


AFRICA'S POTENTIAL FOR AGRICULTURE

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INTRODUCTION

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Africa is a vast continent with more diversity in agricultural production than likely any other continent in the world. It is also a continent that was shortchanged on soil fertility during the periods of soil formation. In the Midwest of the United States, glaciers deposited valuable minerals and sediment that created some of the most productive soil profiles in the world. This is also true in places like the Ukraine, Argentina and other parts of the world. However, Africa is home to some of the oldest and most weathered landscapes.[1] As a result, less than 10 percent of Africa has what is considered high-quality soils, including the lower third of West Africa; parts of East Africa; and areas within several countries in southern Africa including Zambia, Zimbabwe, South Africa and Mozambique.[2] The rest of Africa's 54 countries and two disputed territories did not receive the same amount of natural benefit.

Africa has unique ecosystems such as the savannah of the Mara and Serengeti, the volcanoes of Virunga, and the Afromontane and coastal forests from western to eastern Africa. It has vast wildlife corridors traversing multiple countries, oftentimes combining significant national parks. Africa is home to 119 ecoregions, and of those, 89 have less than 10 percent of their area protected.[3]

These areas need continued protection against misuse, improper exploitation and unsustainable agricultural expansion. The Food and Agriculture Organization (FAO) estimates that 65 percent of agricultural land throughout Africa has been degraded by human activity.[4] The Montpellier Panel – a prominent group of agriculture, ecology and trade experts from Africa and Europe – estimates that these degraded soils are too damaged to sustain viable food production. Its report *No Ordinary Matter: Conserving, Restoring and Enhancing Africa's Soil* notes that Africa suffers from the triple threat of land degradation, poor yields and a growing population.[5] Therefore, to find realistic solutions to African production, we must be realistic about the physical, cultural and political impediments, none of which are small.

AFRICA'S GAP

The history of Africa's soils and land use complicates the strategy for increasing productivity in agriculture. It is not as simple as introducing Western production techniques which rely heavily on synthetic fertilizer and hybrid seeds. African biodiversity is closely linked to achieving food security. Nearly three-fourths of recorded protein consumption in Africa is derived from plant sources.[6]

This means that many crops that Africans depend on for consumption do not fall within the 20 crop species that have had historical economic importance to the rest of the world.[7] The primary crops which have benefited from significant research funds are not many of the traditional African crops. As a result, African agriculture runs the risk of being pushed towards monoculture production, jeopardizing the historical reliance on crop diversity and negatively affecting food security. This is important to note because our Foundation supports strategies to maintain biodiversity and crop diversity. We think this is critical to Africa's future.

This analysis demonstrates the sizeable investment gap that exists to reach peak food production if Africa uses so-called "first world farming" techniques. However, we are not advocating blanket monoculture production or other developed world farming systems which could harm Africa's fragile soils, its ecosystems or reduce a farmer's choices. This is simply an analysis to demonstrate the sizeable financial requirements to achieve increased food production using methods that are commonly promoted in Western development circles.

We propose thinking about Africa's potential for agriculture through a different lens: how we analyze opportunities for farmers and how soils are remediated and protected will be a key in our success or failure to support farm populations, which are as high as 90 percent in some African countries. Africa does not "look" like the United States, whether you're analyzing climates, soils, crops, wildlife, terrain, cultures or history. So Africa should not "look" like the United States when it comes to training, crop research, technical assistance or production methods. African farmers and institutions should instead borrow relevant lessons from the United States, Brazil, Australia and others, but also protect and embrace their unique diversity to develop a system for agriculture that is adapted to their circumstances. If they do not, the continent overall will continue its per capita decline in productivity. One of the critical components of getting the solutions right is starting with reasonable assumptions and a realistic understanding of the practical challenges of the barriers which exist.

EXISTING ANALYSIS

A number of organizations and institutions have analyzed Africa's potential for agriculture using different methodologies and assumptions. The different approaches have yielded vastly different results as measured by the amount of available (not always appropriate) arable land in Africa. The actual amount of available and appropriate arable land and its potential productivity is critical to Africa's food security interests and the question of whether Africa can feed itself in the future.

Therefore, we set out to understand why different analyses produced significantly different estimates, and to see if we could take it one step further to move it beyond a desk analysis by incorporating two critical assumptions: the practical barriers farmers face in their daily operations and the political barriers that affect change made at scale.

This analysis is based on available public information and our experience on the ground. We believe on-the-ground experience is critical to achieve the most accurate results. However, it is not possible to physically inspect and incorporate every country's actual and planned programs that could affect this type of analysis. A case in point is a recent visit to Rwanda where we observed an ambitious program by the Rwandan government to implement irrigation systems on 247,000 acres (100,000 hectares) with a plan that incorporates smallholder farmers. If implemented successfully, this program will improve yield levels and the reliability of production on a large scale. The effects of the Ebola outbreak in Liberia, Sierra Leone and Guinea will have a serious but as yet unknown effect on food security and farming. As of October 2014, an estimated 40 percent of farms have been abandoned in the hardest hit areas of Sierra Leone.[8] Therefore, we are not claiming 100 percent accuracy in this analysis; however, we believe that other analyses have failed to take into account the political, social and cultural barriers that impact agricultural production and they often treat all apparently arable land as the same - two significant mistakes.

OUR EXPERIENCE

As a farmer, I am regularly amazed at how frequently non-farmers are charged with producing analyses and recommending solutions that will have tremendous influence on the issues farmers face. It is the equivalent of asking a non-medical person to perform surgery. Just as trained doctors are best equipped to perform medical procedures, farmers are best equipped to understand the issues farmers face, and they are best equipped to participate in developing practical solutions that work in the real world, not in hypothetical situations. When hypothetical solutions drive policy, it is a recipe for failure.

Our Foundation operates farms in South Africa, Arizona, Nebraska and Illinois for a total of over 16,000 acres (6,475 hectares). I have personally farmed for over 30 years, and have faced crop failures from drought, floods and frost, and watched record crop yields destroyed by hail storms. But my experiences pale in comparison to most African farmers.

One reason this is true, and another mistake that is frequently repeated, is the assumption that all farmers are similar. In fact, there are significant differences among farmers across a range of issues. Failing to recognize the differences between a farmer who has regular market access and a farmer who has a family that regularly experiences hunger periods is like thinking a Volkswagen and a Ferrari are the same because they both use gasoline-powered engines.

If we do not account for these differences, and if we do not accurately assess the barriers which keep farm productivity low and communities food insecure, then we are simply presenting nice ideas that will keep people hungry.

I once showed someone a DVD compilation of some of my photographs. The person said, "You need to separate the conflict images from the hunger images." Conflict and hunger are inextricably linked; to suggest otherwise shows a fundamental lack of understanding of both issues. Food is power; hunger is a tool for those who perpetuate conflict; and conflict creates hunger. Hunger itself can create conflict. That is the reality in many countries where we work. There is nothing pleasant about hunger or conflict, but we must discuss these issues openly and honestly if we hope to solve production shortfalls on the African continent.

The truth matters if we want to focus on the right solutions. I recently presented aspects of this analysis to an individual who is a leading voice among the donor community supporting Africa. He told me that it was time to be positive, that the "old trend" was to focus on the problems but the "new trend" is to focus on the successes. I don't care about trends. I care about solving problems, and no amount of positive thinking or rhetoric can overcome flooding or droughts or rebuild depleted soils. Positive talk does not build roads, create markets or overcome corruption. We remain positive but realistic.

I have seen too many hungry farmers to worry about being polite. There is something seriously wrong when a farmer cannot feed his or her family, when they have lost their own children to hunger. Therefore I make no apologies for calling it the way I see it. If we do not treat African soils and policies with realistic ideas based on realistic solutions, then we will fail the farmers we all want to help.

The analysis that follows was not conceived by or designed to meet the needs of academic institutions, bureaucrats or economists. It is designed to be a reality check on the depth of the challenges faced by millions of smallholder farmers in Africa. It is hopefully a wake-up call to the critically important and sizeable role that African governments and institutions must play to achieve food security. It is designed to illustrate the point that current commitments by governments and donors are not enough, and frankly, are not even close to what is needed. Our goal is to have the debate around Africa's potential for agriculture be grounded in reality, so that everyone is focused on the highest-priority solutions to the significant practical and political barriers that must be overcome to meet Africa's growing food needs.

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[1] Study of land use and deforestation in Central Africa Tropical Forest using low regulation SAR satellite imagery. Saatchi, et al.
[2] USDA Natural Resources Conservation Service, World Soil Resources, Soil Survey Division, 1996.
[3] The Encyclopedia of Earth
[4] Turning the tides of soil degradation in Africa: capturing the reality and exploring opportunities. July 10, 2003. FAO
[5] No Ordinary Matter: Conserving, Restoring and Enhancing Africa's Soil. December, 2014.
[6] Biodiversity in Africa. July 1, 2009. UNEP
[7] Biodiversity in Africa. July 1, 2009. UNEP
[8] IFAD

ANALYSIS BACKGROUND

CONTEXT AND CAVEATS

The goal of this analysis is to construct a comprehensive, data-driven and quantitative story about the practical potential for agricultural production in Africa. Drawing from well-regarded data sources, literature and documented programmatic experience, we have integrated, potentially for the first time, three disparate threads of analysis:

- *Location-specific geographic information system (GIS)-calculated land availability and crop yields using varying farming practices*
- *Quantification of real-life practical and political barriers to agricultural progress in Africa*
- *Detailed cost and return on investment (ROI) analyses of scalable, comprehensive programs to affect sustainable increases in production*

To put this effort into context, it is important to discuss what this analysis is and isn't, what it includes and doesn't include, and what limits we should place on its interpretation and application.

THIS IS NOT AN ACADEMIC EXERCISE, IT IS AN ENTIRELY PRACTICAL ONE

Peer-reviewed academic works for publications have a certain standard that must be met. This analysis is not intended to meet that standard. The audience for this analysis is anyone who believes that "one should not let the perfect be the enemy of the good" or that something can be accurate and actionable without proving statistical significance. As a Foundation committed to affecting change and challenging the status quo, we count ourselves as part of this audience.

