Maize Yield Trends and Agricultural Policy in East Africa
Macro-Level Literature Review for Six Countries
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Abstract

Cereal yield variability is influenced by initial conditions such as suitability of the farming system for cereal cultivation, baseline production quantities and yields, and zone-specific potential yields limited by water availability. However, exogenous factors such as national policies, climate, and international market conditions also impact farm-level yields directly or provide incentives or disincentives for farmers to intensify production. We conduct a selective literature review of policy-related drivers of maize yields in Ethiopia, Kenya, Malawi, Rwanda, Tanzania, and Uganda and pair the findings with FAOSTAT data on yield and productivity. We consider three broad sources of maize yield variability: policy incentives and the broader enabling environment, biophysical and climate factors, and international shocks to supply and demand. This report presents our cumulative findings along with contextual evidence of the hypothesized drivers behind maize yield trends from 1993 to 2013 for the selected countries.

Key Cereal Yield Trends over Time

- Most countries in this report have experienced steady growth in cereal yields, or at least slow growth over time. Exceptions to this overall trend include highly volatile maize yields in Tanzania, as well as major fluctuations in paddy and wheat yields in Kenya, rapid growth in paddy yields in Rwanda, and a divergence in Rwanda over the last several years as sorghum and millet yields decreased while paddy and maize yields increased.
- In Ethiopia, Malawi, Rwanda, and Uganda, maize yields have risen since 2003 as both production quantity and area harvested have increased. In Kenya and Tanzania, maize production quantity and area harvested have risen only slightly, while yields have remained constant or declined.

Notable Policy Events and Maize Yield Trends

Attributing change to policy or regulatory events is extremely difficult because of the many simultaneous confounding factors (including climate events in any single year) and because behavior change, if it occurs, can precede, coincide with, or lag the policy implementation. Though we cannot attribute causal change to the policy interventions in this review, we highlight several observed associations between maize yield trends and policy factors at the national level.

- Though most of the focus countries liberalized their markets in the early 1990s, some have minimal state intervention (Uganda, Tanzania), while others have more developed subsidy, extension, and price

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stabilization programs (Ethiopia, Malawi). Cereal yields have increased in Ethiopia over this time, though they have stagnated or been volatile in Malawi, Tanzania, and Uganda.

- During the food price crisis of 2007-2008, yields trended differently depending on whether the country tended to import or export maize. Production and yield jumped in the net exporters Uganda and Rwanda, while yield fell in Malawi and Kenya which imported maize during the crisis.
- The establishment of Ethiopia's input program in 1994 coincides with some increase in maize yields, though this was also a time of political conflict. The largest yield increase over the 20-year period was 2006, which was preceded by the end of a drought and an increase in cereal prices. Though maize yields have increased in Ethiopia over the last two decades, input use remains low relative to neighboring countries, and some authors argue that inflexible input packages have contributed to low rates of input use. However, since 2007, donor agriculture expenditures have been high and yields have increased steadily.
- Kenyan maize yield rose in 1994 as smallholder farmers gained access to fertilizer through private sector cooperatives, maize meal prices were deregulated, and import tariffs were removed. Another increase in yield in 2010 was preceded by an Economic Stimulus Program, adoption of a National Land Policy, and an input subsidy and distribution program. Though national agriculture spending rose after the introduction of these programs, it has subsequently decreased, and yields have remained constant since 2010.
- Malawi's Input Subsidy Program (ISP) started in 2005, a year prior to increases in maize yield despite rising fertilizer and transportation costs. Yield continued to rise the following year, after the Growth and Development Strategy was established in 2006. Malawi's total agriculture expenditure is among the highest in East Africa, but yields have remained relatively constant since 2009.
- Tanzania's increase in maize yield in 2010 followed the introduction of fertilizer vouchers and tax exemptions in 2009. National agricultural spending increased from 2007 to 2010, but then dropped, as have yields.
- Rwanda's maize yield began to rise after 2007 and continued to rise through 2011, preceded by a Crop Intensification Program and Economic Development and Poverty Reduction Strategy (though the evidence base for determinants of yield in Rwanda and the role of the regulatory environment is particularly weak). Though maize yields leveled out after 2010, production has continued to grow steadily.
- Uganda's maize yield increased dramatically in 2008 during the world food crisis and an increase in the domestic price of maize. Donor and national agriculture expenditures peaked in 2010 following a drought, but have declined since, while yields have increased gradually. Uganda's markets are highly liberalized and public interventions in agriculture are infrequent.

Introduction

Maize is commonly grown and widely traded in domestic and international markets in Sub-Saharan Africa, and exhibits high variability in yields among countries. Maize and other cereal yield variability is influenced by initial conditions such as suitability of the farming system for cereal cultivation, baseline production quantities and yields, and zone-specific potential yields limited by water availability. However, exogenous factors such as national policies, climate, and international market conditions also impact farm-level yields directly or provide incentives or disincentives for farmers to intensify production.

We group the major aggregate drivers[1] of yield variability as deriving from policy, biophysical and climate factors, and international shocks, as suggested by the academic literature and national policy reports. The yield effects of biophysical factors such as climate variability, drought, pests and diseases, and soil degradation, as well as global shocks to supply and demand and international prices, are felt across national boundaries. However, national policy decisions and funding allocation affect the availability and affordability of inputs such as land, credit, fertilizer, chemicals, and improved seed, and can also influence accessibility of cereal markets, and input and output price variability, which may lead to diverging yield trends across countries. Policies may be maize-specific (e.g., output price subsidy or export ban), or applicable to all cereals (e.g., fertilizer subsidies). In the case of broader cereals policies, policy shocks may show up across all cereals within a single country, or differentially affect the most "important" or profitable crops.

The extent to which policy, biophysical and climate, or international factors (changes over time or "shocks") can affect maize yields depends on baseline production and yield potential. We therefore begin with a few initial conditions, including farming systems, base maize production levels, and current yield gaps and trends. We compare initial conditions for maize and other cereal crops in Ethiopia, Kenya, Malawi, Rwanda, Tanzania, and Uganda[2] using data from FAOSTAT.[3] We consider the relative importance of maize in national crop production, report on maize yield potential and yield gaps, and compare maize yield trends with yield trends of other main cereal crops in each country.

For all donor and national public expenditure figures, we use data from the Monitoring and Analysing Food and Agricultural Policies (MAFAP) program of the FAO. As with FAOSTAT data, these figures are reported administratively, and may be subject to bias or measurement inconsistency. More information on data sources and methods of analysis is provided in Appendix A.

After establishing some initial conditions, we present our findings in charts and tables relating changes in the national policy environment to maize yield trends for each of the six countries, and offer some initial observations. But within a normal or viable range (e.g., a yield gap), how responsive or malleable farm-level yield is to exogenous determinants such as national policies, public spending, climate variability, and international markets and prices is complex. This responsiveness is influenced, in some cases, by the price, availability and suitability of substitute cereal crops and production options. For example, fertilizer subsidies will prompt an increase in fertilizer use, the magnitude of which is based on its price elasticity of demand. This elasticity is in turn affected by the relative price and substitutability of other inputs, and the relative price and substitutability of the output and the share of cost fertilizer represents (which all affect the net profitability of purchasing fertilizer to increase yield). In the case of precipitation or temperature changes, vulnerability in a

[1] "Aggregate" refers to macro-level trends, rather than plot level variability arising from farm or household management and production decisions.
[2] Maize is not a primary staple crop in Rwanda and Uganda, as it is in Malawi, Ethiopia, Tanzania, and Kenya.
[3] FAOSTAT is a key source of readily available data on agricultural production worldwide, but because the data are reported administratively, some inconsistencies in measurement and classification exist across countries, and yield estimates may vary substantially from calculations from household-level survey data. In a forthcoming sub-national data analysis, we will calculate national yields based on plot-level data for comparison with FAOSTAT published national yield estimates.

rain-fed system is largely determined by the relative biophysical robustness of crops (e.g., sorghum compared to maize). The effect of international market fluctuations depends on how "open" the country is, and the share of maize that is exported. Trade openness is somewhat geographically determined, but is also influenced by national level policies.

We look at several potential climate and international factors over this same time period, but intend for this initial empirical analysis to provide the basis for a discussion identifying the most likely hypotheses of yield variation that can be further explored in the sub-national LSMS-ISA data for selected countries.

Findings: Relevant Initial Conditions for Maize Production

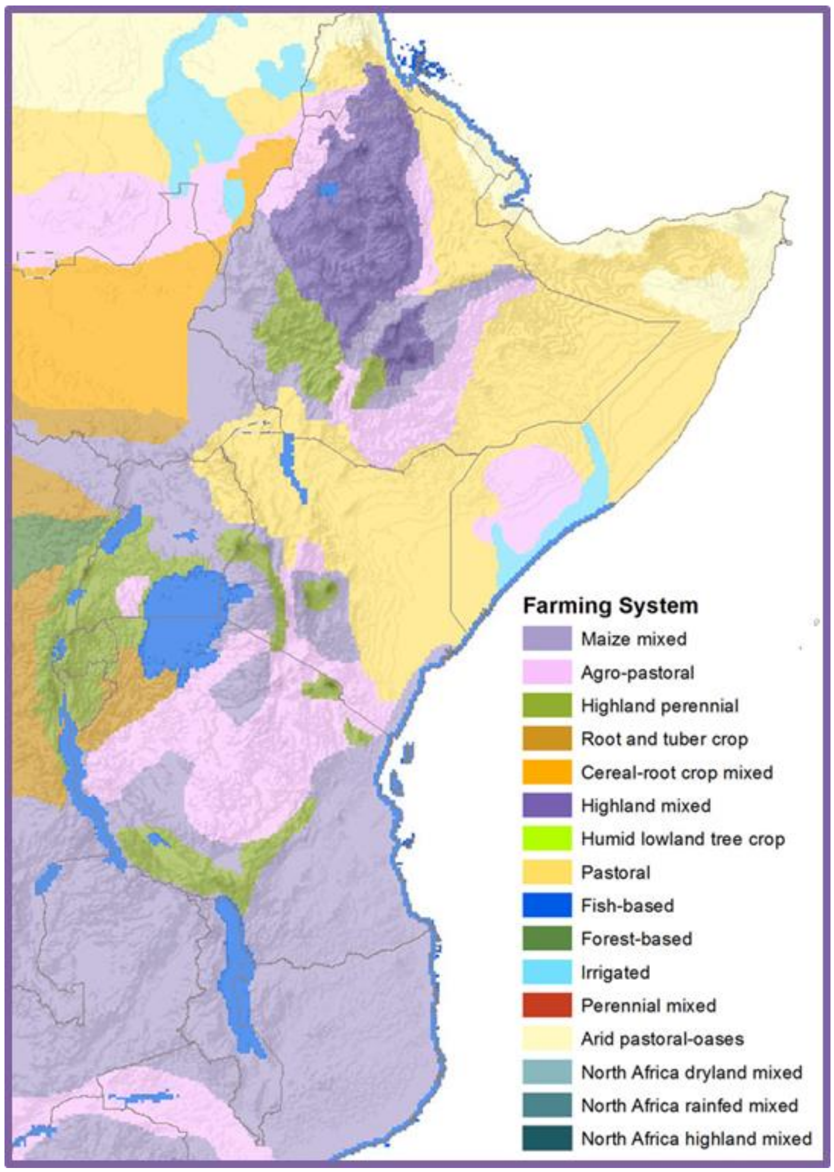
In this section, we summarize the total production of cereal crops, the relative importance of maize as a food crop, the trends in maize production quantity, area harvested, and yield over the last 20 years, and gaps between actual and potential yields for the six countries.

Importance of Maize in National Agricultural Production

The decisions of farmers about what to grow, and of policymakers about which crops to promote, are based on growing conditions and other available resources. Map 1 shows the farming systems in the six focus countries. These range from pastoral systems in the more arid northeast, to maize mixed areas in several countries, and some zones characterized by root and tuber or perennial cropping systems.

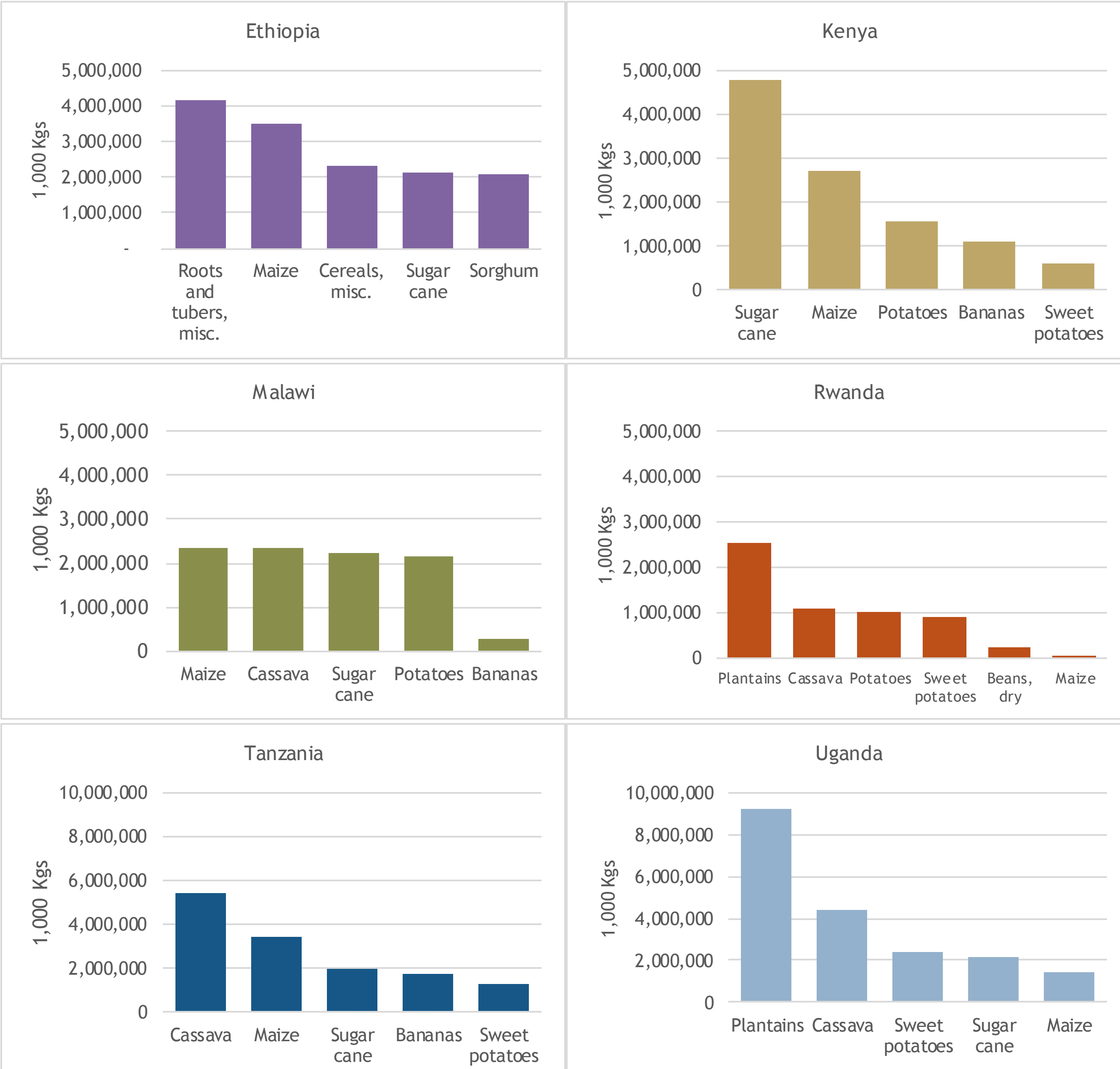
As a result of this wide range of farming systems, maize varies in importance as a staple crop among the focus countries, as illustrated in Figure 1. While maize is a main subsistence crop and the primary cereal grown in Kenya, Tanzania, Malawi, and Ethiopia, it is less important relative to other crops in the root and tuber cropping systems of Uganda and, in particular, in Rwanda, where very little maize is produced.

***Map 1**: Farming Systems of East Africa*



***Source**: Auricht, et al., 2014*

Figure 1*: Top Commodities by Average Production, 1993-2013*[4]



Source*: FAOSTAT, 2013*

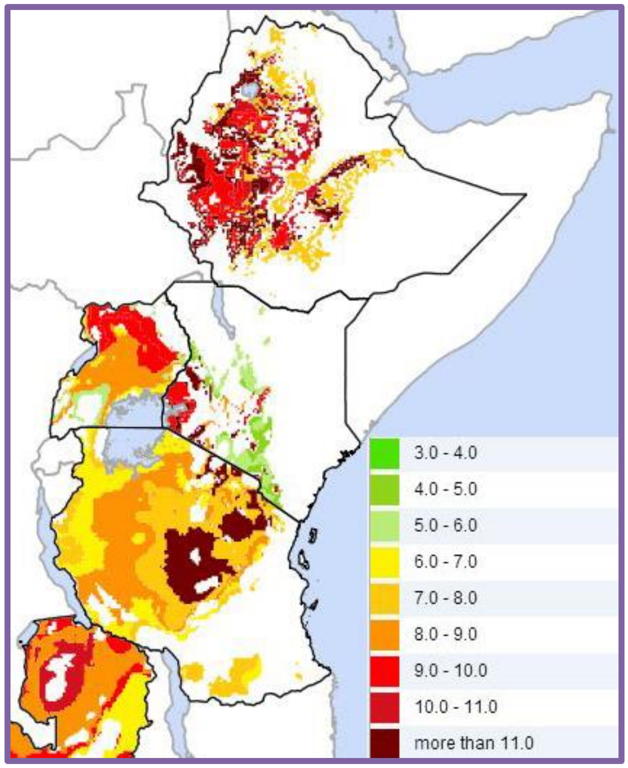
[4] Cereals, misc., as seen on the Ethiopia chart, includes teff, a commonly grown cereal in Ethiopia.

Maize Yield Potential and Gaps

Throughout Sub-Saharan Africa cultivation is predominately rain-fed and the yields of smallholder farmers for maize and other cereal crops are well below the potential yield (defined as the yield when biotic stresses are controlled and water and nutrient availability is not limited). The difference between actual yield and potential yield is shown in Map 2. Maize yield gaps vary widely at the local level, and reach 10,000 kg/ha in certain climate zones in Ethiopia, Kenya, Tanzania, and Uganda (Global Yield Gap Atlas, 2015).

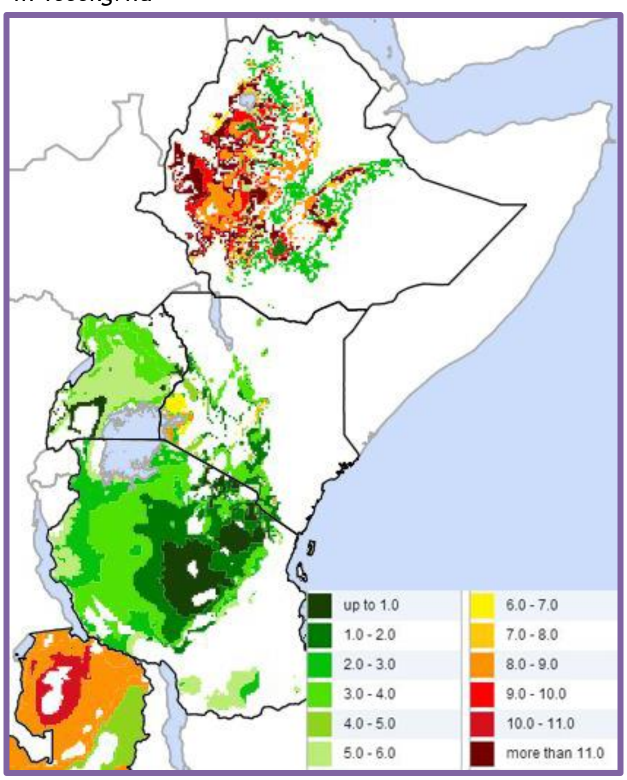
Because access to irrigation systems in Sub-Saharan Africa is uncommon, water-limited yield gaps are often high, as shown in Map 3. Water-limited potential yield is influenced by plot topography and soil type (Global Yield Gap Atlas, 2015). But this portion of the yield gap can be closed by improving management of biotic stresses and using appropriate inputs, even under existing water constraints. As seen in Map 3, parts of Tanzania are achieving maize yields within 1000kg/ha of water-limited potential, while areas in Ethiopia's highlands remain 10,000kg/ha below water-limited potential.

