
Overview

Cereals and pulses are important food and cash crops for farmers and rural households in Ethiopia. Wheat, sorghum, and maize supply over 50% of average daily caloric intake. Cereal production accounts for roughly 60% of rural employment and 80% of total cultivated land. Households spend an average of 40% of their total food budget on cereals.¹ Pulses occupy 13% of cropland in Ethiopia and are the second most important element in the national diet after cereals.² Despite the economic and food security importance of these crops, data and opinion suggest a yield gap: actual smallholder farm yields do not achieve estimated potential yields for wheat, sorghum, maize, lentils and peas. Furthermore, cereal prices in Ethiopia fall between import and export parity prices, limiting their international trading prospects. Although there are significant wheat imports, these reflect the influx of food aid and not competitive trade on the international market.³

The purpose of this brief is to help estimate yield gaps in important Ethiopian crops in order to identify potential areas for productivity gains. According to the World Food Programme, 46% of the Ethiopian population is undernourished, underscoring the importance of increasing domestic food productivity.⁴ FAO data is available for wheat, sorghum, maize, lentils and peas, which form the bulk of this analysis. Teff is not reported separately by the FAO, and is instead likely reported with other minor cereal crops under the category “cereals, not elsewhere specified.” Similarly, other pulses are reported under the aggregate categories “not elsewhere specified.”

Research included University of Washington libraries, FAO, CGIAR, Google and Google Scholar searches using the search terms crop productivity, food security and yield gap, in combination with Ethiopia and top crops produced or imported as well as pulses and teff.

The principal resources for the analysis of wheat, sorghum and maize come from the CGIAR Generation Challenge Programme *Cultivating Plant Diversity for the Resource Poor*. Specifically, yield gaps and productivity constraints were estimated and analyzed in two studies (Gibbon et al 2007 and Waddington et al 2009) under the ongoing project “Getting the focus right.” *Appendix 1* provides more information on the study methodology, and particularly the selection of expert panelists. The principal resource for the analysis of pulses is a 2004 report on pulse crops from the Ethiopian Export Promotion Agency, a government institution. Only two reports were available for the analysis of teff; one from the Ethiopian Institute of Agricultural Research (circa 2000, exact publication date unknown) and the other from the International Plant Genetic Resources Institute at the FAO from 1997.

Appendix 2 contains the top ten constraints and attributed yield gaps for each crop by farming system according to the

NOTE: The findings and conclusions contained within this material are those of the authors and do not necessarily reflect positions or policies of the Bill & Melinda Gates Foundation.

qualitative assessment of expert panelists through the Generation Challenge Programme. *Appendix 3* provides yield graphs for the 20 most important crops in terms of production quantity as well as lentils and peas. *Appendix 4* provides a list of the landrace and improved varieties of each crop currently cultivated in Ethiopia.

Selection of Crops for Analysis

Wheat, sorghum and maize were selected for this analysis due to their relative importance in domestic production and imports, trade deficits, and yields below the world and/or regional averages. Wheat in particular demonstrates a significant yield gap in comparison to the East Africa regional and world averages, and domestic production accounted for only 79% of local supply in 2007. Export crops were excluded because FAO data indicate that average yearly national yields since 1993 exceed regional and continent averages for most years, and even world averages in the case of coffee, sesame seeds and chickpeas. These data suggest that significant productivity gains in output per hectare are unlikely. *Appendix 3* provides yield data for the top 20 goods produced in comparison with East Africa, Africa and world average yields from 1993–2008.

The main pulse crops grown in Ethiopia are horse beans, chickpeas, haricot beans, lentils, dry peas and vetches.⁵ Lentils and peas were selected for this analysis due to their relative importance in Ethiopian food security, trade deficits, and yields well below the world and regional averages. Chickpeas are a major export crop for Ethiopia, but were excluded because average yearly national yields since 1993 already exceed regional and continent averages, and even world averages for most years, according to FAO data. These data suggest that significant productivity gains in output per hectare are unlikely. Similarly, dry beans (the category containing haricot beans), were excluded because Ethiopia has produced and exported a surplus every year since 1993 and exceeded world and regional average yields in most years. Finally, broad beans and horse beans were excluded because Ethiopia has produced a modest surplus every year since 1993; achieving 90% of world average yields and exceeding regional average yields.

Defining & Measuring Yield Gaps

Yield gaps are defined as the difference between yield potential and average farmers' yields over a given spatial or temporal scale.⁶ However, there are different types of potential yields, which give rise to three distinct types of yield gaps. Scientists conceive and breed improved varieties based on the first type of yield gap: the difference between theoretical crop potential and experiment station yield. The second type of yield gap results from the difference between experiment station yield and potential farm yield due mainly to environmental conditions and the technologies available at research stations that are non-replicable at the farm level. This form of yield gap is generally difficult to close and not economically viable. Finally, the third type of yield gap is the difference between potential farm yield and actual farm yield. This gap results mainly from management practices, such as low input usage and lack of improved seed, and can be cost-effectively narrowed.⁷

Three methods have been designed to calculate yield potential. Firstly, crop models can simulate yield potentials under specified parameters. Secondly, field experiments under controlled management and sanctioned yield contests can indicate crop yield potential for a given region. Finally, maximum farmer yields can be used as a proxy for yield potential.⁸ Where Ethiopia specific data are unavailable, this analysis compares national, regional, continent-wide, and world average yields using FAO data and farm-level data where available.

Wheat

Table 1. *Wheat in Ethiopia At-A-Glance*

	2005	2006	2007
Production (tonnes)	2,306,862	2,779,058	2,219,095
Local supply (tonnes)*	3,168,813	3,305,264	2,819,332
Percent of local supply from domestic production	73%	84%	79%
Trade surplus/deficit (tonnes)	-861,951	-526,206	-600,237
Average yield (Kg/Ha)	1,469	1,904	1,506
East African regional average yield (Kg/Ha)	1,667	2,005	1,691

Source: FAOSTAT

*Consumption is estimated as production plus imports, minus exports but may not accurately estimate demand for wheat since food aid receipts of wheat are included in import figures.

Production

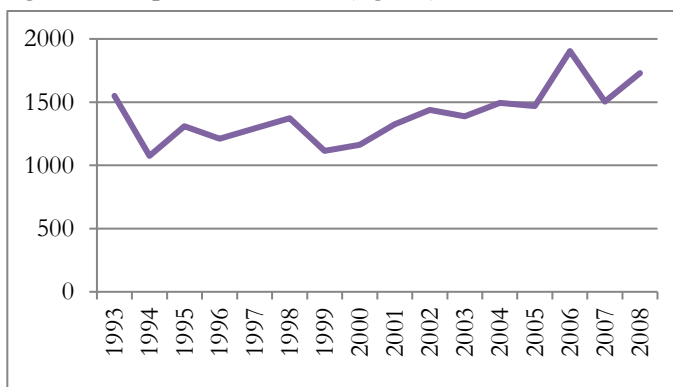
In Sub-Saharan Africa (SSA), wheat is grown in sub-humid or humid agro-ecological zones of the highland temperate mixed farming system (according to FAO classification). Ethiopia contains the majority of this cropping system in the Africa, although there are smaller areas in the highlands of Eritrea, Lesotho, South Africa, Angola, Cameroon and Nigeria. This cropping system accounts for only four percent of cultivated area in SSA, but supports seven percent of the regions' population.⁹

Within Ethiopia, the Oromia and Amhara regions produce 59% and 27% of the country's wheat, respectively, with an additional nine percent coming from the Southern Nations, Nationalities, and Peoples Region (SNNPR). Bread wheat accounts for about half of all the area planted; wheat, durum and emmer wheat account for the remainder. Bread wheat is widely grown in the highland and semi-highland areas of the Tigray, Amhara and Oromiya regions. Emmer wheat is mainly grown in the Oromiya region.

Productivity

Ethiopian wheat yields have been consistently well below East African and world average yields, indicating low productivity of the crop. According to FAO data, Ethiopian wheat yields fluctuated between 88% and 99% of the regional average yield between 2004 and 2008. Even in the highest yielding year (2008), this amounted to only 77% of average African wheat yields and 56% of world average yields.

Figure 1. *Ethiopian Wheat Yields (Kg/Ha)*



Source: FAOSTAT

Waddington et al (2009) compared highest farmer yields to average farmer yields to identify a smallholder wheat yield gap in SSA of 2,120 kilograms per hectare. The highest smallholder yield was 4,140 kilograms per hectare, while the regional average was only 2,020 kilograms per hectare. This yield gap amounts to 105% of average farm yields.¹⁰

In 2007, domestic wheat production accounted for only 79% of local supply. In the peak-yielding year of 2006, this figure was 84%. Based on 2007 data, if Ethiopia were able to achieve an 11% increase in yields to meet the Eastern Africa regional wheat yield average, it could decrease imports by ten percent and maintain the same quantity of local supply. If Ethiopia were able to achieve even greater yield gains and meet African average yields, *ceteris paribus*, it could decrease wheat imports by 25% and maintain the same quantity of local supply.¹¹

Constraints

Within each crop by farming system pair, the Generation Challenge Programme at CIMMYT asked expert panelists to identify the six most important constraints from a long list in each of four categories: socio-economic, biotic, abiotic, management. Additionally, they asked the experts to estimate the yield losses for each constraint. Waddington et al. (2009) reported the ten constraints with the greatest estimated yield losses in each crop by farming system combination. For wheat, these ten constraints likely account for 58% of the estimated smallholder wheat yield gap in SSA, with numerous “minor” constraints likely accounting for the remainder.¹² *Appendix 2* contains the top ten constraints to wheat productivity in the highland temperate mixed maize system.¹³ According to the panelists, limited access to inputs and biotic constraints account for more of the yield gap than farm management practices.¹⁴

Lack of available quality seed was reported as a primary constraint to wheat productivity in SSA, affecting two thirds of the crop area in most years and resulting in an estimated yield loss of 167 kilograms per hectare, eight percent of the total yield gap. The combination of several soil fertility related constraints led to an additional estimated yield loss of 411 kilograms per hectare. These include expensive or limited nitrogen fertilizer, nitrogen deficiency, and soil fertility depletion. These conditions were present in over 40% of wheat area, and account for 20% of the total yield gap. Farmer level constraints, including lack of timely access to the right machinery and difficult access to finance, result in an estimated yield loss of another 196 kilograms per hectare.

