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Can Ethiopia feed itself by 2050? Estimating cereal self-sufficiency to 2050

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Introduction

Photo: Georgina Smith / CIAT.

Producing adequate food to meet global demand by 2050 is widely recognized as a major challenge, particularly for sub-Saharan Africa (SSA) (Godfray et al. 2010; Alexandratos and Bruinsma 2012; van Ittersum et al. 2016). Increased price volatility of major food crops (Koning et al. 2008; Lagi et al. 2011), an abrupt surge in land area devoted to crop production in recent years (Grassini et al. 2013) and extensive labour force mobilization (NEPAD 2013) reflect the powerful forces underpinning this challenge to increase production. The 2008 price spikes triggered the Food and Agriculture Organization of the United Nations (FAO) and the World Food Programme (WFP) to issue warnings, noting the 60–70 percent increase in food production by 2050 that will be needed to meet the escalating food demand for the expected 9.7 billion global population. **In this policy brief we focus on the feasibility to meet such increase by 2050 with scenarios of population increase and dietary changes under current climate conditions.** Current climate variability is very high in sub-Saharan Africa causing significant yield variations across years (e.g., Shiferaw et al. 2014; www.yieldgap.org). Climate change will further add to the food production challenge (Porter et al. 2014; Vermeulen et al. 2012; McKersie 2015). Smallholder farmers will need to adapt to a changing climate while at the same time they are expected to increase production in such way that it has a minimum effect on the drivers of climate change, i.e. mitigating greenhouse gas emissions.

A number of studies argue that it is possible to meet projected global food demand using existing agricultural land by narrowing yield gaps between actual farm yields and yield potential (Koning et al. 2008; Tilman et al. 2011; Foley et al. 2011; Mueller et al. 2012; Mauser et al. 2015; Pradhan et al. 2015; Erb et al. 2016). Although meeting the increased global demand may be possible, a more pressing question is whether and how different regions of the world can meet their respective demands for staple food crops. More specifically, despite the fact that Africa's current self-sufficiency ratio in staple cereals is ca. 0.8, it is among the regions with the lowest cereal self-sufficiency percentage, while it faces the greatest projected increase in population by 2050 (UN 2015; Sulser et al. 2015). Self-sufficiency is defined here as the ratio between domestic production and total consumption (or demand); the latter is assumed to be equal to domestic production plus net imports.

While recognizing that food self-sufficiency is not an essential precondition for food security, self-sufficiency for low-income developing countries is of great concern because many lack adequate foreign exchange reserves to pay for food imports and the infrastructure needed to store and distribute food efficiently. Cereals make up about 50 percent of Africans' caloric intake and account for about 50 percent of the cropland area in SSA (FAOSTAT 2015). In this policy brief, future self-sufficiency for five main cereals—maize, sorghum, millet, wheat, and rice—is reported for Ethiopia, where these five crops make up 40 percent of the total arable crop area. The production and consumption of these five cereals is expressed in maize equivalents. The reported findings are based on a recent publication in the *Proceedings of the National Academy of Sciences of the United States of America* (van Ittersum et al. 2016).

Current cereal self-sufficiency and trends in Ethiopia

Ethiopia's current cereal self-sufficiency is estimated at 0.95, using 2010 as the reference year. Future cereal self-sufficiency in Ethiopia will depend on the increase in national population, dietary changes, yield increases, and area expansion. The national population in 2010 was 87 million (UN 2015). Population scenarios for 2050, developed by the United Nations, project 169 million, 188 million, and 209 million people for low-, mid-, and high-fertility scenarios, respectively. In other words, the population is expected to approximately double by 2050. Because of anticipated income growth and associated dietary changes, cereal demand in 2050 is expected to increase by a factor of 2.4 relative to 2010 (van Ittersum et al. 2016). In this paper we focus on maize as an example as it is the dominant cereal in SSA, in terms of production and consumption, with on average the largest absolute yield gap. Note that the future cereal self-sufficiency scenarios presented later are based on the yield trends and yield potential of each of the five cereal crops, taking into account the area share of each.