***Map 2**: Absolute Yield Gaps for Maize, in 1000kg/ha*



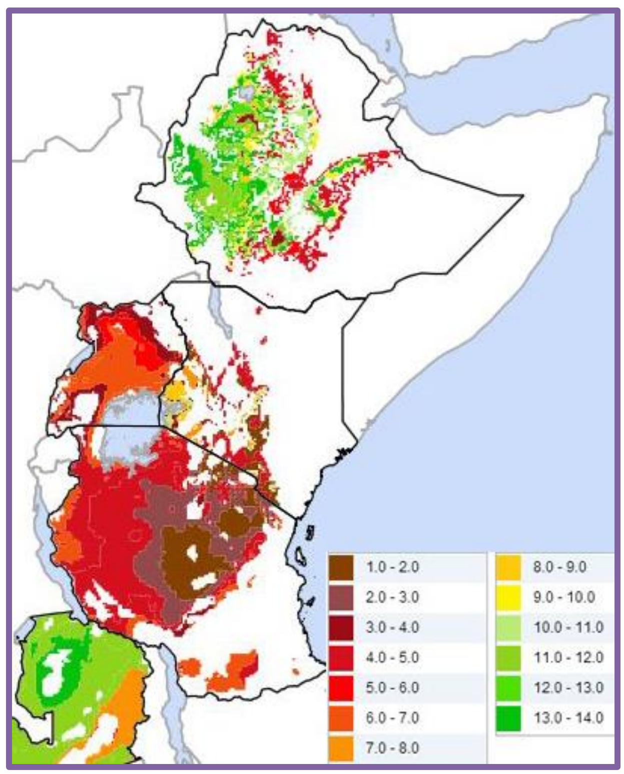
***Source**: Global Yield Gap Atlas, 2015*

***Map 3**: Water-limited Yield Gaps for Rain-fed Maize, in 1000kg/ha*



***Source**: Global Yield Gap Atlas, 2015*

***Map 4**: Water-limited Potential Yield for Rain-fed Maize, in 1000kg/ha*



***Source**: Global Yield Gap Atlas, 2015*

However, some of this cross-country variation in yield gaps is attributable to geographical differences in yield potential: water-limited potential yields are much higher in parts of highland Ethiopia than in Tanzania, Kenya, or Uganda for example (Map 4). According to these data, parts of central Tanzania (those shown in brown in Map 4) are too water-constrained to achieve average maize yields higher than 3000 kilograms per hectare – hence even areas with very low yields may have very low yield gaps due to low yield potential. While parts of northern and western Tanzania do have water-limited potential yields in the range of 4000-6000 kg/ha, the opportunity to narrow yield gaps is much greater in much of highland Ethiopia, which has the potential to achieve yields of 8000-14000 kg/ha without irrigation, with many places seeing yield gaps as high as 6000 kg/ha or more.

Maize Yield Trends

Common crop yield, as calculated by the FAO, divides the total production weight by the land area harvested. Thus, changes in yield at the household as well as the national level can be driven either by changes in the crop quantity harvested, or by changes in the land area cultivated and harvested. Figure 2 shows the trend in production quantity for the six focus countries, with notable volatility but an overall increase over time, even in countries with very low maize production. Figure 3 shows the change in maize cultivated area. In each country, farmers have expanded maize cultivated area since 1993, either by switching land under other crops to maize cultivation, or by expanding into previously uncultivated area. When cultivated area is increased into more marginal lands or by farmers less experienced with maize, national aggregate yields may drop, stay steady, or rise more slowly. The general upward trend in harvested area exhibits a temporary drop between 2005 and 2007 in most countries, and has been particularly dramatic and volatile for Tanzania.

***Figure 2**: Total Maize Production Quantity in Priority Countries, 1000kg (FAOSTAT)*

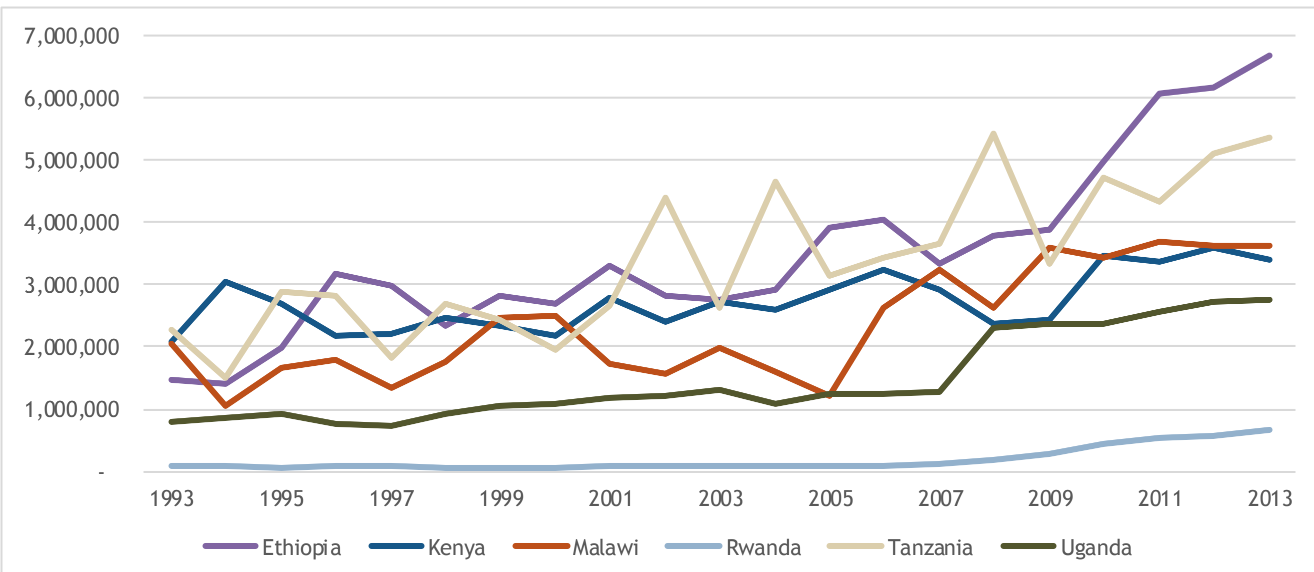
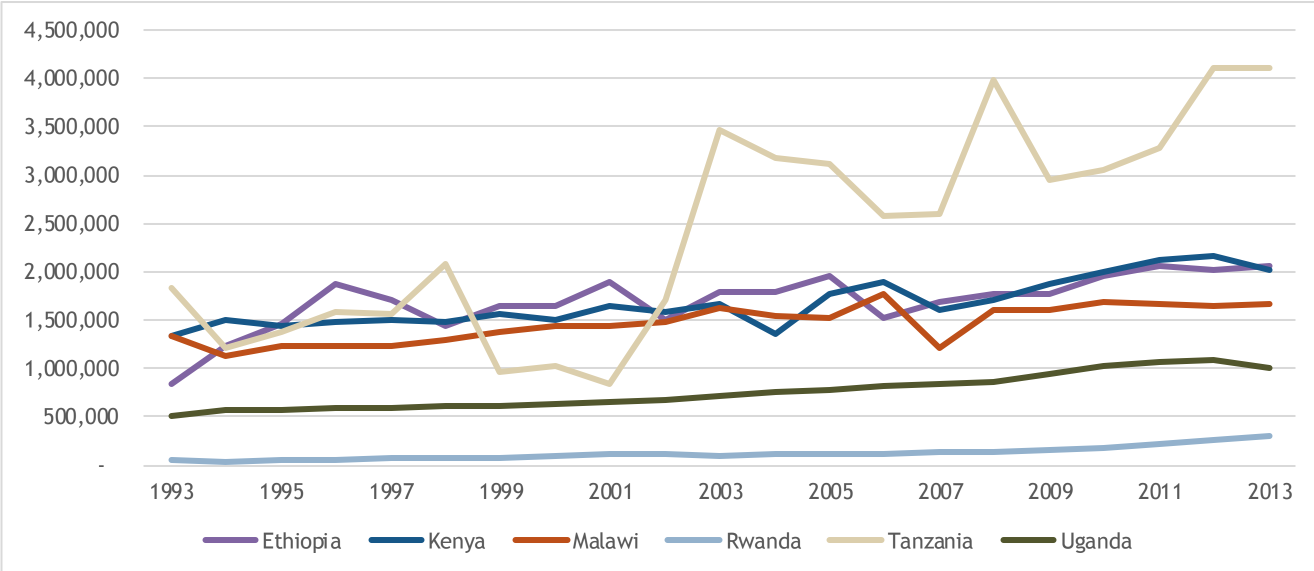
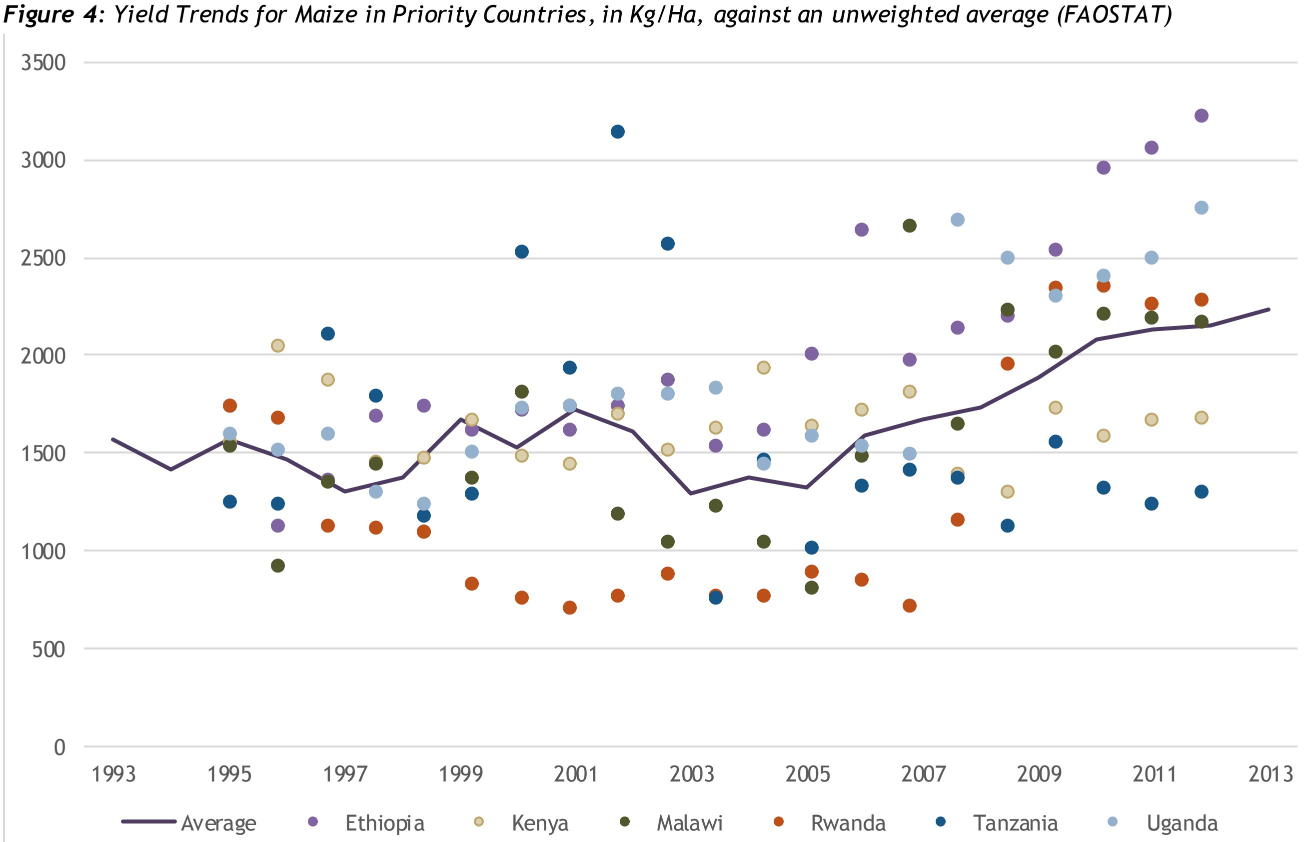


Figure 3*: Total Maize Harvested Area in Priority Countries, hectares (FAOSTAT)*



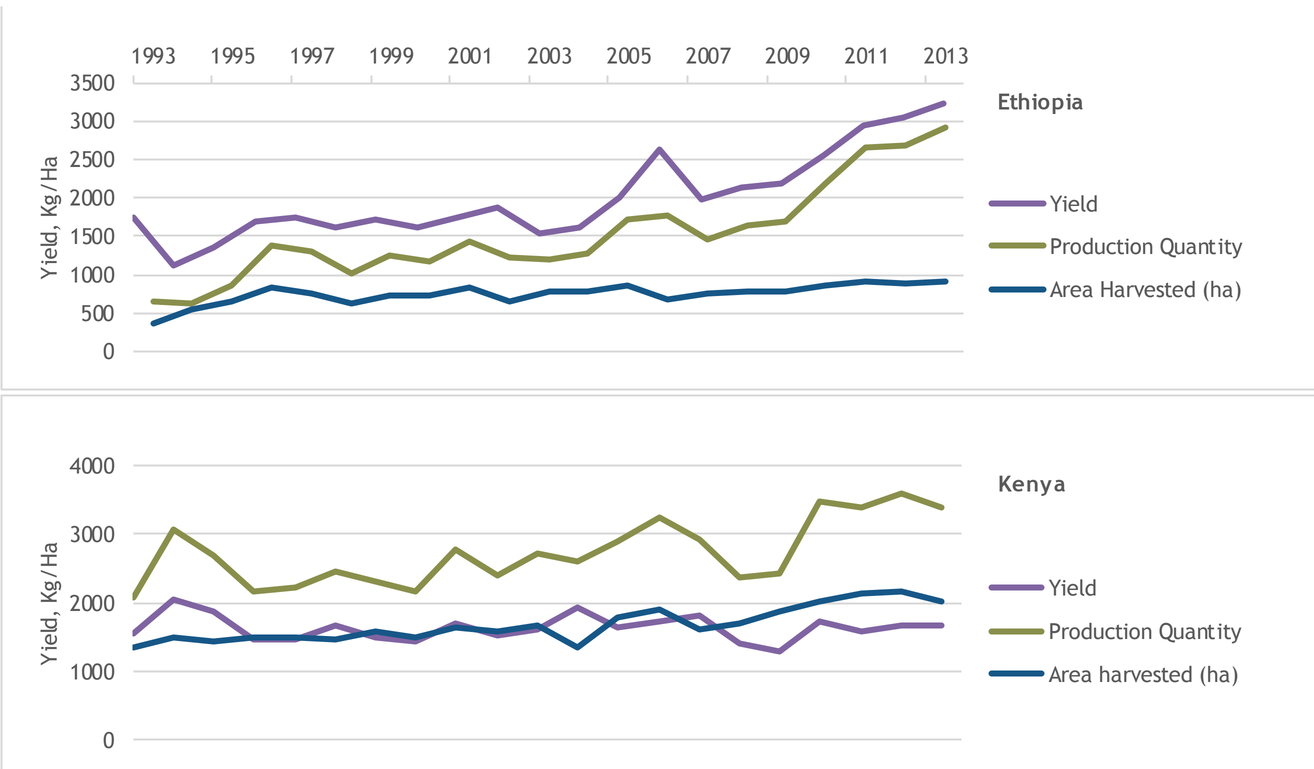
Maize yield estimates from FAOSTAT for the six focus countries indicate that maize yields on average have increased between 1993 and 2013, but that there is variation among countries (Figure 4). The solid line in Figure 4 represents the unweighted average of national-level maize yields over time. Many countries experienced significant overall increases in maize yield, though some have more year-over-year variation than others. The individual country trend lines show the volatility of maize yields over this time period (Figure 5).

Figure 4*: Yield Trends for Maize in Priority Countries, in Kg/Ha, against an unweighted average (FAOSTAT)*

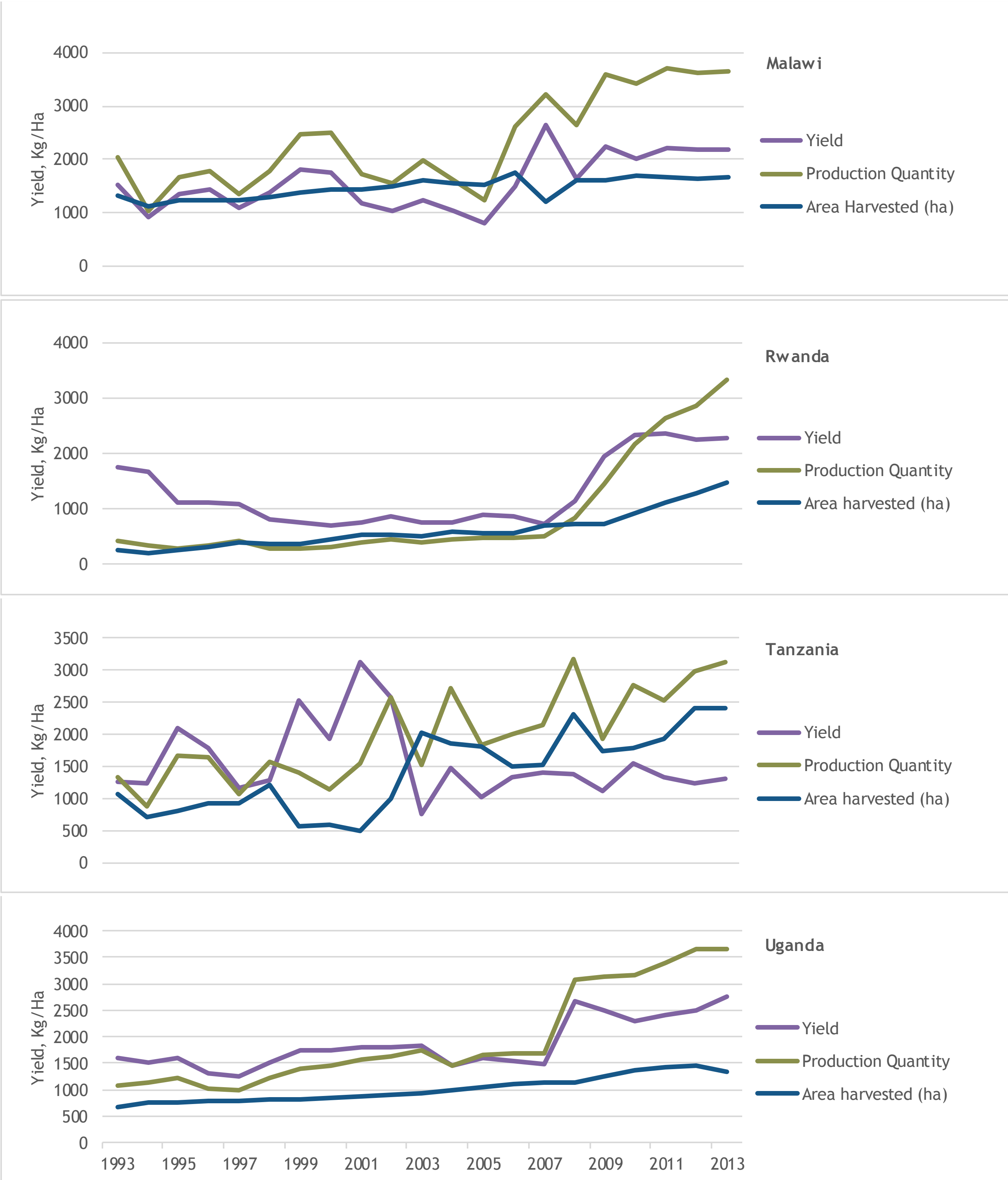


Maize yields appear, on net, to have increased over the past two decades in Ethiopia, Malawi, Rwanda, and Uganda. Maize yield in Ethiopia in 2013 was approximately double that in 1993, with most of the yield gains coming between 2007 and 2013. Malawi's maize yields more than tripled between 2005 and 2007, from 810 to 2680 kilograms per hectare, but appear to have stabilized at just below 2500 kilograms per hectare since then. In Rwanda[5] maize yields increased more than threefold between 2007 and 2011, from 720 to 2340 kilograms per hectare, and have since leveled off. Yields in Uganda have increased by approximately 1000 kilograms per hectare between 1993 and 2013, with the majority of that increase coming between 2007 and 2009. Maize yields do not appear to have increased between 1993 and 2013 in Kenya or in Tanzania. Yields in Kenya have remained fairly steady at around 1500 kilograms per hectare, with slight annual fluctuations. Reported maize yields from Tanzania have generally remained at just under 1500 kilograms per hectare, but we observe larger annual fluctuations than in the other five countries. Although maize yields more than doubled between 1997 and 2001, from 1290 to 3140 kilograms per hectare, in 2003 they dropped to nearly half of the 1998 reported yield amounts, 750 kilograms per hectare.

***Figure 5**: Maize Yield Trends by Country, in Kg/Ha, with Quantity and Area Harvested (FAOSTAT)*



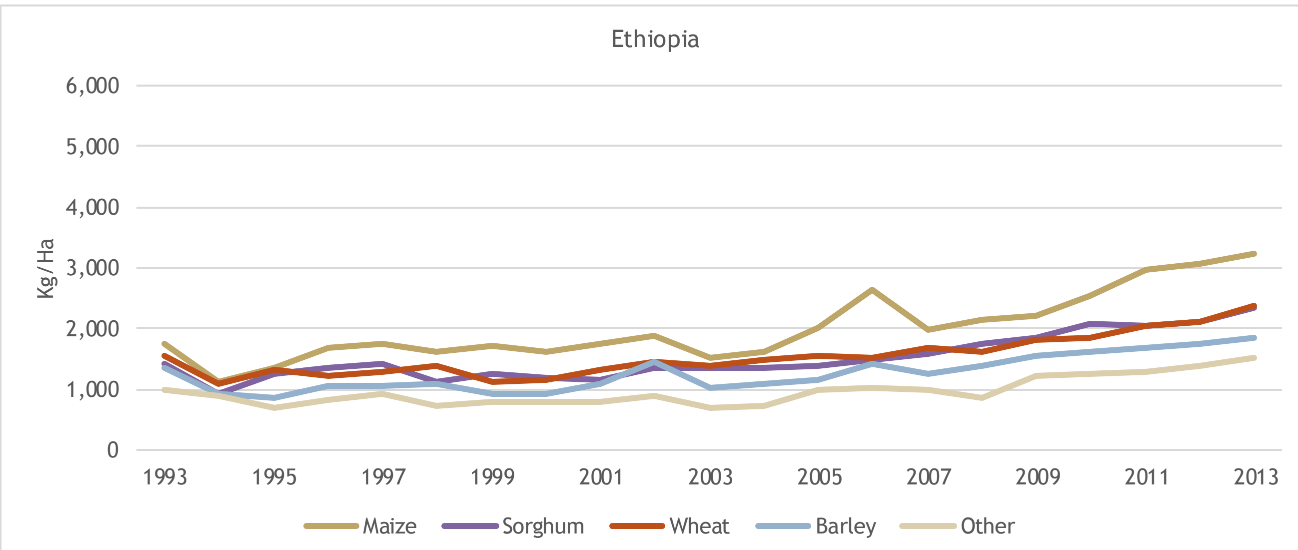
[5] Maize is less commonly grown in Rwanda than in the other countries in this sample (NISR, 2014).