Management constraints accounted for another 20% of the total yield gap according to the study. Inadequate access to agricultural information and farmer production and utilization of knowledge and training are estimated to result in a combined 198 kilograms per hectare loss. Finally, biotic constraints account for another 10% of the yield gap. These include rusts and wheat competition, estimated to be responsible for yield losses of 142 and 120 kilograms per hectare, respectively.¹⁵

Consumption

Wheat and barley are the main staple foods in highland temperate areas, and selling wheat is generally not a primary economic activity for producers.¹⁶ Wheat accounts for nearly 20% of daily caloric intake in Ethiopia, second to maize.¹⁷ The Ethiopian Commodity Exchange reports that household consumption accounts for about 60% of wheat produced, 20% is sold and the remainder is used for seed, in-kind payments for labor, and animal feed.¹⁸

Marketing

The wheat market participants in Ethiopia include smallholder and commercial producers, wholesalers, retailers, part-time farmer-traders, brokers, agents, assemblers, processors, cooperatives, the Ethiopian Grain Trade Enterprise (EGTE), and consumers. Prices generally follow the annual pattern of relatively low post-harvest January prices followed by a period of rising prices that peak during the main rainy season (July and August). However, there is significant price variability in the Ethiopian wheat market. For example, intra-year price variation in the Addis Ababa central market was 36% in 2004 and 26% in 2006.¹⁹

Sorghum

Table 2. Sorghum in Ethiopia At-A-Glance

	2005	2006	2007
Production (tonnes)	2,200,241	2,313,041	2,173,599
Local Supply (tonnes)	2,189,682	2,312,758	2,187,665
Percent of local supply from domestic production	100%	100%	99%
Trade surplus/deficit (tonnes)	10,559	283	-14,066
Average yield (Kg/Ha)	1,469	1,904	1,506
East African regional average yield (Kg/Ha)	1,032	1,002	1,077

Source: FAOSTAT

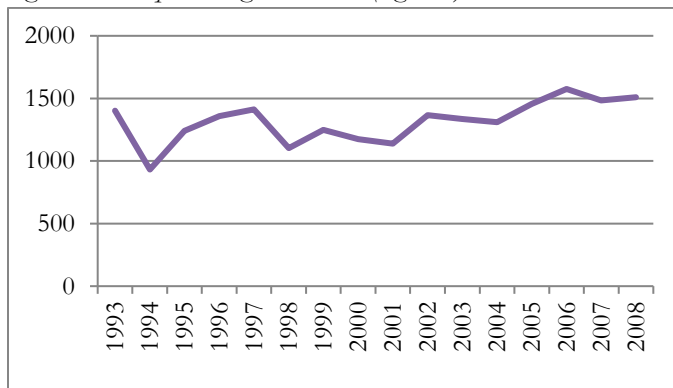
Production

Sorghum in Ethiopia is produced both in highland temperate mixed farming systems and mixed maize systems. As mentioned above, Ethiopia contains the majority of SSA's highland temperate mixed zones. The maize mixed system covers 19% of cultivated area and provides livelihoods for 15% of the population in SSA.²⁰ Contrary to regional trends, men are primarily responsible for sorghum production and marketing in Ethiopia. Women are primarily responsible for post-harvest handling. Sorghum is typically planted between April and July and harvested from October to December.²¹

Productivity

Between 1993 and 2008, Ethiopia achieved an average 96% of world average sorghum yield according to FAO data, exceeding world averages in seven of those years, including every year between 2005 and 2008.

Figure 2. Ethiopian Sorghum Yields (Kg/Ha)



Source: FAOSTAT

Ethiopian sorghum yields exceeded both regional and world average yields in 2008. However, average yields still remain well below mean U.S. yields, for example, which average 4,300 kilograms per hectare.²²

Sorghum is a crop dominated by resource poor smallholders and typically produced under adverse conditions.²³ Therefore, although yields are above East African and world average yields, Waddington et al (2009) suggest there is significant room for improvement. Expert panelist responses identified a smallholder sorghum yield gap in SSA of 1,640 kilograms per hectare in highland temperate mixed systems and 1,230 kilograms per hectare in mixed maize systems. The highest smallholder yield was 3,440 kilograms per hectare in the highlands and 2,930 in mixed maize areas. However, the regional average smallholder yields were only 1,800 and 1,130 kilograms per hectare for each farming system, respectively.²⁴ In 2008, Ethiopia harvested 1,533,537 hectares of sorghum. Closing the yield gap would therefore produce between 1,886,250 and 2,515,000 additional tonnes of sorghum.

Adugna and Tesso (2006) tested the potential of 14 sorghum hybrids in different environments in Ethiopia. They recommend four hybrid varieties (genotypes 1, 2, 3 and 5) with good stability and yield as suitable for drought-stressed areas of Ethiopia.²⁵

However, Adugna (2007) notes that these improved varieties have not been well assimilated in Ethiopia. In addition to poor extension linkages limiting farmers' access to information about improved varieties, the lack of widespread dissemination may result from several other factors. Firstly, in a good season, the local cultivar is still higher yielding than the hybrid varieties. Secondly, the early maturing varieties, specifically, are more vulnerable to bird attack. And finally, the hybrid varieties have reduced biomass and therefore less value to farmers as animal feed.²⁶ Improved varieties could increase sorghum production in Ethiopia, however sorghum productivity faces additional constraints that limit this agronomic potential.

Constraints

The Generation Challenge Programme also asked expert panelists to identify the six most important constraints to sorghum productivity in each of the four categories and estimate the yield losses for each constraint.²⁷ Waddington et al. (2009) reported the ten constraints with the greatest estimated yield losses in each crop by farming system combination. The ten constraints associated with the greatest yield losses explain 50% of the estimated smallholder sorghum yield gap in highland temperate mixed systems and 39% of the sorghum yield gap in mixed maize systems. Limited access to inputs and biotic constraints account for more of the yield gap than farm management practices in both production systems.²⁸ *Appendix 2* lists the top ten constraints and respective yield gaps identified in this study.

In the highland temperate mixed system, biotic constraints are the primary factors limiting sorghum productivity. Leaf, stem and panicle pests, weed competition and striga result in an estimated 312 kilograms per hectare loss, accounting for 19% of the total yield gap. In addition, soil fertility issues such as nitrogen deficiency, soil physical degradation, and soil fertility depletion are responsible for an additional 225 kilograms per hectare loss, accounting for 14% of the yield gap. Drought and cold stress result in another 136 kilograms per hectare, or eight percent of the total yield gap. Finally, farm management constraints including difficulties establishing the crop and inadequate farmer knowledge and training contribute another 144 kilograms per hectare loss, accounting for nine percent of the total yield gap.²⁹

In the mixed maize system, weed competition was identified as the main constraint to sorghum productivity, responsible for an 81 kilogram per hectare loss and seven percent of the total yield gap. Weed competition was present on 46% of land cultivated with sorghum in most years, but panelists noted that it appears to be improving. Soil degradation, on the other hand, was found on 40% of land and was said to be getting worse. In addition to drought and bird damage, these biotic constraints accounted for an estimated 194 kilograms per hectare loss, comprising 16% of the total yield gap. Input related constraints include expensive or short supply of fertilizer, nitrogen deficiency, and insufficient access to agricultural information. These were responsible for an estimated 121 kilogram per hectare loss and 11% of the total yield gap. Finally, management constraints (inadequate farmer knowledge and training and difficulty establishing the crop) resulted in an estimated 81 kilograms per hectare loss, amounting to seven percent of the yield gap.³⁰

Consumption

Sorghum is not considered a main staple in either of the farming systems where it is grown, but it is the third most important food grain in Ethiopia.^{31,32} From 2004–2007, domestic production supplied 99–100% of sorghum consumption in Ethiopia.³³

The main use of sorghum in Ethiopia is for producing injera, the traditional bread.³⁴ Sorghum accounts for an average ten percent of daily caloric intake.³⁵ Expert panelists surveyed by Waddington et al (2009) noted that sorghum is often valued more for home consumption purposes (human food, fodder and beer making) than for grain yield or income.³⁶ Sorghum stover (stalks and leaves) is an important source of animal fodder and cooking fuel. Stover accounts for 37% of the crop value in Ethiopia, compared to the rest of SSA where it accounts for only 26% of the total crop value.³⁷

Marketing

Only 29% of sorghum produced is marketed; the majority is used for household consumption.³⁸ In general, community institutions and market linkages in the maize belt tend to be better developed than in other farming systems. In Ethiopia, this includes the Benishangul-Gumu and Gambela regions as well as the western part of the Somali region and parts of Oromia.