THIS ANALYSIS INTRODUCES A CONCEPT CALLED A HEADWIND INDEX

It is a number from zero to 100 percent that represents the gap between theoretical production increases and practically and politically feasible production increases. For example, if a country were to invest in a program to expand cropland and improve yields, should the country expect the resulting increase in production to match the theoretical added acreage x the theoretical improved output of the soil? Of course not. There are real-life barriers to improvement like poor governance, illiteracy, lack of capital, poor infrastructure, insufficient agricultural research, poor access to markets, limited extension programs and co-ops, imperfect water policies, and many more. These must be accounted for. The *Headwind Index* attempts to quantify this.

If this example country had a *Headwind Index* of 88 percent, and the math said its program could theoretically yield an increase of 1M tonnes of maize, we would apply the *Headwind Index* to project a practically and politically feasible increase of 120,000 tonnes of maize, assuming the program did not address any of the headwinds. Because change doesn't happen in isolation, one would hope that any well-designed program would strive to reduce these headwinds, closing the gap between the theoretical and practically and politically feasible improvements. That is the whole point of highlighting the *Headwind Index* separately from land and yield calculations.

It is not possible to statistically correlate the *Headwind Index* to the gap between theoretical production increases and actual production increases. First, historical data on theoretical increases does not exist, and even if it did, normal yield fluctuations would muddy any statistical analysis. Second, the *Index* is comprised of 36 metrics and 55 sub-metrics across four major categories. Few, if any, of these could be independently correlated to production because there are too many factors that drive change. And third, headwinds change over time, so we cannot assemble a time-series data set.

Additionally, there is no guarantee that the index is linear and a *Headwind Index* of 88 really translates into an 88 percent reduction of theoretical increased production. We have gone to great lengths to define a *Headwind Index* of zero to mean no friction and a *Headwind Index* of 100 to mean no improvement. We did this by a) defining best-in-world countries for each sub-metric, min-max normalizing every variable, and creating a composite, imaginary "perfect country with no headwind" and b) identifying countries in Africa which have shown, despite attempted intervention, little to no improvement on each of the four major categories and defining their scores as 100 percent headwind. Between 0 percent and 100 percent we assumed a linear relationship.

Finally, and not surprisingly, there was missing and unreliable data. This is normal for any analysis of Africa, and we clearly indicate where data is absent or dated (it tends to be five to six countries consistently) and alternate metrics were used where data quality was a major concern. As an example, academic experts suggested we weight child mortality higher than poverty rate as a poverty metric because the former is harder for reporting countries to manipulate than the latter.

Ultimately one must decide whether the quantified *Headwind Index* can be valuable, practical and directionally correct without being statistically provable. Some academics we have shared this with said it can, some said it can't, and some didn't know. We believe it can.

THIS ANALYSIS IS NOT IN ANY WAY A COMMENTARY ON THE EFFECTIVENESS OF FOREIGN AID

While it may be tempting to interpret the *Headwind Index* as "wasted aid dollars," this is not the intent. We did not attempt to look at any aid programs, nor did we review the vast literature on the subject. We fully recognize that aid effectiveness is a current, important and polarizing topic. We are not engaging in this debate with this analysis.

What we are suggesting with this analysis is that programs to address agricultural improvement in Africa should focus on country-specific headwinds in addition to land and yield. We not only attempt to quantify the impact, but we attempt to quantify the costs and return on investment (ROI). This naturally leads to interesting discussions about where actors should prioritize agricultural improvement resources. This is an entirely appropriate use of the analysis.

THIS ANALYSIS IS A STATIC SNAPSHOT IN TIME

Because historical data on land, yields and headwind metrics were not consistently available, it was necessary to frame this analysis as a static snapshot. However, any agricultural improvement programs would take time. This presents a few challenges:

- *Data may be stale*: There is no way around this. Most of our data is from 2008-2012, though some is older and we have highlighted areas of particular concern (e.g., where there has been recent regime change).
- *Population and food consumption are growing*: We have used OECD consumption standards in all of our analyses and used straight-line population growth assumptions by country.
- *Headwinds change over time*: This is absolutely true. A great example is road construction. Over time, more land becomes accessible for farming, access to markets improves, etc. Our solution to this was to focus on five-year program costs in our ROI analysis. In this window, it is safe to assume that, with the exception of conflict and regime change, most headwind metrics should be stable.

THE ANALYSIS OMITS SEVERAL IMPORANT FACTORS

As with all complex analyses, we had to stop somewhere. Here are the major topics not covered, and we would welcome collaborative additions from others interested in tackling these issues:

- *Climate change*: Land quality and crop yield data use the Global Agro-Ecological Zones (GAEZ) model which, like the rest of our analysis, is a snapshot. It includes detailed weather and rainfall data but cannot account for climate change.
- *Loss of farmable land from poor farming practices and urbanization*: Again, this analysis is a static snapshot. We did model conservation agriculture techniques, and the GAEZ model does include soil preservation as a bundled variable. Urbanization was not included.

- *R&D for seed varietals*: In our ROI analysis, we model purchase costs for high-quality seed along with training and extension, but not all of those seeds exist today. We do not explicitly model the availability or development cost, either public or private, of these improved seeds.
- *Irrigation*: The entire analysis is based on rain-fed/dryland farming.
- *Livestock and fishing*: Because our focus was on farming output, as opposed to measuring food security, we limited the analysis to crops. Obviously, livestock and fishing are important for diet, economics and land use.
- *Impacts of extreme events:* This analysis was completed before the Ebola outbreak in West Africa. Extraordinary circumstances like this can be devastating to a country's progress and potential.

OUR ANALYSIS OF OPTIMAL CROP CHOICE IS DIRECTIONAL AT BEST

We use the GAEZ crop model and GIS mapping to calculate yields by crop under various levels of farming sophistication. The resolution of the GAEZ model is 10 x 10 km square "pixels" for the entire continent. While this is impressive, it is still 10,000 Ha per pixel…a very large collection of farms with varying conditions. We know from land cover GIS data how much of a pixel is being farmed, but we don't know the actual crop grown in each pixel. We only know this at the country level.

To determine the impact of improving yields, we must make an assumption about what crop is currently grown in each pixel.

Our model assumes that farmers grow the "optimal" crop, i.e., the highest output of calories and protein (equally weighted) for their particular land (which will not always be the case). We next compare this to current output by crop for each country. The difference in calorie and protein output is considered to be the benefit of "optimal crop choice."

Clearly there are many assumptions embedded here: uniformity of 10,000 Ha pixels, farmer training, local tradition and market demand, availability and cost of seed, nutrient management, etc. While we can confidently model the costs of implementing crop selection programs (based on existing programs) and apply our Headwind Index to reduce the impact, we recognize the challenges in modeling large shifts in crop decisions.

We believe it is critical to engage in the optimal crop choice discussion as part of the broader agricultural improvement and headwind discussion, and it is an integral, unavoidable component of our yield modeling. That said, the specific output benefits, resulting crop mixes and costs should be taken as directional with large error bars.

It is always easier to poke holes in analysis than it is to create new analysis. For every anecdote or case study presented, there is one that demonstrates a contradictory conclusion. We believe that what we have created is compelling and can be a valuable resource to inform practical, results-oriented actors looking to improve agricultural output and reduce headwinds to farming productivity in Africa.

At the same time, we are mindful of the limitations and assumptions inherent in the data and in our methodology.

This introductory narrative is intended to frame these known issues and allow readers to evaluate the analysis in a balanced fashion.

METHODOLOGY

Improving Food Production: Theory vs. Reality

There are two big levers to improving output…

Land farmed

- Farm unfarmed land
- Extend all-weather roads
- Shorten effective distance to markets

Yield per acre

- Improve inputs
- Optimize crop choice
- Improve techniques
- Improve soil health

Theoretical opportunity (granular GIS data)

…however, the impacts are dampened by real-life barriers

Practical & political barriers

- Governance & socioeconomics
- Government support for agriculture
- Farming catalysts
- Infrastructure

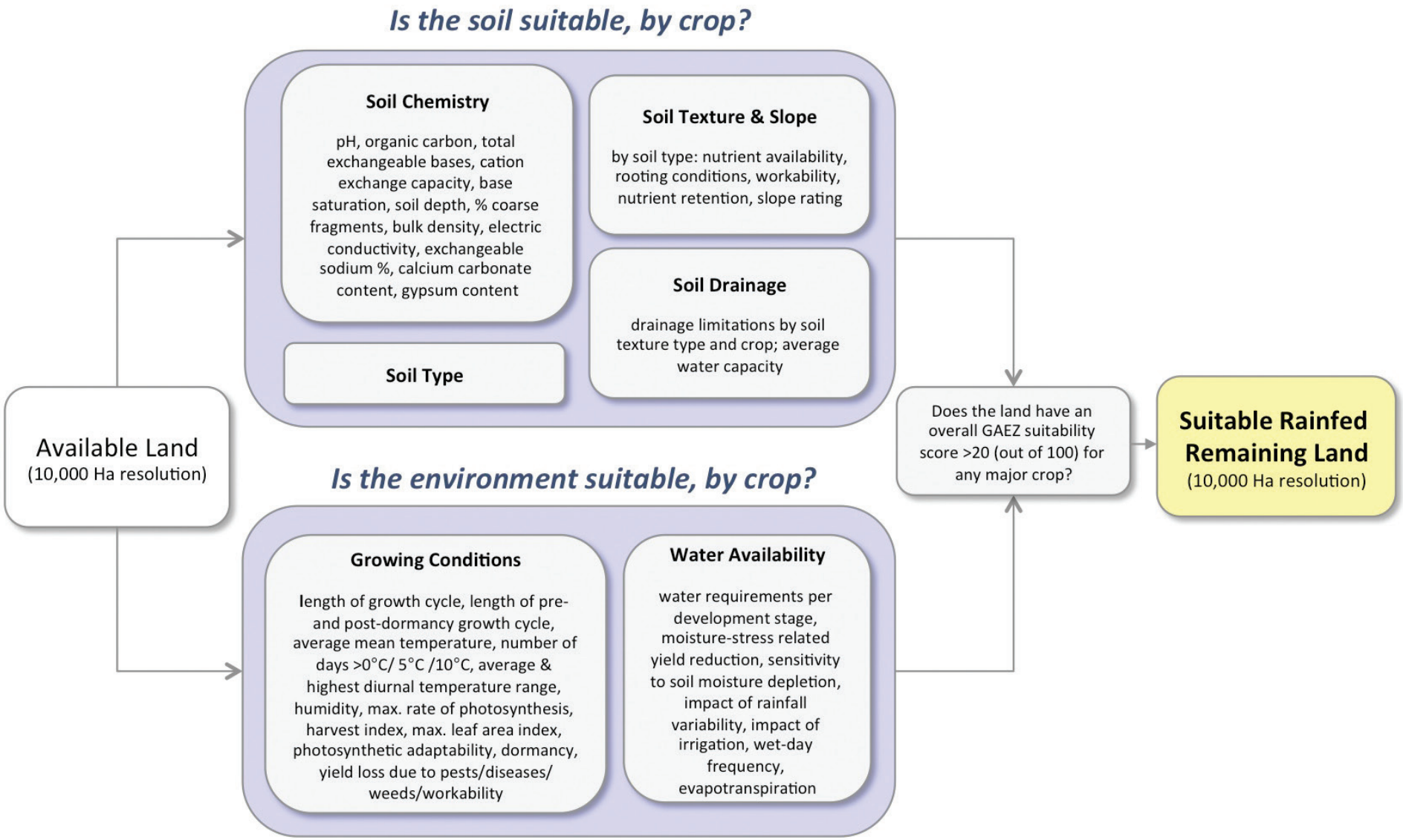
Real world "headwinds" to improvement (country-level metrics)