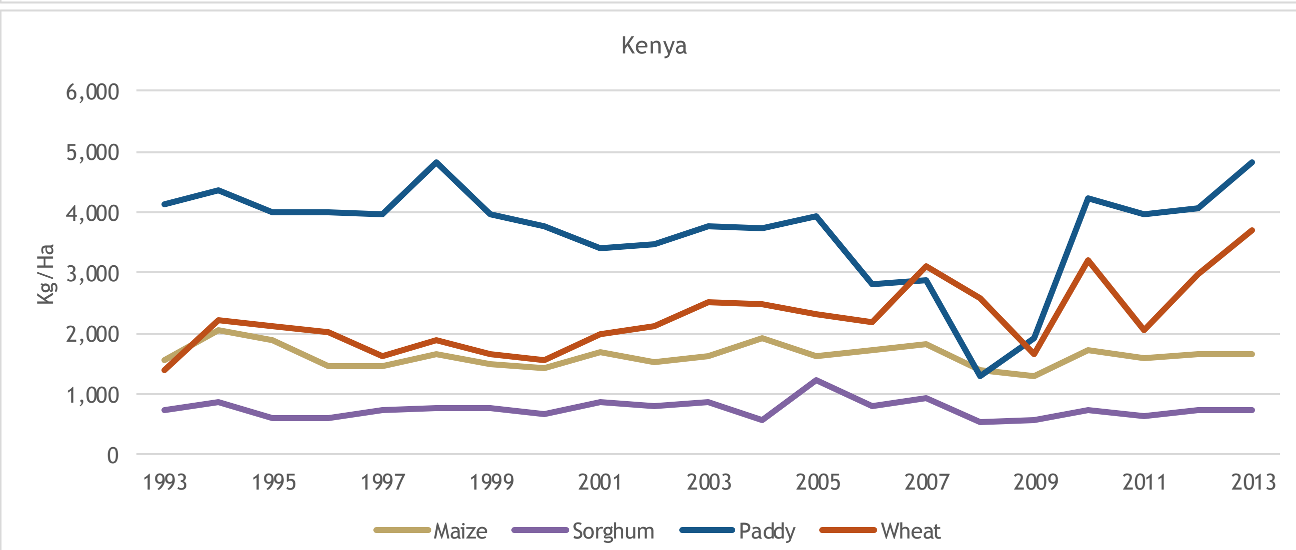

Malawi
Yield, Kg/Ha
4000
3000
2000
1000
0
Yield
Production Quantity
Area Harvested (ha)
Rwanda
Yield, Kg/Ha
4000
3000
2000
1000
0
Yield
Production Quantity
Area harvested (ha)
Tanzania
Yield, Kg/Ha
3500
3000
2500
2000
1500
1000
500
0
Yield
Production Quantity
Area harvested (ha)
Uganda
Yield, Kg/Ha
4000
3500
3000
2500
2000
1500
1000
500
0
Yield
Production Quantity
Area harvested (ha)
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013

Comparing Trends in Yields of Maize and Other Cereals

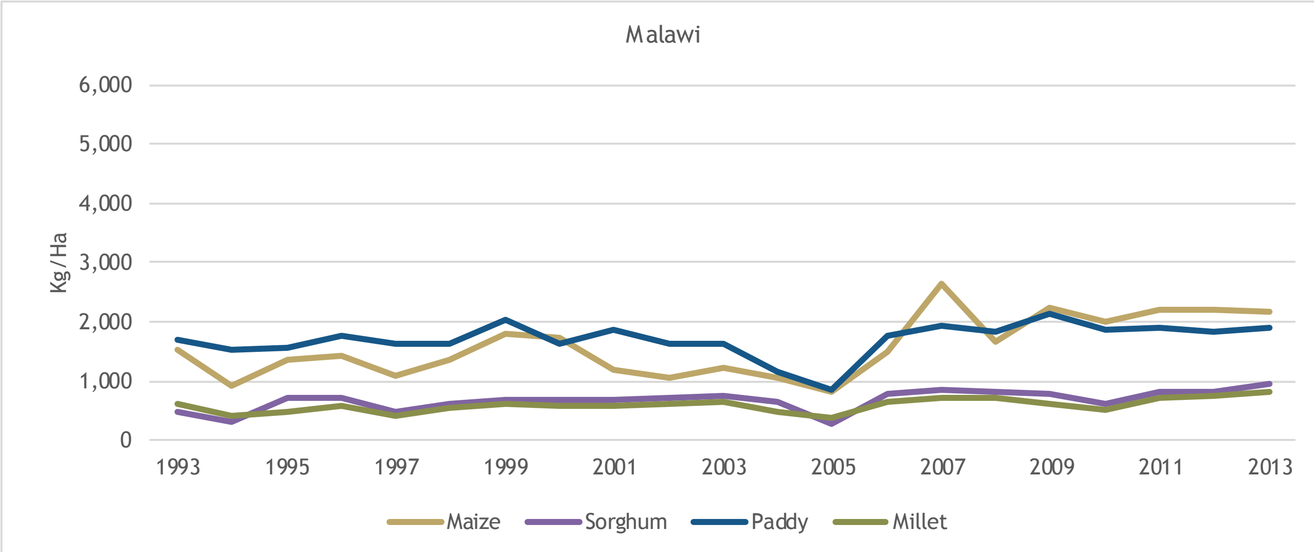
National-level cereal yield trends throughout this sample show variation among countries and among crops. Figure 6 presents the yield trends for the top cereals in each focus country. Between 1993 and 2007 cereal yields and yield trends in Ethiopia and Uganda are similar among all cereal crops, though we observe more differences in yields among cereal crops after 2007. The most diversity among cereal yields appears in Kenya, Rwanda, and Tanzania. In both Rwanda and Kenya paddy yields are generally much higher and less in sync than the other three top cereal crops. In Rwanda, the other three crops, maize, sorghum, and wheat, are generally tightly clustered around 1500 kilograms per hectare until 2008 when maize and wheat yields increase and sorghum remains stagnant. In Tanzania maize and paddy generally have higher yields than sorghum or millet until 2003, when maize yields decreased from 3140 to 750 kilograms per hectare; continuing to be only slightly higher than the yields of sorghum and millet through 2013. Variations in maize yields appear mostly similar to trends of the other most commonly grown cereals. The exception is Tanzania, where maize yields fluctuated more than other cereals between 1993 and 2003, though since 2003 variation in cereal yields has moved similarly.

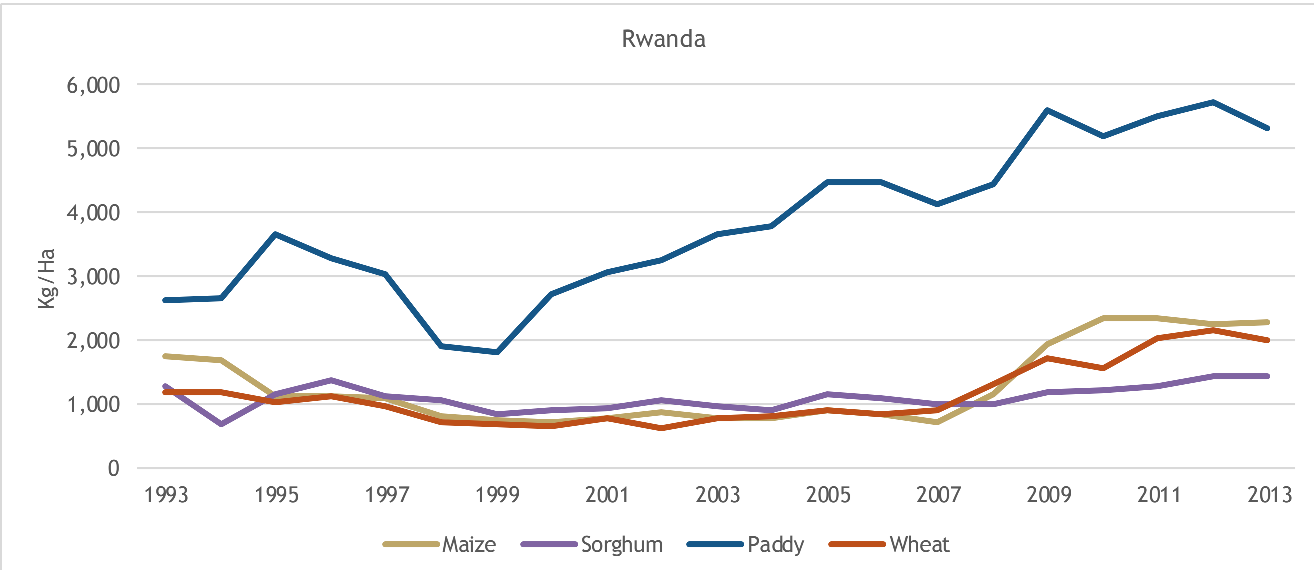
***Figure 6**: Yield Trends of Top Cereal Crops per Country, in Kg/Ha*[6]

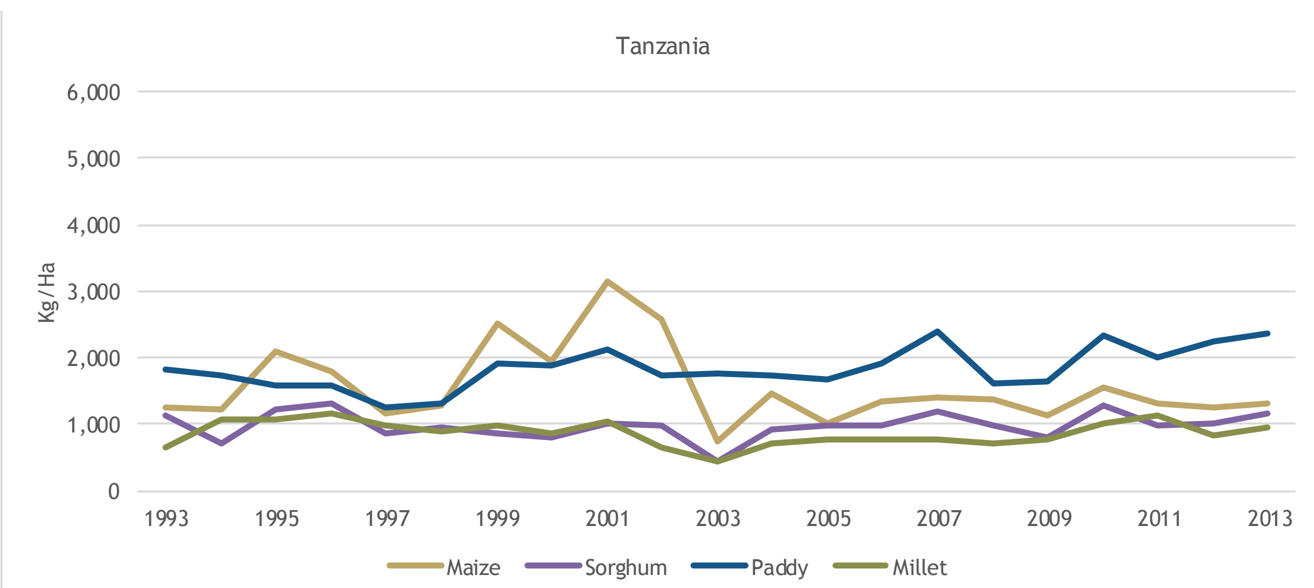


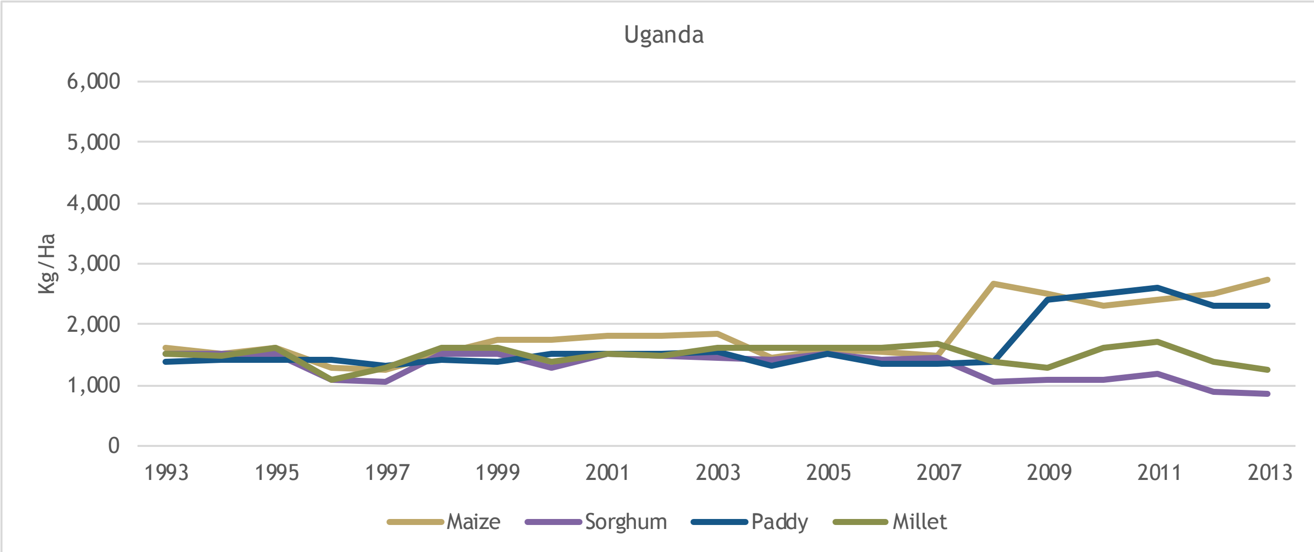


[6] "Other", as seen on the Ethiopia graph, includes teff, a cereal crop commonly grown in Ethiopia.


Malawi
6,000
5,000
4,000
3,000
2,000
1,000
0
Kg/Ha
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
Maize
Sorghum
Paddy
Millet


Rwanda
6,000
5,000
4,000
3,000
2,000
1,000
0
Kg/Ha
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
Maize
Sorghum
Paddy
Wheat


Tanzania
6,000
5,000
4,000
3,000
2,000
1,000
0
Kg/Ha
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
Maize
Sorghum
Paddy
Millet



Findings: Determinants of Yield

We consider three broad sources of macro-level maize yield variability: policy incentives and the broader enabling environment, biophysical and climate factors, and international shocks to supply and demand.

Policy Drivers of Yield

While our literature search focused on policy drivers of cereal crop yields, other relevant drivers, such as biophysical drivers, were frequently mentioned in the body of evidence. For some countries, like Ethiopia - a large country with lots of active research - we found plentiful evidence. However, evidence on national policies was limited or unavailable for some of the smaller countries. Table 1 lists existing evidence for three groups of yield determinants potentially affected by national policy decisions (input use, the enabling environment, and research and extension), as well as biophysical drivers of yield. Biophysical drivers are further discussed in the next section. For each determinant, we indicate whether the overall evidence suggests a positive (+) or negative (-) impact on maize or general cereal yields.

***Table 1**: Determinants of Yield Discussed in Policy Evidence Base*

		Ethiopia	Kenya	Malawi	Rwanda[7]	Tanzania	Uganda
INPUT USE	**Fertilizer use improves yields (+)**	*Chang, 2009; EEA, 2005; Abate et al., 2015*	*Ariga et al., 2009; Ogada et al., 2014; Ogada et al., 2011; Olwande et al., 2015*	*Lunduka et al., 2013; Javdani, 2012; Matchaya et al., 2014; Mazunda, 2013; Ricker-Gilbert et al., 2014; MAFAP, 2014; Karamba et al., 2015*	*N/A*	*Malley et al., 2009*	*Sserunkuuma, 2005; Okoboi, 2010*

[7] Rwanda's primary agricultural crops are roots and tubers, followed by potatoes, bananas, and vegetables. Cereals, including maize, make up a very small percentage of the nation's crop production. Consequently, little to no literature is available on yield determinants of maize or cereals in Rwanda.

	Poor service delivery and high cost of fertilizer drives low use (-)	*Spielman et al., 2010; Chang, 2009; EEA, 2005*	*Ogada et al., 2011; MAFAP, 2013a*	*Lunduka et al., 2013*	*N/A*	*Malley et al., 2009; MAFAP, 2013b; MAFSC, 2013*	*Sserunkuuma, 2005; Okoboi, 2010*
	Improved seed use improves yields (+)	*Rashid et al., 2010; Alemu et al., 2011; Abate et al., 2015*	*Ariga et al., 2009; Ogada et al., 2014; Ogada et al., 2011; Olwande et al., 2015*	*Lunduka et al., 2013; Mazunda, 2013; Ricker-Gilbert et al., 2014; MAFAP, 2014; Karamba et al., 2015*	*N/A*	*N/A*	*Sserunkuuma, 2005; Okoboi, 2010*
	Poor service delivery and limited availability of improved seed drives low use (-)	*Taffesse et al., 2011; Alemu et al., 2010; Spielman et al., 2010*	*Ogada et al., 2011; MAFAP, 2013a*	*Lunduka et al., 2013*	*N/A*	*MAFSC, 2013*	*Sserunkuuma, 2005; Okoboi, 2010*
ENABLING ENVIRONMENT	**Lack of access to credit constrains yields (-)**	*Rashid et al., 2010; Davis et al., 2009*	*Ogada et al., 2014*	*Ricker-Gilbert et al., 2014; MAFAP, 2014*	*N/A*	*MAFSC, 2013; MAFAP, 2013b*	*Sserunkuuma, 2005*
	Political instability constrains production (-)	*N/A*	*Ariga et al., 2009; MAFAP, 2013a; Ogada et al., 2011*	*N/A*	*N/A*	*N/A*	*N/A*
	Land availability or population pressure constrains production (-)	*Headey et al., 2014; Taffesse et al., 2011; EEA, 2005*	*Ogada et al., 2011*	*N/A*	*N/A*	*N/A*	*Sserunkuuma, 2005; Okoboi, 2010*
	Constraints in market development or operation limit production (-)	*Wondemu, 2015; Rashid et al., 2013; Taffesse et al., 2011; Alemu et al., 2010; Rashid et al., 2010; Chang, 2009; EEA, 2005*	*Ogada et al., 2011; MAFAP, 2013a*	*Mazunda, 2013 MAFAP, 2014*	*N/A*	*MAFAP, 2013b; MAFSC, 2013; MAFSC, 2011*	*MAFAP, 2013c; Sserunkuuma, 2005*
	Restrictive regulatory environment constrains production (-)	*Abraham, 2014; Rashid et al., 2013*	*N/A*	*MAFAP, 2014*	*N/A*	*MAFAP, 2013b; MAFSC, 2013; MAFSC, 2011*	*N/A*
	Lack of regulatory protection for producers constrains production (-)	*EEA, 2005*	*N/A*	*MAFAP, 2014*	*N/A*	*N/A*	*MAFAP, 2013c*
	Limited transportation constrains production (-)	*Rashid et al., 2013*	*Ogada et al., 2011; MAFAP, 2013a*	*MAFAP, 2014; Ricker-Gilbert et al., 2014; Mazunda, 2013*	*N/A*	*MAFAP, 2013b; Malley, 2009*	*MAFAP, 2013c*

RESEARCH AND EXTENSION	**Extension services improve yields (+)**	*Headey et al., 2014; Davis et al., 2009; Chang, 2009; Ayele et al., 2006; EEA, 2005; Abate et al., 2015*	*N/A*	*N/A*	*N/A*	*N/A*	*Okoboi, 2010*
	Lack of quality extension constrains production (-)	*Taffesse et al., 2011*	*Ogada et al., 2011*	*Mazunda, 2013; Lunduka et al., 2013*	*N/A*	*MAFSC, 2011; MAFSC, 2013*	*Sserunkuuma, 2005; Okoboi, 2010*
	Active public agricultural research improves yields (+)	*EEA, 2005; Abate et al., 2015*	*Ariga et al., 2009*	*N/A*	*N/A*	*N/A*	*N/A*
	Insufficient public agricultural research constrains yields (-)	*Taffesse et al., 2011*	*N/A*	*Mazunda, 2013*	*N/A*	*MAFSC, 2011*	*N/A*
BIOPHYSICAL DRIVERS	**Changing climate, weather variability, or drought constrains yields (-)**	*Taffesse et al., 2011; Awulachew, 2010; Spielman et al., 2010*	*Ariga et al., 2009; Ogada et al., 2014; Ogada et al., 2011; Olwande et al., 2015; MAFAP, 2013a*	*Ricker-Gilbert et al., 2014; Matchaya et al., 2014; MAFAP, 2014*	*N/A*	*Malley, 2009; MAFSC, 2013*	*Sserunkuuma, 2005; Okoboi, 2010*
	Low soil quality or degradation constrains yields (-)	*Taffesse et al., 2011; Awulachew, 2010; Spielman et al., 2010; EEA, 2005*	*Ogada et al., 2014; Ogada et al., 2011*	*Lunduka et al., 2013; MAFAP, 2014; Karamba et al., 2015*	*N/A*	*Malley, 2009; MAFSC, 2013; MAFAP, 2013b*	*Sserunkuuma, 2005*
	Irrigation improves yields (+)	*Awulachew, 2010*	*Ogada et al., 2011; Olwande, 2015*	*N/A*	*N/A*	*MAFAP, 2013b; MAFSC, 2011; MAFSC, 2013*	*N/A*

Analysis of National Policy Environment and Maize Yield Trends

In this section we map policy and non-policy related events against timelines of maize yield (FAO, 2015) and donor and national agriculture-specific expenditures (MAFAP, 2015) for each country (Figures 7-12). Though attributing changes in behavior and outcomes to changes in policy incentives is highly speculative (for a variety of reasons, including leads and lags in behaviors that anticipate ex-ante or fail to comply ex-post), the timeline is intended to offer information on some potential associations between the national policy environment and maize yield trends. Each timeline is followed by a table with additional detail from the literature on the country policies or events.