Tobacco, coffee and cotton are main cash crops in this farming system, which may account for some of the marketing infrastructure.³⁹

Maize

Table 3. *Maize in Ethiopia At-A-Glance*

	2005	2006	2007
Production (tonnes)	3,911,869	4,029,630	3,336,795
Local supply (tonnes)	3,939,699	4,089,229	3,368,690
Percent of local supply from domestic production	99%	98%	99%
Trade surplus/deficit (tonnes)	-27,830	-59,599	-31,895
Average yield (Kg/Ha)	2,006	2,640	1,969
East African regional average yield (Kg/Ha)	1,227	1,414	1,461

Source: FAOSTAT

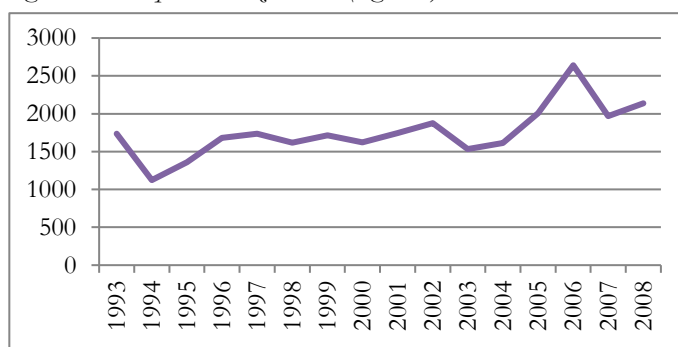
Production

Ethiopian maize is also cultivated mainly in the highland temperate mixed farming system, with some production in the cereal-root crop mixed system of western Amhara. However, in comparison to other farming systems in SSA, the highland temperate system has the lowest area devoted to maize.⁴⁰ The majority of Ethiopia's maize comes from three regions: Oromia (61%), Amhara (20%) and SNNPR (12%).

Productivity

According to FAO data, Ethiopian maize yields exceed East African and African average yields, but remain well below world average yields. On average between 1993 and 2008, Ethiopia obtained only 39.5% of world averages, with the only exception in 2006 when it yielded 55% of the world average. Yields have remained well over the East African yields, averaging 126% of the regional mean yield and achieving as much as 186% in 2006.

Figure 3. *Ethiopian Maize Yields (Kg/Ha)*



Source: FAOSTAT

The highland temperate mixed farming system has the highest potential farm yields for maize (1,000 to 3,500 kilograms per hectare) of any maize farming system in the developing world.⁴¹ Using expert panelist responses, Gibbon et al (2007) identified a smallholder maize yield gap in the highland temperate mixed systems of SSA of 1,792 kilograms per hectare.⁴² 2005 data from SG-2000 on-farm demonstration plots in Amhara and Oromia measure the yield potential of several maize varieties under two input-management scenarios. The largest sample size available is for farmers cultivating the QPM BH 542 maize varietal (n=28). Under conservation tillage management, farmers applied Round Up and 100 kilograms per hectare each of DAP and urea. The average yield results were 3,860 kilograms per hectare. Under standard management conditions, the same farmers used no herbicide and the same fertilizer dosage and obtained average yields of 3,778 kilograms per hectare.⁴³

In 2008, Ethiopia cultivated 1,767,389 hectares of maize. Producing an additional 3,167,161 tonnes of maize would close the

yield gap identified by Gibbon et al. (2007).⁴⁴ Similarly, if Ethiopia were producing at world average yield levels (5,109 kilograms per hectare in 2008), *ceteris paribus*, it would produce 159% of current domestic supply.⁴⁵

Constraints

The Generation Challenge Programme also identified the ten constraints associated with the greatest yield losses that explain 26% of the estimated smallholder maize yield gap in the highland temperate mixed systems. Soil fertility and biotic constraints account for more of the yield gap than farm management practices.⁴⁶ *Appendix 2* details the top ten constraints and respective yield gaps.

Low soil fertility is the primary constraint to maize productivity in SSA, accounting for an estimated 122 kilograms per hectare loss or seven percent of the total smallholder yield gap. Additional soil fertility and biotic constraints such as acid soils, *Turicum* leaf blight, weeds, grain weevils, grain borers, maize stem borer and grey leaf spot are responsible for an estimated 272 kilograms per hectare loss, accounting for 15% of the yield gap. Management constraints, including late planting and weeding, account for an additional three percent of the gap, resulting in an estimated loss of 54 kilograms per hectare.⁴⁷

Additionally, according to the Ministry of Agriculture and Rural Development, maize is grown in the same belt as coffee but without a comparative advantage in that system.⁴⁸

Consumption

Maize is the primary food staple in Ethiopia, averaging slightly more than 20% of daily caloric intake.⁴⁹ The Ethiopian Commodity Exchange reports that three-quarters of maize produced is used for household consumption, only about ten percent is marketed and the remainder is used for seed, in-kind payments for labor, and animal feed.⁵⁰

Marketing

Close to 95% of the marketed quantity comes from smallholders and the rest from commercial and state farms. Other market participants in the maize trade include producers (smallholders and commercial farms), wholesalers, retailers, part-time farmer-traders, brokers, agents, assemblers, processors, cooperatives, EGTE, and consumers. Prices generally follow the annual pattern of relatively low post-harvest January prices followed by rising prices.⁵¹ Ethiopia also exports some maize regionally. In 2005/06, Sudan received 67% of Ethiopian maize exports with the remainder exported to Djibouti.⁵²

Teff

Ethiopia is the origin of the teff plant and it is grown throughout the country. Ethiopia does not import teff. Data from the 1990s indicate limited exports.^{53,54}

Production

The Shewa, Gojam and Gonder Wello are the major teff producing regions of Ethiopia.⁵⁵ The crop is highly evolved and diversified within the country and can grow in a variety of agroecological conditions, including marginal areas where other crops are more difficult to cultivate. Teff can grow between sea level and 3,000 meters, performing best at altitudes between 1,700 and 2,400 meters. It is mainly cultivated in high rainfall areas with long growing periods, but can also grow in dryer, drought-prone areas with shorter growing seasons and frequent moisture stress. Teff tolerates reasonable levels of both drought and water logging better than most other cereals and can also grow in a variety of soil types.⁵⁶

Productivity

According to a study of teff production in the 1990s, between 1992 and 1998, teff yielded an average 890 kilograms per hectare. Farmers using improved varieties and management practices can obtain 1,700–2,500 kilograms per hectare. The highest recorded yield on research plots was 5,000 kilograms per hectare.^{57,58}

2005 data from SG-2000 on-farm demonstration plots in Amhara and Oromia measure the yield potential of local and improved teff varieties under two input-management scenarios. Farmers cultivating the DZ-01-354 teff varietal applied Round Up and 100 kilograms per hectare each of DAP and urea under conservation tillage management. The average yield results were 1,270 kilograms per hectare. Under standard management conditions, farmers used no herbicide and the same fertilizer dosage and obtained the same average yield per hectare. Using local varieties of teff, average yield under conservation tillage ranged from 1,320–1,405 kilograms per hectare depending on the seed rate (25–40 kilograms per hectare). Average yield for local varieties under standard management conditions was 1,280 kilograms per hectare at a seed rate of 25–30 kilograms per hectare.⁵⁹

Constraints

Constraints in teff production include low-yielding varieties, low moisture stress resistance, waterlogging, frost, weeds, poor soil fertility, diseases and insects.⁶⁰ In addition, the small size of teff seed poses problems during sowing, weeding and threshing. Controlling seed density is difficult during planting and the resulting scattered plant stands make mechanical weeding exceedingly difficult. Seed loss is common during threshing because the small, light seeds are often blown away with the chaff. Teff is more resistant to disease than other cereal crops.⁶¹ Teff rust and head smudge are reported as serious disease constraints. Higher prevalence of damping-off (caused by *Drechslera poae*) is observed under higher seed rate and early sowing date conditions.⁶² Pests threatening the teff plant include Welo bush-cricket, central shootfly, and red teff worm.⁶³ Despite these constraints, teff is well adapted to a variety of environments and is therefore seen as a lower risk crop by farmers. In particular, in water constrained environments where farmers face the potential of complete crop failure, teff can be a better choice to get at least some harvest.⁶⁴

Consumption

Ethiopia mainly produces teff for human consumption, and the grain provides two-thirds of daily protein intake on average. It has high nutritional content, including better amino acid composition and more calcium, copper, and iron than other cereal grains. Although the iron content likely results from soil contamination during threshing and is not intrinsic to the grain, the nutrient is generally prevalent at the time of consumption. Teff is deficient in the critical nutrient lysine, however it is commonly supplemented with fenugreek or eaten with *wot*, both of which supply this nutrient.^{65,66}

Teff flour is mostly used to make the traditional *injera* bread, and sometimes to make porridge. It can also be used to produce local beer and liquor. Teff straw is an important source of animal fodder and has been shown to be more nutritious animal feed than other crop residue fodder.^{67,68}

Marketing

Both teff grain and straw command a relatively higher market price than other cereal crops. Teff is therefore an important cash crop for many farmers.^{69,70}

