |
| **Zimbabwe** | 112 | 815 | 517 | 265 | 246 | 239 | 421 | 313 | 217 |

Source: FAOSTAT
NA = Not Available

**Table 4.2. Annual compound growth rates (%) of millet area, yield, production, 1980-2012.**

| Country/ region | Production | | | Area harvested | | | Yield | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1981-2012 | 1981-1999 | 2000-2012 | 1981-2012 | 1981-1999 | 2000-2012 | 1981-2012 | 1981-1999 | 2010-2012 |
| **World** | 0.37 | 0.07 | 0.73 | -0.53 | -0.19 | -1.30 | 0.90 | 0.27 | 2.06 |
| **Africa** | 2.21 | 2.98 | 1.93 | 1.92 | 3.36 | 0.16 | 0.29 | -0.37 | 1.76 |
| **Eastern Africa** | 0.70 | 0.75 | -2.69 | 1.35 | 2.51 | -0.46 | -0.63 | -1.72 | -2.24 |
| **Southern Africa** | 0.67 | 1.13 | 1.16 | 0.14 | 0.58 | 0.02 | 0.53 | 0.55 | 1.14 |
| **Western Africa** | 2.49 | 3.44 | 1.92 | 2.27 | 3.59 | 0.57 | 0.22 | -0.14 | 1.34 |
| ***Southern Africa*** | | | | | | | | | |
| **Botswana** | 0.20 | -4.25 | 12.79 | -2.34 | -5.21 | 9.74 | 2.60 | 1.01 | 2.78 |
| **Namibia** | 1.53 | 1.71 | -2.62 | 1.82 | 3.23 | -0.39 | -0.29 | -1.47 | -2.24 |
| **South Africa** | -2.66 | -1.71 | -4.98 | -1.56 | -0.53 | -3.61 | -1.12 | -1.19 | -1.42 |
| **Swaziland** | 0.00 | -0.47 | 2.00 | 0.00 | -1.11 | 2.37 | 0.00 | 0.65 | -0.37 |
| ***Eastern Africa*** | NA | NA | 8.82 | NA | NA | -0.27 | NA | NA | 9.12 |
| **Burundi** | 0.00 | -0.47 | 2.00 | 0.00 | -1.11 | 2.37 | 0.00 | 0.65 | -0.37 |
| **Eritrea** | NA | NA | 8.82 | NA | NA | -0.27 | NA | NA | 9.12 |
| **Ethiopia** | NA | NA | 7.26 | NA | NA | 1.50 | NA | NA | 5.68 |
| **Kenya** | 1.15 | 0.67 | 4.41 | 1.27 | 0.66 | 2.02 | -0.12 | 0.01 | 2.35 |
| **Malawi** | 5.81 | 6.98 | 4.88 | 4.37 | 5.90 | 2.33 | 1.38 | 1.02 | 2.49 |
| **Mozambique** | 7.50 | 12.25 | 3.34 | 5.33 | 7.62 | 5.26 | 2.06 | 4.30 | -1.83 |
| **Rwanda** | 4.82 | 3.67 | 6.99 | 1.32 | 1.86 | 0.64 | 3.45 | 1.78 | 6.31 |
| **Sudan** | -0.96 | -0.11 | -2.24 | 0.19 | 3.78 | -3.85 | -1.14 | -3.75 | 1.68 |
| **Uganda** | -2.16 | 1.30 | -6.32 | -1.72 | 1.26 | -6.34 | -0.44 | 0.04 | 0.02 |
| **Tanzania** | -0.87 | -2.01 | -0.20 | -1.75 | -4.52 | 0.28 | 0.90 | 2.63 | -0.48 |
| **Zambia** | 2.09 | 8.90 | -4.08 | 1.24 | 9.08 | -6.47 | 0.84 | -0.16 | 2.56 |
| **Zimbabwe** | -3.61 | -5.17 | 0.21 | -0.48 | -2.53 | 3.79 | -3.15 | -2.70 | -3.45 |

Source: FAOSTAT
NA = Not Available

### Production

Within ESA, millets are concentrated in eastern Africa, where annual production averages 1 million t. Four ESA countries – Ethiopia, Zimbabwe, Uganda and Tanzania, in that order – account for the bulk of production. Ethiopia is the largest single producer in the region, with an average of 676,000 t and 424,000 ha planted in 2010-12. Within eastern Africa, there have been important shifts in the location of millet production. Millet production in Ethiopia grew by 7.26% a year between 1991-93 and 2010-12, from 135,000 to 676,000 t, overtaking Uganda as the region's biggest millet producer. By contrast, the production of millets in Uganda was halved. Production also fell in Zimbabwe, from 815,000 t in 1991-93 to 517,000 t in 2010-12.

### Yield

While worldwide the yield of millets rose by 15%, in Africa average yields fell by 9%, from 714 kg/ha in 1981-83 to 652 kg/ha in 2010-12. Average yields in Africa grew by just 0.29% per year. However, between 2000 and 2012 yield growth in Africa picked up to reach 1.76% per year. For ESA, the trend in millet yields was positive, increasing by 57% from 579 kg/ha in 1991-93 to 828 kg/ha in 2010-12. Only in Zimbabwe did average yields decline. Ethiopia showed the strongest growth in yields (125%), rising from 768 to 1,594 kg/ha over the period.

Millet yields in eastern Africa were the highest in the continent, averaging 1,001 kg/ha in 2010-12, compared to just 652 kg/ha in western Africa and a mere 217 kg/ha in southern Africa. Higher millet yields in eastern Africa may reflect the status of finger millet as a cash crop, whereas in western and southern Africa, millets are grown primarily for home consumption. Within eastern Africa itself, average yields ranged widely, from 1,594 kg/ha in Ethiopia to just 217 kg/ha in Zimbabwe, where millets are grown in semi-arid areas as an insurance against drought. For the region as a whole, the average yield was 828 kg/ha. In 2010-12 only Ethiopia and Uganda had yields above 1 t/ha i while three countries – Mozambique, Eritrea and Zimbabwe – had average yields of below 0.5 t/ha... Since few farmers use improved crop management for millets, yield variations reflect differences in agro-ecological conditions.

## 4.3. Variability in production and area planted

Since millets can be kept for up to 10 years without significant storage losses, farmers may not plant millets every year but only in the years following a poor maize harvest when all their millet has been consumed and they need to replenish their stores. In Zimbabwe, the area planted to millet shrinks after a bumper harvest of maize but expands after a poor harvest (Muchinerepi 2014; Hedden-Dunkhorst 1993). Although millets are a minor cereal crop, nevertheless they may be critical for household food security.

We explored the relationship between millet and maize using time series data for Zimbabwe and Kenya (Figure 4.2). For Zimbabwe, Panel 1 charts the trend in area planted to millets against the production of maize in the previous year. Although millet is grown primarily in the semi-arid region (Natural Region IV) figures for maize production were not available by region and maize production is at national level. Over the 41 years between 1970 and 2011, there were 19 years when farmers increased the area planted to millet. In nine of these years (47%), the previous year had seen a fall in maize production, while in ten of these years (53%) the previous year had seen a rise in maize production. In strict numerical terms, therefore, the relationship does not hold. However, the period 1975-79 did see a series of drops in maize production and an increase in the area planted to millets. By the 1990s, however, the two series are moving in parallel rather than in opposite directions.

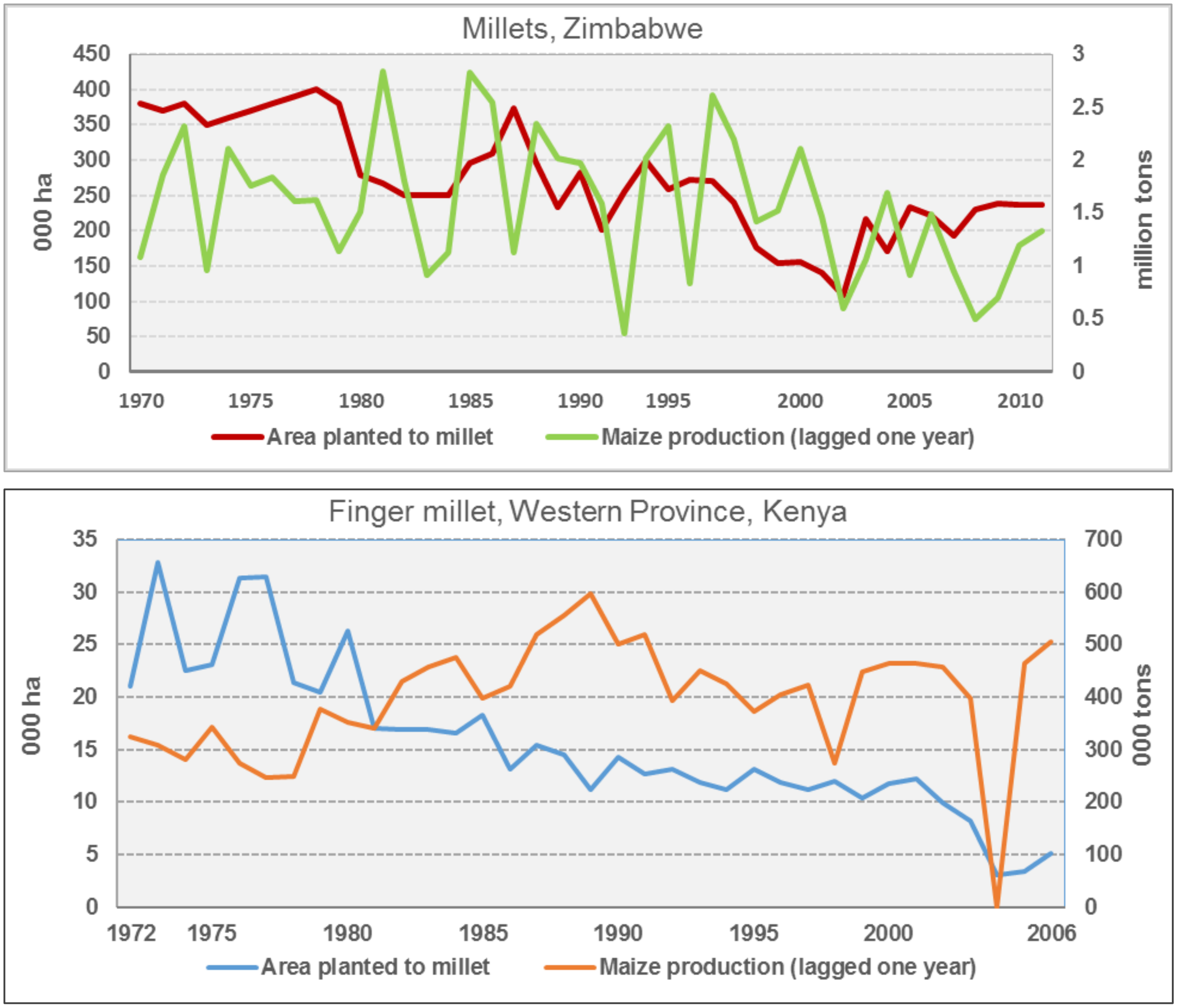



*Figure 4.2. Changes in the area planted to millets in Zimbabwe and Kenya, 1970-2010.*

Source: African Development Indicators (Zimbabwe), Ministry of Agriculture, Kenya, 2007

For Kenya, Panel 2 in Figure 4.2 charts the trend in maize production in Western Province, Kenya, between 1971 and 2006 against the area planted to finger millet in three counties in Western Province (Bungoma, Busia and Kakamega). Over the 36 years, there were 15 years when the area planted to millet increased. In nine years, the previous year saw a drop in maize production, while in six years, the previous year had seen maize production rise. However, the period 1975-1979 did see a drop in maize production accompanied by a rise in the area planted to millets. From the 1990s, however, the area planted to millet and maize production seems to move in parallel rather than in opposite directions.

## 4.4. Utilization

Millets are used almost exclusively for food and for food processing to make local beer. Although South Asia has seen growing demand for pearl millet as poultry feed, the higher price of millet relative to maize has so far prevented the development of this value chain in ESA.

**Table 4.3. Trends in millets utilization, by region and country, 1981-2012 ('000 t)[4].**

| | 1980-82 | | | | | 2009-2011 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Country/ region | Available supply (for domestic utilization[a] | Food[b] | Feed | Food pro-cessing[c] | Other uses[d] | Available supply (for domestic utilization[a] | Food[b] | Feed | Food pro-cessing[c] | Other uses[d] |
| **World** | 25,876 | 20,462 | 2,560 | 305 | 37 | 30,516 | 22,717 | 3,868 | 388 | 358 |
| **Africa** | 7,436 | 5380 | 724 | 305 | 37 | 15,632 | 11,103 | 1,739 | 388 | 358 |
| **Eastern Africa** | 1,220 | 780 | 59 | 267 | 0 | 1,467 | 985 | 44 | 309 | 0 |
| **Southern Africa** | 52 | 36 | 10 | 0 | 0 | 71 | 55 | 8 | 0 | 0 |
| **Western Africa** | 5,444 | 3930 | 651 | 30 | 37 | 12,728 | 8,897 | 1,647 | 69 | 358 |
| ***Southern Africa*** | | | | | | | | | | |
| **Botswana** | 2 | 1 | 0 | 0 | 0 | 3 | 2 | 0 | 0 | 0 |
| **Namibia** | 35 | 31 | 0 | 0 | 0 | 55 | 48 | 0 | 0 | 0 |
| **South Africa** | 15 | 4 | 10 | 0 | 0 | 13 | 5 | 8 | 0 | 0 |
| **Swaziland** | | | | | | 0 | | 0 | | |
| ***Eastern Africa*** | | | | | | | | | | |
| **Ethiopia** | 0 | 0 | 0 | 0 | 0 | 604 | 480 | 0 | 85 | 0 |
| **Kenya** | 57 | 34 | 5 | 12 | 0 | 71 | 41 | 6 | 14 | 0 |
| **Malawi** | 8 | 7 | 0 | 0 | 0 | 28 | 26 | 1 | 0 | 0 |
| **Mozambique** | 5 | 4 | 0 | 0 | 0 | 45 | 40 | 0 | 0 | 0 |
| **Rwanda** | 2 | 2 | 0 | 0 | 0 | 8 | 7 | 0 | 0 | 0 |
| **Sudan (former)** | 383 | 348 | 0 | 0 | 0 | 675 | 600 | 17 | 0 | 0 |
| **Tanzania** | 336 | 146 | 7 | 146 | 0 | 349 | 151 | 7 | 151 | 0 |
| **Uganda** | 452 | 311 | 46 | 55 | 0 | 269 | 186 | 27 | 33 | 0 |
| **Zambia** | 16 | 6 | 1 | 7 | 0 | 46 | 17 | 3 | 21 | 0 |
| **Zimbabwe** | 138 | 108 | 0 | 19 | 0 | 49 | 36 | 0 | 6 | 0 |

Source: FAOSTAT commodity balances

[a] ***'Available supply for domestic utilization'*** is defined as production + imports + changes in stocks (decrease or increase) – exports

[b] ***'Food'*** is defined as available supply for domestic utilization – feed – seed – waste – food processing and – other uses.