Ethiopia

Figure 7: *Ethiopia Yield and Public Agriculture Spending Trends and Relevant Policies*

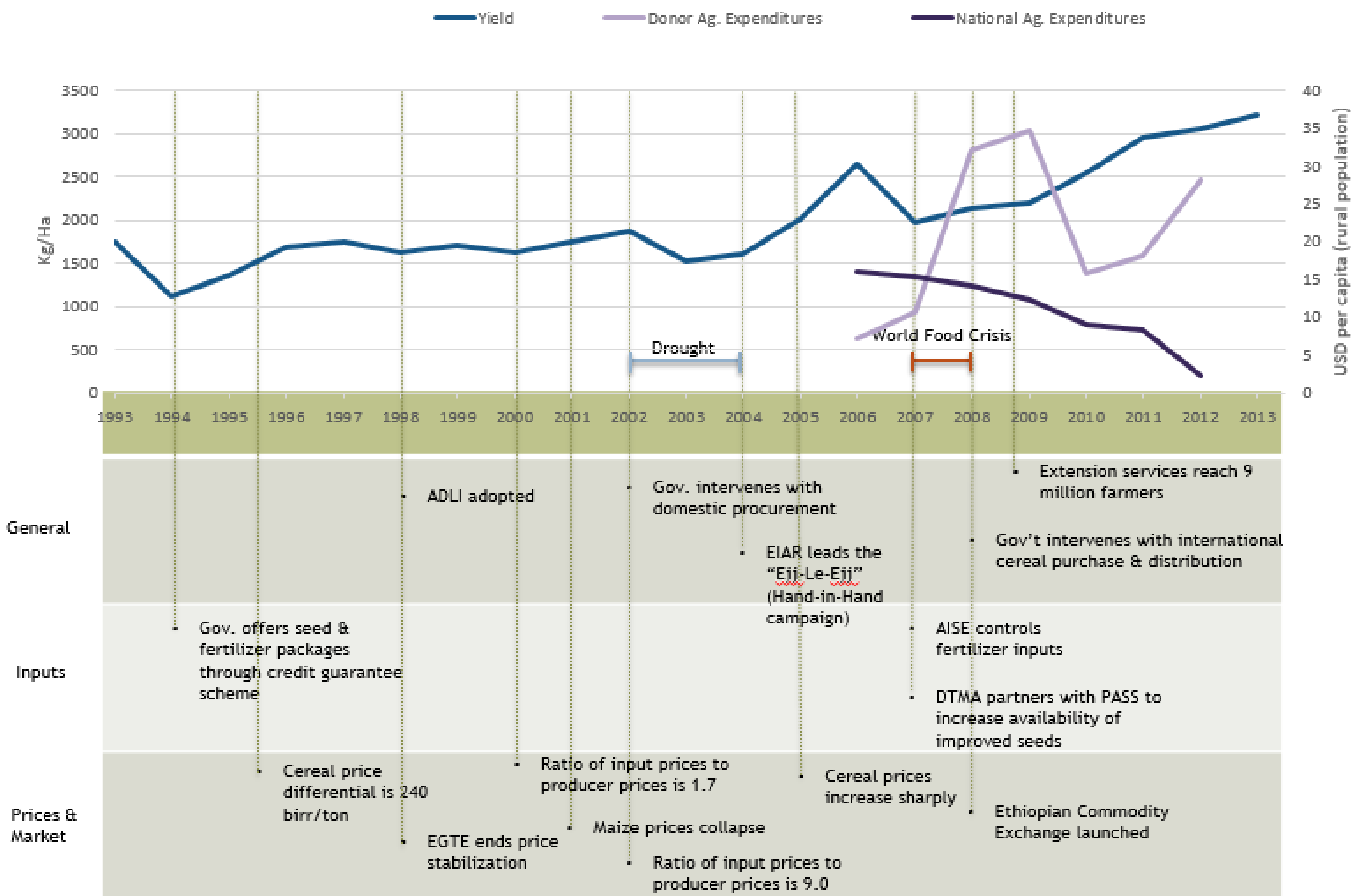


Table 2: Agricultural Policies in Ethiopia

General policy	• **As maize yields increased overall in Ethiopia, national spending on agriculture decreased between 2006 and 2012. Meanwhile, donor spending increased until peaking in 2009, right after the world food crisis. It dropped in 2010 then steadily climbed until 2012 (MAFAP, 2015).** • **Policies in Ethiopia have followed the 'Washington Consensus' and include features of structural adjustment such as devaluing the exchange rate, liberalizing product markets, deregulating prices, reducing subsidies, and lowering duties and taxes (Chang, 2009).** • **In the 1990s and 2000s, the government of Ethiopia emphasized cereal productivity in all of its policy strategies (Rashid et al., 2010).** • **In 2005, the budget allocation to agriculture increased to 17%, up from 8% of the total budget in 1951 (Chang, 2009).** • **From 2005-10, the Plan for Accelerated and Sustained Development to End Poverty (PASDEP) prioritized labor, land use, and innovation specific to agroecological zones (Davis et al., 2009).**
Fertilizer prices, access, subsidies	• Fertilizer must be imported in Ethiopia, which contributes to high prices and barriers to entry in the market (EEA, 2005; Spielman et al., 2010). • Ethiopia's input distribution systems are standardized and inflexible, leaving farmers unable to experiment, access input packages appropriate to specific crops or agroecological systems, or adapt technologies to their own needs. This may cause negative returns to fertilizer use for some farmers, driving low production and low fertilizer use (Spielman et al., 2010). • According to a 2008 IFPRI/EDRI survey, an average of 17% of Ethiopian farmers use fertilizer, though 37% of maize farmers do. 11% of cereal growers use both improved seed and fertilizer. Fertilizer consumption per hectare increased only marginally in the 2000s (Rashid et al., 2010; Spielman et al., 2010). • In the early 1990s, the fertilizer sector liberalized, soon after the end of the Derg regime. Prices were liberalized and subsidies removed (Abate et al., 2015). By 1996, many private firms were involved in the market, but these exited within a few years. Since 2007, the public Agricultural Inputs Supply Enterprise (AISE) and cooperative unions have controlled fertilizer inputs. Though the AISE's wholesale and retail market shares dropped below 50% during the mid and late 1990s, it has held the majority wholesale share since 2001, and nearly all distribution goes through the public sector and cooperative unions (Chang, 2009; Spielman et al., 2010). • In 1994, regional governments began to offer seed-fertilizer packages through a 100% credit guarantee scheme with the state-owned Commercial Bank of Ethiopia. Credit is offered through cooperatives, local government offices, and microfinance institutions. The government delivers 90% of fertilizer on credit at below-market interest rates, which has displaced most retail and cash-basis sales (Chang et al., 2009; Spielman et al, 2010). • Between 1995 and 2005, fertilizer use increased by 30% following the push for intensification. However, there is evidence that many farmers have foregone input packages over time due to high cost and insufficient credit. The distribution system provides two types of fertilizer, which are only available in 50kg bags. A 2004 survey revealed several issues with the fertilizer distribution system. Half of survey respondents reported late delivery, 32% reported underweight bags, 25% reported poor fertilizer quality, and nearly 40% delayed planting because of problems with fertilizer (Spielman et al., 2010). • After the drought and maize price collapse of 2001-02, loan repayment rates for fertilizer sold on credit, which had been high, dropped to 60% in some regions, forcing loans to be rescheduled and driving up costs and risks of the loan guarantee program (Spielman et al., 2010). • Between 2004 and 2013, as maize yields grew by 6.3% per annum, the application rate of mineral fertilizer on maize increased from 16 kg/ha to 34 kg/ha, while the use of organic fertilizer declined over the same period (Abate et al., 2015).
Improved seed prices, access, subsidies	• In the early 1990s, liberalization and structural adjustment policies eliminated government input and credit subsidies for agricultural inputs in Ethiopia, including seed (Abate et al., 2015) • In 2009, cooperatives provided 38% of credit for improved seeds (Abate et al., 2015).

	• In 2007, Partnership with Drought Tolerant Maize for Africa (DTMA) and the Program for Africa's Seed Systems (PASS) launched. These programs provided and increased availability of drought- and other stress-tolerant varieties to smallholder farmers, enhanced the frequency with which varieties were released and commercialized, and increased private sector involvement in seed production (Abate et al., 2015). • Between 2004 and 2013, the maize area under improved varieties increased from 14% to 40% (Abate et al., 2015). • Until recently, the Ethiopian Seed Enterprise (ESE), a state-owned company, was the only formal source of improved seed for many crops (Spielman et al., 2010). Now, regional government owned-companies (the ASE, OSE, and SSE) have entered the seed market (Abate et al., 2015). • In the public sector, which supplies 60% of hybrid maize seed through in-kind loans to farmers, inaccurate demand planning, inefficient contract grower schemes, poorly managed capacity and delivery, and an inflexible distribution model contribute to supply shortages (Spielman et al., 2010; Alemu et al., 2010). • In the private sector, which supplies 40% of hybrid maize seed, government intervention throughout the seed delivery chain prevented distribution through private channels and maintained artificially low prices. Significant barriers to entry exist due to high distribution and marketing costs (Alemu et al., 2010; Spielman et al., 2010). • Farmers report many problems with Ethiopian Seed Enterprise (ESE)-supplied seed, such as broken seeds, low germination rates, presence of mixed seeds, late delivery, and varieties inappropriate for local weather conditions (Spielman et al., 2010). • Since the early 1990s, state-led cereal intensification programs have focused on distribution of improved maize seeds, but many factors contribute to low adoption and rejection of the practices, such as limited supply, lack of choice of varieties, low seed quality, late deliveries, high cost, and insufficient credit (Taffesse et al., 2011; Spielman et al., 2010). • Throughout the 1990s, the price of improved cereal seed rose, but has declined in real terms since 2003-04 (EEA, 2005; Spielman et al., 2010). • Use of improved seed increased by 50% between 1995 and 2005. However, only 12% of cereal growers are estimated to use improved seed, though 26% of maize growers do. About 11% of cereal growers use both fertilizer and improved seed. Hybrid maize adoption is lower in Ethiopia than anywhere else in Eastern or Southern Africa (Spielman et al., 2010; Rashid et al., 2010). • In 2004, only eight firms, most of which produced hybrid maize seed and acted as ESE subcontractors, were involved in seed production, even though seed production and distribution was opened to the private sector in the 1990s (Spielman et al., 2010).
Other input prices, access, subsidies	• The inefficient input marketing system, which is characterized by high costs to farmers and unmet demand, contributes to low agricultural performance throughout Ethiopia (EEA, 2005). • The input package and extension program increased yields in high rainfall areas and locations well-connected to markets, but has not seen the same success in the marginal areas that make up 67% of Ethiopia (EEA, 2005). • The 2005-10 Plan for Accelerated and Sustained Development to End Poverty (PASDEP) planned to develop irrigation for 820,000 hectares, of which only 640,000 have been irrigated, with performance estimated at 30% below design (Awulachew, 2010).
Transportation	• Transportation costs in Ethiopia, which average USD 0.11/t/km and have decreased in recent years, are higher than in Uganda and Tanzania, equal to in Kenya, double China's costs, and triple Brazil's costs. High transport costs prevent trade with neighbors or through port in Djibouti (Rashid et al., 2010). • In the 1990s and 2000s Ethiopia invested significant resources in new roads and upgraded highways (EEA, 2005; Rashid et al., 2013; Wondemu, 2015). • Between 1991 and 2008, the length of rural road increased fivefold, the length of asphalt road increased by 71%, and the length of gravel road increased by 60%. Grain, however, can only be transported on rural roads during the dry season, and it is expensive to operate trucks. The number of trucks has increased appreciably since 1991 (Rashid et al., 2013).

Market access	• Output markets in Ethiopia are dominated by small grain traders with limited access to resources, warehouses, and market information. Traders operate within a small radius, and grain may change hands many times along the value chain. Long distance trade is limited (Chang, 2009; Rashid et al., 2010). • Farmers sell up to 60% of their crop during the first three months after harvest, and 25% in the next three. When prices peak, an average farmer has 16% of the market volume remaining, and may not see the full benefit of higher prices as only a few large traders supply grain during the lean period (Rashid et al., 2010). • In 1992, the Agricultural Marketing Corporation was renamed the Ethiopian Grain Trade Enterprise (EGTE), and it began to compete in the open market as a public enterprise. It was intended to stabilize prices, stimulate foreign exchange, and maintain a food reserve. Between 1999 and 2000, the EGTE's mandates were revised. It was required to end price stabilization and focus on export promotion and disaster preparedness. Its market share diminished from 40% in the 1980s to around 3% in the early 2000s. • From 1996-08, transaction costs per ton of grain declined 83% in real terms (Rashid et al., 2013). • In the 2000s Ethiopia had about 300,000 small traders, about 14 times more than the number of small traders in the 1980s, indicating increased competition and the importance of cereal trading for rural livelihoods (Rashid et al., 2013). • In 2008, the Ethiopian Commodity Exchange (ECX) was launched (Abate et al., 2015), but traders were not required to trade through ECX, and it traded around 1000 tons of maize in its first year. All coffee and pulse exports go through the ECX. • By 2008, membership in agricultural cooperatives had risen to 36% of smallholders, up from 9% in 2005. Growth in membership was higher in cereal-growing regions (Amhara, Oromiya, and SNNP) (Rashid et al., 2013).
Trade policy	• In Ethiopia, most cereals are non-tradable, as domestic wholesale prices are typically above export parity but below import parity, and transportation costs to port in Djibouti are high (Rashid et al., 2010). • Food aid constitutes a significant share of the Ethiopian grain market, as the government relies on it to manage risk. Donors have begun procuring food locally in food surplus regions, but the purchases have been poorly timed so as to increase risk and price variability (Spielman et al., 2010; Rashid et al. 2013).
Output prices, subsidies	• Subsidies are inconsistently applied across major crops in Ethiopia: "While commodities such as flour, cotton and sugarcane are given generous incentives, food grains have not received this type of support" (Chang, 2009). • Grain markets in Ethiopia exhibit significant short- and long-term asymmetric price transmission, as well as significant market inefficiency, causing food prices to adjust to shocks slowly (Wondemu, 2015). • In the 1990s, cereal prices were relatively stable, but have been more volatile since the Ethiopian Grain Trade Enterprise (EGTE) stopped intervening regularly to stabilize prices. The price of maize is more volatile than that of wheat (Rashid et al., 2013; Chang, 2009). • The EGTE and the Central Statistical Agency (CSA) collect information on cereal prices for agency use only. From 1996 through 1998, price information was disseminated via radio under the Grain Market Research Project, but when the project ended, wholesale traders returned to getting price information from brokers in central markets (Rashid et al., 2013). • In 2001-02, maize prices collapsed following a bumper harvest the previous year, and the EGTE intervened with domestic procurement and a price floor for maize (Abate et al., 2015). However, many farmers had already sold their crops prior to the intervention because no price floor was in place and it was unclear whether the EGTE would step in. Others found it unprofitable to harvest their maize (Rashid et al., 2010; Rashid et al., 2013). • "The ratio of input prices to producers' prices increased from 1.7 in 2000 to about 9.0 in 2002." Between this price increase and a drought in 2003, fertilizer application declined by 22% in the next cropping year (Rashid et al., 2013).

	• In 2003, Ethiopia experienced a severe drought. In 2005, cereal prices began to rise sharply in spite of good harvests. In 2008 when prices shot above import parity, the EGTE intervened, again on an ad-hoc basis, procuring grain internationally and distributing it (Rashid et al., 2013). • In 2008, the cereal price differential declined from USD 25 per ton in 1996 to USD 8.85 per ton in nominal terms (Rashid et al., 2013).
Public agricultural research	• Ethiopia has well-established programs for conventional crop breeding, and has created an agricultural biotechnology center for regeneration, cloning, and GMO detection (Abraham, 2014). • Between 1973 and 2013, The Ethiopian National Agricultural Research System (NARS) released a total of 61 maize varieties (Abate et al., 2015). • In the 1990s, agricultural research activities were institutionalized and decentralized. The Ethiopian Agricultural Research Organization (EARO) was established in 1997 and is the primary agricultural research entity in Ethiopia, coordinating research activities of federal and regional research centers and universities (EEA, 2005). • Throughout the 1980s and 1990s, public spending on agricultural research increased significantly, reaching USD 11.5 million in 2000, but remains under .5% of agricultural GDP (EEA, 2005). • In the early 2000s, the Ethiopian Institute of Agriculture (EIAR) introduced a paradigm shift that relied on partnerships with farmers to develop and diffuse agricultural technology to Ethiopian farmers (Abate et al., 2015). • Spending on agriculture research and development grew by 10.9% between 1991 and 1996, and by 16.5% per year between 1996 and 2001 (Abate et al., 2015).
Extension	• Ethiopia spends over USD $50 million on extension programs each year, amounting to almost 2% of agricultural GDP (Spielman et al., 2010). • The agricultural extension package supplies inputs such as seed, fertilizer, and chemicals, and provides incentive, technical support, and training to farmers (EEA, 2005). • Ethiopia's extension worker to farmer ratio is 1:476 (Abate et al., 2015). • About 8,500 Farmer Training Centers exist throughout Ethiopia, staffed by 63,000 Development Agents. Though agents generally have strong technical skills and training, some regions implement extension better than others, and basic infrastructure is lacking. The field extension system "is often limited in its ability to meet farmer needs and demands" (Davis, 2009). • Total Factor Productivity is higher among maize producers with access to extension services than among those without access (Ayele et al., 2006). • 1993, Ethiopia launched the National Extension Intervention Program (NEIP) with Sasakawa Global 2000 (Abate et al., 2015). • Since 1991, the public extension system has expanded and decentralized to reach previously neglected lowland areas and to fund more and more qualified community level extension workers. Extension activities provide support to smallholder farmers to increase their productivity, a key goal of the Agricultural Development Led Industrialization (ADLI) strategy adopted in 1999. While yields increased in some cereal growing areas with good weather and soil fertility, the extension program did not met expectations (EEA 2005). • In 2004, the EIAR led the "Ejj-Le-Ejj" (Hand-in-hand) campaign, which strengthened partnerships among agriculture research and development stakeholders, intensified promotion and enhance adoption of new agricultural technologies (Abate et al., 2015). • By 2008-09, extension services were reaching 9 million farmers, and 65,000 additional extension agents began services to improve coverage. The system remains more focused on distributing inputs than on providing technical advice, but input provision is now shifting to cooperatives, and new extension packages will be crop- and zone-specific (Spielman et al., 2010).
Regulatory Environment	• The agricultural marketing system in Ethiopia lacks regulatory frameworks to protect producers, especially smallholders (EEA, 2005). • In 2009, the Ethiopian Biosafety Proclamation was enacted. Due to the stringent requirements of the proclamation, research on genetic engineering (GE) technologies has not been initiated. Though the government's stance on GE technologies has softened over the past few years and it

	attempted to introduce insect-resistant cotton seed, foreign technology providers will not work in Ethiopia because of the unfavorable regulatory conditions (Abraham, 2014).