Lentils

Table 4. Lentils in Ethiopia At-A-Glance

	2005	2006	2007
Production (tonnes)	63,357	57,603	81,094
Local Supply (tonnes)*	100,057	77,194	73,101
Percent of local supply from domestic production	63%	75%	111%
Trade surplus/deficit (tonnes)	-36,700	-19,591	7,993
Average yield (Kg/Ha)	657	679	835
East African regional average yield (Kg/Ha)	660	679	827

Source: FAOSTAT

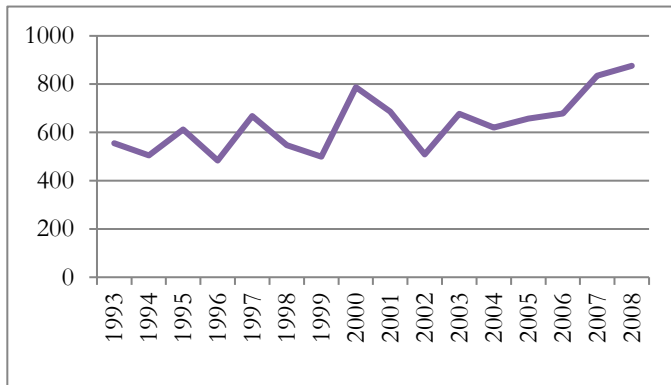
Production

Lentils are produced in the high altitude areas of Ethiopia.⁷¹ They are a winter crop, particularly important in Oromia and Amhara and also grown in parts of the SNNPR and Tigray regions.⁷² Smallholders grow the majority of Ethiopia's lentils. Most producers follow traditional production techniques based on indigenous knowledge and use no chemical inputs.

Productivity

National average lentil yields since 2000 have fluctuated between 509 (2002) and 876 (2008) kilograms per hectare. Productivity varies by region, however. The Ethiopian Export Promotion Agency reports that improved varieties yield 1,400–5,000 kilograms per hectare on research fields and 900–3,000 kilograms per hectare on farmers' fields.⁷³

Figure 4. Ethiopian Lentil Yields (Kg/Ha)



Source: FAOSTAT

In 2007, domestic lentil production supplied 111% of lentils consumed. However, this was the first year since 1993 that Ethiopia produced a surplus of lentils. On average from 1993 to 2007, Ethiopia produced 92% of local lentil supply. 2007 was the highest yielding year since 1993, the earliest data available, but still remained below world average yields. Ethiopian lentil yields are on par with East African average yields and slightly greater than continent-wide averages for most years on record. Based on 2007 data, if Ethiopia were able to increase yields by six percent to meet world average yields, it could produce 117% of current supply levels.⁷⁴

Constraints

The most important biotic constraints facing lentil production in Ethiopia are rust and the wilt/root-rot complex. In addition, water-logging, drought, poor management and lack of improved technology limit lentil productivity.⁷⁵ According to the FAO and the World Food Programme, in 2009, there were only 809 quintals planted with improved lentil seed, compared to 123,215 quintals of improved wheat and 29,657 quintals of improved maize.⁷⁶

Consumption

Lentils are an important part of the daily diet for most Ethiopians. Most lentils produces are consumed domestically.⁷⁷ According to the Ministry of Agriculture and Rural Development, demand for lentils in both local and international markets has increased significantly in recent years.⁷⁸

Marketing

Pulse crops are usually available at *woreda* (local), regional and terminal markets from wholesalers and retail shops as well as directly from producers at weekly markets in rural areas.⁷⁹ Lentils command a high price and enjoy a strong demand in the national market, leading to their low export share compared to other pulses. The main destinations for exported lentils are Pakistan, Yemen and Djibouti.⁸⁰

Peas

Table 5. Peas in Ethiopia At-A-Glance

	2005	2006	2007
Production (tonnes)	197,021	182,268	210,095
Local supply (tonnes)	205,886	197,331	233,682
Percent of local supply from domestic production	96%	92%	90%
Trade surplus/deficit (tonnes)	-8,865	-15,063	-23,587
Average yield (Kg/Ha)	779	817	948
East African regional average yield (Kg/Ha)	692	702	781

Source: FAOSTAT

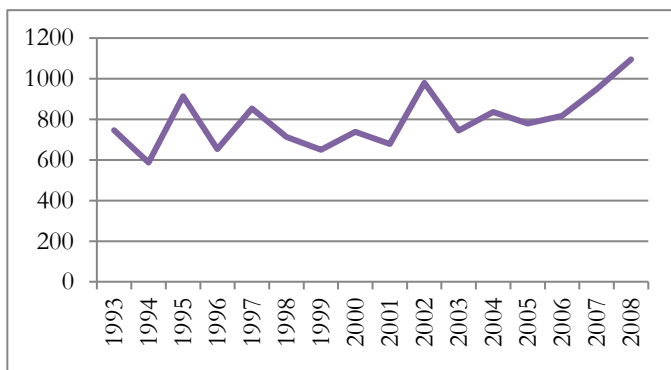
Production

Peas include garden peas and field peas. Field peas are one of the oldest crops grown in Ethiopia.⁸¹ They are widely planted in the mid- to high-altitude areas of the Oromia, Tigray, Amhara and SNNPR regions. Smallholders are the main pea producers and use no chemical inputs.⁸²

Productivity

The Ethiopian Export Promotion Agency reports that research fields using improved technologies and inputs achieved yields as high as 4,000–6,000 kilograms per hectare. In contrast, pea yields in Ethiopia since 2000 have fluctuated between 678 (2001) and 1,085 (2008) kilograms per hectare.

Figure 5. Ethiopian Pea Yields (Kg/Ha)



Source: FAOSTAT

In 2007, Ethiopia produced 90% of the peas consumed. Ethiopian yields were well above East African (120%) and African (130%) average yields, but achieved only 63% of average world pea yields. If Ethiopia were able to achieve world average yields, it could produce 123% of the local supply quantity.⁸³

The Ethiopian Export Promotion Agency highlights use of improved seed as critical to increasing pea productivity. National research has led to 13 improved varieties released since 1981, which yield 2,500 to 4,500 kilograms per hectare under good management conditions in research fields. On-farm yields average 1,000 to 3,000 kilograms per hectare.⁸⁴

Constraints

The most significant constraints facing pea production in Ethiopia include mildew, root rot, and lack of improved seed. Field peas are a nitrogen-fixing crop, so fertilizer is generally not required and therefore lack of use does not pose a constraint to pea productivity.⁸⁵ According to the FAO and the World Food Programme, in 2009, there were only 419 quintals planted with improved pea seed, compared to significantly larger areas planted with improved wheat and maize seed, as mentioned above.⁸⁶

Consumption

The majority of peas produced are consumed domestically and peas are an important part of the daily diet for most Ethiopians.⁸⁷

Marketing

Similar to lentils, peas are usually available at local markets from wholesalers, retailers, and directly from producers at weekly markets in rural areas.⁸⁸

Constraints to Agricultural Productivity in Ethiopia

Key constraints to agricultural productivity in Ethiopia include low availability of improved or hybrid seed, lack of seed multiplication capacity, low profitability and efficiency of fertilizer use due to the lack of complimentary improved practices and seed, and lack of irrigation and water constraints. In addition, lack of transport infrastructure and market access decrease the profitability of adopting improved practices.^{89,90}

Investments in productivity increases higher up the food value chain, such as through marketing and transportation infrastructure, would increase prices farmers receive for output while also putting downward pressure on urban food prices. Higher producer prices would create incentives for farmers to invest in productivity increasing technologies since output increases would offer substantial gains.⁹¹

Lack of reliable data also poses a critical constraint to understanding the potential for productivity gains in Ethiopia. As Dercon and Hill (2010) point out, data from the Central Statistical Authority (CSA) report a significant increase in area harvested in the previous decade, however the source and quality of this land remains unclear, as land pressure has long been noted as a critical constraint to agricultural production in Ethiopia. Furthermore, according to Bachewe et al. (2008) and Nisrane et al. (2009), there is evidence that farmers moved closer to the production possibility frontier during the period from 1994–2004, but that these gains were largely due to increased use of traditional inputs such as land, labor, oxen and hoes. There is no evidence of an expansion of the frontier, which would indicate technological change or intensification.^{92,93} Dercon and Hill (2010) also question the reliability of the CSA yield data, and point to a small household survey (Minot, 2008) and satellite data suggesting that CSA data may overestimate yield gains. Given that there has been little expansion in the use of modern inputs such as fertilizer (on a kilogram per hectare basis), improved seed, and irrigation, there are additional grounds to question the validity of the CSA data. However, an important caveat in this argument concerns the quantity of land under cultivation. If these data are overestimated, input use per hectare would increase and be more consistent with yield gains due to intensification since overall use of inputs has increased while per hectare use has remained relatively constant.⁹⁴

Conclusion

Wheat, sorghum and maize all exhibit the potential for yield gains to increase domestic food availability. Access to inputs, low soil fertility and biotic constraints are the central factors currently limiting crop productivity. Opportunities for increasing yields appear to exist through increasing access to inputs, and investing in research to overcome the biotic constraints specifically facing these food crops. Additionally, all three crops experienced significant spikes in yield in the 2006 season. Further investigation into the climate conditions and policy in place that year may generate potential strategies to increase future yields.

Analysis of Ethiopian lentil and pea yields suggest that productivity gains may be possible to increase food availability. Limited access to improved technologies appears to be the main constraint to pulse productivity in Ethiopia. Opportunities to increase lentil and pea yields appear to exist through increasing cultivation of improved varieties.