[c] ***'Food Processing'***. 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 FAO food balance sheet either in the same or in another food group (eg, 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, eg, oil for soap, are shown under 'Other Uses'.

[d] Category ***'Other Uses'*** represents the amounts of the commodity in question used during the reference period for the manufacture for *non-food purposes* (eg, oil for soap). Also statistical discrepancies are included here. They are defined as an inequality between supply and utilization statistics.

[4]Available supply also contains seed use which is not included in Table 4.3

In Kenya, Tanzania and Uganda, finger millet is widely recognized by consumers as a nutritious cereal, particularly for infants, the sick and the elderly. This has led to growing demand from urban, middle-class consumers. In northern Ethiopia and western Kenya, finger millet remains an important staple cereal, while in southern Africa, farmers in semi-arid areas plant millet alongside maize to insure against crop loss from drought.

Worldwide, three quarters of the total available supply of millet in 2009-2011 was consumed as food, with only 25% going to other uses (Table 4.3). Over time, there was a small decline in the share of millet used as food, from 79% in 1980-82 to 75% in 2009-11, and a small increase in the share of millets used as livestock feed, from 10% in 1980-82 to 13% in 2009-11. Utilization in Africa followed a similar pattern, with the bulk of millets consumed as food (71% in 2009-11). The share of millets used for feed and food processing in Africa remains small.

In ESA, while in 2009-11 1.5 million tons (68%) was used as food, a relatively high share of millets (0.3 million tons, or 20%) was used for food processing. This reflects the traditional use of millet to produce local beer. Within ESA, food processing is concentrated in Tanzania (0.2 million tons in 2009-11, or 43% of the available supply). In Sudan, the biggest regional producer, no millet was used for alcohol processing since the majority of the population is Muslim. Similarly, in Ethiopia, the second biggest regional producer, only 14% of available supply was used for this type of processing. In ESA as a whole, only 3% of total supply was used as feed in 2009-11.

## 4.5. International trade

International trade in millets is thin. In 2003-05 world exports averaged 357,000 t, which was only 1% of world millet production (Table 4.4). However, this represents an increase of 64% over the period 1980-82, when world exports averaged only 218,000 t. Africa accounts for a very small share of world exports (<2% in 2009-2011) but for one-quarter of imports. For most countries in the region, the volume of recorded trade is too small to appear. One exception is Kenya, where imports averaged 11,000 t in 2009-2011. Kenya's large processing industry relies on imports to meet market demand for finger millet flour which is used as a weaning food for infants (Schipmann-Schwarze et al. 2014).

**Table 4.4. Trends in millets trade by region and country, 1981-2012 ('000 t).**

| | Exports | | | | Imports | | | |
|---|---|---|---|---|---|---|---|---|
| **Country/ region** | **1980-1982** | **1990-1992** | **2000-2002** | **2009-2011** | **1980-1982** | **1990-1992** | **2000-2002** | **2009-2011** |
| World | 218 | 207 | 256 | 357 | 264 | 259 | 273 | 412 |
| Africa | 36 | 30 | 44 | 6 | 66 | 15 | 58 | 109 |
| Southern Africa | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| Western Africa | 3 | 11 | 4 | 6 | 1 | 1 | 1 | 13 |
| Eastern Africa | 29 | 19 | 39 | 1 | 62 | 13 | 54 | 21 |
| ***Southern Africa*** | | | | | | | | |
| Botswana | 0 | 0 | 0 | 0 | 0 | 3 | 66 | 0 |
| Lesotho | - | - | - | - | - | - | - | - |
| Namibia | 0 | 0 | 0 | | 0 | 0 | 0 | 2 |
| South Africa | 1 | 0 | 0 | 0 | 1 | 1 | 2 | 6 |
| Swaziland | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Eastern Africa*** | | | | | | | | |
| Burundi | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Eritrea | NA | NA | 0 | 0 | NA | NA | 0 | 0 |
| Ethiopia | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 |
| Kenya | 0 | 10 | 0 | 0 | 0 | 0 | 1 | 11 |
| Malawi | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mozambique | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 |
| Rwanda | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Somalia | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| Sudan | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Uganda | 2 | 0 | 0 | 5 | 1 | 0 | 0 | 0 |
| Tanzania | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Zambia | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Zimbabwe | 0 | 4 | 3 | 0 | 0 | 17 | 1 | 10 |

Source: FAOSTAT
NA = Not Available

## 4.6. Prices

World prices for millets ranged from (USD) $200 to $400 per t between 1991 and 2010 (Figure 4.3). This is double the world price for sorghum (Figure 3.7). World prices were lower than national prices in Ethiopia, the largest regional producer, and much lower than in Kenya, where prices were the highest in the region. The price spike for food grains in 2007 and 2008 also affected millets with the world price for millet peaking at $362 per t in 2009. In Kenya, millet reached $768 per t in 2009. In 2010 millet prices in Ethiopia and Kenya were still well above the levels of the 1990s.

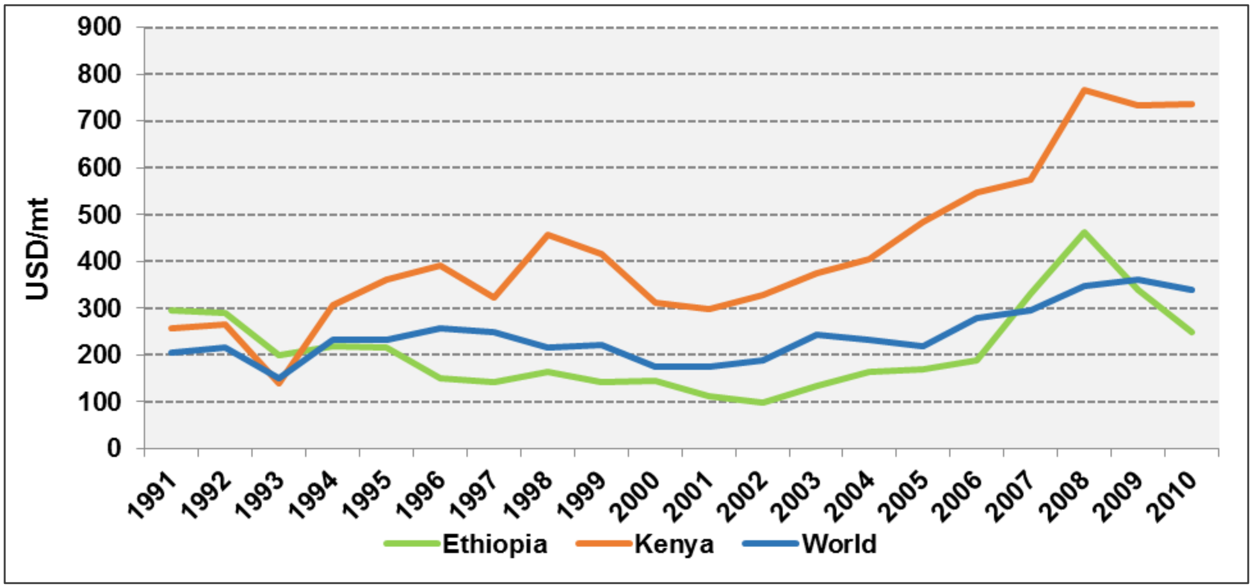



*Figure 4.3. Millet wholesale prices 1980-2010 ($/t).*

Source: FAOSTAT

Figure 4.4 shows the price ratios for millets and maize for three ESA countries. Only in Zimbabwe does millet fit the stereotype as an inferior crop. Starting in the 1990s, the ratio falls below 1, and never exceeds 1 in the subsequent decade. In Ethiopia, the price ratio for millet/maize remained around 1 for the entire period, suggesting that consumer preference for millet stayed strong and that, unlike Zimbabwe, millet was not regarded as inferior to maize. Finally, the price ratio of millet/maize in Kenya shows a strong upward trend. Until the mid-1980s, the ratio was below 1, but this changed in the late 1980s and since 2001 the ratio has been above 2 and rose to over 3 in 2010. In Kenya, therefore, millet is better described as a ‘rich man’s crop’ that is now twice the price of maize, the staple cereal. The high price of millet in Kenya reflects low supply, with millet cultivation largely confined to western Kenya, which forces processors to meet demand with imports from Uganda and Tanzania, and high demand based on millet’s reputation as a nutritious cereal and weaning food among urban, middle class consumers.

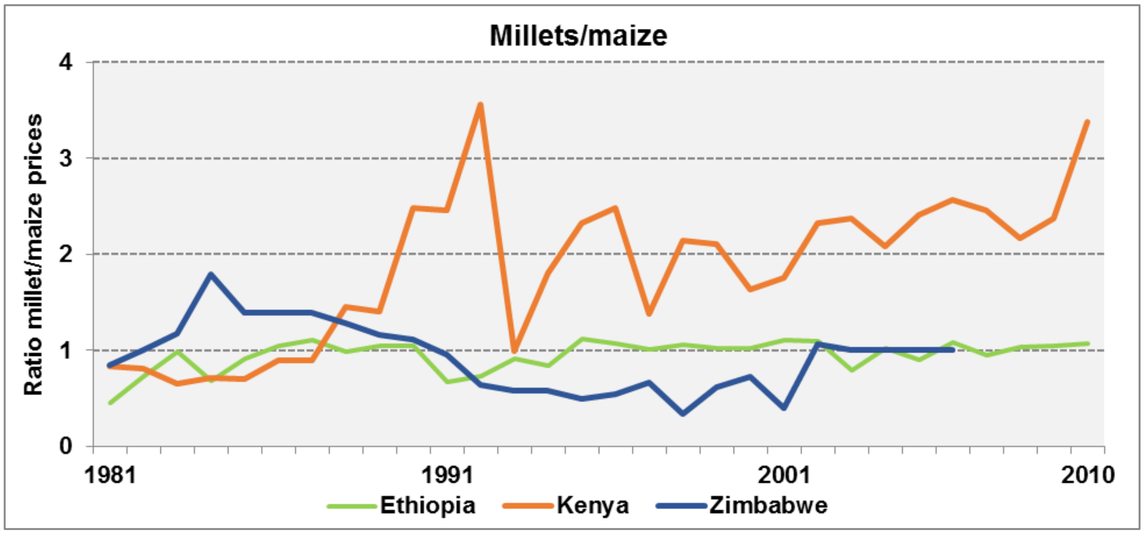



*Figure 4.4. Price ratios for millets/maize in ESA, 1980-2010.*

Source: World Bank (2015), African Development Indicators

## 5. Markets, Institutions and Policies

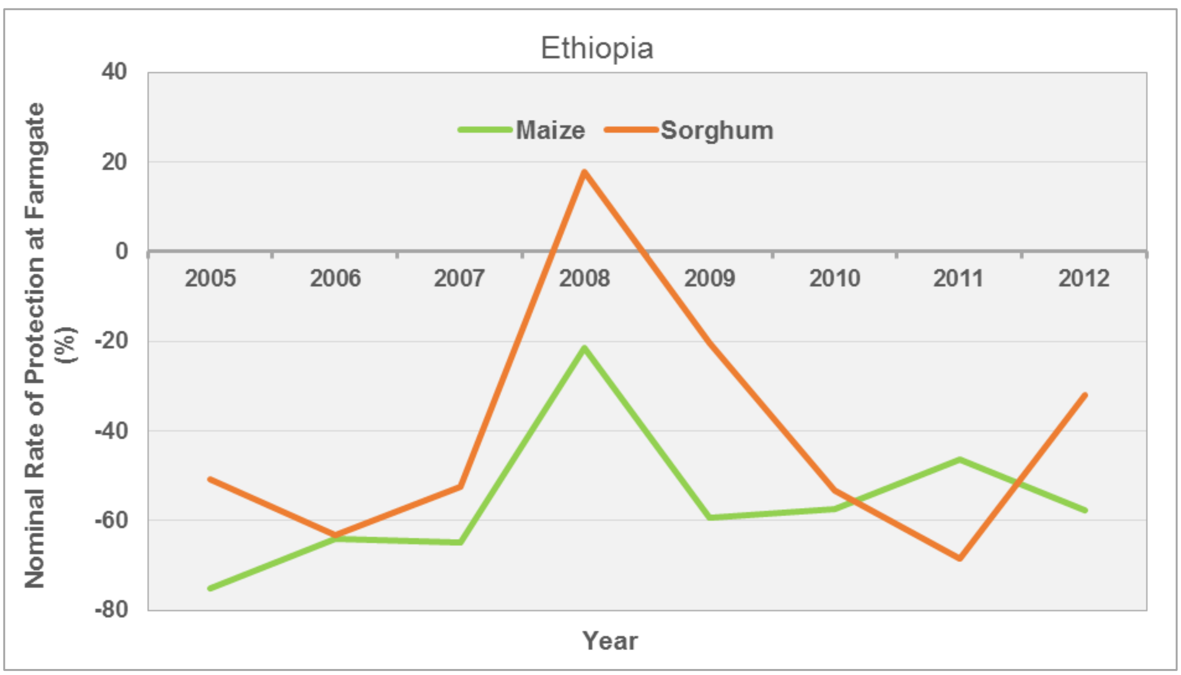
Since 2000, five countries in eastern Africa (Burundi, Kenya, Rwanda, Tanzania and Uganda) have been members of the East Africa Community (EAC). From 2005, the EAC has operated a customs union. Tariffs are charged on imports from non-EAC countries (Booth et al 2007). In 2008, the EAC customs union was extended to include the members of the Southern Africa Development Community (SADC), which includes South Africa, Malawi and Mozambique, and to include members of the Common Market for Eastern and Southern Africa (COMESA), which includes Ethiopia, Zimbabwe, Sudan and Zambia. In theory, therefore, all ESA countries are members of the same free trade area. In practice, most have their own policies for staple food grains that include tariffs, export bans and price support. Trade between the three blocs is also subject to tariffs. In Kenya, imports of sorghum from SADC countries and the rest of the world are normally subject to a tariff of 25% (Kilambya and Witwer 2013).