By quantifying the real-world headwinds, we can restrict the theoretical opportunity to what is feasible, given existing practical and political barriers

Source: Lake Partners analysis

Assessing Soil Suitability with the GAEZ Model

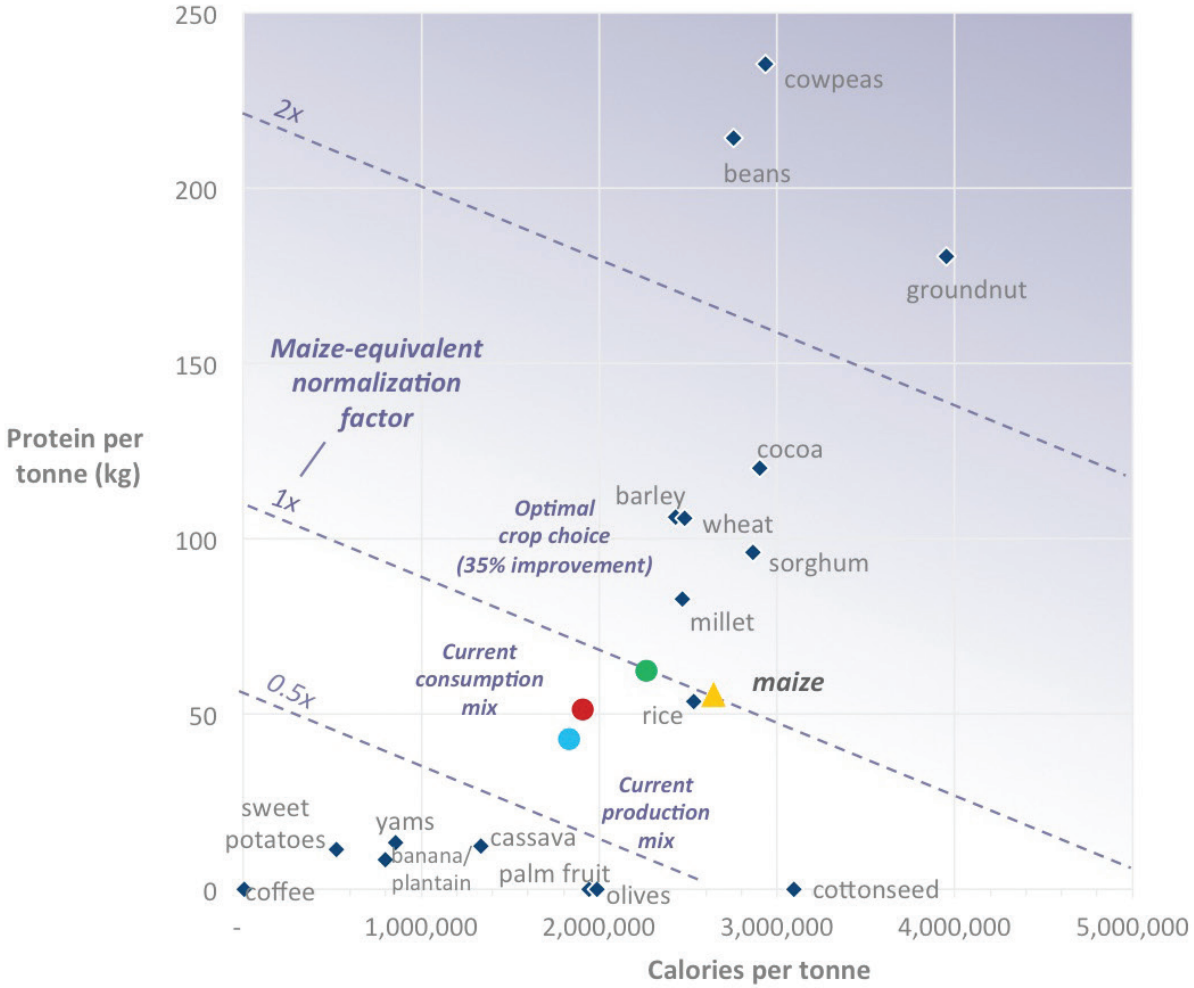
We begin by assessing the biophysical suitability of the soil for major crops



Source: FAO, UN, Lake Partners analysis

Optimizing Crop Types

We use caloric and protein content to assess the most nutritious crop for local conditions



For every 10 km x 10 km square, we pick the crop that yields the most calories and protein (equally weighted)

This results in a theoretical 35% increase in calories and protein

It also provides increases in 15 of 18 vitamins and minerals[1]

For comparison between crops, we normalize production relative to calorie and protein density of maize

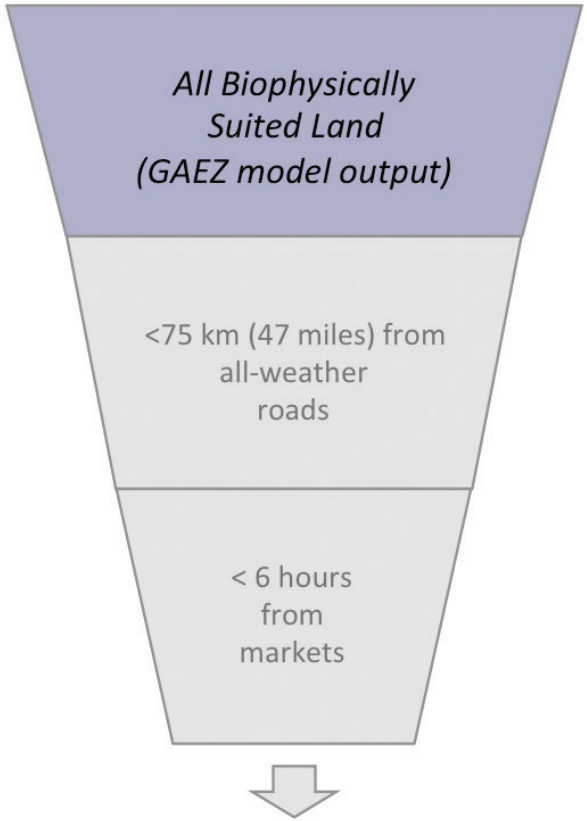
We use "tonnes" of harvested weight for production and "maize-equivalent tonnes" for comparisons to food demand

[1] Folate is reduced by 4% while vitamins A & C are significantly reduced, primarily from the model choosing grains over bananas/plantains, sweet potatoes and yams
Source: FAO, USDA, Lake Partners analysis

Land Accessibility

We then restrict biophysically suitable land by its accessibility to roads and markets

Accessibility of roads and markets affects ability to sell crops and access to inputs and advanced farming techniques



Rationale

100% of currently heavily cropped land is <75 km (47 miles) from an all-weather road, with ~80% of intensely farmed land within 37.5 km (23 miles)

6 hours to market allows a farmer to sell his/her crops and return to his/her farm in a single day; common measure by World Bank and FAO

Source: GAEZ, FAO, Lake Partners analysis

Practical & Political Metrics

We use 36 metrics to assess the political & practical climate of each country

We assembled 36 metrics (and 55 submetrics) across 4 categories related to a country's ability to increase agricultural production from its own land

1) Governance & Socioeconomics

Rule of law
Corruption
Poverty rates
Civil & economic freedom
Social justice for women
Cultural heterogeneity
Child mortality rates
Orphans & child head-of-household
Literacy rates
Cell phone use

2) Government Support for Agriculture

Government spending on agriculture
Extension, research and education
Regulation of protected seeds
Commodity reserves
Import tariffs
Trade delays
Water resource management

3) Farming Catalysts

Availability of fertilizer (usage as a proxy)
Pesticide use
Number of tractors in use
Access to capital
Access to agricultural inputs & markets
Entrepreneurial opportunity
Water resources
Rural organizations (co-ops)
Land rights
Women farmers
Foreign direct investment
Orphan crops
Farm size
Availability of skilled workforce

4) Infrastructure

Public investment in infrastructure
Road condition
Grain storage
Rail condition
Rural electrification

Source: Lake Partners analysis

Interpreting Barrier Metrics

For some metrics, whether a high score is "good" or "bad" is debatable in the ag community