Please direct comments or questions about this research to Leigh Anderson, at eparx@u.washington.edu

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Appendix 1. CGIAR Generation Challenge Programme “Getting the Focus Right” Summary of Methodology¹

The pilot study of maize by Gibbon et al. 2007 established a study methodology that was then modified and repeated for the additional crops in Waddington et al. 2009. Both study methodologies are summarized below. The list of expert panelists is available from the program’s website.²

In the maize study, CIMMYT researchers assisted with identifying potential panelists who were presumed to have personal experience with maize research, extension or development in one or more of the identified farming systems. Panelists were drawn from a range of disciplines. A rapid, interactive, procedure was employed for capturing the knowledge and experience of expert panels for assessing and prioritizing recognizable constraints to maize production within each farming system. The method of interaction adopted was a modified version of the Delphi technique, originally developed by the RAND corporation, where expert panels were polled in four rounds - receiving the panel results of the previous round for revision and adjustment, as well as some additional questions. In the initial round the potential panelists (initially 227 who responded to the initial round, but ultimately more than 390 were contacted in Asia, Africa and Latin America) were provided with descriptions and distribution maps of 14 major farming systems and were asked to assess their level of familiarity with each. For one or more systems with which they were most familiar, they were asked to indicate the key maize production constraints for the system, augmenting the initial constraints list as appropriate, to establish the master list of constraints. In a second round, panelists were asked to identify and rank the top ten constraints. In the third round, these summaries were shared with the panelists who were asked to review, reconsider and revise as appropriate the ranking of the top ten constraints and the estimated yield loss. In the fourth round, panelists were asked to consider the summarized results from earlier rounds, notably: the relative importance of abiotic, biotic, socioeconomic and crop management constraints on maize productivity; and the rankings and the estimated reductions in yield due to these constraints under small farm conditions. In this process the responses had converged to a substantial degree. Finally, panelists were asked to estimate the proportion of fields and the proportion of years with serious yield losses from each of the top ten constraints.³

In the follow-up study, researchers sought the expert knowledge of at least 15 panelists per farming system, per crop. In addition, twelve persons in government research, universities and CGIAR centers acted as focal persons for the survey in China, the Philippines, India, Bangladesh, Nepal, Ethiopia, Zimbabwe, Nigeria, Benin and Mexico. Six hundred and seventy two panelist returns were received in the first round. Overall, 22.7% of the respondents were plant breeders or geneticists/biotechnologists, 4.6% plant protection scientists, 24.7% agronomists/soil or water scientists, 8.8% were social scientists or economists. There was variation in panel size for the different crop x system combinations. Sorghum in the Root Crop system of Sub-Saharan Africa was dropped during the survey because of insufficient responses. Within each crop by farming system pair, researchers asked expert panelists to identify the six most important constraints from a long list in each of four categories: socio-economic, biotic, abiotic, management. Additionally, they asked the experts to estimate the yield losses for each constraint. Waddington et al. (2009) reported the ten constraints with the greatest estimated yield losses in each crop by farming system combination. A mean yield loss was calculated for each constraint and adjusted for frequency of occurrence. Constraints were ranked according to the size of their mean yield losses, separately for each of the four categories of constraint. The estimated yield losses for the top six constraints in each category were then given in the second round questionnaires and panelists were invited to make revisions. Adjustments were made to calculate the final mean losses.⁴

¹ More information on the Generation Challenge Programme can be found at: <http://www.generationcp.org>

²<http://www.generationcp.org/UserFiles2/File/SP5-Socio-economics/Socio-economics/Kayoko/SI%20No.%207%20App%204%20Panelist%20Lists.pdf>

³ Summarized from Gibbon et al (2007)

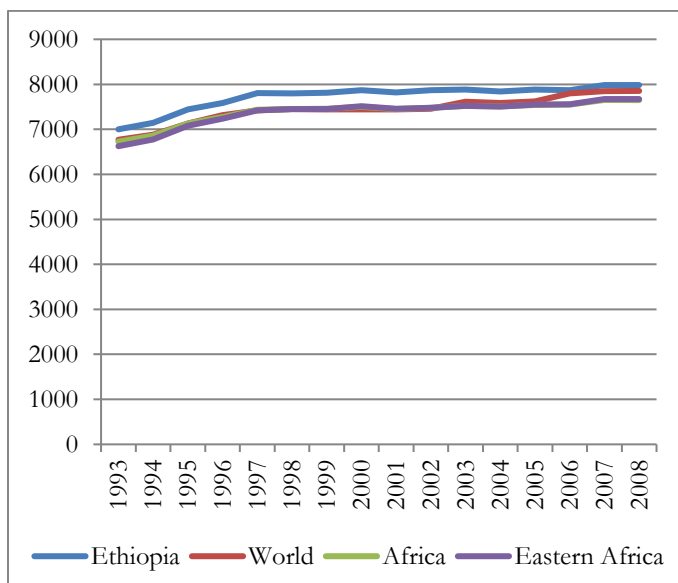
⁴ Summarized from Waddington et al (2009)

Appendix 2. "Getting the Focus Right" Summary of Results

Wheat constraint	Yield loss (kg/ha)	% of yield gap	Maize constraint	Yield loss (kg/ha)	% of yield gap
<i>SS Africa—Highland Temperate Mixed</i>			<i>SS Africa—Highland Temperate Mixed</i>		
Unavailability of quality seed	167	8	Low soil fertility	122	7
N fertilizer expensive/in short supply	159	8	Drought	34	2
N deficiency	146	7	Low soil nitrogen	16	1
Rusts (stem, leaf, yellow)	142	7	Acid soils	21	1
Weed competition	120	6	Weeds generally	84	5
Soil fertility depletion	106	5	Striga	50	3
Insufficient access to agricultural information	102	5	Late planting	20	1
Farmers do not have timely access to right machinery	98	5	MSV	33	2
Difficult access to finance	98	5	Grey Leaf spot	36	2
Inadequate farmer production and utilization knowledge/training	96	5	Maize stem borer	32	2
Total	1235	58	Total	448	26
<i>SS Africa—Cereal Root Crop Mixed</i>			<i>SS Africa—Cereal Root Crop Mixed</i>		
Leaf, stem, panicle pests	113	7	Drought	551	
Weed competition	111	7	Low soil nitrogen	902?	
N deficiency	102	6	Low soil fertility	472	
Crop establishment difficulties	93	6	Striga	373	
<i>Striga</i>	88	5	Weeds generally	502	
Drought (water deficit) during crop establishment	81	5	Grain weevils	137	
Soil physical degradation	64	4	Zinc deficiency	58	
Soil fertility depletion	59	4	Termites	126	
Cold stress/frost damage	55	3	Lodging: high winds	53	
Inadequate farmer production and utilization knowledge/training	51	3	African Pink borer	34	
Total	816	50	Total	3,208	unknown
<i>SS Africa—Maize Mixed</i>					
Weed competition	81	7			
Soil physical degradation	63	5			
Drought, dry spells, with developing crop or in grain filling	49	4			
Drought (water deficit) during crop establishment	48	4			
Inadequate farmer production and utilization knowledge/training	47	4			
Fertilizer expensive/in short supply	46	4			
N deficiency	44	4			
Crop establishment difficulties	38	3			
Bird damage	34	3			
Insufficient access to agricultural information	34	3			
Total	482	39			

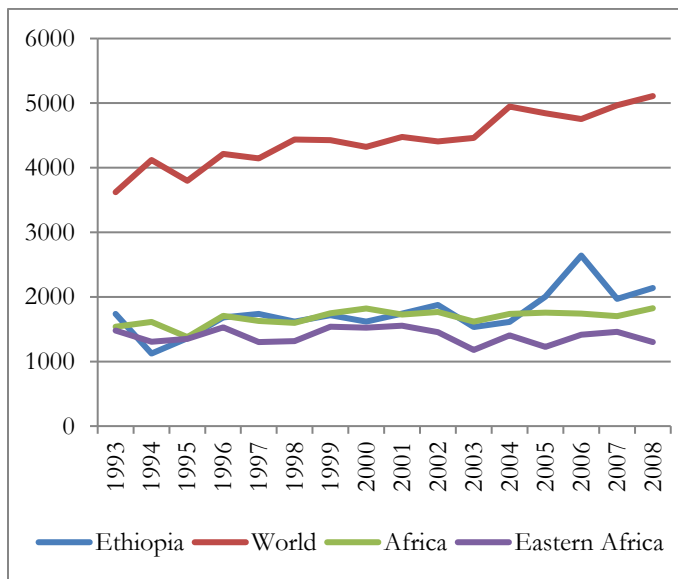
Appendix 3. Comparative Yield Data, (Kg/ Ha), 1993–2008, Ranked in order of Production Quantity