Kenya

Figure 8: *Kenya Yield and Public Agriculture Spending Trends and Relevant Policies*

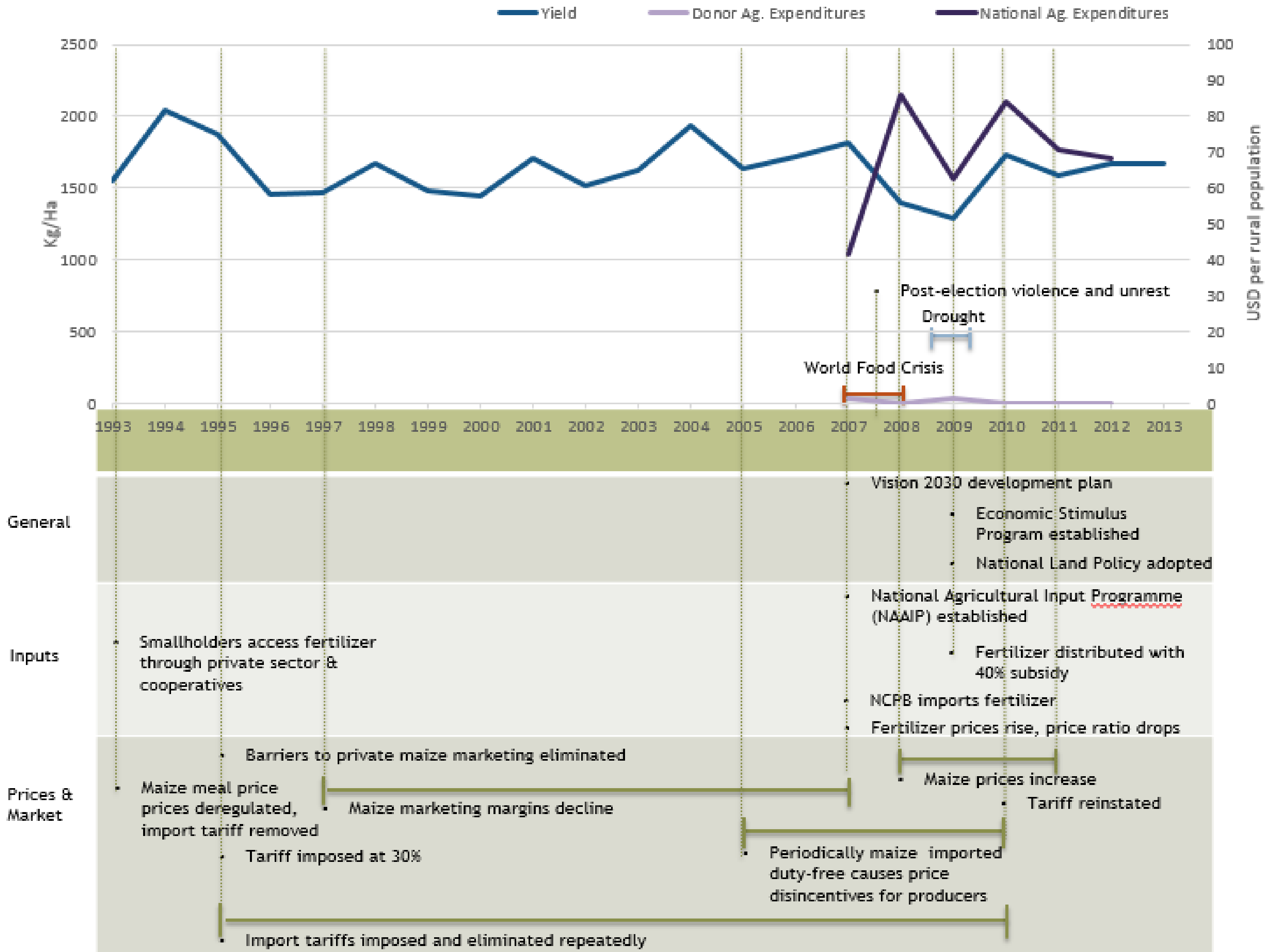


Table 3: Agricultural Policies in Kenya

General policy	• In the early 1990s, Kenya began to liberalize its markets after changes to world economic ideology, perceived corruption and paternalism, fiscal deficits, and pressure to reform from international financial institutions (Ariga & Jayne, 2009). • Donor spending on agriculture in Kenya remained low from 2007 to 2012. National spending has been volatile, doubling between 2007 and 2008, dropping by 50% in 2009, and increasing by nearly 50% in 2010 before steadily declining until 2012. Yields, meanwhile, have remained relatively stagnant despite high national spending (MAFAP, 2015). • Created in 2007, Kenya's Vision 2030 Development Plan delegated the responsibility of developing rural infrastructure, providing agricultural inputs, researching, and providing extension services to private and de-concentrated regulatory boards (MAFAP, 2013a). • Since the 2008 food crisis and recent natural disasters, government interventions have been primarily in short-term emergency situations (MAFAP, 2013a).
Fertilizer prices, access, subsidies	• Cash vouchers for fertilizer and seed in Kenya have failed to reach the poorest of the targeted producers (MAFAP, 2013a). • In the early 1990s, the government removed price controls on fertilizer, halted government distribution of free fertilizer, eliminated import quotas, and legalized private trade. By 1993, smallholders accessed fertilizer exclusively through the private sector and cooperatives (Ariga & Jayne, 2009). • The liberalization of markets and public investments in agriculture spurred private investment in fertilizer retailing and increased competition in distribution (Ariga & Jayne, 2009; Ogada et al., 2011; Ogada et al., 2014; Olwande et al., 2015). • Between 1997 and 2007, fertilizer use increased by 34% among smallholders, and yields increased by 18%. Up to 70% of households use inorganic fertilizer, and up to 50% use organic fertilizer. (Ariga & Jayne, 2009; Ogada et al., 2011; Ogada et al., 2014; Olwande et al., 2015). • Until 2007, fertilizer prices were low. In Kenya, fertilizer and improved maize seed are available in small units, and input retailers are increasingly accessible even at the village level (Ogada et al., 2011). • In 2007, the Kenyan government established the National Agricultural Input Programme (NAAIP) to promote food security, input use and market development, and agricultural productivity. The program was available only to maize farmers, aiming to provide 2.5 million smallholders with vouchers for seed and fertilizer (Ogada et al., 2011). • In 2007, in the face of the food crisis, the National Cereal and Produce Board (NCPB) again began to import fertilizer for distribution to farmers, but late delivery in 2008 contributed to low production. In 2009 the Kenyan government distributed fertilizer with a 40% subsidy, but poor rains caused production to drop to its lowest levels in recent history. Fertilizer was again imported and distributed in 2010 (MAFAP, 2013a; Ariga & Jayne, 2009). • In 2008, the positive trend in fertilizer use between 1990 and 2007 was reversed by civil disruption, drought, and rising world fertilizer prices. Fertilizer price ratios historically ranged between 0.4 and 0.6 at the time of planting, but in 2008 dropped to 0.25, making fertilizer very expensive for smallholders (Ariga & Jayne, 2009).
Improved seed prices, access, subsidies	• Kenya's government has invested in seed variety development and multiplication, especially for the maize subsector. This has not yet inspired widespread smallholder market participation (Olwande et al., 2015). • Since 1995, at least 10 new maize hybrid or open pollinating varieties were released in Kenya, but newer varieties offer small yield advantages over the previously released improved varieties (Ariga & Jayne, 2009). • In 2007, Kenya's Vision 2030 plan allocated 34% of its agriculture budget to input subsidies (MAFAP, 2013a). • Since 2007, the NAAIP has provided maize seed and fertilizer vouchers redeemable through private input sellers (Ogada et al., 2011).

	• In 2010, the adoption rate of hybrid maize seed increased to 82% from 68% in 2000, while yield increased by only 16%. The adoption of improved seed for other crops remains below 6% (Olwande et al., 2015; Ogada et al., 2011).
Other input prices, access, subsidies	• 114,600 hectares of Kenya's land is irrigated (1.7% of total cultivated land). Irrigation potential is estimated at 540,000 hectares. Smallholders make up 18% of irrigated land. Individual farmers often develop their own irrigation systems, especially for export crops (Ogada et al., 2011). • The 2009 Economic Stimulus Program, the 2003-2007 Economic Recovery Strategy, and the 2007 Vision 2030 plan emphasized expansion of irrigation infrastructure (Ogada et al., 2011; MAFAP, 2013a). • In 2009, Kenya adopted a National Land Policy, which aimed to promote investment in agriculture by improving land quality and reducing squatting, landlessness, underutilization and abandonment of farmland, and tenure insecurity (Ogada et al., 2011).
Transportation	• Only 14.3% of Kenya's roads are paved. Poor infrastructure results in high transaction costs for farmers and reduces access to inputs and market (MAFAP, 2013a). • From 2000 to 2010, the average distance from farms to input and output markets and to improved roads decreased. Between 2004 and 2007, average distance from the farm to a motorable road was cut in half. In 2004, a policy reform allocated 2.5% of total government revenue for infrastructure funding in Kenya's constituencies (Ariga & Jayne, 2009; Olwande et al., 2015). • In 2008, the government reduced the proportion of roads in poor condition to 28% from 43% in 2003 (Ogada et al., 2011).
Market access	• High market access costs in Kenya are driven by fuel costs, poor infrastructure, delays and corruption at Non-tariff Trade Barriers (NTBs), high processing costs, and a lack of enforceable quality and safety standards. The government spends 5% of its budget on marketing. Kenya also spends on infrastructure to reduce market access costs, but has invested more in increasing production and productivity than on increasing market access and reducing marketing costs (MAFAP, 2013a; Ogada et al., 2011). • Despite a reduction in wholesale prices, 88% of households in all regions found it more convenient to sell grain after liberalization than before, though many of them did not sell. Now, farmers can sell at the farm gate and receive cash on the spot, whereas under the NCPB, farmers had to move produce to depots and payments were often delayed for months (Ariga & Jayne, 2009). • In 1993, maize meal price controls were eliminated, and barriers to private maize marketing were eliminated by 1995 (Ariga & Jayne, 2009). • Over the period of 1997 to 2007, maize marketing margins declined, while maize yields increased by 18% (Ariga & Jayne, 2009).
Trade policy	• Kenya has the highest number of road blocks at Non-tariff Trade Barriers (NTBs) among EAC countries (Ogada et al., 2011). • Negotiated bilateral and multilateral trade agreements, lengthy documentation, high fuel costs, and underdeveloped communication technologies impeded business development (Ogada et al., 2011). • In 1993, maize meal prices were deregulated and the import tariff was removed, but it was re-imposed at 30% in 1995. An export ban was imposed in 1996 following a dip in production, and another import tariff was imposed in 1997 after a poor harvest (Ariga & Jayne, 2009). • Starting in 2005, tariff barriers to trade with neighboring East African Community (EAC) countries (Uganda and Tanzania) were removed (Ariga & Jayne, 2009). • From 2006 to 2007, exports increased, then dropped drastically through 2009. Generally, Kenya exports limited quantities of maize. (Ogada et al., 2011). • Kenya imports maize from Uganda and Tanzania below world market prices. In 2008 and 2009, EAC countries could not meet Kenya's production shortfall, and Kenya imported maize from South Africa. In 2009, Kenya waived its maize tariff and imports increased, but domestic wholesale prices remained high despite approximating import parity. The tariff was reinstated in 2010 (Ogada et al., 2011; MAFAP, 2013a).

Output prices, subsidies	• In the 15 years following liberalization, the partial withdrawal of government marketing board interventions led to a decline in the real price of maize (Ariga & Jayne, 2009). • Until the mid-1990s, the NCPB supported maize price levels in maize-surplus areas, but its operations have since scaled down. It now buys maize in a few major surplus zones in order to stabilize prices (Ariga & Jayne, 2009). • Producers faced price disincentives in 2005, 2006, 2007, and 2010 as Kenya imported duty-free maize from its neighbors, yet maintained normal levels of production (MAFAP, 2013a). • In late 2007, maize prices began to increase following political unrest (MAFAP, 2013a). • In 2009, maize prices began to increase due to drought (MAFAP, 2013a). • In 2011, the purchase price of maize rose to double the market price (MAFAP, 2013a).
Public agricultural research	• The Kenyan government has invested in production and dissemination of high-yielding varieties and inorganic fertilizers. Adoption has improved, especially among maize-growers, yet productivity is stagnating or declining (Ogada et al., 2014). • In the 1990s, policy reform focused on seed research by the Kenya Agriculture Research Institute and private firms, contributing to improved maize productivity and smallholder farm income (Ariga & Jayne, 2009).
Extension	• Kenya's extension worker to farmer ratio is 1:1000 (Abate et al., 2015). • Limited extension services have contributed to below-potential productivity, but farmer groups have begun to form, providing access to extension, agricultural information, and even loans (Ogada et al., 2011).
Political unrest	• In 2008, post-election violence in the Rift Valley Province contributed to a sharp drop in maize productivity. Physical infrastructure such as petrol stations and grain storage facilities in western Kenya were destroyed in early 2008, as was 0.3 billion kgs of maize, and many input supply stores closed. The next planting season saw a 20% reduction in maize area planted (Ariga & Jayne, 2009; Ogada et al., 2011; MAFAP, 2013a).

Figure 9: Malawi Yield and Public Agriculture Spending Trends and Relevant Policies

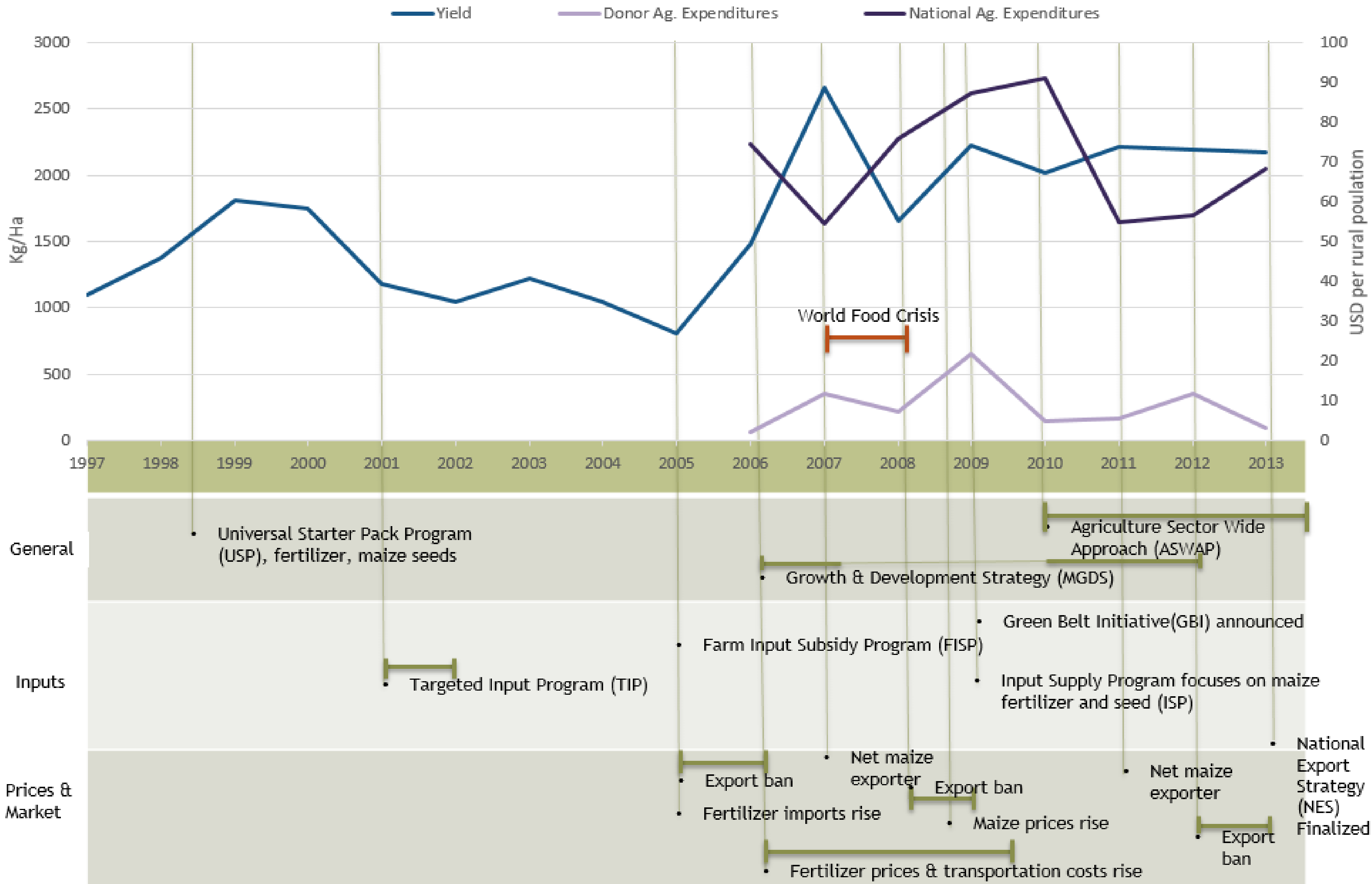


Table 4: Agricultural Policies in Malawi

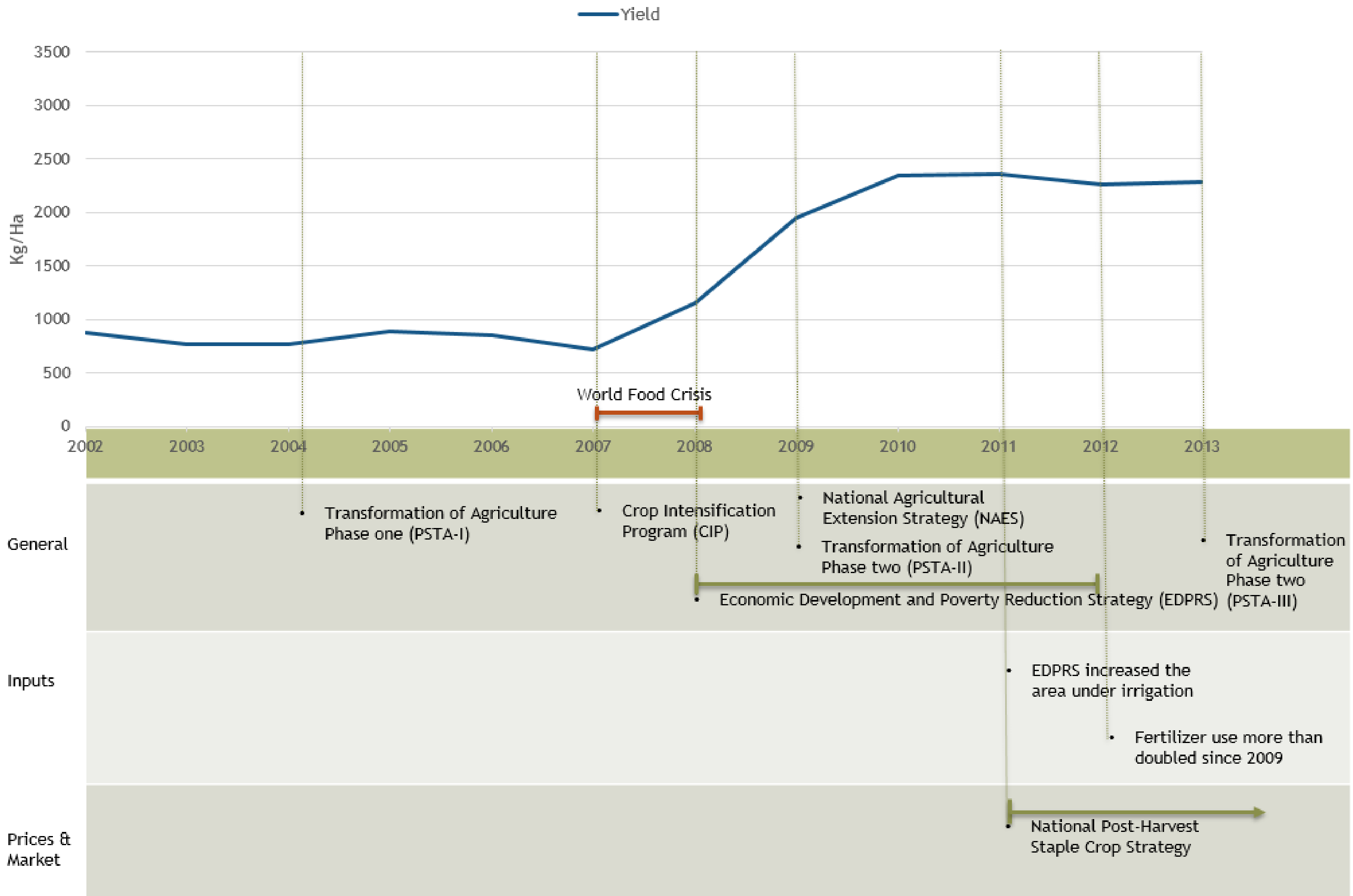
General policy	• **In 1993, Malawi became a multi-party democracy (Matchaya et al., 2014).** • **Malawi's overarching development strategy is outlined in the Malawi Growth and Development Strategy (MGDS), the theme of which is to promote sustainable economic growth, particularly in agriculture (Matchaya et al., 2014).** • **Donor spending remained low from 2006 to 2012, spiking briefly in 2009 following the food crisis. National spending rose from 2007 until 2010, then dropped. Yields have been volatile during this period (MAFAP, 2015).** • **In 2006-07 and 2010-11, the first MGDS was implemented (Matchaya et al., 2014; MAFAP, 2014).** • **In 2009, the Green Belt initiative was launched to improve access to credit and irrigation (MAFAP, 2014).** • **In 2010, Malawi enacted the National Irrigation Policy and Development Strategy.** • **From 2010-2016, Malawi has implemented the National Agricultural Policy Framework to achieve national food security by promoting agricultural productivity and sustainable land management (MAFAP, 2014).** • **In 2011-12 and in 2015-16, Malawi carried out the second MGDS (Matchaya et al., 2014; MAFAP, 2014).** • **In 2012, Malawi launched the Economic Recovery Plan (ERP), an implementation plan to reduce poverty through commercializing agriculture and agro-processing (MAFAP, 2014).** • **In 2010 through 2014, Malawi implemented the Agriculture Sector Wide Approach (ASWAp) to prioritize investment strategies for the agricultural sector (Matchaya et al., 2014). Malawi implemented the ASWAp in order to accomplish the Millennium Development Goals (MDGs), which sought to halve poverty and hunger by 2015 (Matchaya et al., 2014; MAFAP, 2014).**
Fertilizer prices, access, subsidies	• In the 1998-99 cropping season, Malawi initiated the Universal Starter Pack Program (USP). In order to lay a solid foundation for long-term economic growth, the USP focused on improving productivity of smallholder maize farmers by increasing access to fertilizer technology among other inputs. In each of the two years of the USP, maize production was at its highest, 67% higher than the 20-year average (Mazunda, 2013). • From 2001 to 2002, the Malawi government provided input subsidies for poor farmers through its Targeted Input Program (TIP). Malawi created this program as an "exit-strategy" that would provide safety nets and kick-start agricultural production. The program distributed fertilizer to some 1 to 2.8 million households (Mazunda, 2013). • Implemented in 2005, the Farm Input Subsidy Program (FISP) contributed to significant increases in sales and adoption of fertilizer and in maize outputs. Each beneficiary of the ISP program received input vouchers that subsidized two-thirds or more of the cost of 100 kg of fertilizer (Mazunda, 2013). It is estimated that the use of subsidized fertilizer contributed to a 38 to 55% increase in national maize production between the 2005-06 and 2008-09 growing seasons (Javdani 2012). • For the years 2005-06 and 2008-09, maize output prices did not increase at the same rate as fertilizer prices (Lunduka, 2013). • Program costs for FISP more than doubled between 2006-07 and 2008-09 due to rising global fertilizer prices (Mazunda, 2013). • In 2009-10, the Farm Input Subsidy Program (FISP) focused on the provision of maize fertilizers and seed, along with legume seeds and storage pesticides (Lunduka, 2013). • By the 2010-2011 cropping season, fertilizer consumption in Malawi had increased by around 30% since the introduction of the FISP in 2005 (Matchaya et al., 2014).
Improved seed prices, access, subsidies	• Starting in 1998 through 2000, the Universal Starter Pack (USP) aimed to increase access to improved maize seed technology and inputs (Mazunda, 2013). Under the program, farmers received 2 kg of hybrid seed (Ricker-Gilbert et al., 2014). In each of the two years of the USP maize production was at its highest, 67% higher than the 20-year average (Mazunda, 2013).