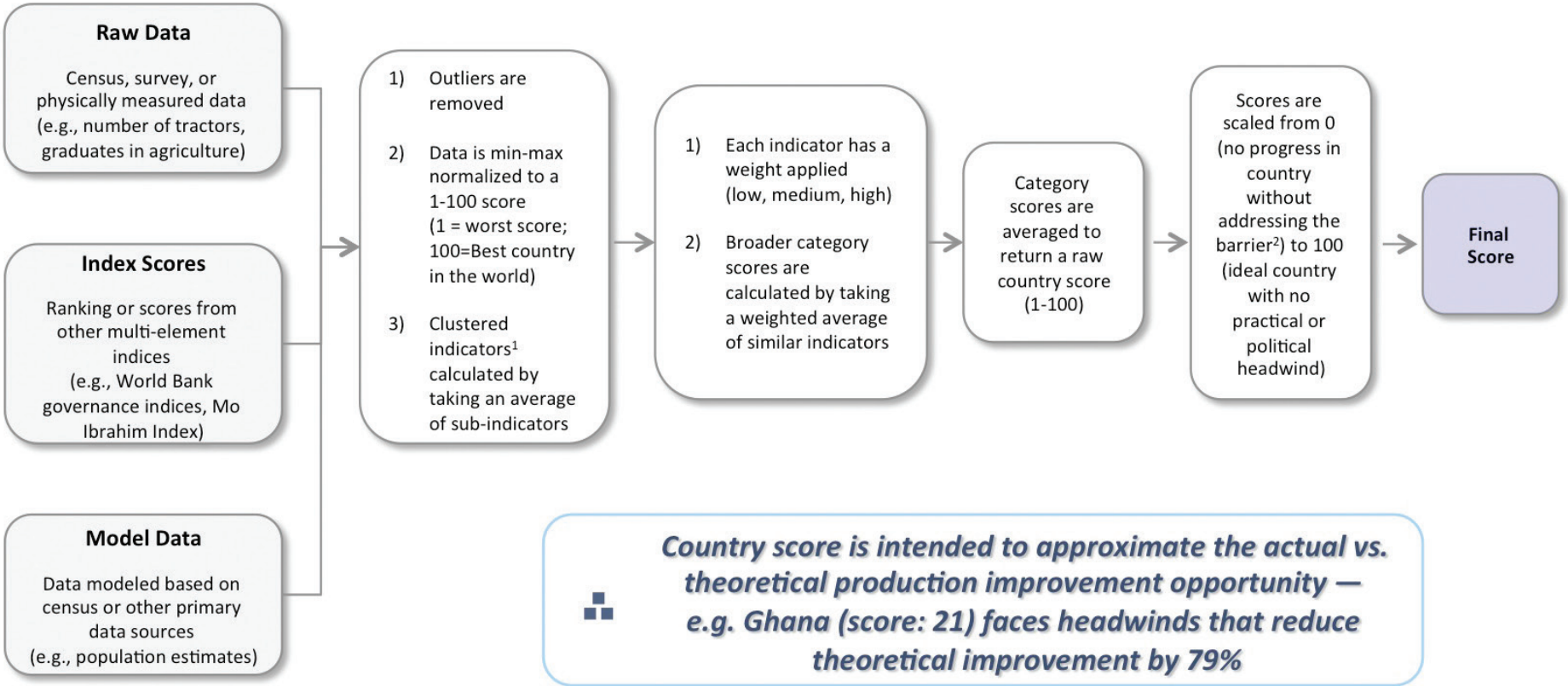
Metric	High Score Definition & Rationale (used in this analysis)	Low Score Definition & Alternate Rationale
Regulation of Protected Seed	Adoption of UPOV[1] Farmers have access to improved seed and the country is joining the international ag community	Non-Adoption of UPOV[1] Local farmers lose certain seed storage and reuse rights, putting them at risk
Import Tariffs	Low Tariffs Country is more likely to engage in free flow of trade with neighbors for ag inputs and outputs	High Tariffs Potential foreign dumping of ag outputs can threaten fragile ag market economies
Availability of Fertilizer (Usage as a Proxy)	High Usage Usage indicates availability and, at a country level, is one indicator of modern farming, which makes incremental improvement more likely	Low Usage Sustainable farming using conservation techniques actually require less fertilizer while improving yields and farmer economics
Tractor Usage	High Tractor Count Tractor usage is one indicator of modern farming, which makes incremental improvement more likely	Low Tractor Count Mechanization can displace farm workers if local economies are not ready to absorb them
Women Farmers	Low Percent of Ag Workforce Women often cannot own land or access credit. Also indicates lack of men in ag economy	High Percent of Ag Workforce In countries with gender equality, it can indicate women's access to land and credit
Foreign Direct Investment	High FDI One indicator of stability and a country's ability to maintain robust local economies	Low FDI FDI can indicate "land grabs" or equivalents and increased export of locally needed production
Farm Size	Larger Farms Commercial scale farming is one indicator of modern farming, which makes incremental improvement more likely	Smaller Farms Thriving smallholders are critical for ag success in Africa and commercial farming does not always improve food security or long term soil health

[1]UPOV refers to an organization called the "International Union for the Protection of New Varieties of Plants" and the UPOV Convention was adopted in 1961 to protect intellectual property and encourage breeding of new plant varieties.

Source: Lake Partners analysis

Practical & Political Score Methodology

INDICATOR DATA → *DATA CLEANING & NORMALIZATION* → *CATEGORY INDICATOR SCORES* → *RAW SCORE* → *SCALING* → ***FINAL SCORE***



[1]Clustered indicator: composed of two or more variables that measure the metric; they may come from difference sources or mix qualitative & quantitative data
[2]Governance and Sodoeconomics = CAR; Government Support for Agriculture = Benin; Farming Catalysts= Burundi; Infrastructure = Congo
Source: Lake Partners analysis

Estimating Growth with Practical & Political Scores

Practical & Political (P&P) Score = 100
(= 100% Production Growth)

	1) Governance & socioeconomics	2) Government support for ag	3) Farming catalysts	4) Infrastructure
Threshold Raw P&P Category Score (= 0% production growth)	24 (CAR)	35 (Benin)	22 (Burundi)	26 (Congo)
Criteria	Most countries with scores <24 are engaged in active conflict	Most countries with scores <35 spend <3% of budgets on ag subsidies	Countries <22 have less than moderately unsatisfactory access to inputs & markets (<3 score on UN-IFAD's Access to Inputs & Markets score)	Most countries <26 have <15% paved roads
Rationale	Precludes ag growth due to insecurity & destroyed infrastructure	Poorly subsidized ag programs do not expand easily due to lack of funding	Access to inputs & markets is crucial to shift to higher-intensity farming.	Poor roads restrict access to inputs, markets, & extension services
Case study	Somalia's production fell >50% following 1991 conflict, and has not yet recovered	Burundi's ag subsidies dropped from 7.2% to 1.8% from 1993-1998, leading to 13% drop in production (compared to a 33% growth rate the previous decade)	Liberia increased from a 2 on the UN-IFAD "Access to Inputs & Markets" score in 2004 to a 3 in 2008 and has seen a ~300% increase in production over that period	Cameroon increased paved roads from 8% to 17% from 2004-8, and saw a 46% jump in productivity, 15% greater than average for Central Africa
Category Weight[1]	0.24	0.26	0.25	0.25

To estimate a country's ability to grow agricultural production, we use its individual rescaled and weighted category scores

[1]Country weights are calculated based on the number of high-, medium- and low-weighted sub-indicators in each category
Source: Country-level reports, FAOSTAT, ReSAKSS, Lake Partners analysis

Estimating Feasible Production Growth: Example – Ghana

Potential Additional Production On Available Farmland Using Improved Farming Techniques:
182.8 M maize-equivalent tonnes

	Score [range of new scale]	*Production Growth Potential %*	*Category Weight*
1) Governance & socioeconomics	55 [24-100]	41%	0.24
2) Government support for ag	47 [35-100]	19%	0.26
3) Farming catalysts	34 [22-100]	16%	0.25
4) Infrastructure	32 [26-100]	8%	0.25

Weighted Production Growth Potential = 20.7%

*20.7% * 182.8 M maize-equivalent tonnes =*
37.8 M maize-equivalent tonnes

Source: FAO-GAEZ, Lake Partners analysis

Addressing Uncertainty in Metrics

Definitions for "suitable and accessible" land are meant to be liberal while "practically and politically feasible" are meant to be realistic

- Our GAEZ suitability criteria of 20/100 for any major crop is more inclusive than other major models (>40/100), and includes marginal soils
- We also assumed that farmers choose crops with greatest nutritional value, while consumption patterns don't change
- "Accessible" land is defined broadly, with 75 km from a road including 100% of currently farmed land and <6 hours to market as a common measure by the World Bank & FAO
- We assume no land loss due to urbanization, while prevention of soil degradation is implicit in GAEZ medium- and high-input scenarios
- Practical and political metrics are designed to realistically measure the headwinds to improvement scaled against an idealized, global standard
- However, headwinds are only applied once when in reality some may be multiplicative (e.g., headwind on changing crops x headwind on farming new land x headwind on yield increases)

Data for our metrics are mainly taken from 2008-2012 and may not capture very recent regime change and its effect on agriculture

- We identified countries that have had major regime change in the past two years[1]
  - Six countries were identified and are noted on maps: Libya, Tunisia, Egypt, Mali, Guinea-Bissau and Somalia
  - Libya, Tunisia and Egypt are excluded from rankings where noted