Roots and Tubers

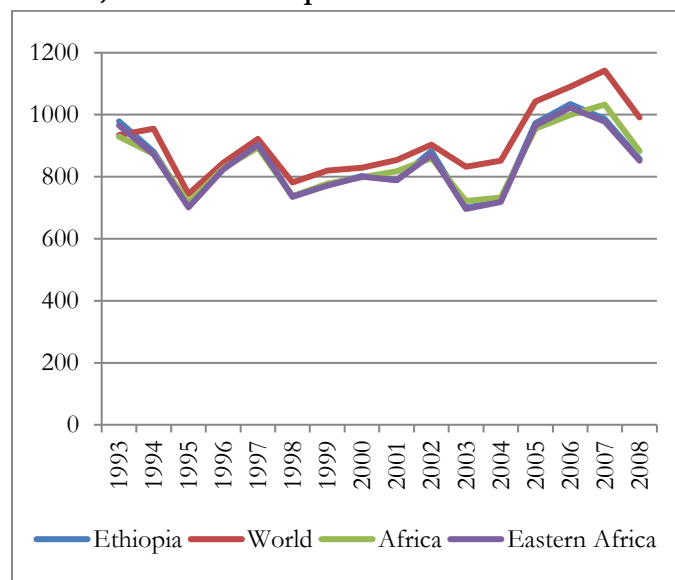


* Ethiopia's main root and tuber crops are enset and potato. Enset is likely the crop captured in the magnitude of roots and tubers production

Maize

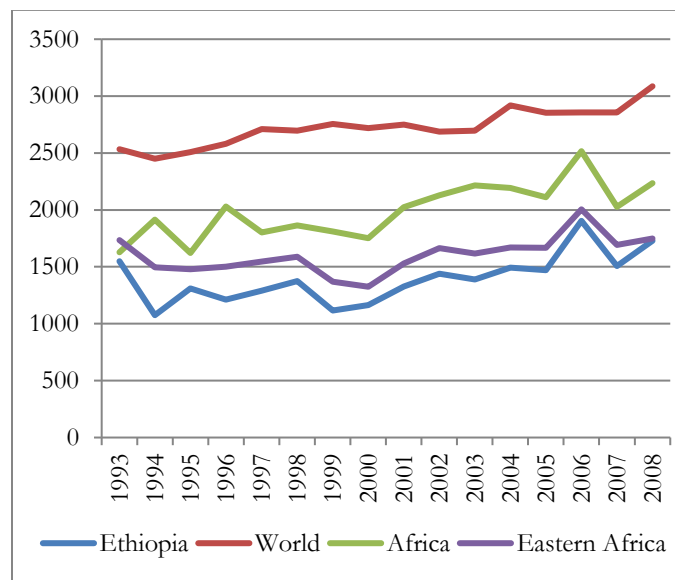


Cereals, not elsewhere specified

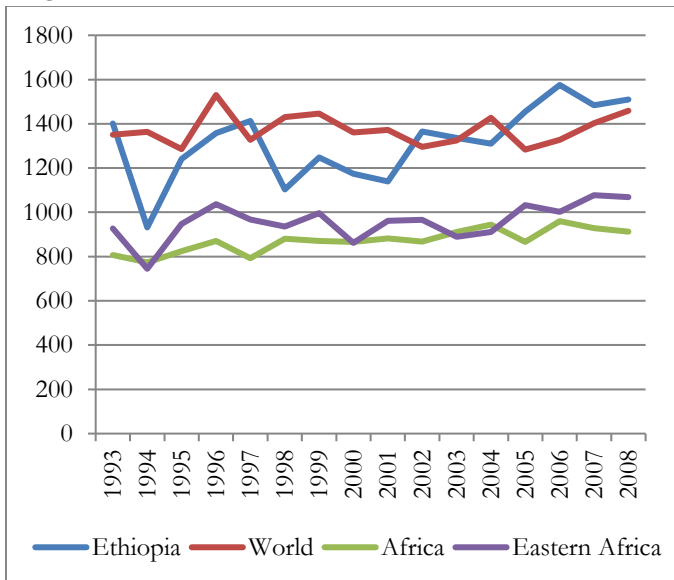


* Ethiopia's main cereal crops are teff, sorghum, barley and wheat. Teff production is likely the crop captured in this category.