All ESA countries impose import duties on food commodities in order to protect local producers. High world food prices between 2008 and 2009 saw the suspension or reduction of import tariffs for food products, subsidized food prices in Ethiopia (2008 and 2009), Kenya (2008) and Tanzania (2009) (Angelucci et al. 2014). In response to high inflation and food shortages, in 2011 Ethiopia banned the export of food. In March 2011, Tanzania followed suit. In retaliation, Kenya banned the export of seed (including maize) to other EAC member states. Uganda continued to allow food exports. In October 2011, Tanzania lifted its ban on food exports (SID 2012).

One result of these policies is a gap between the world market price and the price received by farmers. The size of this gap is given by the Nominal Rate of Protection (NRP), which compares domestic market prices to reference prices free from domestic policy interventions. Reference prices are calculated from a benchmark price, such as an import or export price expressed in local currency, that is converted to a wholesale or farmgate price by adjusting for quality, wastage and the cost of market access. The NRP is expressed as a ratio, and represents the price gap between the domestic market price and the reference price divided by the reference price. A positive NRP indicates that farmers enjoy a price advantage over imports or exports, while a negative NRP indicates that farmers face a price disadvantage.

Figure 5.1 shows the NRP at the farmgate for sorghum and maize for Ethiopia between 2005-12 and for Kenya between 2005-13. In Ethiopia, the NRP for both sorghum and maize was negative, except for the year 2008, when there was a spike in world food prices. Farmers in Ethiopia therefore faced a price disincentive for maize and sorghum, since local prices were below border prices. This reflects government policies to maintain low food prices for consumers, encouraging imports and subsidizing sales of wheat, which led to low producer prices (Angelucci et al. 2014).

In Kenya, by contrast, the NRP for sorghum and maize was either positive or close to zero in most years, except in 2008. Kenyan farmers therefore had a price incentive, since local prices were above border prices. This reflects government policies to support maize farmers, including the procurement of maize by the National Cereals and Produce Board (NCPB), and strong demand for sorghum from breweries to produce sorghum beer. Kenya is a net importer of both maize and sorghum, which is imported duty-free from countries within the EAC and COMESA regions. However, imports have not been sufficient to reduce prices for consumers, except in 2008 when a regional drought and high world food prices led to imports from the USA and Europe. The 25% tariff on imports may have been waived in response to severe drought (Kilambya and Witwer 2013).



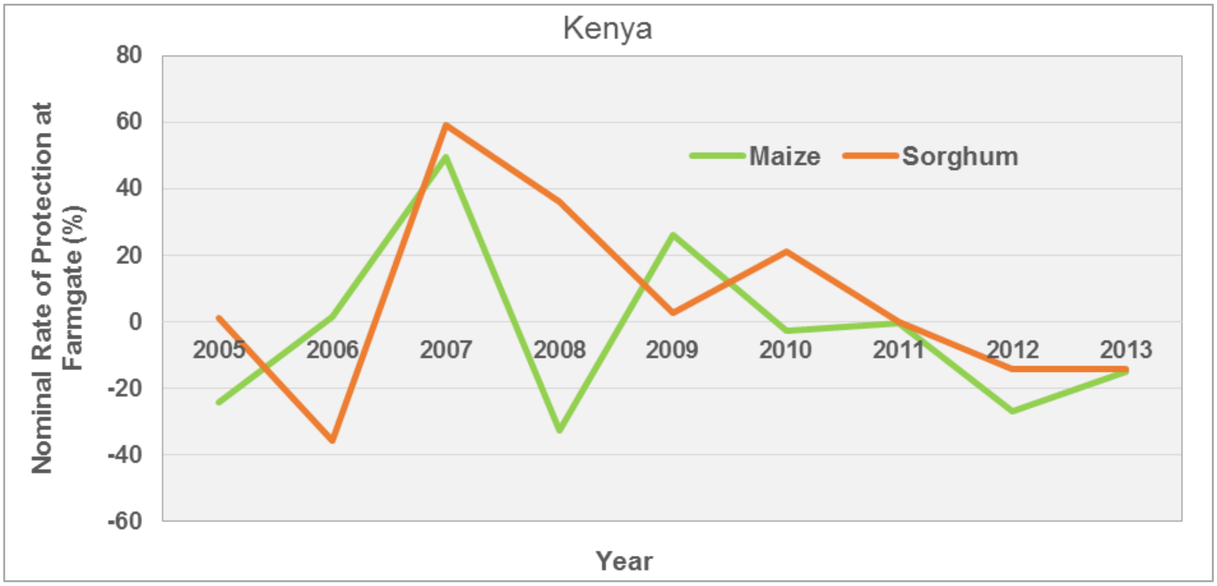



*Figure 5.1. Nominal Rates of Protection at the farmgate for sorghum and maize in Ethiopia and Kenya, 2005-2013.*

Source: MASAP database, http://www.fao.org/in-action/mafap/database/en/

# 6. Outlook for Sorghum and Millets

This section examines possible future scenarios for sorghum and millets in ESA. The projections discussed here are not predictions, but projections based on economic modeling. They provide orders of magnitude that can help evaluate the likely impact of different scenarios on the production of dryland cereals in ESA.

## 6.1. Outlook projections

The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) model was used to assess the long-term future of agricultural commodities supply, demand and prices in ESA. IMPACT is a multi-commodity, multi-country partial equilibrium agricultural model which simulates 62 agricultural commodity markets which are representative of the bulk of food (cereals[5], pulses[6], roots and tubers, meats, milk, eggs etc.) and cash crops and livestock whose production is spread across 320 Food Production Units (FPUs) in 159 countries (Robinson et al.2015).

In the model, supply is determined by crop area, prices and the rate of productivity growth ('intrinsic productivity growth rates', or IPRs). These crop- and country-specific IPRs summarize the improvements that can be achieved in agricultural productivity from advances in management practices, crop improvement and agricultural extension. Supply, demand and price relationships for each commodity are based on elasticities derived from country-level studies. For countries for which these elasticities are

[5] Cereals include rice, wheat, maize, sorghum, millets and barley.

[6] Pulse crops include bean, chickpea, cowpea, lentil, pigeonpea and other pulses.

not available, approximations are used. The model simulates the operation of national and international markets, solving for production, demand and prices that equate supply and demand across the globe. The effect of trade policies has also been included in the model to reflect the price differential between country and world prices. For each country, the difference between supply and demand is resolved by trade, with countries being either net importers or exporters.

The economic model is linked to a number of “modules” that include climate models (general circulation models, or GCMs), water models (hydrology, water basin management and water stress models), crop simulation models (for example, Decision Support System for Agrotechnology Transfer [DSSAT], value chain models (for example, sugar, oils, livestock), land use (pixel-level land use, cropping patterns by regions), nutrition and health models and welfare analysis. The IMPACT model system integrates information flows among the component modules in a consistent equilibrium framework that supports longer-term scenario analysis.

The two general circulation models(GCM) used in the analysis of this report are GFDL-ESM2M (Dunne et al. 2012) and MIROC-ESM-CHEM (Watanabe et al. 2011). We selected these two climate scenarios for this study because they appeared, on average across the globe, to be the driest and wettest, and therefore would provide two extreme climates to compare the impacts of climate change on sorghum and millets production in ESA. The economic scenarios used in the IMPACT model are based on Shared Socioeconomic Pathways (SSPs) (O’Neill et al. 2014). In this study we used the SSP2[7] scenario, which is a middle-of-the-road scenario that follows historical trends.

Four scenarios for ESA were developed and analyzed in this study. They are:

1. The “baseline” scenario, where assumptions about income and population growth are both set to medium level and with no climate change.
2. The “optimistic” scenario, where assumptions about population growth are set to low levels and income growth is set to high levels, and with no climate change.
3. The “increased yield scenario”, where the productivity growth rates of sorghum, millets and maize were increased by 25% compared to the baseline level.
4. The “climate change scenario”, where the impact of two GCMs (GFDL-ESM2M and the MIROC-ESM-CHEM) on the production of sorghum and millets were compared with baseline scenario without climate change impacts.

Figure 6.1 shows the IMPACT model projections for sorghum and millet production in ESA for 2013-2050, together with production for the period 1960-2012, as given by the FAO statistics. We can distinguish three distinct sub-periods. Between 1960 and 2000, production of sorghum and millets was roughly constant at between 2 and 4 million t per year. Between 2001 and 2012, production rose from 4 to 6 million t per year. Thereafter, the IMPACT baseline model projects a steady rise in production until 2050. This projection suggests the need for caution in interpreting the IMPACT model projections. The base-period for the model (2003-05) was one of rising production that followed a period of 40 years without any significant increase. The period 2001-2012 represents a break with this historical trend. The IMPACT model projects this break forward to 2050, which results in a large increase in production (over 250%) over the base period. This assumes that the break that occurred in 2000-2012 was decisive and a genuine turning point in the trend of stagnant production before 2000.

[7] Economic development continues but is not uniform. Environmental degradation continues but at a slowing pace. There is general improvement, but it is much slower than seen in SSP 1. Climate change presents moderate challenges to both adaptation and mitigation.

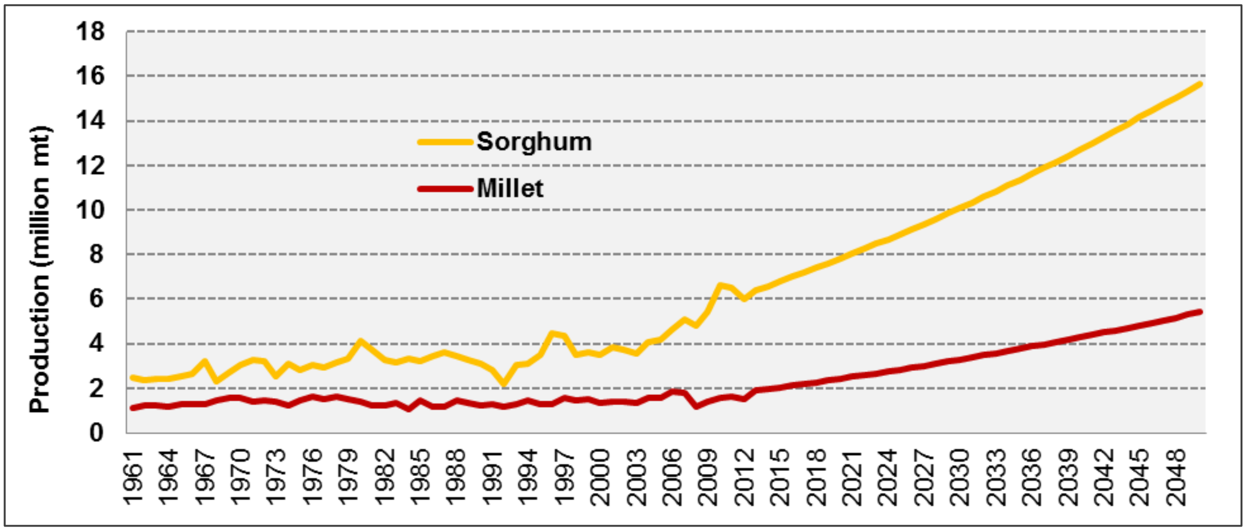



*Figure 6.1. Past and projected trends in production of sorghum and millets, ESA, 1961-2050.*

## 6.2. Baseline projections ("business-as-usual")

### Production, demand and trade

Baseline projections are made given the current level of technology, and assuming medium rates of population and income growth. The scenario they describe may be called "business-as-usual". Table 6.1 presents baseline projections of production, demand and trade for sorghum for the period 2015-2050. Assuming no change in the current growth rates of yields, population and income per head, the worldwide production of sorghum is projected to increase by 83% from 72 million t in 2015 to 131 million t by 2050. Trends in WCA and ESA are similar. In WCA, the trajectory is comparable with global trends and production increases by 105%. In ESA, the increase is greater (171%), reflecting a lower base. Production is ESA is projected to increase from 7 to 19 million t. The projections show an increasing trajectory for all countries in the region. The major producers include Ethiopia, Tanzania and Uganda. Tanzania is projected to have the highest increase in production (over 376%). The projections also suggest major increases in Sudan (106%) and Ethiopia (138%).