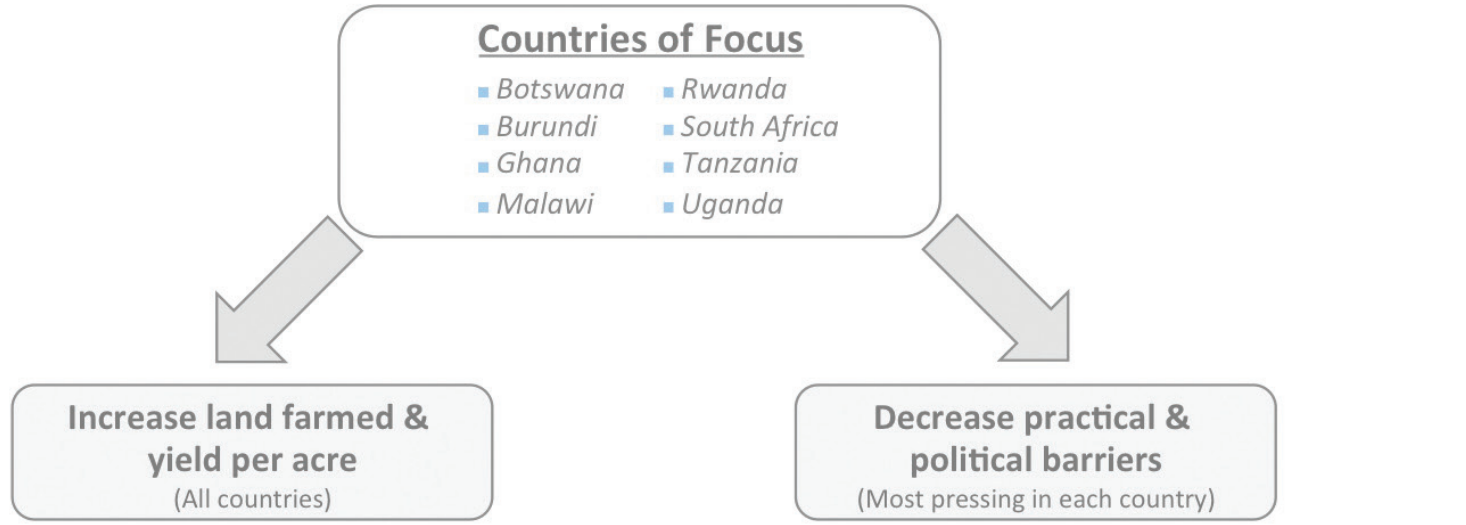
Poor data coverage for some countries also reduces confidence in metrics

- Libya, Somalia, South Sudan and Western Sahara all have less than 50% of the data necessary for our practical & political barrier score calculations (Western Sahara is excluded from all final barrier calculations)
- Poor data coverage is noted on maps where applicable
- Due to lack of current production data, Sudan's production has been approximated by apportioning former Sudan's production by the amount of GAEZ-modeled suitable land in each country

[1] Source: political transition monitoring program also used in the George Mason University State Fragility Index used in our Rule of Law submetric
Source: Lake Partners analysis

Interventions to Improve Production

Interventions were developed to determine the costs of improving production and reducing barriers



Using retail prices and programs with records of success, we developed country-specific interventions to increase farmland and improve yields while reducing barriers to farming

Source: Lake Partners analysis

Decreasing Headwinds by Increasing Yields

Yield improvement interventions can also affect barriers by breeding successful behaviors

	Intervention	Barriers Affected	Rationale
1	**Optimal crop choice**	• **Access to extension services & research**	• Boosts extension services to disseminate new seeds & information
2	**Improved farming techniques**	• **Use of improved seed** • **Availability of fertilizer** • **Number of tractors in use** • **Pesticide use** • **Access to extension services & research**	• Improved use of fertilizer, improved seeds and pesticides will help grow input markets • Also, extension services are improved to help train farmers on use of new techniques
3	**Grain storage**	• **Production loss through poor storage** • **Post-harvest losses of maize** • **Access to adequate storage** • **Commodity reserve**	• Use of improved storage techniques will add efficiency to value-chains, leading to better access • Farmers can also store grain to wait for optimal prices, acting as an on-farm commodity reserve

Multiplicative improvement of several interventions can significantly increase their impact on production

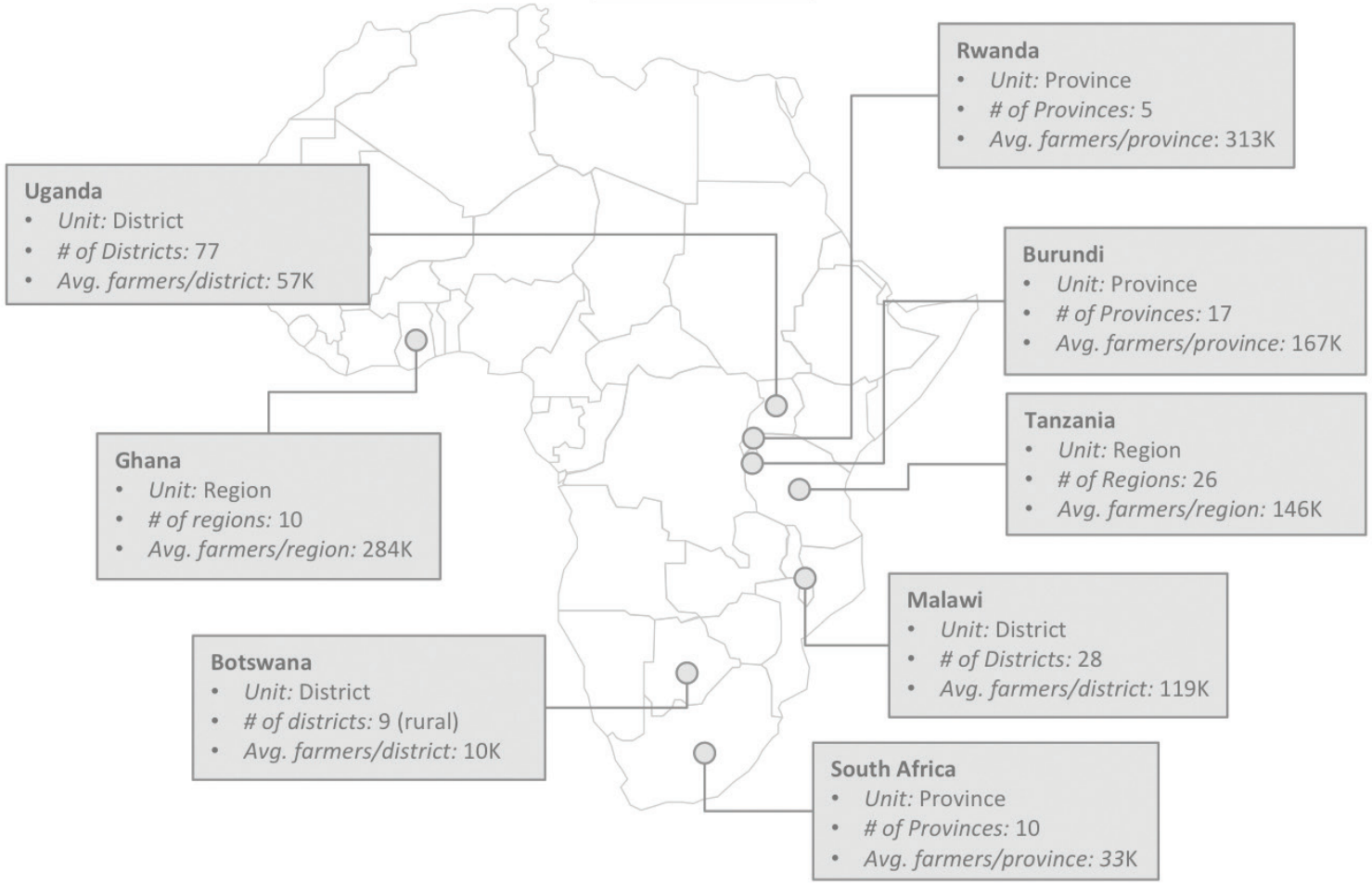
Source: Lake Partners analysis

"Bite-Size" of Interventions

Cost calculations are also estimated at the village[1]- and district-level

"Bite-sized" interventions were used to scale larger projects to manageable chunks

"District"-Level



[1]A village was defined as 100 farms
Source: Lake Partners analysis

EXECUTIVE SUMMARY

Executive Summary

How much available farmable land is in Africa?

- There are 414 million Ha (~1 billion acres) of biophysically suitable and accessible land in Africa (~14% of 3,030 M Ha of total land)
  (Confidence: Medium-High)
  - 1,070 M Ha (2.64 billion acres) of land falls in desert, water, forests or cities
  - 345 M Ha (0.85 billion acres) fall in protected areas or are currently being intensely farmed
  - 225 M Ha (0.55 billion acres) contain very poor soils that are not suitable for growing any major crop
  - 515 M Ha (1.27 billion acres) are inaccessible, being too far from all-weather roads and markets to be feasibly farmed
  - Of the remaining 414 M Ha, only 47 M Ha (117 M acres) are practically and politically feasible

What are feasible production growth estimates, considering additional barriers (practical & political)?

- Given existing practical and political barriers, Africa has the potential to increase its production from 442 M tonnes (322 M maize-equivalent tonnes) to 1,047 M tonnes (1,001 M maize-equivalent tonnes) under rainfed conditions (Confidence: Medium)
  - ~50% of the improvement comes from improving farming techniques (improved seed type, mechanization, nutrients, chemicals, soil erosion mitigation and nutrient management), ~20% from optimal crop selection, ~15% from reducing post-harvest loss and ~15% from expanding into unfarmed land
  - Biophysically, Africa could produce ~7,800 M tonnes (~6,800 M maize-equivalent tonnes), but practical and political barriers create a 85-90% headwind to improvement

Source: Lake Partners analysis

Executive Summary

Based on feasible production estimates, can Africa feed itself?

- Without relieving practical and political barriers, Africa could produce enough to feed itself until 2043, when population growth dominates production increases (Confidence: Medium)
  - This assumes nutrition per person doesn't increase while protein and calories per tonne produced increases 35%
  - This also assumes smooth intra-Africa trade
  - A 3x nutritional production increase would take time, so any window of self-sufficiency would be short
  - Relieving the practical and political barriers has up to a 10x multiplier effect on improvement, increasing substantially the opportunity for self-sufficiency

How do our estimates compare with prior estimates?

- Our estimate of 47 million Ha (117 M acres) of suitable and practically accessible farmland is below other, prior estimates (Confidence: Medium-High)
  - We estimate 666 M Ha of total suitable land, of which 252 M Ha is currently farmed, and practical and political headwinds to improvement limit additionally available land to 47 M Ha
  - Previous models suggest a range of potential farmland from 100–600 M Ha (0.25–1.47 billion acres)
  - However, other models appear to lack the combination of diversity of modeled crop types and the comprehensive effect of political and practical barriers

Source: Lake Partners analysis

Executive Summary

What can we learn from country case studies (Tanzania, Ethiopia, Ghana, Kenya, DRC)?