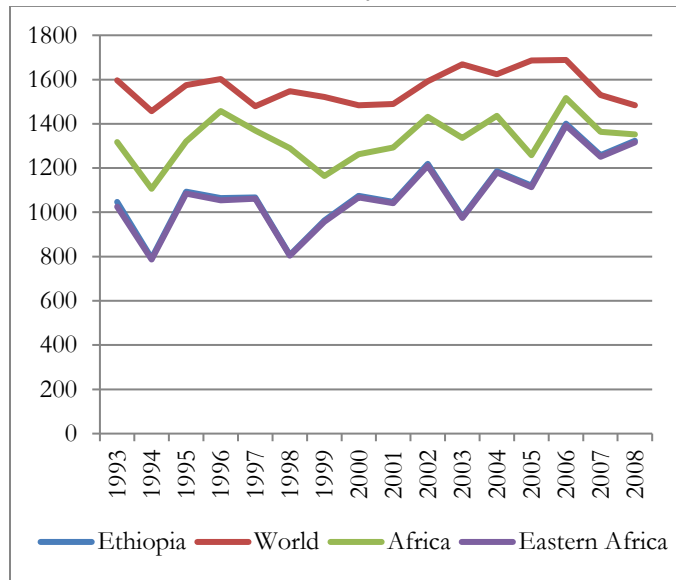
Wheat



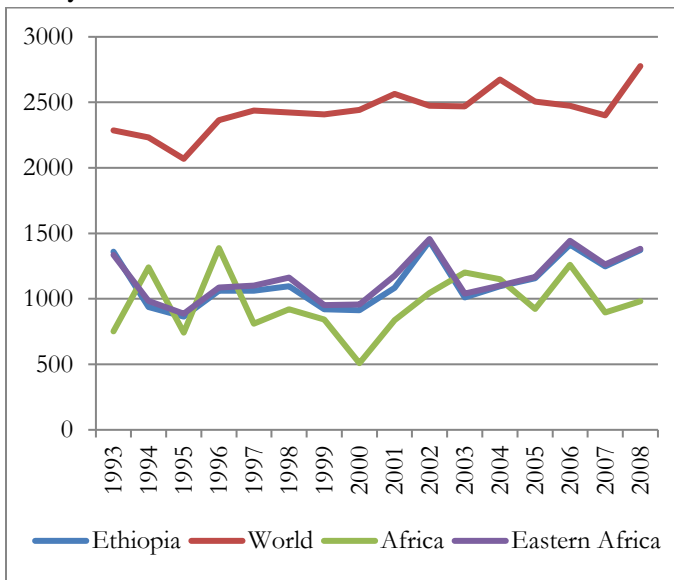
Sorghum



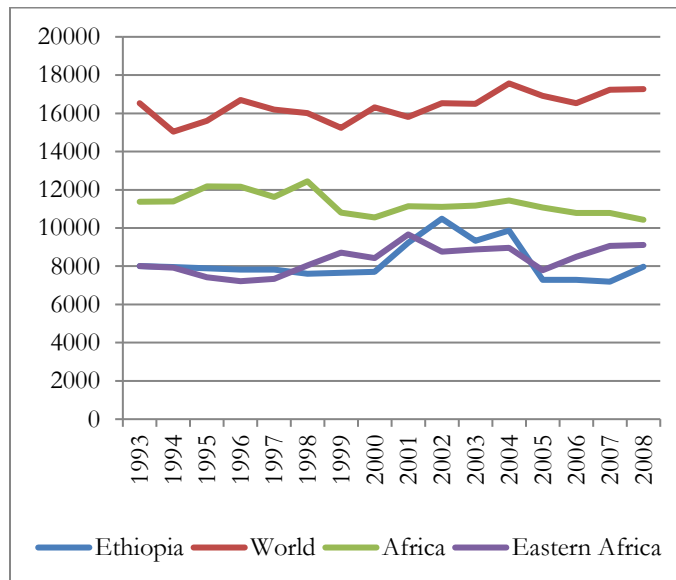
Broad beans, horse beans, dry



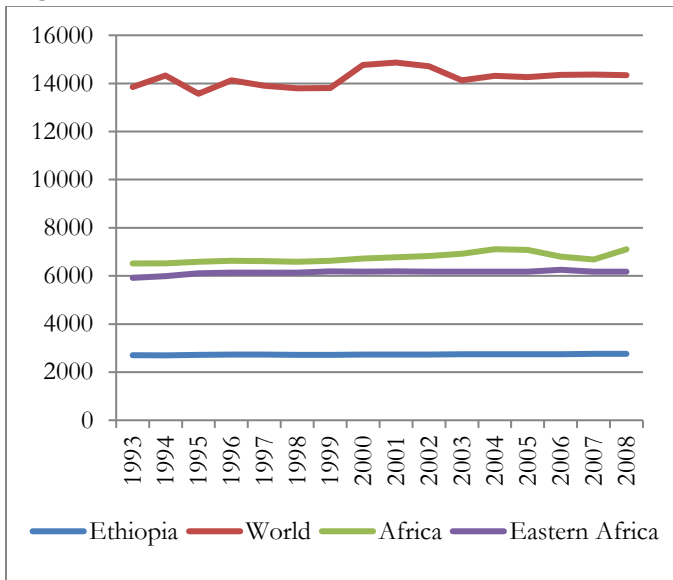
Barley



Potatoes

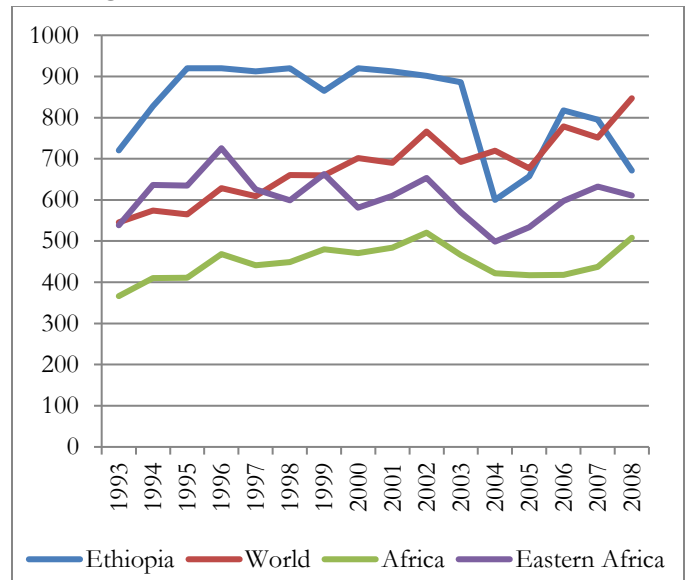


Vegetables, fresh, not elsewhere specified

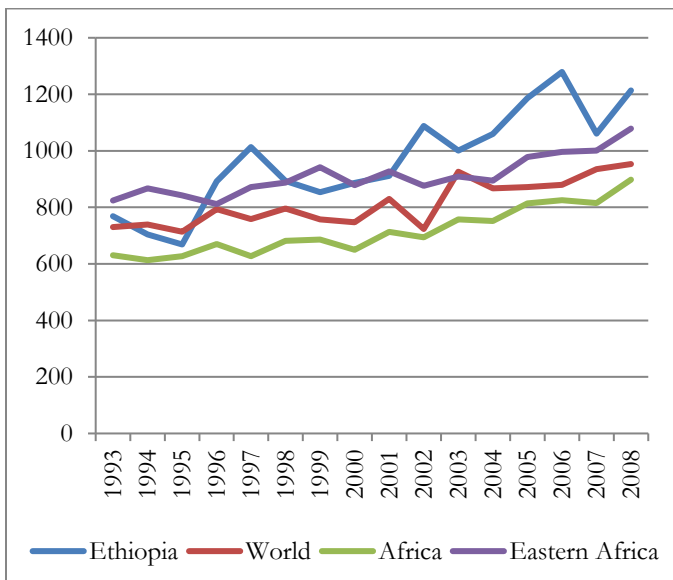


*Ethiopia's vegetable crops (all minor crops) are Ethiopian mustard (kale), pumpkin, chili, cabbage tree and okra. All of these, except chili, are likely reported in this category.

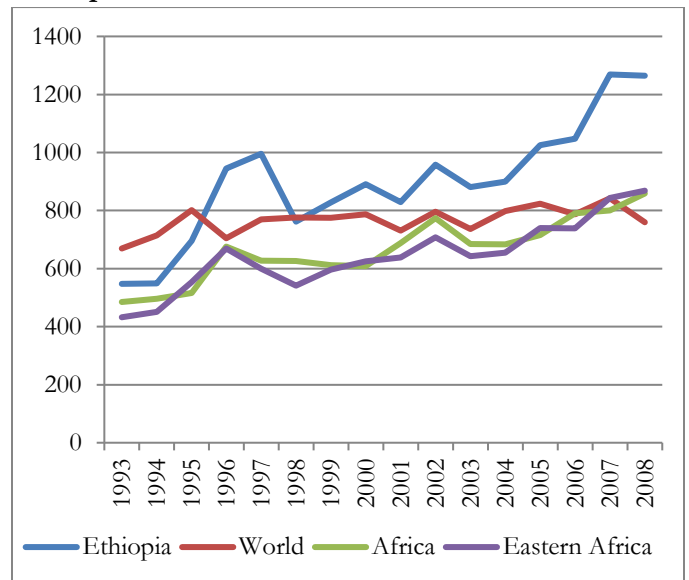
Coffee, green



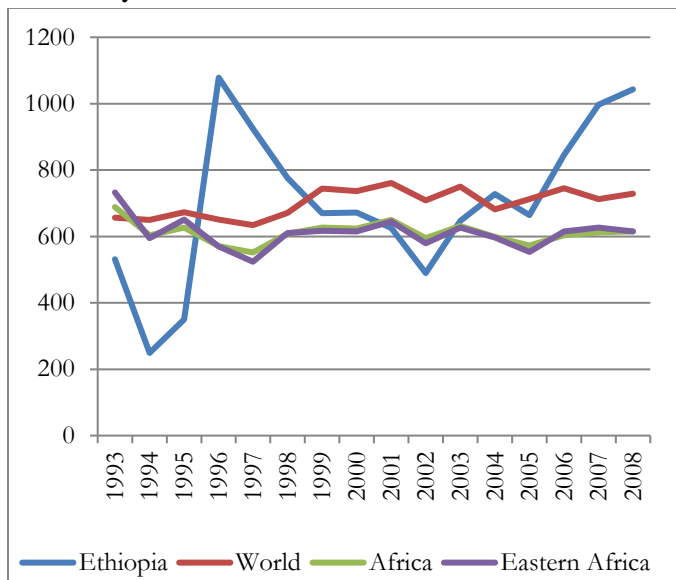
Millet



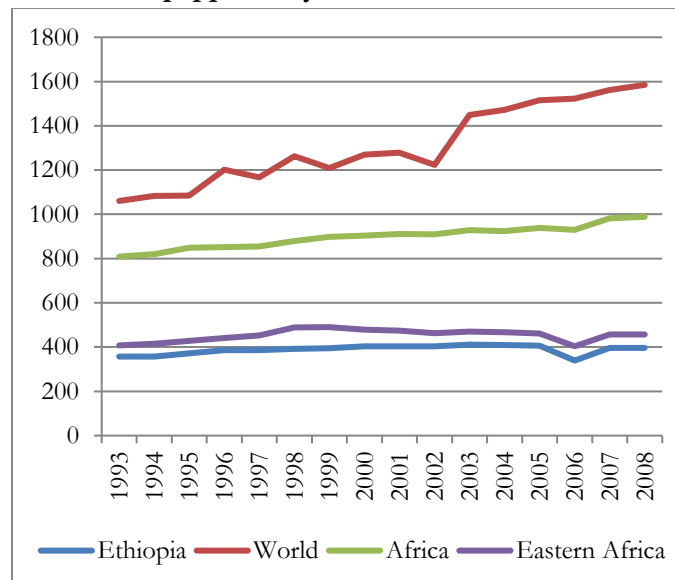
Chick peas



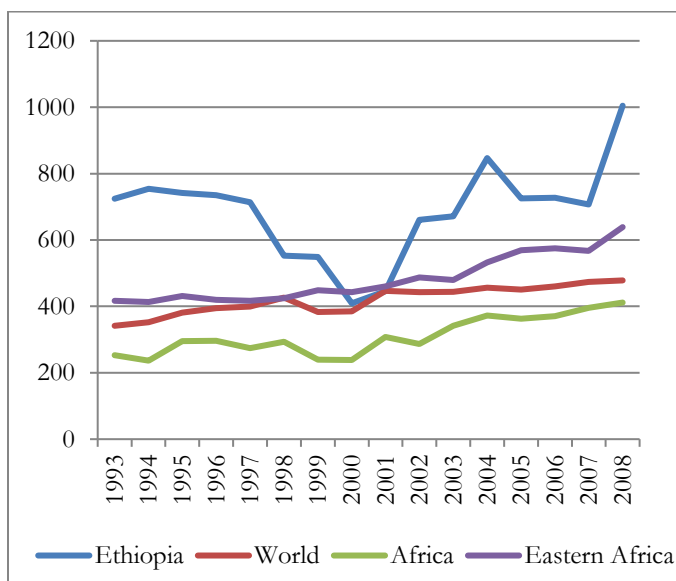
Beans, dry



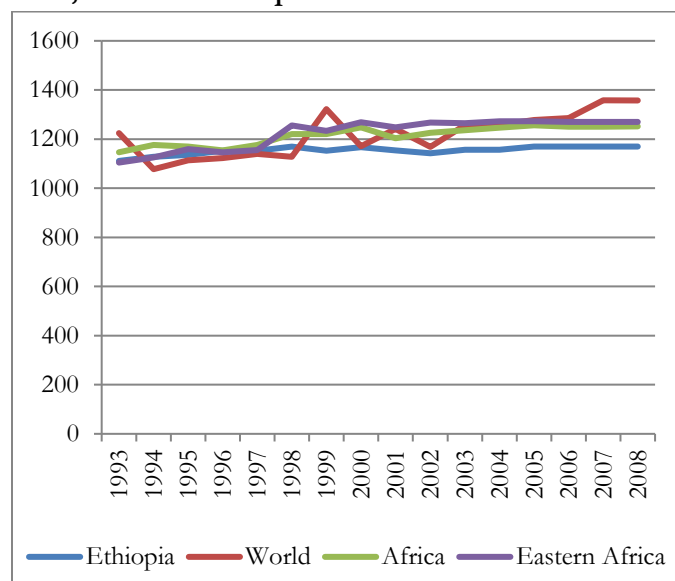
Chillies and peppers, dry



Sesame seed

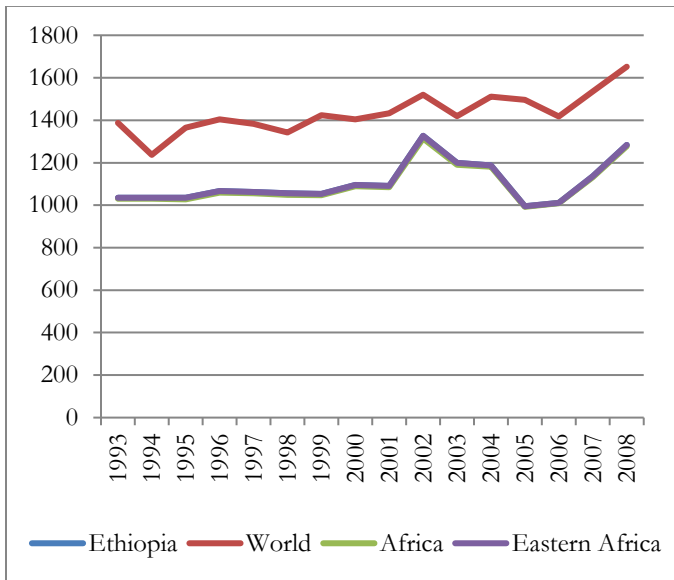


Nuts, not elsewhere specified



*This label includes pecan nut, butter or swarri nut, pili nut, Java almond, Chinese olives, paradise or sapucaia nut, Queensland, macadamia nut and pignolia nut. It is unclear what nuts are reported in this category for Ethiopia.