In WCA, demand will exceed supply, and the region will shift from being a net exporter in 2005 to a net importer by 2050. By contrast, in ESA supply will exceed demand and the region will change from a net importer to being a net exporter of sorghum. ESA will therefore have a trade surplus in sorghum with exports to countries outside the region reaching 2.6 million t by 2050. The main exporters will be the biggest producers – Ethiopia and Tanzania. Sudan will also have a significant trade surplus. Trade within the region is also expected to increase, with smaller producers becoming net importers. By 2050 the volume of exports in ESA will reach 20% of total sorghum production.

In sum, these projections suggest that ESA will experience strong growth in the demand for sorghum over the medium to long term. Four countries – Sudan, Ethiopia, Tanzania and Uganda – will be the main source of demand. ESA has the potential to become a net exporter of sorghum, with the four largest producers showing a net surplus. Most trade will be with countries outside the region.

**Table 6.1. Baseline projections for sorghum, ESA, 2015-2050.**

| | Production ('000 tons) | | | Demand ('000 tons) | | | Net Trade ('000 tons) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2025 | 2050 | 2015 | 2025 | 2050 | 2015 | 2025 | 2050 |
| **World** | 71,839 | 86,597 | 131,943 | 69,982 | 84,740 | 130,086 | 1,857 | 1,857 | 1,857 |
| **Asia** | 11,473 | 12,023 | 12,406 | 13,300 | 14,796 | 17,959 | -1,827 | -2,773 | -5,553 |
| **WCA** | 19,226 | 24,235 | 39,407 | 18,679 | 24,963 | 47,376 | 547 | -728 | -7,969 |
| **ESA** | 6,590 | 9,251 | 19,462 | 6,844 | 9,148 | 16,883 | -253 | 103 | 2,579 |
| **Botswana** | 41 | 60 | 125 | 65 | 76 | 91 | -25 | -16 | 35 |
| **Burundi** | 99 | 114 | 142 | 110 | 184 | 650 | -11 | -70 | -508 |
| **Eritrea** | 197 | 274 | 636 | 282 | 361 | 599 | -86 | -87 | 37 |
| **Ethiopia** | 3,135 | 4,142 | 7,466 | 3,001 | 3,780 | 5,677 | 134 | 362 | 1,790 |
| **Kenya** | 182 | 264 | 607 | 195 | 294 | 652 | -13 | -30 | -45 |
| **Lesotho** | 28 | 40 | 81 | 42 | 48 | 60 | -14 | -8 | 21 |
| **Madagascar** | 1 | 2 | 2 | 1 | 2 | 4 | 0 | 0 | -2 |
| **Malawi** | 51 | 73 | 183 | 71 | 97 | 192 | -21 | -23 | -9 |
| **Mozambique** | 201 | 298 | 669 | 269 | 350 | 496 | -69 | -52 | 173 |
| **Namibia** | 11 | 15 | 27 | 9 | 12 | 25 | 2 | 2 | 2 |
| **Rwanda** | 297 | 408 | 746 | 320 | 515 | 994 | -24 | -107 | -248 |
| **Somalia** | 185 | 282 | 620 | 167 | 214 | 314 | 18 | 68 | 306 |
| **South Africa** | 276 | 358 | 565 | 408 | 500 | 735 | -132 | -142 | -170 |
| **Sudan** | 5,378 | 7,038 | 11,059 | 5,334 | 6,703 | 9,744 | 44 | 334 | 1,315 |
| **Tanzania** | 1,125 | 1,843 | 5,353 | 926 | 1,221 | 2,177 | 199 | 622 | 3,176 |
| **Uganda** | 625 | 895 | 1,881 | 784 | 1,235 | 3,563 | -159 | -341 | -1,682 |
| **Zambia** | 29 | 40 | 84 | 54 | 96 | 352 | -26 | -55 | -268 |
| **Zimbabwe** | 109 | 143 | 274 | 136 | 161 | 299 | -26 | -18 | -24 |

Source: IMPACT model; For the definition of the ESA region, see Appendix 1.

Table 6.2 presents projections of production, demand and trade for millets for the period 2015-2050. Assuming no change in the current rates of yields, population and income per head, worldwide production of millets is projected to increase by 83% from 37 million t in 2015 to reach 68 million t by 2050. Both WCA and ESA show an upward trend in production. In ESA, the upward trend in production is higher, at 209%. Production in ESA is projected to grow strongly from 2.2 million t in 2015 to reach 7 million t by 2050. All countries in the region will have an increasing trajectory in production. Uganda, Tanzania, Ethiopia and Sudan are currently the largest producers of millet in the region. The projections suggest major increases in production in Uganda (151%), Ethiopia (206%) and Sudan (113%). Uganda will be the biggest producer (2.2 million t), followed by Sudan and Ethiopia (each with 1.9 million t). Though a small producer, Zimbabwe is projected to double the production of millets. Over time, the trade surplus for millets in ESA is projected to increase significantly, from just 46,000 t in 2015 to 1.8 million t in 2050, largely due to trade surpluses in Ethiopia and Tanzania. By 2050 net exports from ESA will account for 26% of total millets production. In sum, these projections suggest that ESA will experience a strong growth in demand for millets over the medium to long term. Three countries – Sudan, Uganda and Ethiopia – will be the main source of demand within the region.

**Table 6.2. Baseline projections for millets, ESA, 2015-2050.**

| | Production ('000 tons) | | | Demand ('000 tons) | | | Net Trade ('000 tons) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2025 | 2050 | 2015 | 2025 | 2050 | 2015 | 2025 | 2050 |
| **World** | 37,448 | 4,5220 | 68,023 | 36,814 | 44,586 | 67,389 | 634 | 634 | 634 |
| **Asia** | 14,588 | 15,204 | 15,575 | 14,721 | 16,255 | 19,071 | -134 | -1,051 | -3,497 |
| **WCA** | 17,989 | 23,443 | 40,369 | 17,294 | 22,525 | 39,700 | 695 | 918 | 669 |
| **ESA** | 2,278 | 3,303 | 7,046 | 2,233 | 2,941 | 5,232 | 46 | 362 | 1,814 |
| **Botswana** | 1 | 1 | 3 | 0 | 1 | 1 | 0 | 0 | 2 |
| **Burundi** | 12 | 16 | 24 | 14 | 23 | 72 | -2 | -7 | -49 |
| **Eritrea** | 45 | 62 | 122 | 35 | 46 | 109 | 9 | 16 | 13 |
| **Ethiopia** | 617 | 898 | 1,888 | 589 | 745 | 1,039 | 28 | 153 | 849 |
| **Kenya** | 87 | 134 | 327 | 90 | 132 | 273 | -3 | 2 | 54 |
| **Malawi** | 25 | 38 | 102 | 32 | 42 | 78 | -7 | -4 | 24 |
| **Mozambique** | 22 | 30 | 52 | 28 | 37 | 55 | -6 | -7 | -3 |
| **Namibia** | 98 | 147 | 336 | 86 | 104 | 144 | 12 | 42 | 192 |
| **Rwanda** | 5 | 7 | 14 | 7 | 11 | 20 | -2 | -3 | -6 |
| **South Africa** | 12 | 17 | 38 | 17 | 19 | 24 | -5 | -2 | 14 |
| **Sudan** | 899 | 1,214 | 1,915 | 1,199 | 1,504 | 2,048 | -300 | -290 | -133 |
| **Tanzania** | 306 | 493 | 1,308 | 304 | 399 | 685 | 2 | 94 | 623 |
| **Uganda** | 900 | 1,238 | 2261 | 908 | 1,206 | 2,268 | -8 | 32 | -7 |
| **Zambia** | 53 | 77 | 170 | 64 | 109 | 374 | -11 | -32 | -204, |
| **Zimbabwe** | 95 | 144 | 401 | 57 | 65 | 90 | 37 | 79 | 311 |

Source: IMPACT model

## Per capita demand

Although aggregate demand in ESA is projected to increase by 146% for sorghum and by 134% for millets, demand per head will remain low and increase slowly. This is consistent with demand being driven primarily by population growth.

Figure 6.2 shows the projections for per capita consumption in ESA for the period 2005-2050. For sorghum, consumption per head will rise from about 14 kg in 2010 to 32 kg per head by 2050. Sorghum consumption per head is higher in eastern than in southern Africa, where it will average only 9 kg per head by 2050. Average consumption of millet is lower than for sorghum. Overall, there is a nearly threefold increase in per capita demand for millet in ESA between 2005 and 2050. Consumption per head in southern Africa is projected to rise from less than 2 kg to 6 kg per head. As with sorghum, millet consumption per head is higher in eastern Africa. However, thanks to a lower base, the proportionate rise in consumption is higher in southern Africa. This reflects the status of pearl millet as a drought-resistant cereal in Zimbabwe and Namibia.

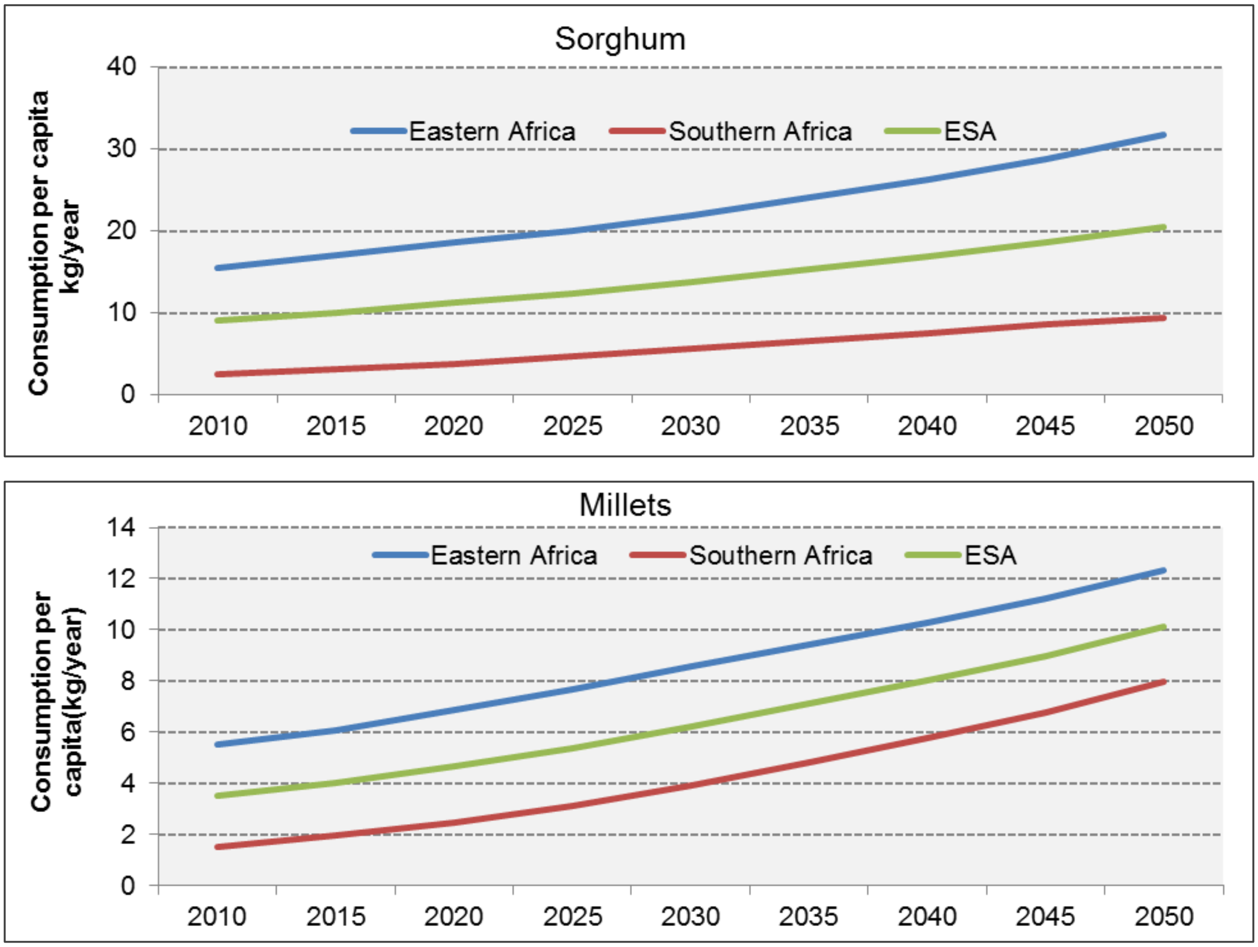



*Figure 6.2. Baseline projectionsof per capita consumption, ESA, 2005-2050.*

Source: IMPACT model

### Producer prices

Producer prices for both sorghum and millets are projected to rise over the period to 2050. Sorghum prices in ESA are projected to increase by approximately 13%, from $142 to $160 per t. For millets in ESA, prices are projected to rise by approximately 20%, from $256 to $308 per t. These projections suggest that millets will maintain their price differential over sorghum, and that rising prices combined with a trade surplus will create incentives for growers to intensify production to meet demand. For sorghum, where average producer prices are less than half those for millets, the incentive for growers to intensify production will be lower and will largely depend on opportunities for trade within and outside the region.