- Country's agricultural growth strategies have had mixed success due to national- or district-level factors

  (Confidence: Medium-High)

  - Tanzania's district-level strategies have shown that access to credit and inputs are major levers to agricultural growth
  - Ethiopia's centrally directed ag economy creates winners and losers by targeting input and infrastructure programs to the highest-impact regions of the country
  - Ghana's market-based reforms have had uneven success, with the agriculturally rich getting richer and the poor getting poorer
  - Kenya's big project approach was not sufficiently supported by detailed policies and administrative competence, and has therefore fallen flat
  - DRC's instability and lack of reliable data makes in-depth investigation difficult

Source: Lake Partners analysis

Executive Summary

What would it take for case study countries to feed themselves and become net agricultural exporters?

- Bringing additional farmland into production, optimal crop choice, improved farming techniques and grain storage are the primary drivers for increased production (Confidence: Medium-High)
  - These dwarf the selected country-specific headwind interventions (1-3 studied per country), but are expensive
  - In most countries improved farming takes longer to pay off than other primary production interventions
  - Large countries with good soil - South Africa ($59B), Tanzania ($231B), Botswana ($1.2B) and Ghana ($128B) - can all achieve self-sustainability in 2043 at OECD consumption levels
  - Malawi ($43B) can get close, but would remain "vulnerable"
  - Smaller countries with poorer soil and higher population densities – Uganda ($103B), Rwanda ($12B) and Burundi ($20B) – can only produce 40-55% of their 2043 OECD consumption with these interventions

- Additional interventions to reduce country-specific headwinds can have significant impacts, but there are no silver bullets (Confidence: Medium)
  - In general, a specific program can reduce a country's headwind 0.5-2.0% (market access in Burundi is an outlier at 4.6%) at a wide range of costs
  - These have multiplicative effects when layered onto the increased land and yield interventions, adding between 0.1-12.0% of 2043 OECD consumption each (with improved road conditions in S. Africa an outlier at 25.5%)
  - For Uganda, Rwanda and Burundi, we did not study enough country-specific headwind interventions to get them to self-sufficiency

Executive Summary

Where should donors focus their time and resources?

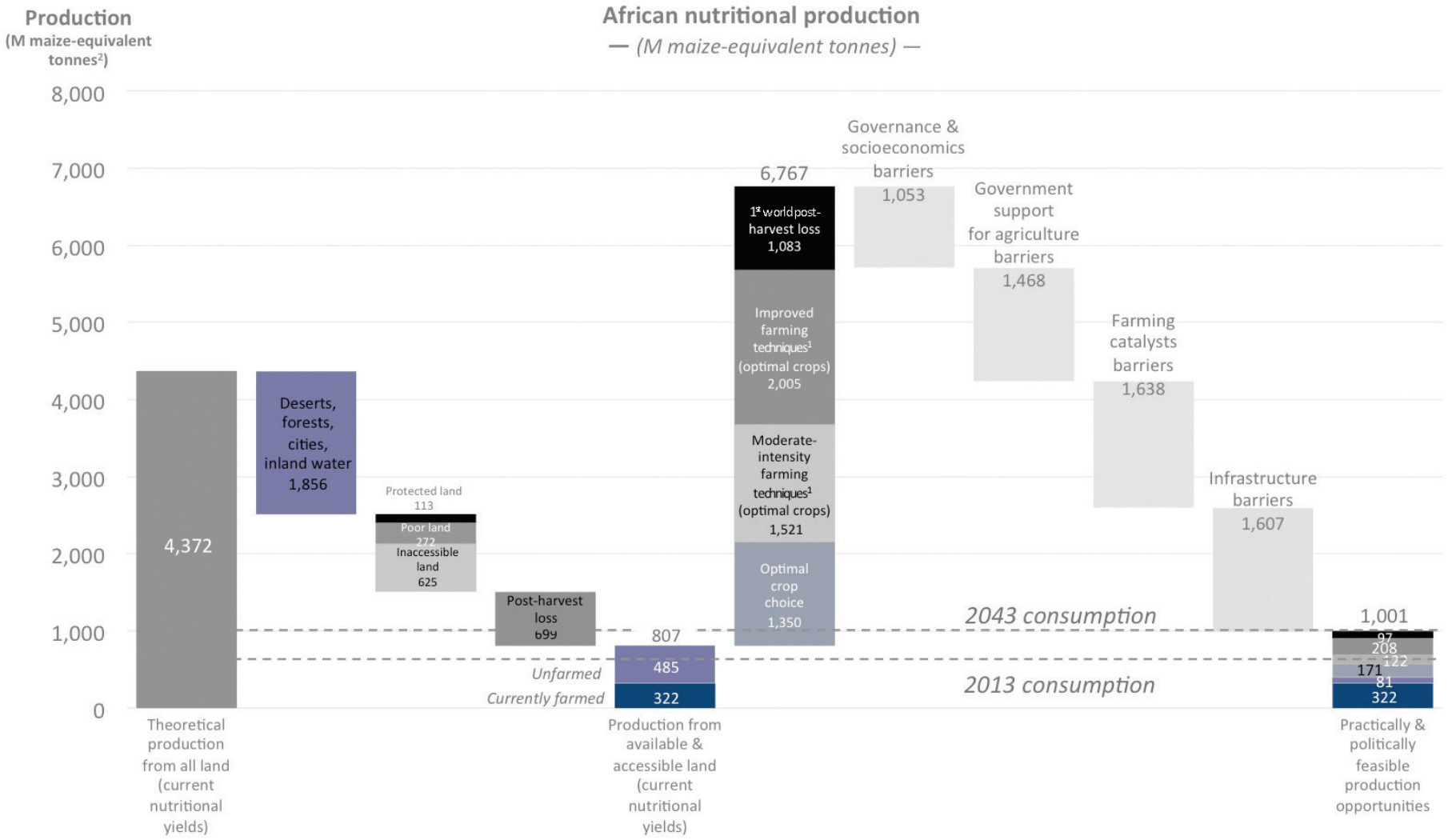
- While interventions yielding the highest production increases tend to have high ROIs, they also tend to be the most expensive and least currently funded (Confidence: Medium)
  - Bringing unfarmed land into production, improved farming and grain storage are priorities, but expensive
  - Optimal crop choice has a high ROI, but is the most theoretical intervention
  - Reducing headwinds for women farmers in Malawi, water resource management in Rwanda and market access in Ghana are examples of lower cost programs that can demonstrate quick payback, albeit with relatively low absolute production increases
  - There is also the opportunity to pick specific parts of detailed, well-funded country plans to foster working relationships with governments

How realistic are current country CAADP plans to boost agricultural production?

- The limited number of agricultural plans we analyzed are largely underfunded and broad (Confidence: High)
  - Most countries' agricultural (e.g., CAADP) plans — Rwanda, Burundi, Malawi, Uganda, Ghana —target an unfeasible number of problems for intervention and lack the necessary funding for implementation, though there are some targeted bright spots
  - Several plans, including those for Burundi and Uganda, have misplaced priorities and have not targeted problems our analysis suggests would have the highest ROI
  - South Africa's ag plan prioritizes incremental improvements on a broad range of issues, similar to other well-developed ag economies
  - Botswana's well-funded ag plan aligns well with issues we identified and will likely be implemented as budgeted

Overview: Theoretical Opportunity & Headwinds

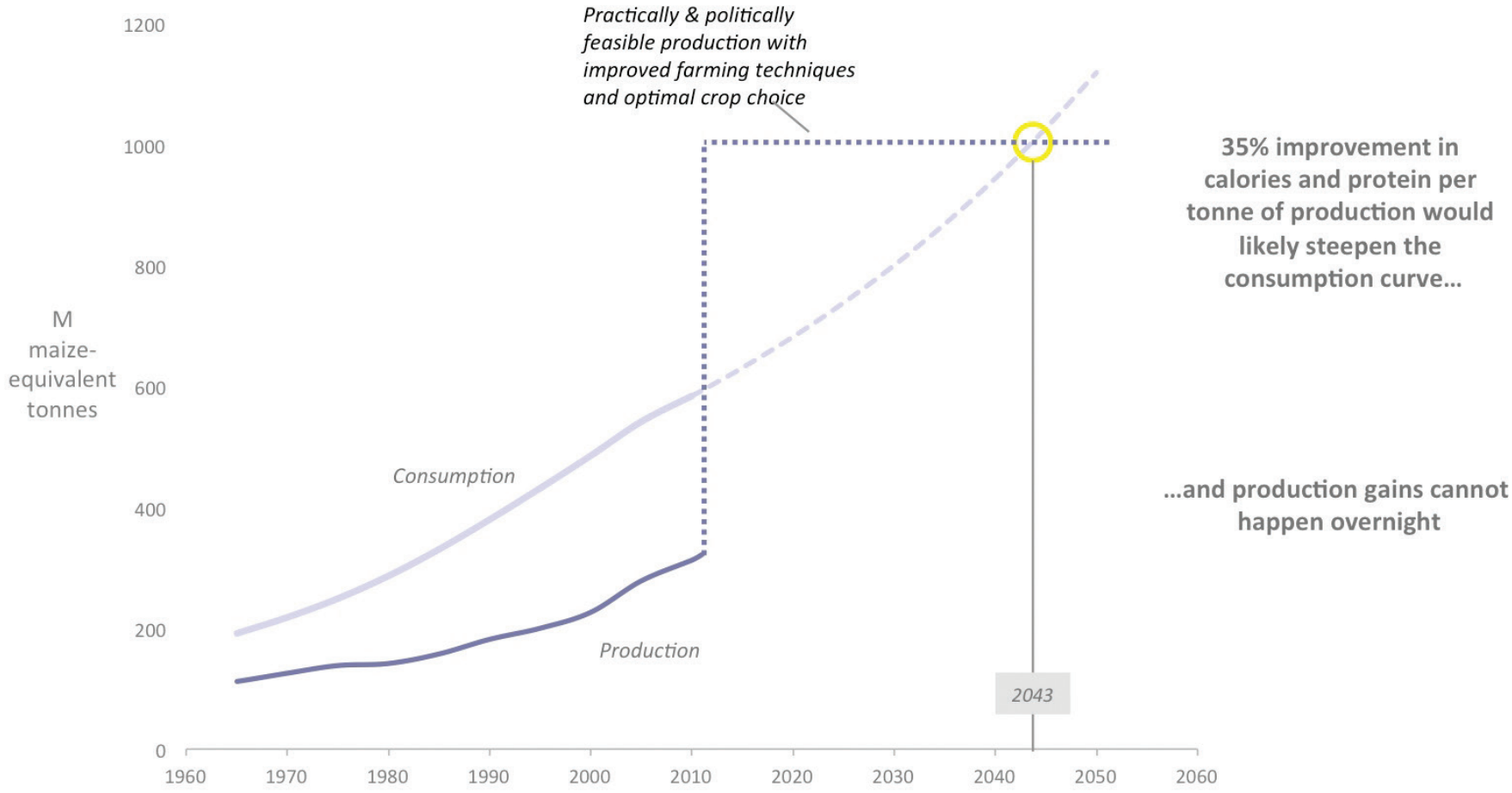
Africa has a theoretical opportunity to increase production over twenty-fold, though real-world headwinds limit growth