	• From 2001 to 2002, the Targeted Input Program (TIP) distributed between 2 and 4 kg of hybrid or open pollinated seed varieties (OPV) of maize (Ricker-Gilbert et al., 2014), to a targeted 1 to 2.8 million households (Mazunda, 2013). • In the second year of the Farm Input Subsidy Program (FISP) (2006-07), the Malawian government distributed vouchers that were redeemable for a small quantity of free improved maize seeds in addition to vouchers for fertilizer. The program aimed to familiarize farmers with modern seeds (Lunduka, 2013). • In 2009-10, the Farm Input Subsidy Program (FISP) focused on providing maize fertilizers and seed, along with legume seeds and storage pesticides (Lunduka, 2013).
Other input prices, access, subsidies	• In 2005, the Malawian government implemented the Farm Input Subsidy Program (FISP), which is now the country's main agricultural investment program. Average maize yields almost tripled within the first two years of the program (Mazunda, 2013). The Malawian government reported a grain surplus every year since the program's inception (Javdani, 2012). • In 2009, the Malawian government announced the Green Belt Initiative (GBI), which seeks to address climate change impacts through irrigation. The GBI helped increase the amount of arable land under irrigation. As of 2011, only 30.2% of irrigable land was under irrigation (Matchaya et al., 2014).
Transportation	• Between 2006-07 and 2008-09, the FISP Program costs more than doubled due to rising transportation costs (Mazunda, 2013).
Market access	• Key strategies of the Malawi Growth and Development Strategy (MGDS) (implemented on and off from 2005 to 2016) include strengthening linkages between farmers to markets by connecting rural communities, focusing on domestic markets and exports. The strategy also includes increasing commercialization and international competitiveness, particularly for smallholder farmers (Matchaya, 2014).
Trade policy	• Export bans on maize were in place in 2005-2006, 2008-2009, and 2012-2013 (MAFAP, 2014). • Since the 2005 implementation of the Farm Input Subsidy Program (FISP), the magnitude of fertilizer imports rose. 2008 had the highest fertilizer imports (Matchaya et al., 2014). • Since 2006, Malawi has been largely self-sufficient in maize, trading relatively low volumes of maize compared to total production. Malawi was only a net exporter of maize in 2007 and 2011. Maize import restrictions have been in place for over a decade (MAFAP, 2014). • A poor harvest in 2008 was caused in part by global and local food price speculation and falling prices for high-value export crops (Mazunda, 2013). • For the years 2013-2018, Malawi has finalized plans for the National Export Strategy (NES). The NES provides a plan to increase export competitiveness and economic empower for vulnerable populations (MAFAP, 2014).
Output prices, subsidies	• During the 1980s, the Malawian government set prices of outputs at the beginning of each growing season so farmers could plan which crops to grow. The Agricultural Development and marketing Corporation (ADMARC) was the primary buyer and seller of outputs. While these policies may have resulted in the maize surplus, they proved unsustainable due to large budget deficits (Matchaya, 2014). • For the years 2005-06 and 2008-09, during the Farm Input Subsidy Program (FISP), maize output prices did not increase at the same rate as fertilizer prices (Lunduka, 2013). • In 2008, 2012, and 2013, sharp price increases in the maize market and government trade policies exacerbated seasonal price variations and reduced incentives for farmers to grow maize. In 2007, 2010, and 2013, farmers were incentivized to grow maize due to high domestic maize prices relative to the region, particularly in years of few trade restrictions. (MAFAP, 2014). • Between 2005 and 2010, maize prices in Malawi increased from USD 100/1000 kgs to USD400/1,000 kgs despite the maize production increases from the Farm Input Subsidy Program (FISP). The increase in maize prices could be due in part to the Malawi government's purchasing of maize for its Strategic Grain Reserves (SGR), which reduced the supply and increased the demand and price for maize domestically (Lunduka, 2013).

Public agricultural research	• The budget allocation to agricultural research shrank as the Malawian government allocated more than 60% of the budget to the Farm Input Subsidy Program (FISP) (Matchaya et al., 2014).
Extension	• The budget for extension services has been squeezed as the Malawian government spends more on the Farm Input Subsidy Program (FISP) (Matchaya et al., 2014). • The extension worker to farmer ratio in Malawi is 1:1603, among the highest in the region (Abate et al., 2015). • Key strategies of the Malawi Growth and Development Strategy (MGDS), which was implemented on and off from 2005-2016, include increased and more effective extension services for farmers (Matchaya, 2014).
Economic and Climate Factors	• 2004-05 drought season yields were lower despite the increase in fertilizer consumption (Matchaya et al., 2014). • In 2012-2013, maize production declined due to poor rains after the 2011 bumper crop (MAFAP, 2014).

Rwanda

***Figure 10:** Rwanda Yield Trends and Relevant Policies*[8]



[8] MAFAP agriculture public expenditure data was not available for Rwanda.

Table 5: Agricultural Policies in Rwanda

General policy	• In 2004, the Rwandan Ministry of Agriculture and Animal Resources (MINAGRI) implemented The Strategic Plan for the Transformation of Agriculture Phase One (PSTA-I). The PSTA-I provided the basis for implementing the National Agriculture Policy, which outlined the main areas of agriculture that needed to be improved and how the government should intervene (MINAGRI, 2009). • In 2007, MINAGRI launched the ongoing Crop Intensification Program (CIP), which is a pilot program with the goal of increasing agricultural productivity of six priority crops including maize. The program focuses on land use consolidation, improved seed and fertilizer use, extension services, and agricultural marketing. As a result of the program, crop productivity increased, including maize production, which increased six fold from 2007 to 2011 (MINAGRI, 2015). • From 2008 to 2012, The Economic Development and Poverty Reduction Strategy (EDPRS) was in effect. The strategy sought to increase economic growth by increasing the contribution of strategic exports, enhancing business climates, and increasing agricultural productivity (IPAR, 2012). • From 2009-2012, Rwanda implemented PSTA-II in conjunction with the EDPRS. The plan articulates the strategy for achieving agricultural growth and productivity through commercialization, particularly for rice crops. The plan seeks to increase agricultural output and incomes through agricultural intensification, sustainable production systems, producer training, and support for commodity chains and agribusiness development (IPAR, 2012). • In 2013 PSTA-III began, with the aims of building upon the prior two phases of PSTA, primarily the intensification and commercialization of Rwandan agriculture (World Bank, 2014).
Fertilizer prices, access, subsidies	• The PSTA-II (2009-2012) included subsidies for fertilizers for rice cultivation in Rwanda (IPAR, 2012). • Since the 2007 implementation of CIP, affordable fertilizers became available through private distributors. The government of Rwanda subsidizes fertilizers, although farmers must pay a small amount through a voucher system (MINAGRI, 2009). • By 2012, fertilizer use more than doubled from 11 to 30 kg per hectare (IPAR, 2012).
Improved seed prices, access, subsidies	• Through CIP (implemented in 2007), the Rwandan Board of Agriculture (RAB) is able to provide a limited quantity of improved seeds (MINAGRI, 2015). • The PSTA-II (2009-2012) includes subsidies for rice seeds (IPAR, 2012).
Other input prices, access, subsidies	• The PSTA-II (2009-2012) includes subsidies for water for rice cultivation (IPAR, 2012). • By 2011, the EDPRS increased the area under irrigation from 15,000 to 17,363 hectares (IPAR, 2012).
Transportation	• The PSTA-II (2009-2012) increased public investments in construction and repairs to feeder roads in order to support rice cultivation (IPAR, 2012).
Market access	• The PSTA-II (2009-2012) supported the development of an efficient private sector and a greater role in policy implementation to markets in order to support rice cultivation (IPAR, 2012). • With a timeline of 2011-2016, the National Post-Harvest Staple Crop Strategy was a policy framework that was created to assist with strengthening harvesting, post-harvest handing, trade, storage and marketing within staple crop value chains. The National Post-Harvest Strategy was created in response to the harvest losses that resulted from of a lack of capacity in post-harvest handling of increased crop yields from the Crop Intensification Program (CIP), which was enacted in 2007 (IPAR, 2012).
Trade policy	• The United Nations-led 2010 Development Driven Trade Policy Framework states that trade policy should be development-driven rather than demand-led. The framework directs investment to diversification of exports, local processing industries, and for employment in rural areas. It also promotes tariff policies that promote imports of industrial inputs, as well as strategically located export processing zones (IPAR, 2012).
Output prices, subsidies	N/A

Public agricultural research	N/A
Extension	• In 2009 The National Agricultural Extension Strategy (NAES) was created to promote farmer organizations, strengthen technical capacity, and improve service delivery to producers (IPAR, 2012). • The PSTA-II (2009-2012) included training and access to finance for rice farmers (IPAR, 2012).

Tanzania

***Figure 11:** Tanzania Yield and Public Agriculture Spending Trends and Relevant Policies*

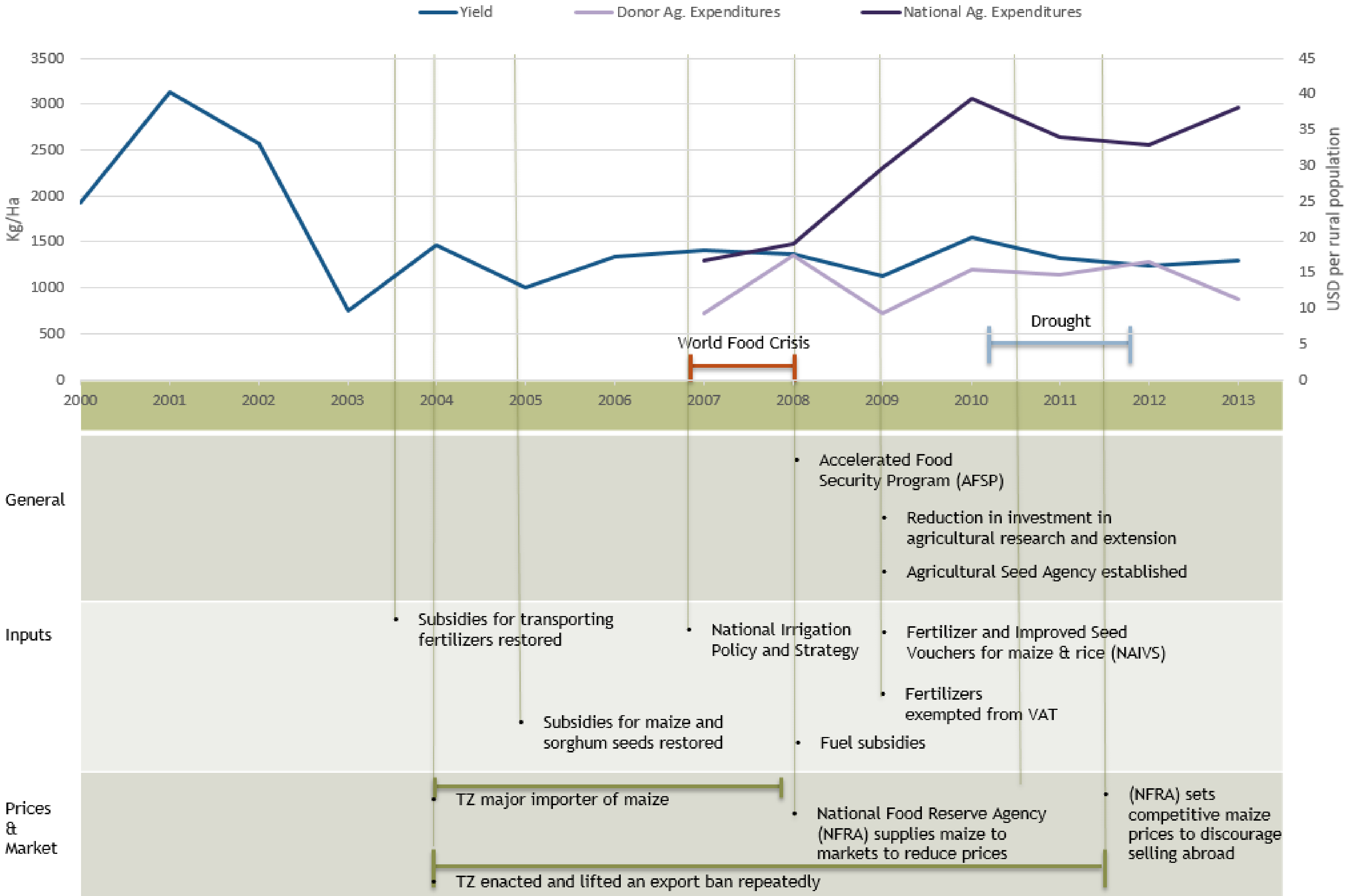


Table 6: Agricultural Policies in Tanzania

General policy	• In 2008, the Tanzanian government launched the Accelerated Food Security Program (AFSP) to boost food production and productivity in response to the food and fertilizer price increases (MAFAP, 2013b). • Yield trends and donor spending remained relatively stable from 2007 to 2013. National spending increased steadily until 2010, and has remained relatively high while yields have declined slightly (MAFAP, 2015). • Prior to 2009, Tanzania spent over 60% of expenditures on general support, including agricultural research, extension, and training. Since 2009, Tanzania decreased its spending on general sector support to less than 50%, and has increased spending for direct input subsidies and payments for farmers and other agents in the agricultural sector. The decrease in general sector spending led to less support for storage facilities, marketing, and infrastructure, though spending on input subsidies for farmers increased (MAFAP, 2013b).
Fertilizer prices, access, subsidies	• In the early 1990s, the Tanzanian government removed general fertilizer subsidies as a part of liberalization reforms (MAFAP, 2013). After the removal of the agricultural input subsidy in 1994, a majority of farmers were unable to afford inorganic fertilizers, and consequently did not adopt the use of inorganic fertilizers (Malley et al., 2009). • In 2003-04, Tanzania restored subsidies for transporting fertilizers (MAFAP, 2013b). • The 2009, National Agricultural Input Voucher Scheme (NAIVS) provided a 50% subsidy on a 100-kg package of fertilizer (MAFAP, 2013b). • In June 2009, Tanzania exempted fertilizers from VAT. Duties on farm-level inputs such as fertilizers had already been removed in July 2008 (MAFAP, 2013b). • "Productivity trends for maize in the URT have been reported to be declining even in spite of the fertilizer subsidy (Druilhe and Barreiro-Hurle, 2012)." (MAFAP, 2013b).
Improved seed prices, access, subsidies	• In 2005, Tanzania restored subsidies for maize and sorghum seeds (MAFAP, 2013b). • The 2009 National Agricultural Input Voucher Scheme (NAIVS) provided farmers 10 kg of improved maize or rice seeds. With the voucher scheme, Tanzania distributed a total of 7,180 tons of improved seeds to farmers (MAFAP, 2013b). • In 2009, Tanzania established the Agricultural Seed Agency to support private sector seed production (MAFAP, 2013b).
Other input prices, access, subsidies	• In 2007, following the drafting of the National Irrigation Policy and Strategy, six irrigation schemes were financed in separate regions in Tanzania. In Mombo, the mid-term budget review estimated that maize yields increased from 1,500 kgs/ha to 4,000 kgs/ha from the new irrigation scheme (MAFAP, 2013b). • In 2008, Tanzania implemented a pilot input subsidy program. The Tanzanian government expanded this program in 2009 as the National Agricultural Input Voucher Scheme (NAIVS). The NAIVS originally focused on six crops, including maize and paddy, and has since expanded to several other crops, including sorghum. A total of 737,000 farmers benefited compared with a target of 700,000, a success rate of 105.3% (MAFAP, 2013b). • In 2008, the Tanzanian government allocated USD 14.6 million for fuel subsidies (MAFAP, 2013b).
Transportation	N/A
Market access	• Since market liberalization, the lack of functioning markets, poor market performance, and inefficient processing plants in Tanzania has reduced farm gate prices for crops and created disincentives for farmers. FAO recommends that Tanzania spend more on marketing, storage and processing to minimize disincentives for farmers and to maximize production (MAFAP, 2013b).
Trade policy	• Overall, maize is a thinly traded commodity in Tanzania (MAFAP, 2013b). • Tanzania is the only country in East Africa that formally restricts trade, which in turn creates economic incentives that keep maize outputs below potential levels (MAFAP, 2013b). • From 2004-2008, Tanzania was a major importer of maize (MAFAP, 2013b).

	• From 2004 to 2012, Tanzania enacted and lifted an export ban at least ten times, creating uncertainty among agents throughout the maize value chain (MAFAP, 2013b).
Output prices, subsidies	• The National Food Reserve Agency (NFRA), formerly known as the strategic grain reserve, ensures national food security and will intervene in the market to purchase or sell crops, including maize, in order to stabilize prices (MAFAP, 2013b). • In response to rising food prices in 2008, the NFRA supplied the market with some of its maize stock so as to reduce food prices in areas where prices were rising sharply (MAFAP, 2013b). • In response to the 2011 drought, the NFRA intervened in the maize market and set competitive prices so as to discourage farmers from selling abroad. This policy was marginally effective as the set price was lower than wholesale prices in some cases (MAFAP, 2013b).
Public agricultural research	• Since 2009, Tanzania has invested less in agricultural research services as it has shifted funding resources towards input subsidies (MAFAP, 2013b).
Extension	• Since 2009, Tanzania has invested less in extension and training services as it has shifted funding resources towards input subsidies (MAFAP, 2013b). • The extension worker to farmer ratio in Tanzania is 1:2500, more than five times the ratio in Ethiopia and more than twice the ratio in Kenya (Abate et al., 2015).