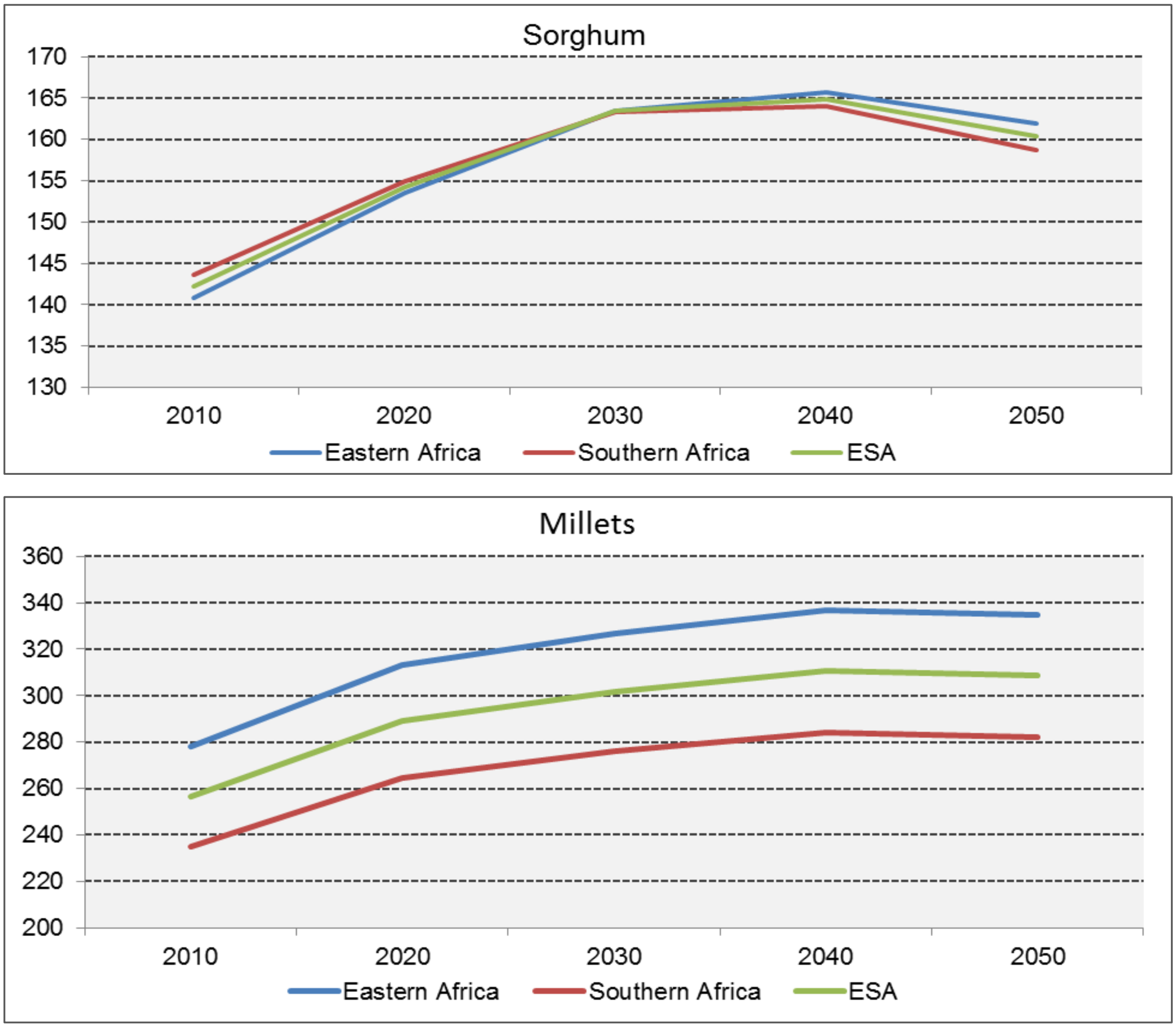



*Figure 6.3. Baseline projections of producer prices, ESA, 2005-2050.*

Source: IMPACT model

## 6.3. 'Optimistic' growth scenarios

Under the 'optimistic' growth scenario of higher income and lower population growth, we would expect that a rise in the level of per-capita income would increase the demand for preferred cereals such as rice and wheat, while reducing demand for less preferred cereals such as sorghum and millets. Conversely, a 'pessimistic' scenario with lower income growth and higher population growth would increase the demand for these cereals. Given the high rate of economic growth experienced in SSA in recent years, we have presented the results only for the optimistic scenario. Under the optimistic growth scenario, the global production of sorghum reaches 122 million tons by 2050, while production in ESA reaches 18 million t (Table 6.3). This represents a decline from the corresponding figures in the baseline projection (131 million t and 19 million t, respectively). Demand in ESA falls from 16.9 million t by 2050 in the baseline scenario to 14.3 million t in the optimistic scenario. Although higher income growth does reduce overall demand for sorghum in ESA, therefore, the effect is relatively small. As in the baseline projection, Sudan, Ethiopia and Tanzania remain the major producers and exporters in the optimistic scenario. As in the baseline projection, by 2050 the region is projected to become a net exporter of sorghum, but the trade surplus for sorghum by 2050 is higher in the optimistic scenario (3.4 million t) than in the baseline (2.6 million t). Thus, the effect of higher income and slower population growth within ESA will be to reduce demand from within the region and raise the share of exports from 13% to 19% of total sorghum production.

**Table 6.3. 'Optimistic' projections for sorghum, 2015-2050.**

| | Production ('000 tons) | | | Demand ('000 tons) | | | Net Trade ('000 tons) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2025 | 2050 | 2015 | 2025 | 2050 | 2015 | 2025 | 2050 |
| **World** | 69,734 | 82,368 | 121,803 | 67,877 | 80,511 | 119,946 | 1,857 | 1,857 | 1,857 |
| **Asia** | 11,179 | 11,520 | 11,678 | 13,505 | 14,890 | 16,877 | -2,326 | -3,370 | -5,199 |
| **WCA** | 18,757 | 23,218 | 36,658 | 17,828 | 23,194 | 43,453 | 930 | 24 | -6,795 |
| **ESA** | 6,373 | 8,722 | 17,750 | 6,410 | 8,172 | 14,332 | -37 | 550 | 3,419 |
| **Botswana** | 39 | 56 | 113 | 62 | 66 | 68 | -23 | -10 | 45 |
| **Burundi** | 95 | 108 | 131 | 103 | 137 | 382 | -7 | -29 | -250 |
| **Eritrea** | 192 | 262 | 587 | 296 | 370 | 561 | -104 | -109 | 26 |
| **Ethiopia** | 3,044 | 3,943 | 6,990 | 2,695 | 3,219 | 4,387 | 349 | 724 | 2,603 |
| **Kenya** | 174 | 246 | 545 | 177 | 230 | 429 | -3 | 16 | 116 |
| **Madagascar** | 1 | 2 | 2 | 1 | 2 | 4 | 0 | 0 | -2 |
| **Malawi** | 49 | 68 | 162 | 72 | 99 | 210 | -23 | -32 | -47 |
| **Mozambique** | 193 | 276 | 595 | 260 | 334 | 517 | -68 | -58 | 77 |
| **Namibia** | 10 | 14 | 24 | 8 | 11 | 18 | 2 | 3 | 5 |
| **Rwanda** | 287 | 386 | 691 | 236 | 306 | 650 | 51 | 80 | 41 |
| **Somalia** | 181 | 267 | 584 | 182 | 242 | 460 | -1 | 25 | 124 |
| **South Africa** | 265 | 332 | 502 | 398 | 468 | 661 | -134 | -137 | -159 |
| **Sudan** | 5,215 | 6,648 | 9,871 | 4,083 | 4,996 | 7,412 | 1,132 | 1,652 | 2,459 |
| **Tanzania** | 1,080 | 1,712 | 4,671 | 946 | 1,290 | 2,623 | 134 | 422 | 2,048 |
| **Uganda** | 604 | 849 | 1773 | 746 | 1097 | 2719 | -142 | -249 | -946 |
| **Zambia** | 27 | 38 | 76 | 49 | 78 | 287 | -22 | -41 | -211 |
| **Zimbabwe** | 104 | 130 | 234 | 134 | 174 | 298 | -30 | -44 | -64 |

Source: IMPACT model

A similar pattern is observed for millets. Global production of millets is projected to decline from 68 million t in the baseline projection to 66 million t in 2050 (Table 6.4). However, by 2050 production in ESA is projected to increase from 7 million t in the baseline projection to 8.1 million t. Similarly, global demand is projected to decline from 67 million t in the baseline projection to 65 million t by 2050. In ESA as well, the optimistic scenario projects a slight decline in demand from 5.2 million in the baseline projection to 4.8 million t. Under the optimistic scenario ESA is projected to remain a net exporter of millets. The volume of exports from the region is projected to rise slightly from 1.8 million t in the baseline projection to 1.9 million t. Ethiopia, Tanzania, Sudan and Uganda are the largest exporters of millets. All other countries in the region except Zambia are indicated to have a trade surplus of varying levels. Thus, higher rates of economic growth will result in falling production and demand for millets within ESA, but the region will continue to have a trade surplus.

**Table 6.4. 'Optimistic' projections for millets, 2015-2050.**

| | Production ('000 tons) | | | Demand ('000 tons) | | | Net Trade ('000 tons) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2025 | 2050 | 2015 | 2025 | 2050 | 2015 | 2025 | 2050 |
| **World** | 37,046 | 44,223 | 65,665 | 36,411 | 43,589 | 65,031 | 634 | 634 | 634 |
| **Asia** | 14,407 | 14,865 | 15,178 | 14,778 | 16,026 | 17,040 | -371 | -1,161 | -1,862 |
| **WCA** | 17,834 | 22,967 | 38,906 | 17,212 | 22,322 | 40,328 | 623 | 645 | -1,422 |
| **ESA** | 2,240 | 3,194 | 6,699 | 2,140 | 2,756 | 4,776 | 100 | 438 | 1,923 |
| **Botswana** | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 2 |
| **Burundi** | 12 | 16 | 23 | 13 | 17 | 43 | -1 | -2 | -20 |
| **Eritrea** | 44 | 60 | 118 | 39 | 51 | 117 | 5 | 9 | 1 |
| **Ethiopia** | 608 | 871 | 1,817 | 512 | 614 | 809 | 97 | 258 | 1,007 |
| **Kenya** | 85 | 128 | 308 | 81 | 104 | 185 | 4 | 24 | 123 |
| **Malawi** | 24 | 36 | 94 | 32 | 43 | 85 | -7 | -7 | 9 |
| **Mozambique** | 22 | 29 | 48 | 27 | 35 | 57 | -6 | -7 | -9 |
| **Namibia** | 97 | 141 | 313 | 85 | 99 | 128 | 12 | 42 | 185 |
| **Rwanda** | 5 | 7 | 14 | 5 | 7 | 14 | 0 | 1 | 0 |
| **South Africa** | 11 | 16 | 36 | 17 | 19 | 22 | -5 | -2 | 14 |
| **Sudan** | 892 | 1,189 | 1,850 | 897 | 1,090 | 1,524 | -5 | 99 | 326 |
| **Tanzania** | 300 | 472 | 1,197 | 309 | 419 | 830 | -9 | 52 | 366 |
| **Uganda** | 888 | 1,208 | 2,230 | 905 | 1,185 | 2,074 | -17 | 23 | 156 |
| **Zambia** | 52 | 73 | 141 | 59 | 90 | 309 | -7 | -17 | -168 |
| **Zimbabwe** | 92 | 135 | 359 | 57 | 72 | 102 | 35 | 63 | 257 |

Source: IMPACT model

The negative impact of higher income growth on production reflects the historical stereotype of sorghum and millets as 'poor man's crops'. As average incomes rise, consumers prefer other cereals like rice and wheat. However, this stereotype does not fit all countries in ESA. As we have seen, the price of sorghum in Ethiopia and Kenya is higher than for maize (Figure 3.8) while the price of millet in Kenya is also higher than for maize (Figure 4.5). In these countries the demand for sorghum and millets exceeds supply, making them valuable cash crops. The IMPACT model results mask these differences between countries, and conceal the incentives for commercialization of sorghum and millets.

## 6.4. Climate change scenarios

Figure 6.4 shows the projected change in the production of sorghum and millets in ESA based on the GFDL-ESM2M and the MIROC-ESM-CHEM models. In terms of their impact on production, there is little to choose between the two models. Both predict significantly higher production for these crops. In the case of sorghum, the two climate models project that production in ESA will increase to 22 million by 2050, compared to 19 million t in the baseline projection. This represents an increase of 16-19% over the baseline. In the case of millets, the two climate models project that production will increase over the baseline projection of 7 million t by 2050. However, the GFDL model (which is the drier model) projects that production will increase to 9 million t by 2050, compared to 8 million t in the MIROC model. This represents an increase of 21-33% over the baseline (Table 6.5). By contrast, both models project a decline in the production of maize. Maize production by 2050 is projected to reach 44 million t by 2050 compared to 46 million t in the baseline projection. This represents a decline of 13-15% over the baseline projection. In sum, the two models suggest that the effect of climate change in ESA will be to increase the production of both sorghum and millets, and to slightly reduce the production of maize.