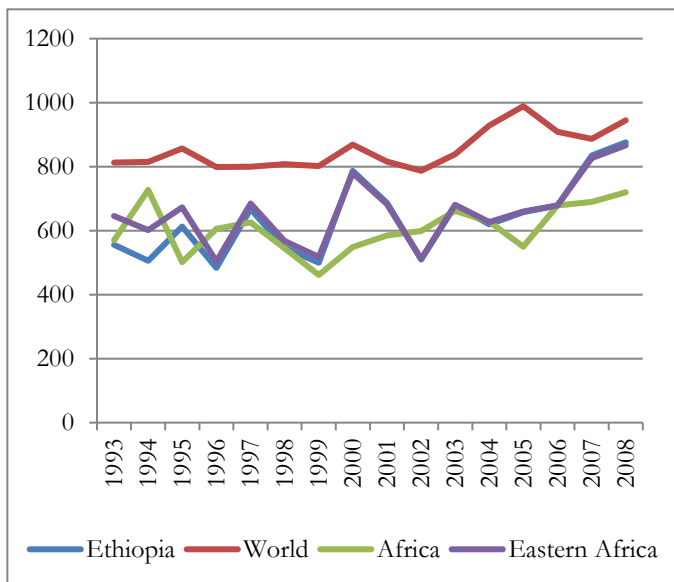
Hops



Source: FAOSTAT

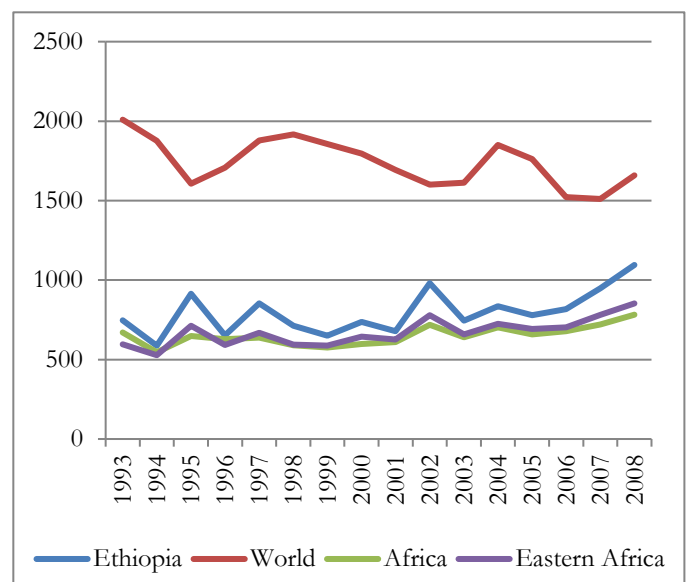
Additional Yield Data for Minor Pulses, (Kg/Ha), 1993–2008

Lentils



Source: FAOSTAT

Peas



Source: FAOSTAT

Appendix 4. Cultivated Seed Varieties

	Landrace	Improved
Wheat Bread wheat	Ktar (HAR 1899), Tura (HAR 1775), Simba (HAR 2536), Hawi (HAR 2501), Dodota (HAR 2508), Watera (HAR 1920), Shena (HAR 1868), Meda welabu (H1480AR), Sof Omar (HAR 1889), Sirbo (HAR 2192), Dure (HAR 1008), Guna (HAR 20292029), and KBG-0 (FH-1-7A).	Dereselign, k-6290-Belik, k-6295-4A, ET 13, Paven 76, Mitike (HAR 1709), Wabe (HAR 710), Kubsa (HAR 1685), Galema (HAR 604), Abol (HAR 1522), Megal (HAR 1595), Tuse (HAR 1407)
Durum wheat	Data unavailable	DZ 04-118 (Arendet), DZ 04-668 (Maru), Kokerit 71, Jerardo, LD 357, Buhe, Foka, Klinto, Bichena, Tob 66 (arsi robe), Quami, Assassa, Robe, and Ginch.
Emmer wheat	Data unavailable	Data unavailable
Sorghum	Data unavailable	Dinkmash 86 (ICSV I), Melkamash 79 (Diallel Pop 7-682), Kobomash 76 (NES-830x705), Seredo, 76T1#14, 76T1#19, 76T1#23, 76T1#16, Medo (M36121), Teshale (3443-2-OP), Gubiye (P9401), Abshir (P9403), Birham (PSL5061), IS9302, IS9323, Red Swazi, Macia, Yeju (ICSV 111Inc), Hormat (ICSV 1112BF), Tadesse (KNE#1098), Padet (KNE#409), Boneya (KNE#411), Kola-1 (ICMV 221)
Maize	Kuleni, A 511, Rare 1 (EV 1), Alemaya composite, UCB, Guto, Abo Bako, Gibe composite 1, and Gamella composite (gusaw)	BH 660, 140, 540, 530, and 670; PHB 3253, 30 F 19 (ajeb); 30 H 83 (tabor); HB 30 G 97 (shendi), and BH QPM 542
Teff	Gea-Lamie, Dabi, Shewa-Gimira, Beten, Bunign, Alba, Ada and Enatit	DZ-01-974, DZ-01-354, DZ-Cr-37, DZ-01-196, DZ-01-787
Lentils	Lens culinaris Medikus; Lens ervoides	Chalew (ILL 358), Chekol (ILL 2704), Adaa (ILL 6027), Gudo (ILL5748), and Alemaya (ILL 6821), ADAA FLIP-86 41L (recommended for export)
Peas	P. sativum subsp. abyssinicum	Data unavailable

Sources: Ethiopian Commodity Exchange, 2009; Adugna, 2007; Ethiopian Export Promotion Agency, 2004; ICARDA, 2003; Fikiru, Tesfaye & Bekele, 2007; Institute of Biodiversity, 2008; Tesfaye, 2000; Ketema, 1997

Endnotes

- ¹ Rashid, 2010
- ² USDA Foreign Agriculture Service, 2003
http://www.fas.usda.gov/pecad2/highlights/2002/10/ethiopia/baseline/Eth_Crop_Production.htm
- ³ Rashid, 2010
- ⁴ <http://www.wfp.org/countries/ethiopia>
- ⁵ Ethiopian Export Promotion Agency, 2004
- ⁶ Lobell, Vassman & Field, 2009
- ⁷ FAO, 2004
- ⁸ Lobell, Vassman & Field, 2009
- ⁹ Waddington et al, 2009
- ¹⁰ Waddington et al, 2009
- ¹¹ FAOSTAT, Author's calculations based solely on yield data and ignoring price and other factors.
- ¹² Stephen Waddington, Personal Communication
- ¹³ Waddington et al, 2009
- ¹⁴ Waddington et al, 2009
- ¹⁵ Waddington et al, 2009
- ¹⁶ Waddington et al, 2009
- ¹⁷ Rashid, 2010
- ¹⁸ Ethiopian Commodity Exchange, <http://www.ecx.com.et/commodities.aspx>
- ¹⁹ Ethiopian Commodity Exchange, <http://www.ecx.com.et/commodities.aspx>
- ²⁰ Waddington et al, 2009
- ²¹ Wortmann et al, 2009
- ²² Wortmann et al, 2009
- ²³ Wortmann et al, 2009
- ²⁴ Waddington et al, 2009
- ²⁵ Adugna & Tesso, 2006
- ²⁶ Adugna, 2007
- ²⁷ Stephen Waddington, Personal Communication
- ²⁸ Waddington et al, 2009
- ²⁹ Waddington et al, 2009
- ³⁰ Waddington et al, 2009
- ³¹ Waddington et al, 2009
- ³² Adugna & Tesso, 2008
- ³³ FAOSTAT
- ³⁴ Wortmann et al, 2009
- ³⁵ Rashid, 2010
- ³⁶ Waddington et al, 2009
- ³⁷ Wortmann et al, 2009
- ³⁸ Wortmann et al, 2009
- ³⁹ Waddington et al, 2009
- ⁴⁰ Gibbon, 2007
- ⁴¹ Gibbon, 2007
- ⁴² Gibbon, 2007
- ⁴³ Ethiopian Institute of Agricultural Research, Raw data, 2005
- ⁴⁴ Author's calculations
- ⁴⁵ FAOSTAT, Author's calculations based solely on yield data and ignoring price and other factors.

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