Over the last two decades, the maize sector, as an example, has experienced unprecedented transformation in Ethiopia. The average actual maize yield (2003–2012) was 2.2 tons per harvested hectare, according to authors' calculation based on Central Statistical Agency (CSA – Ethiopia) Sample Survey data (http://www.csa.gov.et/survey-report/category/59-agricultural-sample-survey-belg). Maize yields have doubled from around 1.6 t/ha in 1990 to more than 3 t/ha in recent years, the highest level in SSA after South Africa. Important reasons for the increased yields include increased availability and use of modern inputs (e.g., modern varieties and fertilizer), better extension services and

Rehabilitated landscape in Debre Berhan, central Ethiopia.

increasing demand (Abate et al. 2015). Despite the rapid yield growth, our research results (van Ittersum et al. 2016) show that considerable opportunities still exist for further yield increase. Yield levels in Ethiopia are still much lower than those achieved in other parts of the world, such as United States and Argentina. The water-limited or rain-fed yield potential of maize in Ethiopia is very high with an average value of 12.5 t/ha. It ranges from over 18.1 t/ha in western Ethiopia to 6.2 t/ha in eastern Ethiopia. Water-limited yield potential assumes crop growth under rain-fed conditions with perfect crop management that avoids limitations from nutrient deficiencies and reductions from weeds, pests, and diseases. In regions of the world with highly productive agriculture, yields can reach 80 percent of the water-limited yield potential; further yield increases are typically not beneficial from an economic point of view nor desirable from an environmental perspective due to diminishing returns to inputs.

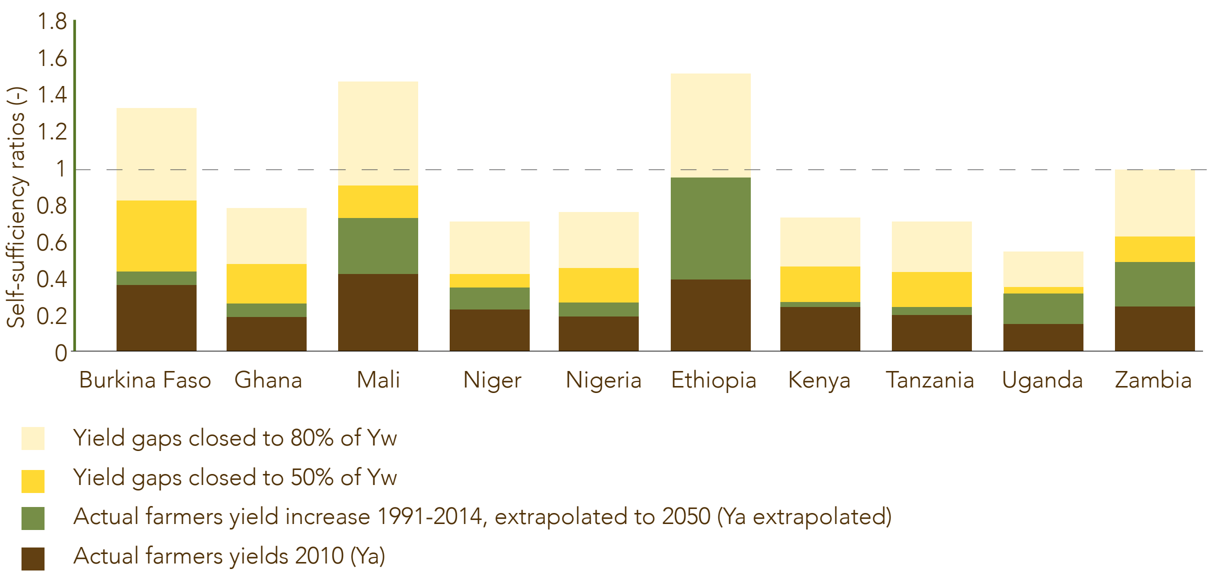
Future cereal self-sufficiency in Ethiopia

Self-sufficiency ratios by 2050 were estimated for four yield increase scenarios for Ethiopia for all five cereals combined. Under the first scenario, based on 2010 actual yields, and assuming no yield changes or area changes until 2050, the self-sufficiency ratio is estimated as 0.45, 0.40 and 0.36 in the low, mid and high population projections, respectively (see Figure 1). Under the second scenario, extrapolating the average yield increases observed between 1991 and 2014 to 2050, the self-sufficiency ratio is 1.08, 0.96 and 0.87 in the low, mid and high population projections, respectively. This second scenario has yields keeping approximately pace with population and demand growth. It leads to yield levels similar to the third scenario, under which yields reach 50 percent of their water-limited potential. The second scenario suggests that current relatively high annual yield increases have to be continued till 2050 to retain today's self-sufficiency levels in Ethiopia's five main cereals.