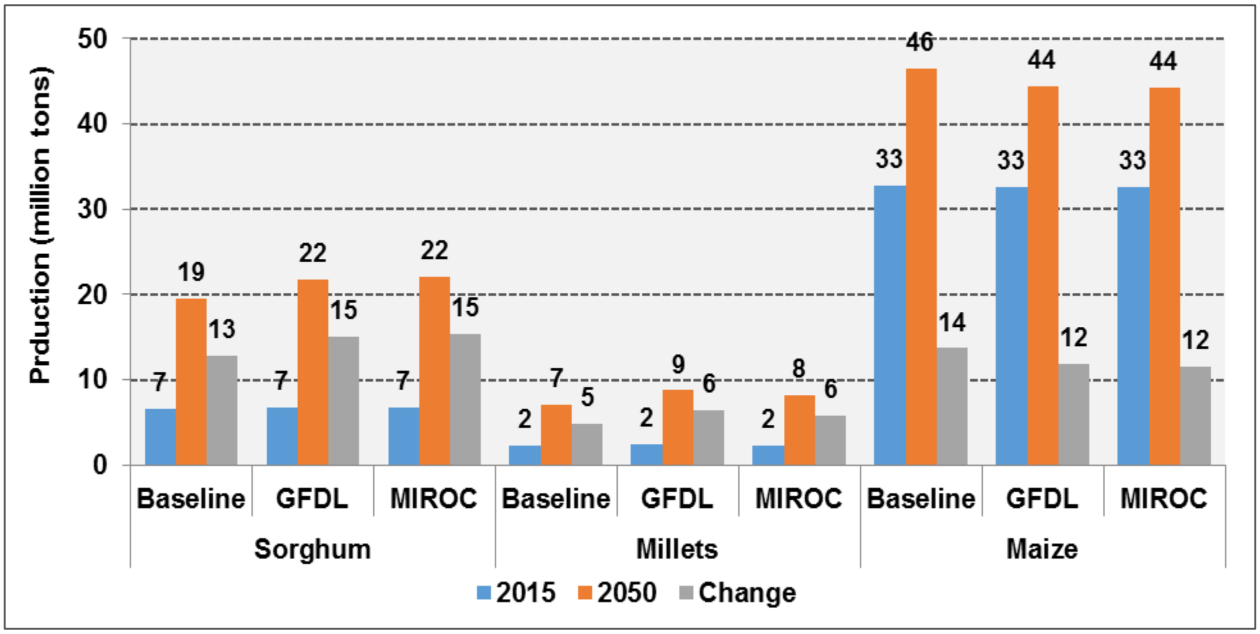



*Figure 6.4. Impact of climate change on cereal production, ESA 2015-2050 (million t).*

Source: IMPACT model

## 6.5. Yield change scenarios

Higher investment in R&D is a key strategy for improving the outlook for smallholder agriculture in the SAT. The yield scenarios capture the potential impact of increased investments in agricultural research for improving the productivity of dryland crops.

Would a modest increase in productivity increase competitiveness for sorghum and millets? With faster yield growth, we would expect to see a general increase in production, and an accompanying decrease in area – created by higher yield per unit of land and reduced pressure to increase production by increasing the cultivated area. Production growth would lead to higher supply and lower market prices – which would also push down the area planted to these crops. However, lower prices would induce greater demand for sorghum and millets, for both food and feed. The partial equilibrium framework of the IMPACT model allows us to see which of these competing effects would have the strongest influence on production.

Table 6.5 shows that a 25% increase in the growth rate in the yield of sorghum in ESA would increase production of sorghum in ESA to 25 million t by 2050, which represents an increase of 32%over the 19 million t in the baseline projection (Table 6.1). However, demand for sorghum in ESA would increase to 17 million t in 2050, which represents an increase of only 0.6% over the 16.9 million t in the baseline projection (Table 6.1). The result would be to increase the net surplus of sorghum in ESA to 8 million t by

2050, compared to a net surplus of 2 million t in the baseline projection (Table 6.1). Net trade for the ESA region would rise from 0.6% of total supply in 2015 to 32% in 2050. Thus, faster productivity growth for sorghum would increase production but not demand within the region, resulting in the export of surplus production outside the region.

**Table 6.5. Effect of a 25% increase in the growth rate in the yield of sorghum, 2015-2050.**

| | Production ('000 tons) | | | Demand ('000 tons) | | | Net Trade ('000 tons) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2025 | 2050 | 2015 | 2025 | 2050 | 2015 | 2025 | 2050 |
| **Africa** | 32,412 | 42,366 | 74,864 | 32,053 | 42,561 | 78,140 | -1,455 | -2,009 | -5,090 |
| **WCA** | 19,145 | 23,993 | 38,127 | 18,709 | 25,057 | 47,906 | -264 | -1,763 | -10,478 |
| **ESA** | 7,051 | 10,524 | 25,482 | 6,855 | 9,184 | 17,092 | 41 | 1,186 | 8,236 |
| **Asia** | 11,428 | 11,905 | 12,009 | 13,322 | 14,855 | 18,184 | -1,937 | -2,992 | -6,218 |
| **Eastern Africa** | 6,671 | 9,990 | 24,462 | 6,329 | 8,543 | 16,162 | 188 | 1,292 | 8,146 |
| **Burundi** | 103 | 123 | 164 | 110 | 185 | 660 | -7 | -62 | -496 |
| **Eritrea** | 204 | 301 | 821 | 283 | 362 | 604 | -159 | -140 | 138 |
| **Ethiopia** | 3,370 | 4,650 | 9,178 | 3,005 | 3,792 | 5,730 | 365 | 858 | 3,448 |
| **Kenya** | 195 | 305 | 824 | 196 | 295 | 660 | 0 | 10 | 164 |
| **Lesotho** | 32 | 50 | 117 | 42 | 48 | 61 | -10 | 1 | 56 |
| **Madagascar** | 2 | 2 | 3 | 1 | 2 | 4 | 0 | 0 | -1 |
| **Malawi** | 53 | 83 | 247 | 71 | 97 | 195 | -18 | -14 | 52 |
| **Mozambique** | 209 | 335 | 872 | 270 | 351 | 501 | -61 | -17 | 371 |
| **Rwanda** | 319 | 463 | 943 | 321 | 517 | 1,005 | -23 | -75 | -83 |
| **Somalia** | 194 | 319 | 843 | 167 | 215 | 317 | 27 | 104 | 526 |
| **Tanzania** | 1,216 | 2,186 | 7,584 | 928 | 1,227 | 2,211 | 288 | 958 | 5,373 |
| **Uganda** | 660 | 1,013 | 2,489 | 786 | 1,241 | 3,613 | -125 | -228 | -1,124 |
| **Zambia** | 31 | 47 | 119 | 54 | 96 | 357 | -50 | -76 | -264 |
| **Zimbabwe** | 115 | 163 | 375 | 136 | 162 | 303 | -48 | -26 | 45 |
| **Southern Africa** | 379 | 535 | 1,019 | 526 | 641 | 930 | -147 | -106 | 90 |
| **South Africa** | 287 | 392 | 685 | 408 | 503 | 748 | -121 | -110 | -63 |
| **Swaziland** | 0 | 0 | 1 | 1 | 2 | 4 | -1 | -1 | -3 |
| **Namibia** | 13 | 18 | 39 | 9 | 12 | 25 | 4 | 6 | 14 |

Source: IMPACT model

Table 6.6 shows that a 25% increase in the rate of growth in the yield of millets in ESA would increase production in ESA to 9 million t by 2050, which represents an increase of 29% over the 7 million t in the baseline projection (Table 6.2). Demand for millets in ESA would increase to 5.3 million t by 2050, or a rise of 83% compared to 2.9 million t in the baseline projection (Table 6.2). Since production exceeds demand, the result would be to increase the net surplus of millets in ESA to 4.2 million t by 2050, compared to a net surplus of 0.7 million t in the baseline projection (Table 6.2). Net trade in millets as a share of total production would rise from 8% in 2015 to 44% in 2050. Thus, faster productivity growth for millets would increase the supply of millets above the level of demand within the region, requiring the export of surplus production outside the region.

**Table 6.6. Effect of a 25% increase in the growth rate in the yield of millets, 2015-2050.**

| | Production ('000 tons) | | | Demand ('000 tons) | | | Net Trade ('000 tons) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Country/Region** | 2015 | 2025 | 2050 | 2015 | 2025 | 2050 | 2015 | 2025 | 2050 |
| **Africa** | 21,273 | 28,254 | 50,549 | 20,771 | 27,077 | 47,468 | -132 | 543 | 2,447 |
| **WCA** | 17,942 | 23,255 | 39,203 | 17,314 | 22,595 | 40,088 | -7 | 26 | -1,520 |
| **ESA** | 2,415 | 3,771 | 9,445 | 2,235 | 2,950 | 5,290 | 180 | 820 | 4,156 |
| **Asia** | 14,545 | 15,080 | 15,135 | 14,736 | 16,300 | 19,258 | -191 | -1219 | -4,123 |
| **Eastern Africa** | 2,300 | 3,585 | 8,946 | 2,132 | 2,825 | 5119 | 168 | 759 | 3,828 |
| **Burundi** | 13 | 18 | 30 | 14 | 23 | 73 | -1 | -5 | -43 |
| **Eritrea** | 49 | 71 | 164 | 35 | 46 | 110 | 13 | 25 | 54 |
| **Ethiopia** | 670 | 1,046 | 2,552 | 590 | 747 | 1,048 | 80 | 298 | 1,504 |
| **Kenya** | 92 | 157 | 467 | 90 | 132 | 276 | 3 | 24 | 191 |
| **Malawi** | 26 | 44 | 147 | 32 | 42 | 79 | -6 | 2 | 68 |
| **Mozambique** | 23 | 33 | 62 | 28 | 37 | 56 | -6 | -5 | 6 |
| **Rwanda** | 5 | 8 | 18 | 7 | 11 | 20 | -2 | -3 | -3 |
| **Tanzania** | 320 | 564 | 1,774 | 305 | 400 | 695 | 15 | 164 | 1,079 |
| **Uganda** | 942 | 1,381 | 2,906 | 910 | 1,210 | 2,291 | 32 | 171 | 615 |
| **Zambia** | 56 | 88 | 200 | 64 | 109 | 378 | -8 | -22 | -178 |
| **Zimbabwe** | 103 | 175 | 625 | 57 | 66 | 91 | 46 | 109 | 534 |
| **Southern Africa** | 115 | 186 | 499 | 104 | 125 | 171 | 12 | 61 | 328 |
| **South Africa** | 12 | 20 | 53 | 17 | 20 | 24 | -5 | 0 | 29 |
| **Namibia** | 103 | 165 | 442 | 86 | 105 | 146 | 16 | 60 | 296 |
| **Botswana** | 1 | 1 | 4 | 0 | 1 | 1 | 0 | 1 | 3 |

Source: IMPACT model

We are also interested in evaluating the effect of crop-specific productivity changes on each of the dryland crops. In particular, what would be the effect on the production of sorghum and millets of faster yield growth for maize, the staple cereal in the region? Would faster productivity growth for maize make sorghum and millets less competitive and reduce the increase in production in the baseline projection?

Table 6.7 shows the projected results on sorghum and millets production of a 25% increase in the growth rate in the yield of maize. A 25% faster increase in the yield of maize would, with no change in the rate of increase in the yield of sorghum, increase the production of sorghum in ESA to 19.3 million t by 2050, compared to the 19.5 million t by 2050 in the baseline projection (Table 6.1). Thus, faster productivity growth for maize would have only a minimal effect on the production of sorghum in ESA. The results for millets are very similar. A 25% increase in the growth rate in the yield of maize would, with no increase in the rate of change in the yield of millets, increase the production of millets in ESA to 6.9 million t by 2050 (Table 6.7). The baseline projected that millets production would increase to 7.1 million by 2050 (Table 6.2). As with sorghum, therefore, faster yield growth for maize would have only a slight effect on the supply of millets.

**Table 6.7. Effect of a 25% increase in the growth rate in the yield of maize on production of sorghum and millets, 2015-2050.**

| | Sorghum ('000 tons) | | | Millets ('000 tons) | | |
|---|---|---|---|---|---|---|
| **Country/Region** | 2015 | 2025 | 2050 | 2015 | 2025 | 2050 |
| **Africa** | 32,040 | 41,368 | 70,277 | 21,181 | 27,962 | 49,232 |
| **WCA** | 19,231 | 24,248 | 39,479 | 17,992 | 23,442 | 40,340 |
| **ESA** | 6,570 | 9,207 | 19,251 | 2,271 | 3,283 | 6,941 |
| **Asia** | 11,483 | 12,039 | 12,463 | 14,591 | 15,215 | 15,630 |
| **Eastern Africa** | 6,220 | 8,745 | 18,476 | 2,161 | 3,119 | 6,567 |
| **Burundi** | 99 | 114 | 142 | 12 | 16 | 24 |
| **Eritrea** | 197 | 274 | 632 | 45 | 62 | 123 |
| **Ethiopia** | 3,130 | 4,144 | 7,498 | 617 | 898 | 1,891 |
| **Kenya** | 181 | 263 | 604 | 86 | 133 | 325 |
| **Lesotho** | 27 | 38 | 77 | | | |
| **Madagascar** | 1 | 2 | 2 | | | |
| **Malawi** | 50 | 72 | 177 | 25 | 38 | 100 |
| **Mozambique** | 199 | 294 | 655 | 22 | 30 | 51 |
| **Rwanda** | 297 | 407 | 746 | 5 | 7 | 14 |
| **Somalia** | 186 | 280 | 630 | | | |
| **Tanzania** | 1,120 | 1,826 | 5,160 | 305 | 488 | 1,257 |
| **Uganda** | 624 | 893 | 1893 | 899 | 1,234 | 2,265 |
| **Zambia** | 28 | 40 | 84 | 52 | 76 | 150 |
| **Zimbabwe** | 107 | 136 | 252 | 93 | 137 | 368 |
| **Southern Africa** | 351 | 462 | 774 | 110 | 164 | 375 |
| **South Africa** | 272 | 349 | 546 | 11 | 17 | 37 |
| **Namibia** | 11 | 15 | 27 | 98 | 147 | 335 |
| **Botswana** | 40 | 59 | 125 | 1 | 1 | 3 |

Source: IMPACT model

If maize was a perfect substitute for sorghum and millets, we would expect that faster productivity growth for maize would lower its relative price and cause a decrease in the demand for sorghum and millets. This decrease in total demand would lower prices for sorghum and millets, and have negative effects on the area and production of these crops. Instead, we observe that faster productivity growth for maize has a minimal effect of the production of sorghum and millets in ESA. This suggests that maize is not a strong substitute for sorghum and millets. Instead, these crops serve different purposes.