Uganda

Figure 12: *Uganda Yield and Public Agriculture Spending Trends and Relevant Policies*

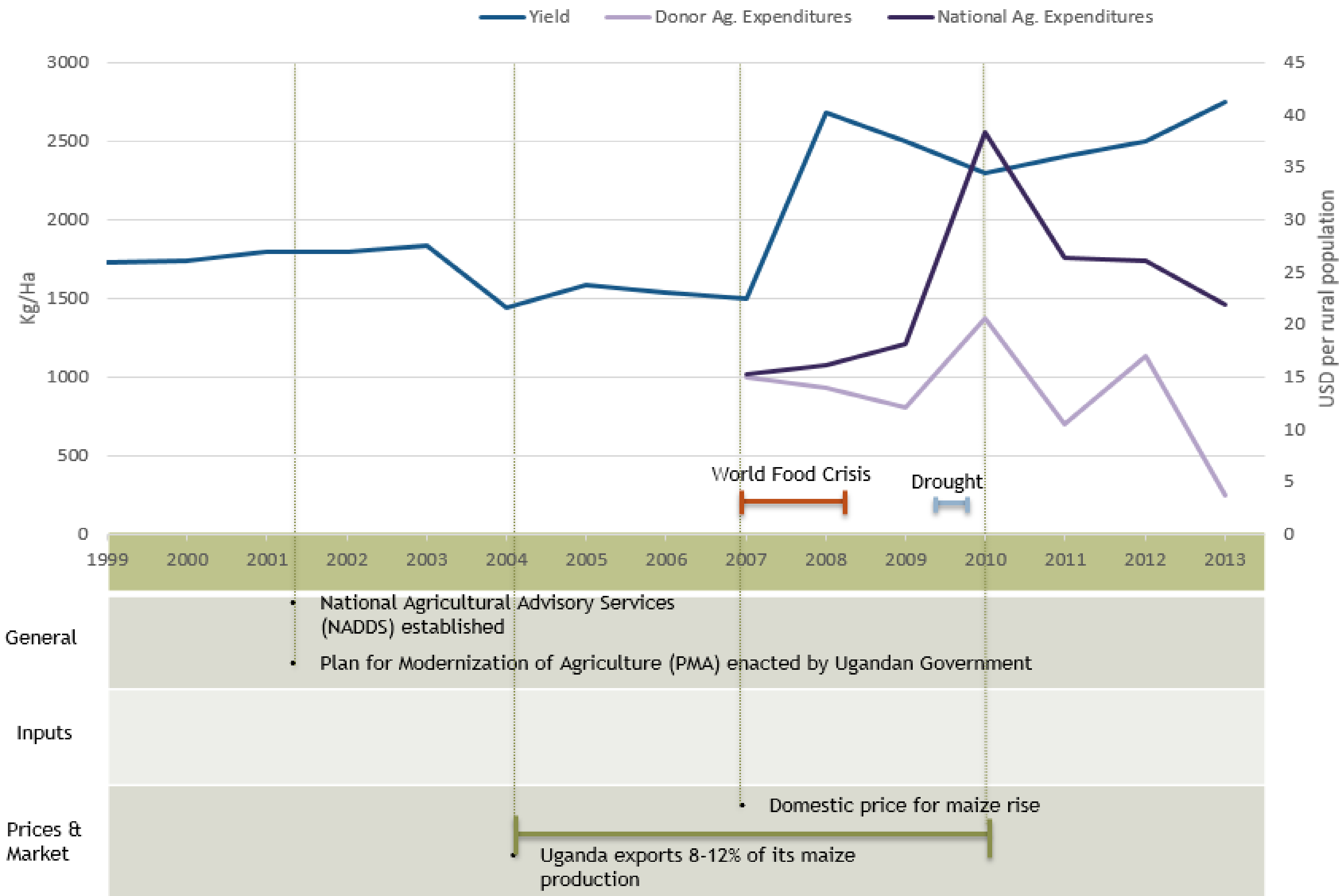


Table 7: Agricultural Policies in Uganda

General policy	• Since 1991, the Ugandan Maize market has been highly liberalized (MAFAP, 2013c). • While donor and national spending on agriculture were roughly equal in 2007, national spending increased until peaking in 2010, while donor spending has been more volatile, with an overall decrease between 2007 and 2013 (MAFAP, 2015). • In 2001, the Ugandan government enacted its Plan for Modernization of Agriculture (PMA). The mission of the plan is to eradicate poverty by re-orienting agricultural production towards commercial agriculture. In addition, the PMA resolved to support the creation, distribution, and adoption of productivity-enhancing technologies (Sserunkuuma, 2005). • Uganda's specific policy on agriculture and maize remains unclear. There are no known incentives for farmers to increase production and no attempts to ensure that farmers receive an economic return for their efforts. Farmers' decision to plant a surplus of maize beyond subsistence needs is highly influenced by price levels (MAFAP, 2013c).
Fertilizer prices, access, subsidies	• "The low demand for fertilizer follows much the same reasoning: lack of knowledge, information asymmetries, liquidity constraints, risk and uncertainty of prices and crop response associated with climate conditions, and high opportunity costs" (MAFAP, 2013c). • Uganda's low yields can be explained in part by low fertilizer use. Only 1% of farmers use fertilizer and Uganda's average kg of nutrients per hectare is among the lowest in the world (MAFAP, 2013c).
Improved seed prices, access, subsidies	N/A
Other input prices, access, subsidies	N/A
Transportation	N/A
Market access	• The maize marketing chain in Uganda is complex, requiring maize crops to pass through several markets before reaching a wholesaler, exporter, or consumer. With each transaction, the margin for marketing maize increases, which negatively impacts producers' incentive to invest in maize (MAFAP, 2013c). • "With a highly liberalized maize market in Uganda, minimal government intervention in price setting, insignificant direct taxes on maize marketing and liberalized foreign exchange market, the above results suggest the presence of significant market development gap" (MAFAP, 2013c).
Trade policy	• Since 1991, the Ugandan maize market has been highly liberalized. The private sector carries out domestic and international trade for all agricultural products (MAFAP, 2013c). • Between 2004 and 2010, Uganda exported eight to 12% of its maize production. However, unofficial maize exports may far exceed the official exports (MAFAP, 2013c). • Prior to 2007, maize producers received prices lower than reference prices. With the onset of the world food price crisis in 2007-08 producers began to receive domestic prices that were higher than reference prices, creating greater incentives for maize producers. These incentives appear to be related to the high export prices during the world food price crisis (MAFAP, 2013c).
Output prices, subsidies	• Uganda does not operate any trading companies that compete with the private sector or that act as buyers or guarantors of a minimum price (MAFAP, 2013c). • The Ugandan government no longer practices price controls as a development or trade policy measure. Instead, markets determine prices (MAFAP, 2013c).
Public agricultural research	• Over the course of the past century, the Ugandan National Agricultural Research System developed and released several productivity-enhancing technologies, including high-yielding crop varieties and land management techniques. Due to the low adoption of these technologies, yields for most major crops stagnated or declined throughout the 1990s (Sserunkuuma, 2005).
Extension	• In 2001, the Ugandan parliament implemented an act to establish the National Agricultural Advisory Services (NADDS) program in order to increase accessibility to agricultural information,

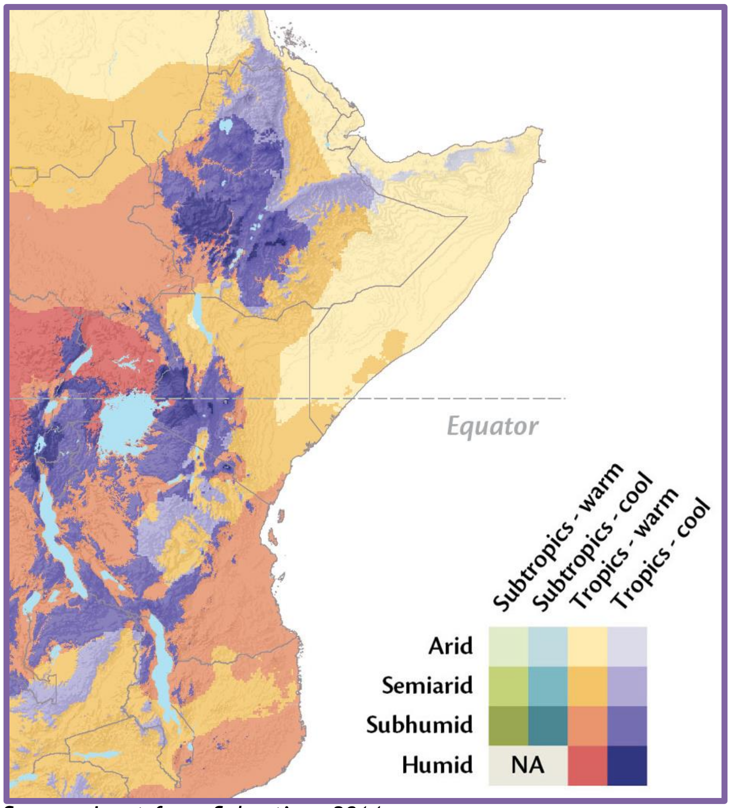
	knowledge, and improved technology among poor, rural farmers in Uganda. Okoboi's study, however, found that the association between farmer participation in National Agricultural Advisory Services (NAAADS) and yield is significant and negative. This study suggests that farmers who participated in NAADS may have relatively lower yields as compared to farmers not engaged in NAADS activities (Okoboi, 2010).
Economic Climate and Climate Factors	• Uganda has yet to live up to its maize production potential due to a number of production constraints including low soil fertility, lack of improved maize seeds, and drought in some seasons. Maize production is generally characterized by low yields (MAFAP, 2013c). • From June through August 2009, Uganda suffered from drought (MAFAP, 2013c).

Biophysical and Climate Drivers of Yield

The body of literature we reviewed suggests that diminishing soil quality, erosion and degradation, and lack of access to irrigation all constrain maize yields (Sserunkuuma, 2005; Ariga et al., 2009; Malley, 2009; Awulachew, 2010; Spielman et al., 2010; Taffesse et al., 2011; Lunduka et al., 2013; Ogada et al., 2014; Olwande et al., 2015). Additionally, studies found that temperature and rainfall variability, which may be increasing with the effects of global climate change, affects cereal yields (Sserunkuuma, 2005; Ariga et al., 2009; Malley, 2009; Okoboi, 2010; Awulachew, 2010; Spielman et al., 2010; Tafesse et al., 2011; Ogada et al., 2014; Ricker-Gilbert et al., 2014; Matchaya et al., 2014; Olwande et al., 2015).

Map 5 shows agroecological zones, which reflect an area's ability to support rain-fed agriculture. These zones are determined by elevation, climate conditions, and rainfall amount and distribution, and influence the types of crops cultivated (Sebastian, 2014).

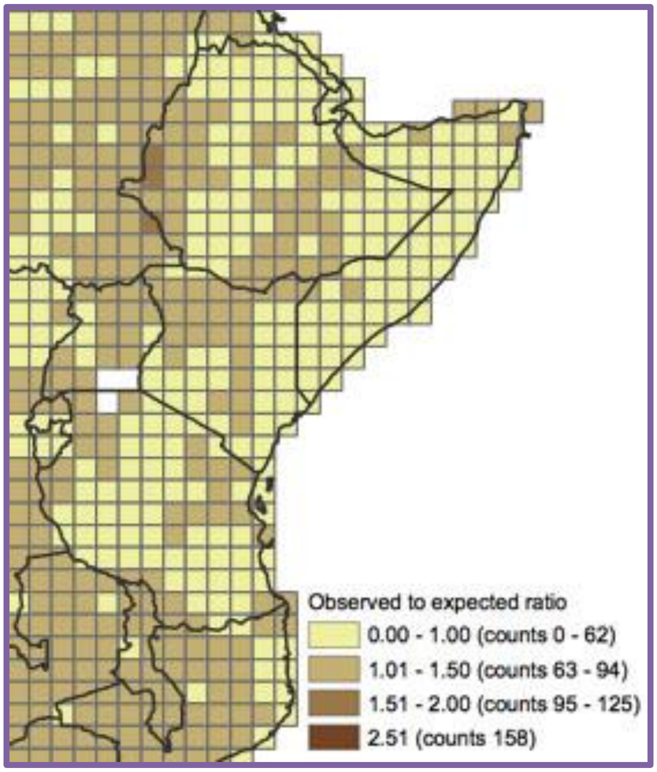
***Map 5**: Agroecological Zones of East Africa*



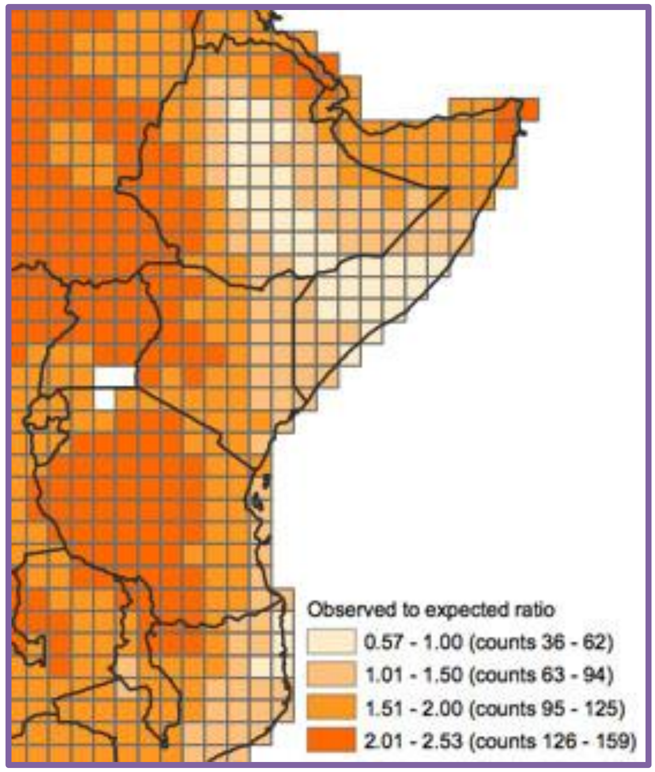
***Source**: Inset from Sebastian, 2014*

High variability in temperature and rainfall leads to less predictable harvests. Map 6 shows a ratio of the number of 'hot' months between 1980 and 2012 (above-average temperature) to the long-term average temperature. Light areas experienced temperatures cooler than usual, while dark areas experienced temperatures hotter than usual. Map 7 shows a ratio of the number of months between 1980 and 2012 with lower-than-average rainfall compared to the long-term average rainfall. Light areas experienced weather wetter than usual, while dark areas have been drier than usual. (The white cells at center with no data available are in Lake Victoria.)

***Map 6**: Temperature Variability in East Africa, 1980-2012*



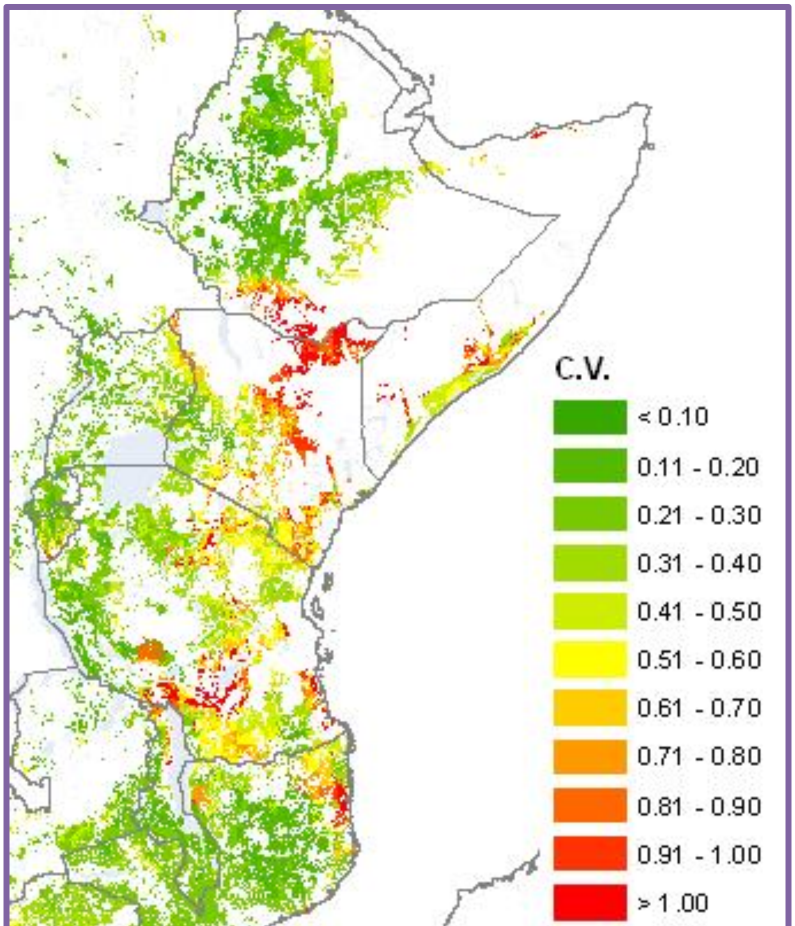
***Map 7**: Rainfall Variability in East Africa, 1980-2012*



***Source**: Insets from O'Loughlin et al., 2014*

Map 8 shows the coefficient of variation (CV) of seasonal rainfall, a ratio of the standard deviation of a set of rainfall data to the average annual rainfall, in maize-growing areas of East Africa. Areas in green have low variability of seasonal rainfall, while areas in red have high variation year-to-year. Variability in rainfall tends to be higher in areas with lower annual rainfall (HarvestChoice, 2010).

***Map 8**: Coefficient of Variation of Seasonal Rainfall in Major Maize Growing Areas, 1955-2004*



***Source**: Inset from HarvestChoice, 2010*

These patterns suggest a range of potential limitations to yield. For example, parts of Kenya and Tanzania have experienced both hotter temperatures and more variable seasonal rainfall, which are expected to constrain yields. Rwanda, Malawi, Ethiopia, and Uganda have experienced less variable seasonal rainfall, but have been hotter on average.

International Shocks to Local Supply and Demand

International maize prices and prices of substitute cereals in international markets are influenced by shocks to global food production (supply), major input prices, and changes in demand.[9] Rising international prices can affect local prices (making domestic consumption more expensive), but also incent local producers to increase the quantity of crop supplied either immediately or in the next planting cycle (to the extent that the initial supply shock was not local).

A country's general trade openness and history of exporting maize or other cereals will affect how much fluctuations in international markets affect incentives for smallholder farmers to increase production quantity and/or invest in higher yields. Figure 13 shows the prices received by producers of maize for each country. While maize producers in Rwanda typically receive high prices, those in Ethiopia regularly receive prices below the unweighted regional average, representing a disincentive to market their maize harvest. Producer prices are highly variable in Kenya, Tanzania, and Malawi relative to the regional average. Data on producer prices for maize in Uganda were not available.

***Figure 13**: Annual Producer Prices for Maize between 1991-2012 by Country, with Unweighted Average (USD/1000Kgs) (FAOSTAT)*

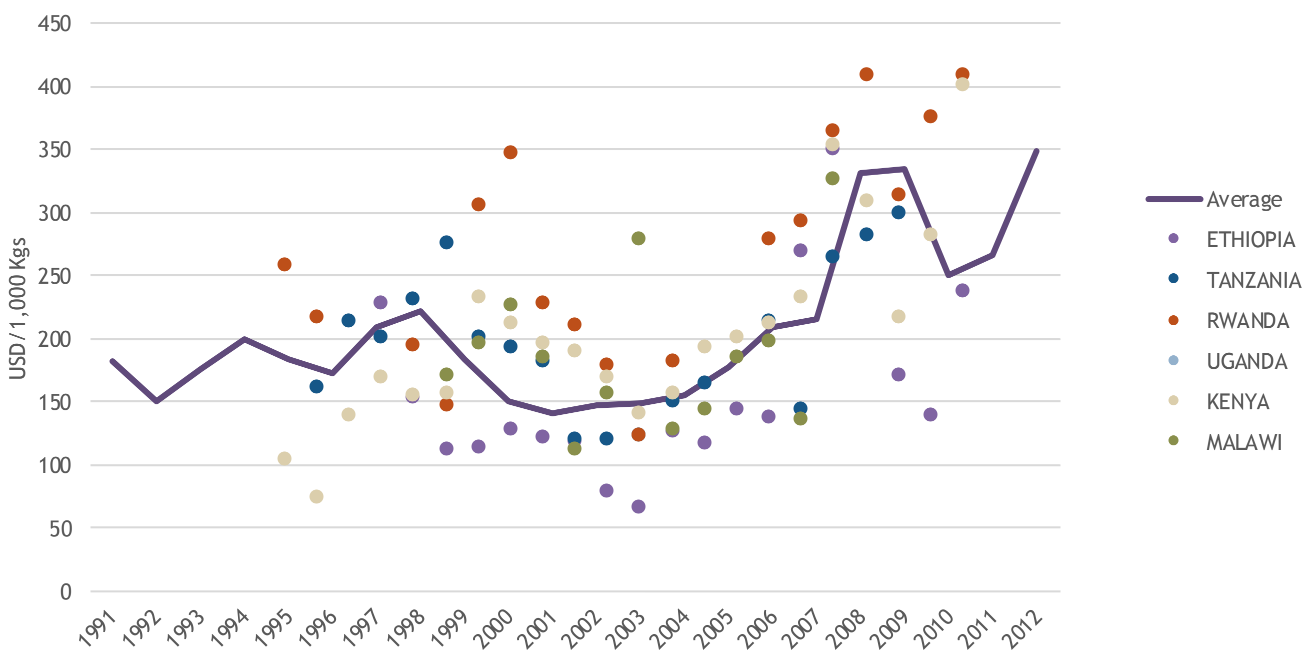
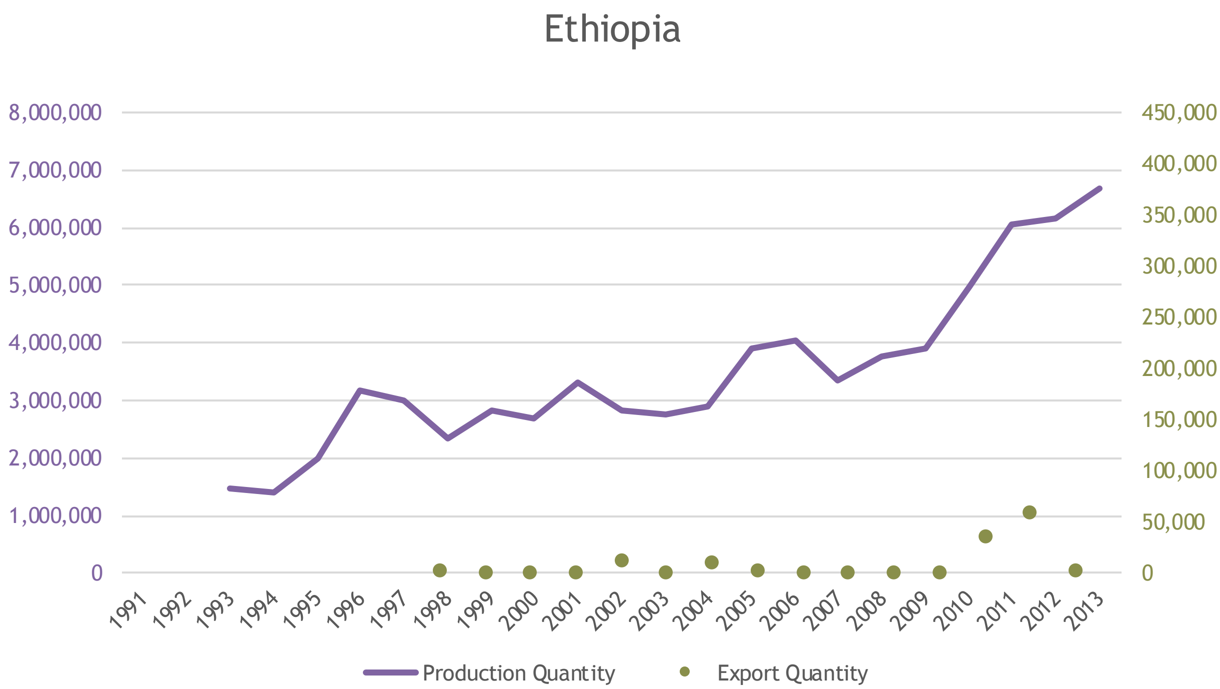
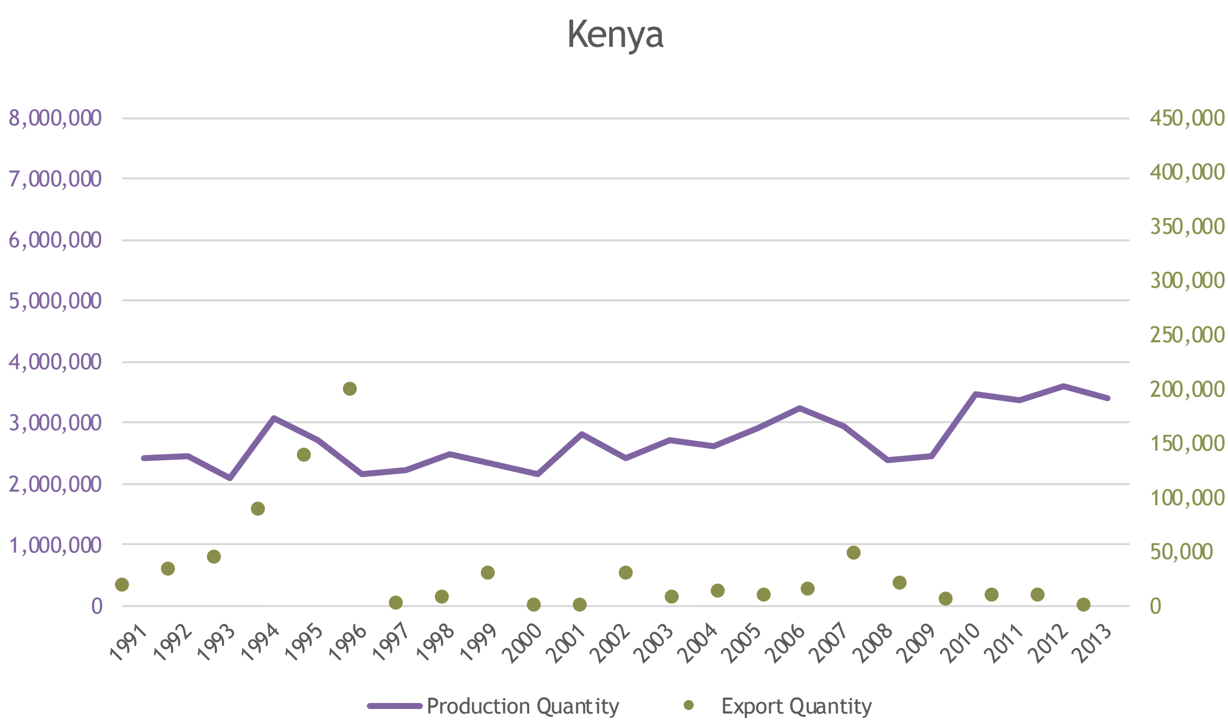