Under the fourth scenario, if farmers raise yields to 80 percent of their water-limited potential by 2050, self-sufficiency ratios exceed one: 1.53 (1.71, 1.38) in mid (low, high) population projections, making Ethiopia a net exporter of cereals.

Required yield and crop area increases in Ethiopia

Current area under the five cereals in Ethiopia accounts for 40 percent (5.8 million hectares [Mha]) of total cropped land (14.6 Mha). Between 2004 and 2013, cropland area increased by 2.8 Mha. Given the current cereal area of 5.8 Mha and the potentially suitable cereal area of 8.2 Mha (Chamberlin et al. 2014), the area required to achieve cereal self-sufficiency of 1 by 2050, under the mid-fertility population scenario, would be 14.6 Mha for the yield scenario based on the 2010 actual farmers' yield, and 6.1 Mha based on an extrapolation of 1991–2014 actual yield increases. Assuming that current yield trend would continue at the same pace until 2050 no significant land expansion would be needed. If yields are increased to 80 percent of their water-limited potential, the cereal area required to reach self-sufficiency is only 3.8 Mha. Hence, further intensification beyond the current yield increase opens opportunities for 2050 to either release land for other purposes or export cereals outside Ethiopia while maintaining self-sufficiency. Exports, because of further intensification, could compensate food deficits in other neighbouring countries and could help avoid biodiversity losses or even stimulate biodiversity bringing some marginal cropland back into forest. Both options would also be very beneficial in terms of greenhouse gas emissions of Ethiopian agriculture.



Source: van Ittersum et al. 2016.

Note: Yield scenarios are as follows: 2010 actual farmers' yields (Ya), actual yield increase 1991–2014 extrapolated to 2050 (Ya extrapolated), yield increased to 50% or 80% of water-limited potential (Yw). Ratios for the 10 countries by 2050, assuming current cereal areas (no expansion) and the mid-fertility population scenario. Note, that for Ethiopia, scenarios with 50% Yw and with Ya extrapolated overlap and hence only one of the two colours is visible.

Figure 1 - Self-sufficiency ratios by 2050, based on various yield increase scenarios of maize, millet, rice, sorghum and wheat (mid-fertility population scenario).

Main messages and implications for agriculture and development policy

Current government policy aims to move Ethiopia toward middle-income-country status through industrialization. Agricultural and industrial production are interdependent—agricultural production will provide food, labour, finances, raw materials, and many other benefits essential to industrialization. Continued increases in productivity and food production by narrowing yield gaps will be important for Ethiopia to realize its development goals.

The demand for cereals is projected to more than double for Ethiopia towards 2050 (relative to the year 2010) due to substantial population growth and dietary changes. The study reveals the significant challenge of keeping up with these projected increases in future cereal demand while also anticipating the effects of on-going climate change resulting in, amongst others, increased yield variability. Continuing the relative high annual yield increases of 1991-2014 on existing cereal land is needed to roughly maintain today's level of self-sufficiency in 2050. While such productivity increase will be very challenging, the situation of Ethiopia is relatively favourable compared to that of other countries in SSA (Figure 1), due to a relatively high yield potential in Ethiopia and a somewhat more modest projected population increase than in other countries. Yet, intensification of agriculture must occur in a sustainable and climate-smart manner, thus minimizing negative environmental impacts, e.g. low emissions to water and atmosphere while increasing adaptive capacity to climate risks. Logically, it should be aligned with the concept of a climate resilient green economy (CRGE).

Continued yield increase for the next 30-40 years will require use of improved cultivars and hybrids (e.g., increased yield potential and increased resistance), and seed, coupled with integrated soil fertility management, nutrient management according to 4 R principles, soil and water

conservation, and modern pest management practices; in short good agronomy. With such agronomy current rates of yield gain can continue sustainably (Abate et al. 2015; Sanchez 2015).

However, further intensification will require greater investment in research and development (R&D) in both public and private sectors. This investment is needed now, and will be even more urgent under future climate change. Investments in agricultural R&D must be matched by enabling policies and public finance for improved transport and communication, market infrastructure, credit, insurance, and improved land entitlements. In the study's calculations, rainfed cereal production is the dominant form of production. Ethiopia's government may also opt to invest in climate resilient infrastructures such as sustainable irrigation systems (including solar powered), which would lead to higher potential yields and more scope for production increases. Further, an increase in intensity of cropping systems (growing more than one crop per 12 months) may help Ethiopia keep up with the future increase in demand (van Ittersum et al. 2016).

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