We can identify at least three ways in which sorghum and millets complement maize:

1. Maize is grown under rainfed conditions in areas where drought threatens household food security. Farmers in these areas may plant sorghum and millets as an insurance crop in case their maize should fail. This is a common risk management strategy in areas where sorghum and millets are grown (Box 1).

2. Consumers may prefer food products made from sorghum or millets rather than maize. This is the case in Ethiopia, where sorghum is blended with teff to make *injera*, and in western Kenya where there are cultural preferences for porridge made from millets rather than maize. Consumers may also prefer traditional brews made from millets and sorghum.
3. Maize may also be preferred as a cash crop since markets for maize are better developed. As the dominant staple cereal in ESA, maize has a ready market and trading networks are well established. Urbanization also increases the demand for maize relative to demand for sorghum and millets (Gierend and Orr 2015). The lower price of maize compared to sorghum and millets means that maize is also more competitive as a source of feed for livestock and poultry. Hence, the market opportunities for maize are greater than for sorghum and millets.

## 6.6. Combined scenarios

Figure 6.5 compares the individual and combined effects of these scenarios on the production of sorghum in ESA. For sorghum, two scenarios have a negative effect on sorghum production. The optimistic scenario (faster growth in income with slower growth in population) reduces the projected production of sorghum in 2050 by 9%, while 25% faster productivity growth in maize reduces the projected production of sorghum by 1%. Thus, the biggest factor in reducing sorghum production is likely to be faster growth in income per head, which will reduce demand. However, the negative effect of these scenarios is relatively small. The remaining scenarios – climate change and 25% faster growth in sorghum yields – both have positive effects on the projected production on sorghum by 2050. The two climate models increase the projected production of sorghum by 11% for the GFDL-ESM2M model and by 13% for the MIROC-ESM-CHEM model, while a 25% faster increase in sorghum yields increases the projected production of sorghum by 31%. Hence, R&D that increases sorghum yields is likely to have a bigger positive effect on future sorghum production than climate change. When we combine these scenarios, the positive effects of faster yield growth and climate change outweigh the negative effects of faster income growth and faster growth in maize yields. The combined scenario projects sorghum production of 25.9 million t by 2050, compared to 19.5 million t in the baseline projection. This represents an increase of 33% over the baseline projection. Based on the orders of magnitude given by these different scenarios, therefore, the outlook for sorghum production in ESA appears to be positive, partly through the effect of climate change, but primarily through the success of R&D in accelerating the growth in sorghum yields.

Figure 6.6 compares the effects of the individual and combined scenarios on the production of millets in ESA. As with sorghum, two scenarios have a negative effect on the production of millets. The optimistic scenario (faster growth in income with slower growth in population) reduces the projected production of millets in 2050 by 6%, while 25% faster productivity growth in maize reduces the projected production of millets by 3%. Thus, the biggest factor in reducing millets production is likely to be faster growth in income per head, which will reduce demand. However, the negative effect of these scenarios is relatively small. The remaining scenarios – climate change and 25% faster growth in millet yields – both have positive effects on the projected production on millets by 2050.

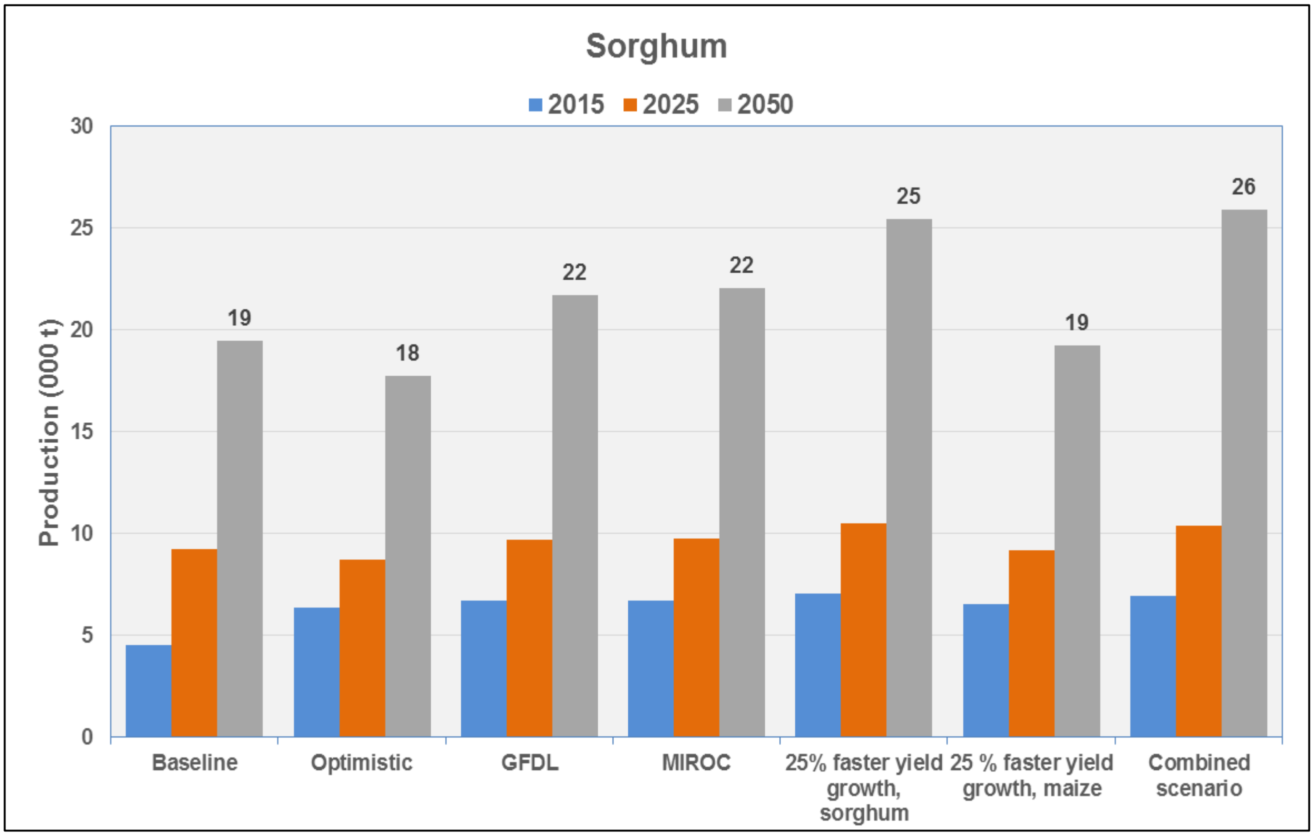



*Figure 6.5. Effect of combined scenarios on production of sorghum in ESA, 2015-2050 (million t).*

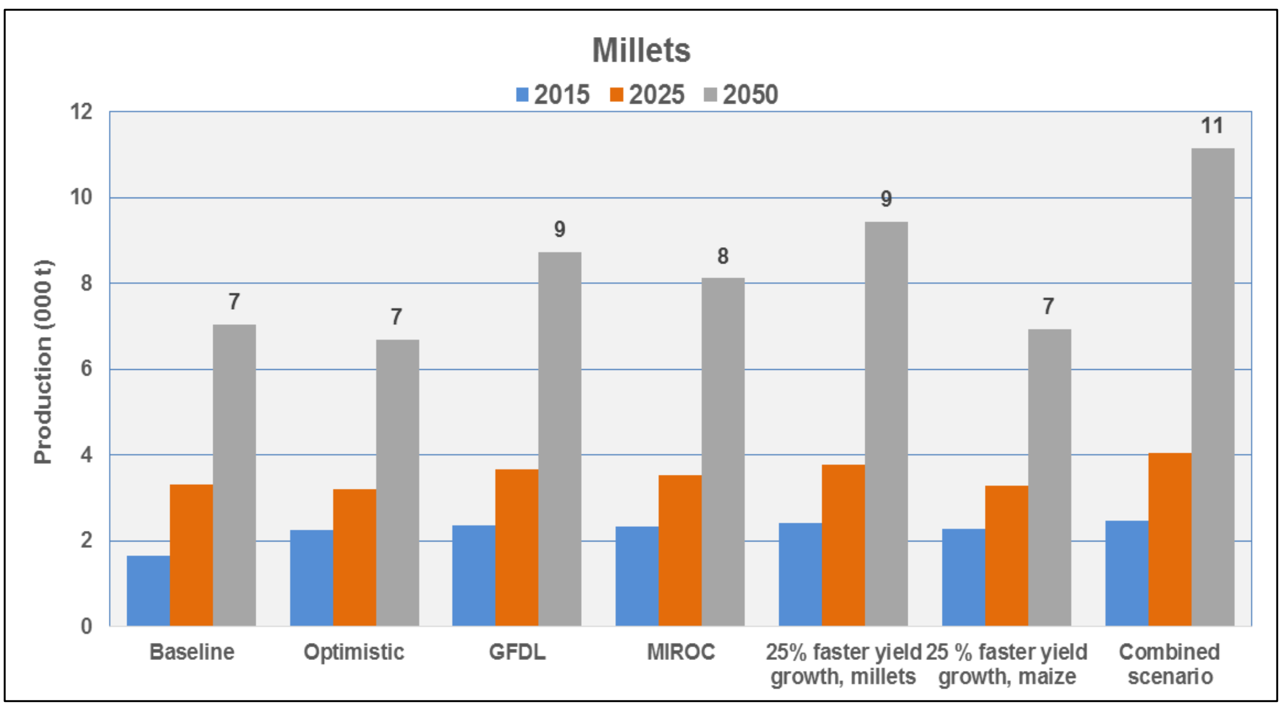



*Figure 6.6. Effect of combined scenarios on production of millets in ESA, 2015-2050 (million t).*

The two climate models increase the projected production of sorghum by 23% for the GFDL-ESM2M model and by 14% for the MIROC-ESM-CHEM model, while a 25% faster increase in the yield of millets increases the projected production of millets by 34%. Hence, R&D to increase millet yields is likely to have a bigger positive effect on future millet production than climate change.

When we combine these scenarios, the positive effects of faster yield growth and climate change outweigh the negative effects of faster income growth and faster growth in maize yields. The combined scenario projects millets production of 11.1 million t by 2050, compared to 7.1 million t in the baseline projection. This represents an increase of 56% over the baseline projection. Based on the orders of magnitude given by these different scenarios therefore, the outlook for the production of millets in ESA appears to be positive, partly through the effect of climate change, but more will depend on the success of R&D in accelerating the growth in millet yields.

In sum, the scenarios from the IMPACT model for ESA give broadly similar results for the outlook for sorghum and millets. The orders of magnitude for the individual scenarios give some insight into the most important drivers of change. The results suggest that the positive effects of climate change and faster growth in yields can more than compensate for the negative effects of faster income growth in reducing demand. Production of sorghum and millets will continue to grow even without faster growth in yields. Demand will be driven primarily by population growth within the region. But accelerating the rate of growth in yields can potentially increase production by over 30% by 2050. The IMPACT model shows that demand exists to meet this increased supply. Increasingly, however, demand will be driven by trade outside the region. This reinforces the need for efficient trade, the development of trade corridors and investment in infrastructure to reduce transport costs.

# 7. Conclusions

There is a widespread perception that sorghum and millets are crops are in terminal decline. While this may be true at the global level, it overlooks regional differences. This review of past trends and the future outlook for sorghum and millets in ESA reveals a more positive picture. Since the 1980s production has stabilized and the IMPACT model suggests that the decline has been reversed. The model projections suggest rising demand with production of both sorghum and millets in ESA expected to double between now and 2050.

Africa bucks the global trend because, unlike in other regions, rising demand for sorghum and millets in SSA is driven primarily by population growth. A high rate of population growth, combined with falling poverty that increases purchasing power, is fuelling the demand for staple grains. Unlike in high income countries and in India, demand for sorghum and millets in ESA is not currently driven by new uses as feed for livestock or poultry, although the demand for sorghum and millets for food processing (flour and alcohol) is growing. This pattern of utilization will change with rising income. However, although poverty in ESA has started to decline, the overall level of poverty remains high. Low average incomes will continue to constrain consumer demand for new products. In the short to medium term, therefore, demand will come primarily from rural households growing sorghum and millets for home consumption.

We are accustomed to thinking of sorghum and millets as competing with maize. This was true in the past, when maize displaced sorghum and millets to become the staple food crop. However, the area planted to sorghum and millets has been stable since the 1980s. These crops are now grown in regions where farmers cannot rely solely on maize for household food security. In Zimbabwe, Tanzania, Uganda and Kenya they are largely grown as an insurance crop. In Ethiopia, they are grown both as an insurance crop and in preference to maize as an ingredient for the staple food, *injera*. Today in ESA, sorghum and millets complement rather than compete with maize. The IMPACT model projections suggest that accelerating the yield of maize will have a minimal effect on the future production of sorghum and millets. This suggests the need to re-think the conventional picture of competing cereal crops and to see sorghum and millets as insurance strategies for household food security in specific farming systems.