[1] Defined as moderate and high use of fertilizer, improved varieties of crops, mechanized tools, use of pesticides and herbicides, soil erosion mitigation, nutrient maintenance and fallow year requirements
[2] Maize-equivalent tonnes describe tonnes of all major crops that are weighted by calorie and protein content relative to maize
Source: FAOSTAT, GAEZ, Lake Partners Analysis

Overview: Projected Consumption & Production

In the current political & social climate, Africa's limited production growth potential may not keep pace with consumption

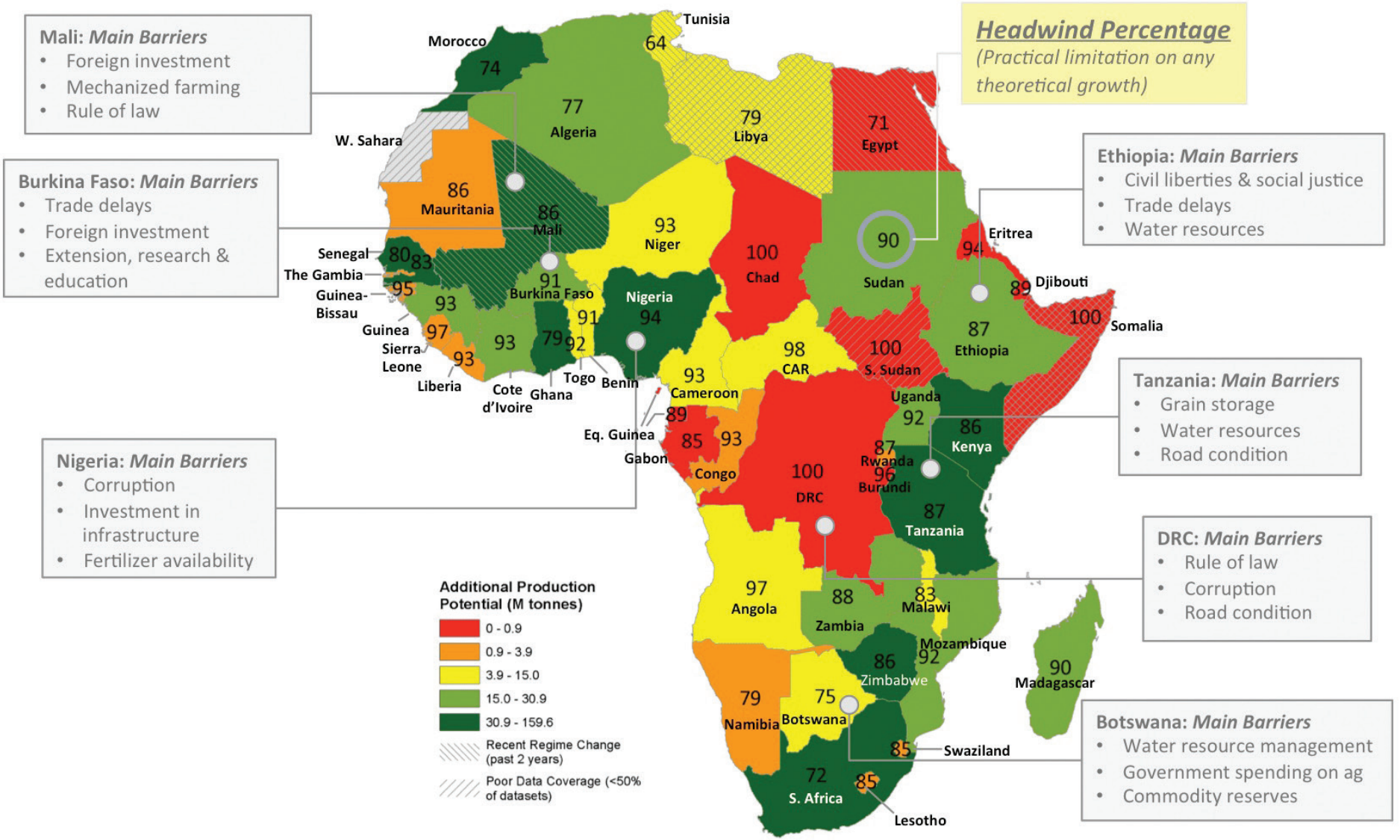


Even farming all feasible land using advanced techniques, potential production will not keep pace with demand unless barriers to growth are addressed

Source: FAOSTAT ("Production"); UN "World Population to 2300"/UNDP ("Consumption");, Lake Partners analysis

Potential Production and Current Barriers to Growth

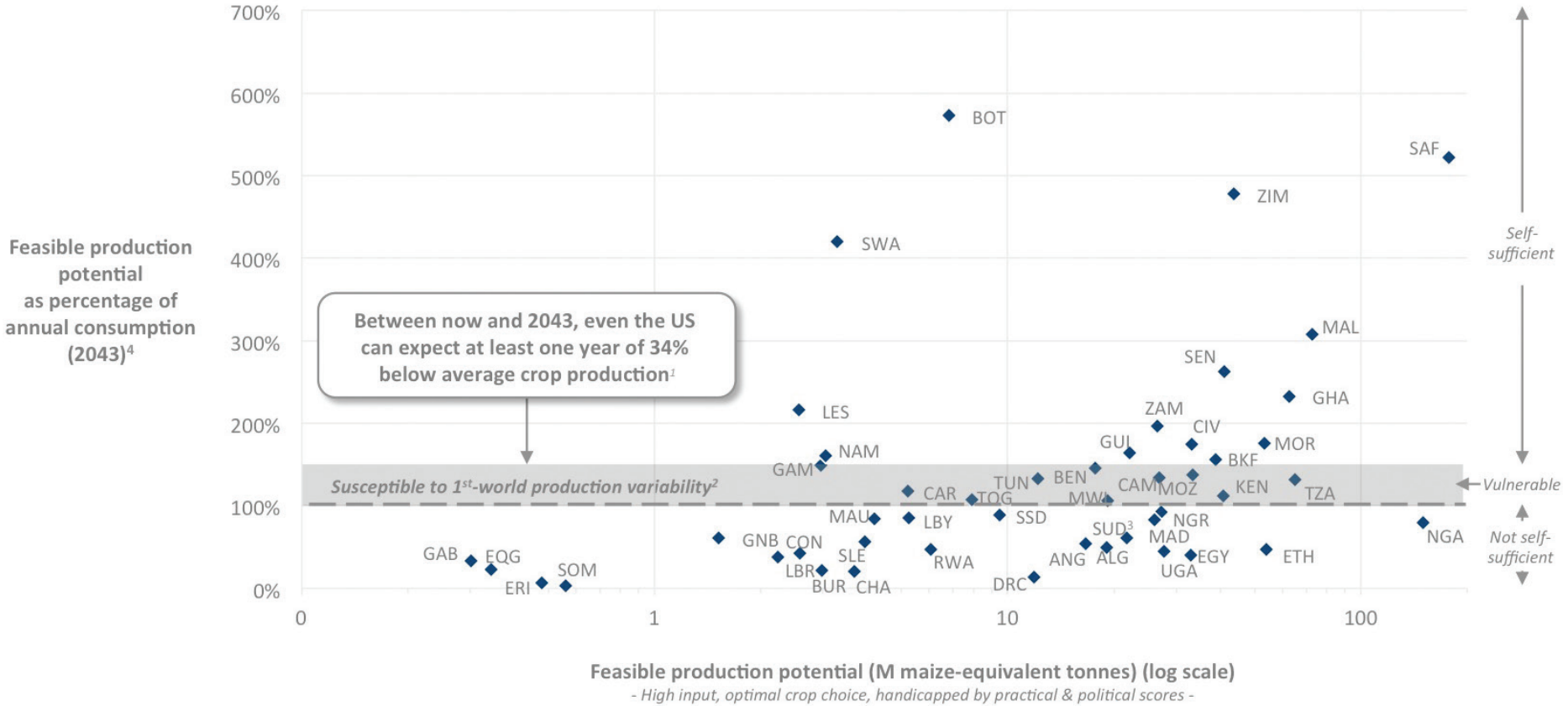
Each country experiences unique barriers to significant agricultural growth



Source: Lake Partners analysis

Potential Agricultural Self-Sufficiency at the Country Level

Most countries will not be self-sufficient unless barriers to growth are addressed



Source: Lake Partners analysis, FAOSTAT, UN "World Population to 2300"/UNDP

Without mitigating practical and political barriers, only 14 countries have the agricultural potential to be self-sufficient in 2043

[1] USDA/FAO Data (1940-2012), Lake Partners analysis
[2] To absorb a 34% production decrease and remain above 100% of consumption, a country must average 151% of consumption (100%/[100%-34%])
[3] The former Sudan's 2011 production of 7.9 M tonnes is apportioned to South Sudan (5.7 M tonnes) and Sudan (2.2 M tonnes) using GIS estimates of currently farmed cropland and GAEZ yield estimates
[4] Assuming constant consumption profile (0.7 tonnes per person per year)
Source: Lake Partners analysis