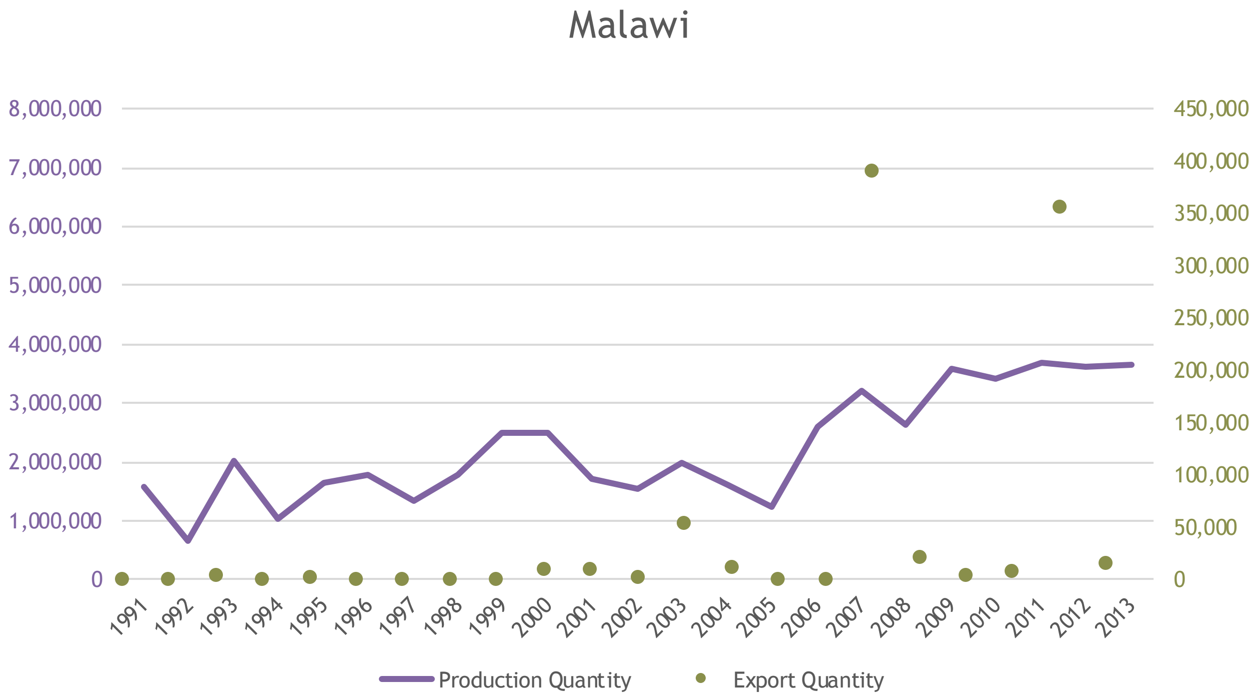
Figure 14 shows the total production (left scale) and export (right scale) quantities of maize for each country over the past two decades. While all six countries have experienced an upward trend in production, export quantities have not typically risen, and have been quite variable in Tanzania, Malawi, Uganda, and Kenya, while remaining low in Rwanda and Ethiopia. The vast majority of maize in all six countries is produced for domestic consumption (or regionally traded). We observe occasional spikes in the quantity of exported maize in Kenya, Malawi, and Tanzania.

[9] Cereal income elasticities and price elasticities also affect maize supply and demand, thus influencing yield. These data, however, were not available for this draft. Research on these elasticities is ongoing and will be included in the final draft.

Figure 14: *Production and Export Quantities of Maize by Country in 1000Kgs (FAOSTAT)*






Malawi
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Production Quantity
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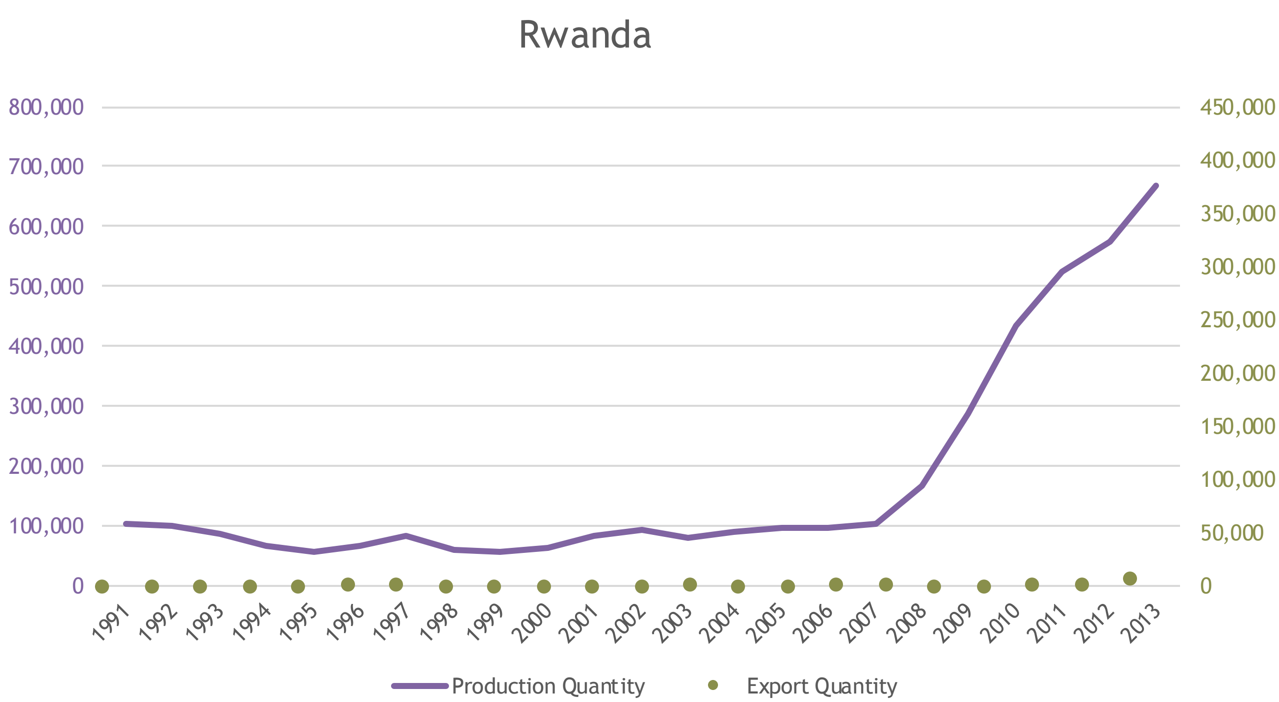
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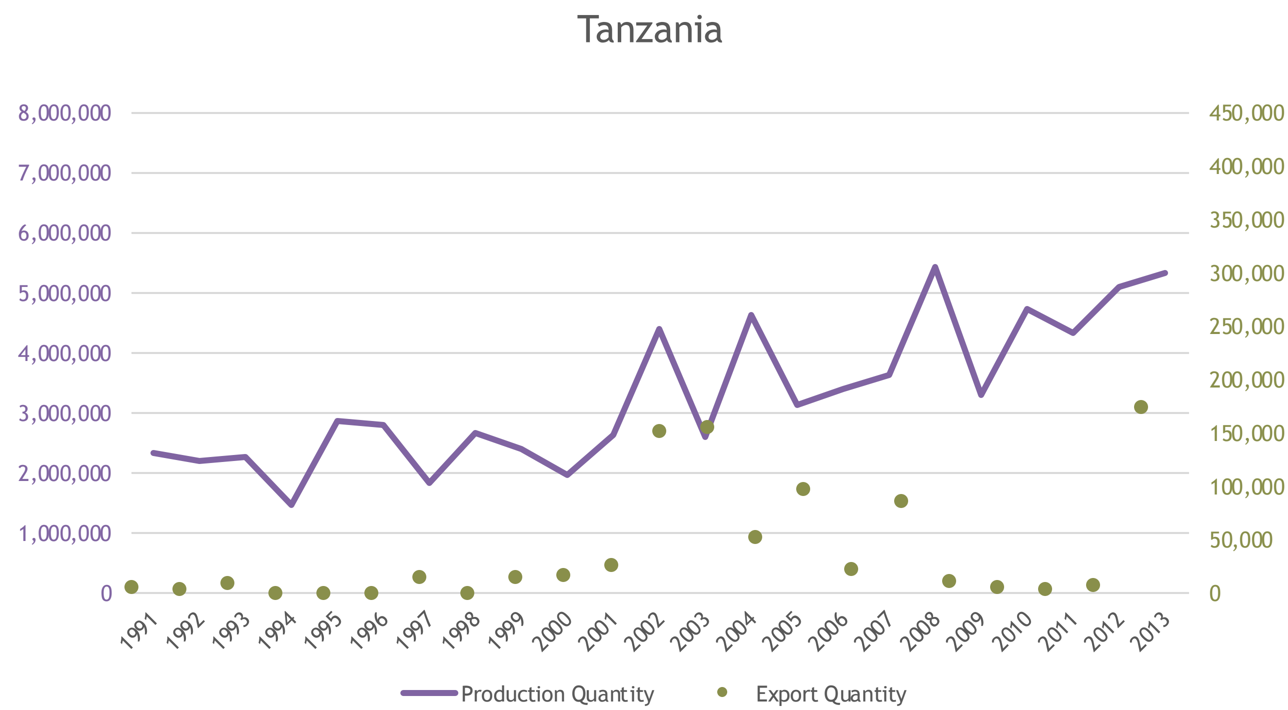
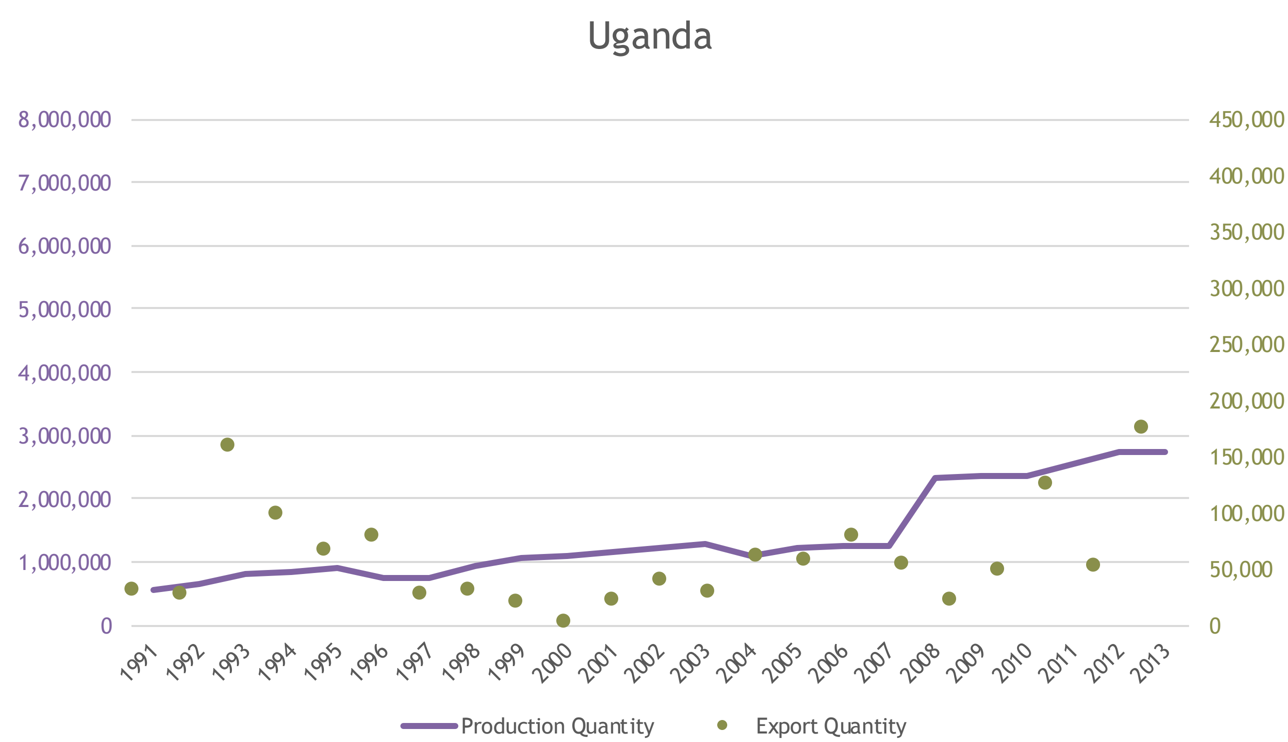
Production Quantity
Export Quantity





Please direct comments or questions about this research to Principal Investigators Leigh Anderson and Travis Reynolds at epar.evans.uw@gmail.com.

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Appendix A: Methodology

We summarize national maize yield trends in the six countries of interest using available FAOSTAT data to compare maize yields across the countries over time. We then compare trends in maize yields with yields of other major cereal crops over time for each country, to identify potential differences in maize yields. To complement these statistical summaries of yield trends, we conduct a macro-level review of the literature to evaluate what national policies may explain within- and between-country variation in yield trends over time based on reports and published scholarship. In addition, we compile public agriculture expenditures using data from the Monitoring and Analyzing Food and Agricultural Policies (MAFAP) database.

FAOSTAT Analysis & National Reports

FAOSTAT data are collected and compiled with the assistance of national governments. For this analysis we include data from a 20 year period, 1993-2013, to illustrate national level changes in reported yield (reported in kilograms per hectare (kg/ha)). To account for the variation in proportion and type of cereal crops grown in Tanzania, Ethiopia, Malawi, Rwanda, Kenya, and Uganda we also report the yield for the top four cereal crops in each country.[10]

MAFAP Public Expenditure Data

Public expenditure amounts are self-reported by countries and are available from 2006 to 2013 for Ethiopia, Kenya, Malawi, Tanzania, and Uganda. Expenditure data were not available for Rwanda. In this report, we include total agriculture-specific expenditures, which is comprised of amounts paid to agents in the food and agriculture sector (producers, consumers, input suppliers, processors, traders, and transporters) and general support to the food and agriculture sector (including research, technical assistance, training, agricultural infrastructure, etc.).

To compute public agriculture spending per capita rural population, for each year, we converted the MAFAP public expenditure amount into US dollars using that year's exchange rate and then divided by the total rural population for the year in question. We considered using number of rural households or total agricultural GDP as alternate denominators, but found that the trends in spending were robust to these different denominators, and the rural population estimates were more consistent across countries. We retrieved historical exchange rates from Oanda and rural population data from the World Development Indicators database from the World DataBank.

Literature Review

The review was conducted using Scopus, ScienceDirect, EconLit, and Google Scholar academic databases, websites of national statistical agencies and ministries of agriculture, research institution websites, and the University of Washington Libraries. We reviewed and coded results that provided evidence from focus countries and included theory or evidence on trends in maize yields or policy or management drivers of crop yields. Additionally, we coded all relevant material found on the websites of national agencies and maize research institutions. If two or more studies provided evidence on the same driver or policy area, we coded the most recent one only, provided the older works had been cited within it. The literature search was limited to literature published since 2005. In addition, we coded 8 results from national ministries of agriculture or statistical agencies. These included national agriculture policies and other reports. We coded 9 more results identified through searches of FAO, IFPRI, and other research institutions.

[10] We also required that the top four crops account for 90% of the national cereal yield.

Scopus Results

Keywords Searched	Search Date	Search Results	Relevant Results	Coded Results
TITLE-ABS-KEY((Ethiopia OR Uganda OR Tanzania OR Kenya OR Rwanda OR Malawi) AND (maize) AND (yield OR productivity) AND (policy OR management)) AND PUBYEAR > 2004	*7/9/15*	*197*	*16*	*7*
TITLE-ABS-KEY((Ethiopia OR Uganda OR Tanzania OR Kenya OR Rwanda OR Malawi) AND (maize) AND (yield OR productivity) AND (policy OR management)) AND PUBYEAR > 2014	*10/26/15*	*9*	*1*	*1*

EconLit Results

Keywords Searched	Search Date	Search Results	Relevant, Non-duplicate Results	Coded Results
(Ethiopia OR Uganda OR Tanzania OR Kenya OR Rwanda OR Malawi) AND (maize) AND (yield OR productivity) AND (policy OR management); Published Date: 20050101-20151231	*7/13/15*	*38*	*15*	*3*
(Ethiopia OR Uganda OR Tanzania OR Kenya OR Rwanda OR Malawi) AND (maize) AND (yield OR productivity) AND (policy OR management); Published Date: 20150701-20151231	*10/26/15*	*0*	*0*	*0*

ScienceDirect Results

Keywords Searched	Search Date	Search Results	Relevant, Non-duplicate Results
TITLE-ABSTR-KEY(((Ethiopia OR Uganda OR Tanzania OR Kenya OR Rwanda OR Malawi) AND (maize) AND (yield OR productivity) AND (policy OR management))); pub-date > 2004	*7/10/15*	*65*	*0*
TITLE-ABSTR-KEY(((Ethiopia OR Uganda OR Tanzania OR Kenya OR Rwanda OR Malawi) AND (maize) AND (yield OR productivity) AND (policy OR management))); pub-date > 2014	*10/26/15*	*5*	*0*

Google Scholar Results

Keywords Searched	Search Date	Search Results	Results Screened	Relevant, Non-duplicate Results	Coded Results
(Ethiopia OR Tanzania OR Malawi OR Uganda OR Rwanda OR Kenya) AND (maize OR cereal OR grain) AND (yield OR productivity) AND (policy)	*7/17/15*	*20400*	*First 150*	*22*	*4*
(Ethiopia OR Tanzania OR Malawi OR Uganda OR Rwanda OR Kenya) AND (maize OR cereal OR grain) AND (yield OR productivity) AND (policy) [results limited to 2015]	*10/28/15*	*5860*	*First 100*	*2*	*1*