Historically, sorghum and millets were 'poor man's crops'. In some parts of ESA, however, they are now relatively more expensive than maize. This reflects supply shortages caused by limited production and their importance for household food security which reduces the amount entering the market. Higher relative prices offer incentives for growers to meet market demand, provided they can compete with imports. Specialization within the region is taking place, with Tanzania, Ethiopia and Sudan projected as the biggest exporters of sorghum and Uganda as the biggest importer. For millets, Ethiopia and Tanzania are projected as the biggest exporters. Although the volume of sorghum and millets traded was a small share of total production in 2015, this share is projected to grow over time. By 2050, trade with countries outside the ESA region is projected to be an important driver of demand for both crops.

Raising yields for sorghum and millets can increase farmers' ability meet growing demand. To date, yields have grown slowly, with most of the growth in production due to an increase in the area planted. Yield gaps between countries and between farmers in the same country show there is potential to raise average yields. Higher investment in R&D has increased the supply of improved varieties. However, higher yields will require not just improved varieties but also investment in improved crop management. So long as sorghum and millets are seen simply as insurance crops for drought years, farmers may have limited incentives to invest in raising yields. Given the low demand for sorghum and millets as sources of livestock feed, growing opportunities for trade outside the region may provide the necessary demand-pull that is required to stimulate investment.

These model projections have big implications for policy. Hitherto, sorghum and millets have been part of food policy. The largest exporters – Tanzania, Uganda and Ethiopia – follow trade policies that discourage exports. Despite being members of the EAC and the same customs union, Tanzania and Uganda periodically impose export bans on cereal crops, while Ethiopia's price policy penalizes farmers and favors the import of cereals to protect consumers. However, the growing importance of export markets projected by the IMPACT model requires a different approach, in which sorghum and millets become part of trade policy. This requires a change in perspective from one that is inward-looking and concerned with national food security to one that is outward-looking and focused on opportunities for trade. This is a difficult balancing act, since periodic droughts will continue to put pressure on domestic food supply, thereby reducing the quantity available for export and disrupting trade. In addition, expanding trade outside the ESA region will require greater investment in infrastructure to reduce transport costs, the development of trade corridors to reduce non-tariff barriers, and a more efficient marketing system to reduce transaction costs for buyers and sellers.

The favorable picture that emerges from the trend analysis – growing demand, price incentives and opportunities for trade – is also supported by the outlook analysis based on the IMPACT model. Under a 'business as usual' scenario based on past trends, between 2015 and 2050 the production of sorghum and millets in ESA is projected to grow by 66% and 68%, respectively. Higher rates of economic growth and faster growth in maize yields will have a negative impact, acting as a brake on production. However, these can be more than offset by the positive effects of climate change, which will create more favorable growing conditions for sorghum and millets and by increasing yields either through plant breeding or improved crop management. Projections suggest that, by 2050, the simultaneous impact of these changes will be to increase the production of sorghum and millets by as much as one-third over the 'business as usual' scenario.

In conclusion, the evidence for ESA does not support the view that sorghum and millets are in terminal decline. The outlook is positive. Sorghum and millets will remain important food crops within the region, particularly in drought-prone areas where household food security cannot rely solely on maize. Their resilience to drought will increase their importance as a source of adaptation to climate change. Higher yields will increase their potential as cash crops to meet demand outside the region. These are powerful arguments for the relevance of sorghum and millets in the region and the need for continued investment in R&D.

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# Appendix

## Appendix 1. Regional Groupings for Eastern and Southern Africa

### Regional Aggregations used by the FAO

| ***Southern Africa*** |
| --- |
| Botswana |
| Lesotho |
| Namibia |
| South Africa |
| Swaziland |
| ***Eastern Africa*** |
| Burundi |
| Comoros |
| Djibouti |
| Eritrea |
| Ethiopia |
| Kenya |
| Madagascar |
| Malawi |
| Mauritius |
| Mayotte |
| Mozambique |
| Réunion |
| Rwanda |
| Seychelles |
| Somalia |
| South Sudan |
| Uganda |
| United Republic of Tanzania |
| Zambia |
| Zimbabwe |

## Regional Aggregations used in the IMPACT model

| Eastern Africa | Central Africa | | Southern Africa | Western Africa | |
|---|---|---|---|---|---|
| **Burundi** | Angola | Rwanda | Botswana | Benin | Mali |
| **Djibouti** | Cameroon | Somalia | Lesotho | Burkina Faso | Mauritania |
| **Eritrea** | Central African Republic | Tanzania | Namibia | Gambia | Niger |
| **Ethiopia** | Chad | Uganda | South Africa | Ghana | Nigeria |
| **Kenya** | Congo | Zambia | Swaziland | Guinea | Senegal |
| **Madagascar** | DRC | Zimbabwe | | Guinea Bissau | Sierra Leone |
| **Malawi** | Equatorial Guinea | | | Ivory Coast | Togo |
| **Mozambique** | Gabon | | | Liberia | |

## Appendix 2. Area planted to sorghum and millets by agro-ecological zone

| Agro-ecology | | Total area | Arid/ Desert | Dry semi-arid | Moist semi-arid | Semi-humid | Humid/ perhumid |
|---|---|---|---|---|---|---|---|
| Length of growing period (ø days/year) | | | < 75 | 75-119 | 120-179 | 180-269 | > 270 |
| ***Eastern Africa*** | Land area (sqkm) | 6,913,099 | 1,019,084 | 871,008 | 1,515,804 | 3,305,883 | 201,320 |
| | Sorghum area (ha) | 6,929,551 | 284,380 | 1,284,824 | 2,210,297 | 2,992,930 | 157,120 |
| | Millet area (ha) | 1,684,599 | 67,124 | 142,477 | 619,459 | 809,311 | 46,228 |
| Burundi | Land area (sqkm) | 27,834 | 593 | 3,516 | 1,271 | 21,331 | 1,123 |
| | Sorghum area (ha) | 56,538 | 4,436 | 11,547 | 1,065 | 39,490 | 0 |
| | Millet area (ha) | 10,900 | 85 | 560 | 103 | 10,152 | 0 |
| Eritrea | Land area (sqkm) | 117,600 | 31,639 | 65,114 | 12,026 | 8,821 | 0 |
| | Sorghum area (ha) | 255,870 | 589 | 234,948 | 19,955 | 378 | 0 |
| | Millet area (ha) | 55,429 | 377 | 50,368 | 4,454 | 230 | 0 |
| Ethiopia | Land area (sqkm) | 1,104,300 | 275,724 | 389,976 | 193,689 | 207,868 | 37,044 |
| | Sorghum area (ha) | 1,827,489 | 53,408 | 688,238 | 613,386 | 409,157 | 63,300 |
| | Millet area (ha) | 431,896 | 1,614 | 48,799 | 193,933 | 182,038 | 5,512 |
| Kenya | Land area (sqkm) | 581,309 | 274,514 | 142,013 | 64,144 | 45,525 | 55,114 |
| | Sorghum area (ha) | 222,455 | 78,307 | 73,476 | 10,688 | 25,943 | 34,041 |
| | Millet area (ha) | 105,899 | 56,417 | 16,724 | 5,547 | 13,911 | 13,301 |
| Madagascar | Land area (sqkm) | 587,041 | 100 | 1,849 | 383,322 | 131,323 | 70,447 |
| | Sorghum area (ha) | 2,414 | 0 | 16 | 1,553 | 580 | 265 |
| | Millet area (ha) | 0 | 0 | 0 | 0 | 0 | 0 |
| Malawi | Land area (sqkm) | 118,484 | 603 | 1,067 | 34,615 | 82,199 | 0 |
| | Sorghum area (ha) | 86,262 | 40 | 93 | 19,377 | 66,752 | 0 |
| | Millet area (ha) | 46,755 | 0 | 0 | 18,173 | 28,582 | 0 |
| Mozambique | Land area (sqkm) | 801,590 | 88 | 464 | 50,436 | 721,285 | 29,316 |
| | Sorghum area (ha) | 628,000 | 0 | 18 | 37,964 | 577,013 | 13,005 |
| | Millet area (ha) | 104,547 | 0 | 38 | 12,497 | 86,249 | 5,764 |
| Rwanda | Land area (sqkm) | 26,338 | 2,028 | 9,471 | 760 | 10,415 | 3,664 |
| | Sorghum area (ha) | 108,540 | 11,989 | 53,137 | 2,790 | 31,887 | 8,737 |
| | Millet area (ha) | 5,392 | 62 | 3,347 | 196 | 1,722 | 64 |
| Somalia | Land area (sqkm) | 637,657 | 365,629 | 178,153 | 41,909 | 51,966 | 0 |
| | Sorghum area (ha) | 242,678 | 91,088 | 123,377 | 27,706 | 507 | 0 |
| | Millet area (ha) | 0 | 0 | 0 | 0 | 0 | 0 |
| South Sudan* | Land area (sqkm) | 619,745 | 7,618 | 20,242 | 272,293 | 319,591 | 0 |
| | Sorghum area (ha) | 2,085,889 | 23,543 | 71,758 | 983,315 | 1,007,273 | 0 |
| | Millet area (ha) | 162,210 | 5,726 | 16,675 | 56,579 | 83,231 | 0 |
| Uganda | Land area (sqkm) | 200,523 | 18,184 | 30,513 | 18,982 | 128,232 | 4,612 |
| | Sorghum area (ha) | 362,333 | 1,486 | 10,653 | 57,670 | 254,751 | 37,772 |
| | Millet area (ha) | 175,667 | 2,650 | 5,952 | 2,128 | 143,400 | 21,537 |
| Tanzania | Land area (sqkm) | 947,303 | 35,944 | 26,872 | 198,551 | 685,936 | 0 |
| | Sorghum area (ha) | 787,325 | 19,091 | 17,554 | 329,013 | 421,667 | 0 |
| | Millet area (ha) | 315,766 | 0 | 0 | 231,919 | 83,799 | 49 |
| Zambia | Land area (sqkm) | 752,618 | 3,743 | 1,011 | 87,494 | 660,369 | 0 |
| | Sorghum area (ha) | 20,424 | 25 | 7 | 6,236 | 14,156 | 0 |
| | Millet area (ha) | 34,137 | 37 | 14 | 7,049 | 27,037 | 0 |
| Zimbabwe | Land area (sqkm) | 390,757 | 2,677 | 747 | 156,311 | 231,022 | 0 |
| | Sorghum area (ha) | 243,333 | 377 | 1 | 99,579 | 143,378 | 0 |
| | Millet area (ha) | 236,000 | 157 | 0 | 86,883 | 148,960 | 0 |

Source: Crop areas from FAOSTAT (ø 2011-2013); *crop area for South Sudan estimated from MapSpam 2005 data set; share of agro-ecological zones from the LGP raster map, ILRI; crop area by agro-ecology calculated from MapSpam 2005 data set (Harvest Choice IFPRI) and extrapolated to ø 2011-2013 FAOSTAT crop area

| Agro-ecology | | Total area | Arid/ Desert | Dry semi-arid | Moist semi-arid | Semi-humid | Humid/ perhumid |
|---|---|---|---|---|---|---|---|
| Length of growing period (ø days/year) | | | < 75 | 75-119 | 120-179 | 180-269 | > 270 |
| ***Southern Africa*** | Land area (sqkm) | 2,674,379 | 241,255 | 419,676 | 1,410,613 | 599,142 | 0 |
| | Sorghum area (ha) | 157,996 | 1,328 | 7,765 | 99,672 | 49,231 | 0 |
| | Millet area (ha) | 259,519 | 665 | 13,213 | 144,682 | 100,959 | 0 |
| Botswana | Land area (sqkm) | 580,011 | 82 | 23,628 | 429,428 | 123,180 | 0 |
| | Sorghum area (ha) | 64,732 | 0 | 0 | 39,799 | 24,934 | 0 |
| | Millet area (ha) | 5,685 | 0 | 0 | 3,330 | 2,355 | 0 |
| Lesotho | Land area (sqkm) | 30,352 | 0 | 0 | 20,235 | 10,117 | 0 |
| | Sorghum area (ha) | 16,005 | 0 | 0 | 14,349 | 1,656 | 0 |
| | Millet area (ha) | 0 | 0 | 0 | 0 | 0 | 0 |
| Namibia | Land area (sqkm) | 825,615 | 112,612 | 269,234 | 371,830 | 71,939 | 0 |
| | Sorghum area (ha) | 17,004 | 0 | 1,301 | 10,720 | 4,982 | 0 |
| | Millet area (ha) | 240,000 | 0 | 13,210 | 140,023 | 86,768 | 0 |
| South Africa | Land area (sqkm) | 1,221,037 | 127,853 | 126,813 | 588,431 | 377,939 | 0 |
| | Sorghum area (ha) | 59,400 | 1,328 | 6,464 | 34,741 | 16,867 | 0 |
| | Millet area (ha) | 13,833 | 665 | 3 | 1,329 | 11,836 | 0 |
| Swaziland | Land area (sqkm) | 17,364 | 708 | 0 | 689 | 15,966 | 0 |
| | Sorghum area (ha) | 855 | 0 | 0 | 63 | 792 | 0 |
| | Millet area (ha) | 0 | 0 | 0 | 0 | 0 | 0 |

Source: Crop areas from FAOSTAT (ø 2011-2013), share of agro-ecological zones from the LGP raster map, ILRI. Crop area by agro-ecology calculated from MapSpam 2005 data set and extrapolated to ø 2011-2013 FAOSTAT crop area