Model Results Comparison

Our model results are below previous estimates of farmable land in Africa

	Estimated African Potential Farmable Land	Model Strengths	Model Weaknesses
McKinsey	590 M Ha *[1.5 B acres]* (SSA only)	• Considers geographic location of countries for potential ag growth	• Does not account for practical, physical or political barriers to farming • Unspecified criteria for land suitability
FAO	451 M Ha *[1.1 B acres]*	• Includes wide variety of crops: cereals, roots and tubers, sugar crops, pulses and oil-bearing crops	• Land only assessed on biophysical suitability – does not account for practical, physical or political barriers to farming • Does not include marginal soils in estimate
EU Soil Atlas	243 M Ha *[600 M acres]* (Includes current farmland)	• Simple model inputs (e.g., elevation, rainfall, poor soils)	• Self-admitted poor correlation with actual farming (over-exclusion of potential land) • Does not account for practical, physical or political barriers to farming
World Bank	96 M Ha *[237 M acres]*	• Includes some practical barriers to cropland expansion (time-to-market & population density)	• Only assesses suitability of five crops: maize, soybeans, sugarcane, oil palm and wheat • Does not include marginal soils in estimate
HGBF/Lake Partners	47 M Ha *[117 M acres]*	• Assesses suitability for 18 major crops • Includes marginally suitable soils in estimate • Includes physical, practical & political barriers to farming	• Country-level data on barriers • Practical & political headwinds applied to 414 M Ha of biophysically & accessible land may not be linear

Source: FAO ("World agriculture towards 2030/2050: the 2012 revision"), World Bank ("Farmland Investments & Food Security"), McKinsey ("Lions on the Move: The Progress & Potential of African Economics"), EU Soil Atlas, Lake Partners analysis

Model Input Comparison

	HGBF/Lake Partners	McKinsey	FAO	EU Soil Atlas	World Bank
	Included?	*Included?*	*Included?*	*Included?*	*Included?*
Land Suitability Model Inputs					
Elevation	✓	✓[1]	✓	<2,000 m	✓
Rainfall	✓	✓[1]	✓	>250 mm/year	✓
Temperature	✓	✓[1]	✓	<28°C	✓
Slope	✓	✓[1]	✓	✓	✓
Land cover	✓	✓[1]	✓	✓	✓
Protected areas	✓	✓[1]	✓		✓
Soil type	✓	✓[1]	✓	✓	✓
Soil properties, textural class & depth	✓	✓[1]	✓		✓
Soil organic carbon	✓	✓[1]	✓		✓
Soil pH	✓	✓[1]	✓		✓
Soil water holding capacity	✓	✓[1]	✓		✓
Soil sodium exchange % & salinity	✓	✓[1]	✓		✓
Soil cation exchange capacity	✓	✓[1]	✓		✓
Soil exchangeable nutrients	✓	✓[1]	✓		✓
Soil lime and gypsum	✓	✓[1]	✓		✓
Erosion, nutrient maintenance, fallow years	✓	✓[1]	✓		✓

[1] McKinsey provides little detail on their model, but we assume they use the GAEZ model as an input based on their citation of the FAO & World Bank model as sources
Source: FAO ("World agriculture towards 2030/2050: the 2012 revision"), World Bank ("Farmland Investments & Food Security"), McKinsey ("Lions on the Move: The Progress & Potential of African Economics"), EU Soil Atlas, Lake Partners analysis

Model Input Comparison

	HGBF/Lake Partners	McKinsey	FAO	EU Soil Atlas	World Bank
	Included?	*Included?*	*Included?*	*Included?*	*Included?*
Land Accessibility and Availability Inputs					
Roads	✓	Coastal vs. landlocked			✓
Ports	✓				✓
Railroads	✓				✓
Time to market	< 6 hours				< 6 hours
Population density	Urban vs. rural				< 25 people/sq. km.
Degradation/Loss of Land	Indirectly via GAEZ				
Governance & Socioeconomic Inputs					
Rule of law	✓	Not considered			
Corruption	✓				
Civil & economic freedom	✓				
Social justice for women	✓				
Cultural heterogeneity	✓				
Poverty rate	✓				
Child mortality	✓				
Literacy rates	✓				
Orphans	✓				
Cell phone use	✓				

Source: FAO ("World agriculture towards 2030/2050: the 2012 revision"), World Bank ("Farmland Investments & Food Security"), McKinsey ("Lions on the Move: The Progress & Potential of African Economics"), EU Soil Atlas, Lake Partners analysis

Model Input Comparison

	HGBF/Lake Partners	McKinsey	FAO	EU Soil Atlas	World Bank
	Included?	*Included?*	*Included?*	*Included?*	*Included?*
Government Support for Agriculture Inputs					
Government spending on ag	✓	Not considered			
Extension, research & education	✓				
Regulation of protected seeds	✓				
Commodity reserves	✓				
Trade delays	✓				
Import tariffs	✓				
Water resource management	✓				
Farming Catalysts Inputs					
Availability of fertilizer	✓				
Pesticide use	✓				
Number of tractors in use	✓				
Access to capital	✓				
Access to ag inputs and markets	✓				
Entrepreneurial opportunity	✓				
Water resources	✓	Abundant vs. scarce			
Rural organizations (co-ops)	✓				

Source: FAO ("World agriculture towards 2030/2050: the 2012 revision"), World Bank ("Farmland Investments & Food Security"), McKinsey ("Lions on the Move: The Progress & Potential of African Economics"), EU Soil Atlas, Lake Partners analysis

Model Input Comparison

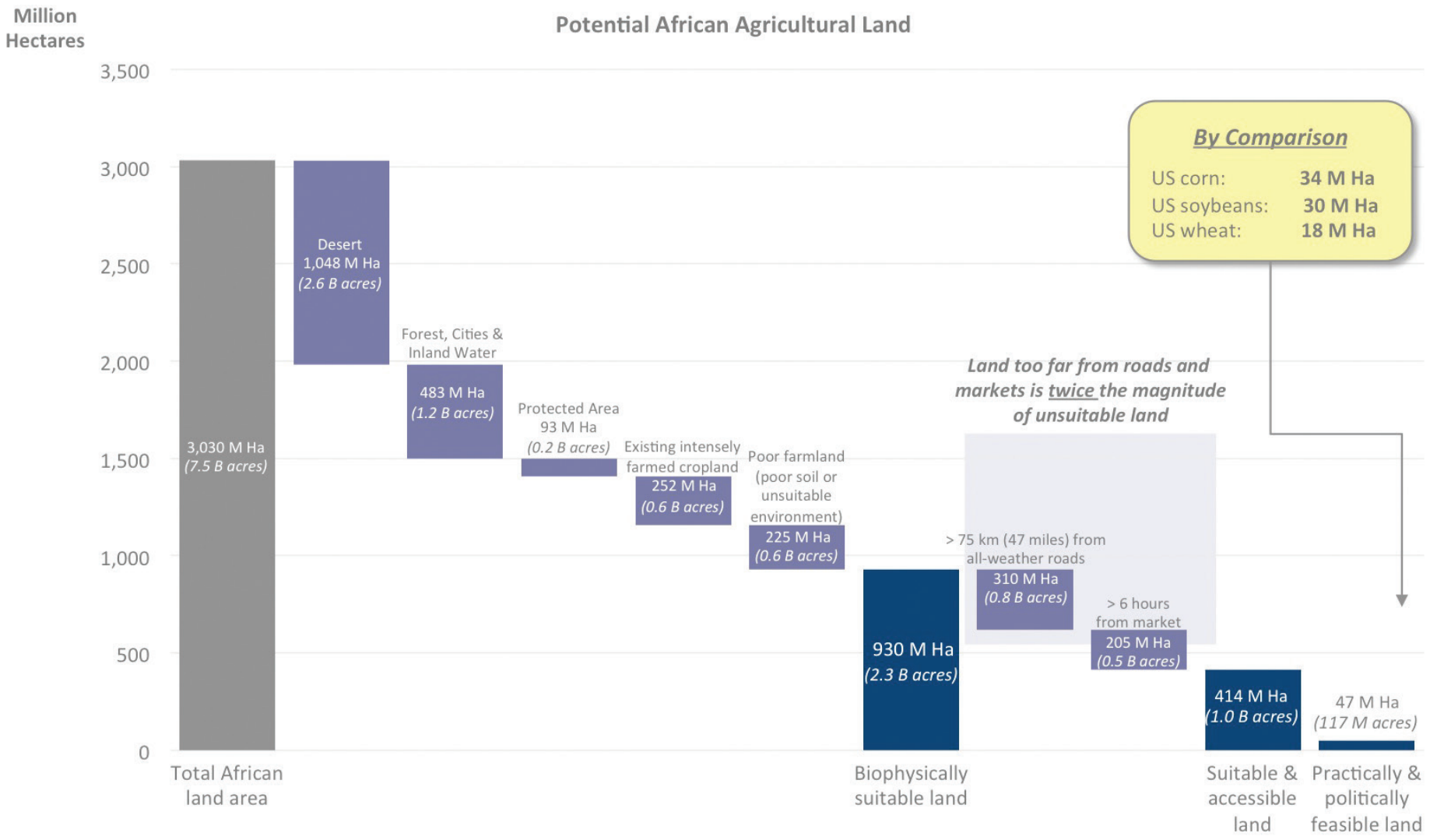
	HGBF/Lake Partners	McKinsey	FAO	EU Soil Atlas	World Bank
	Included?	*Included?*	*Included?*	*Included?*	*Included?*
Farming Catalysts Inputs (cont.)					
Land rights	✓	Not considered			
Women farmers	✓				
Foreign Direct Investment	✓				
Orphan crops	✓				
Farm size	✓				
Availability of skilled workforce	✓				
Infrastructure Inputs					
Public investment in infrastructure	✓	Not considered			
Road condition	✓				
Rural electrification	✓				
Grain storage	✓				
Post-harvest loss	✓				
Rail condition	✓				
Nutrition & Consumption					
Calorie content of crops	✓	Not considered			
Protein content of crops	✓				
Consumption by crop	✓				

Source: FAO ("World agriculture towards 2030/2050: the 2012 revision"), World Bank ("Farmland Investments & Food Security"), McKinsey ("Lions on the Move: The Progress & Potential of African Economics"), EU Soil Atlas, Lake Partners analysis

AVAILABLE AND ACCESSIBLE FARMABLE LAND

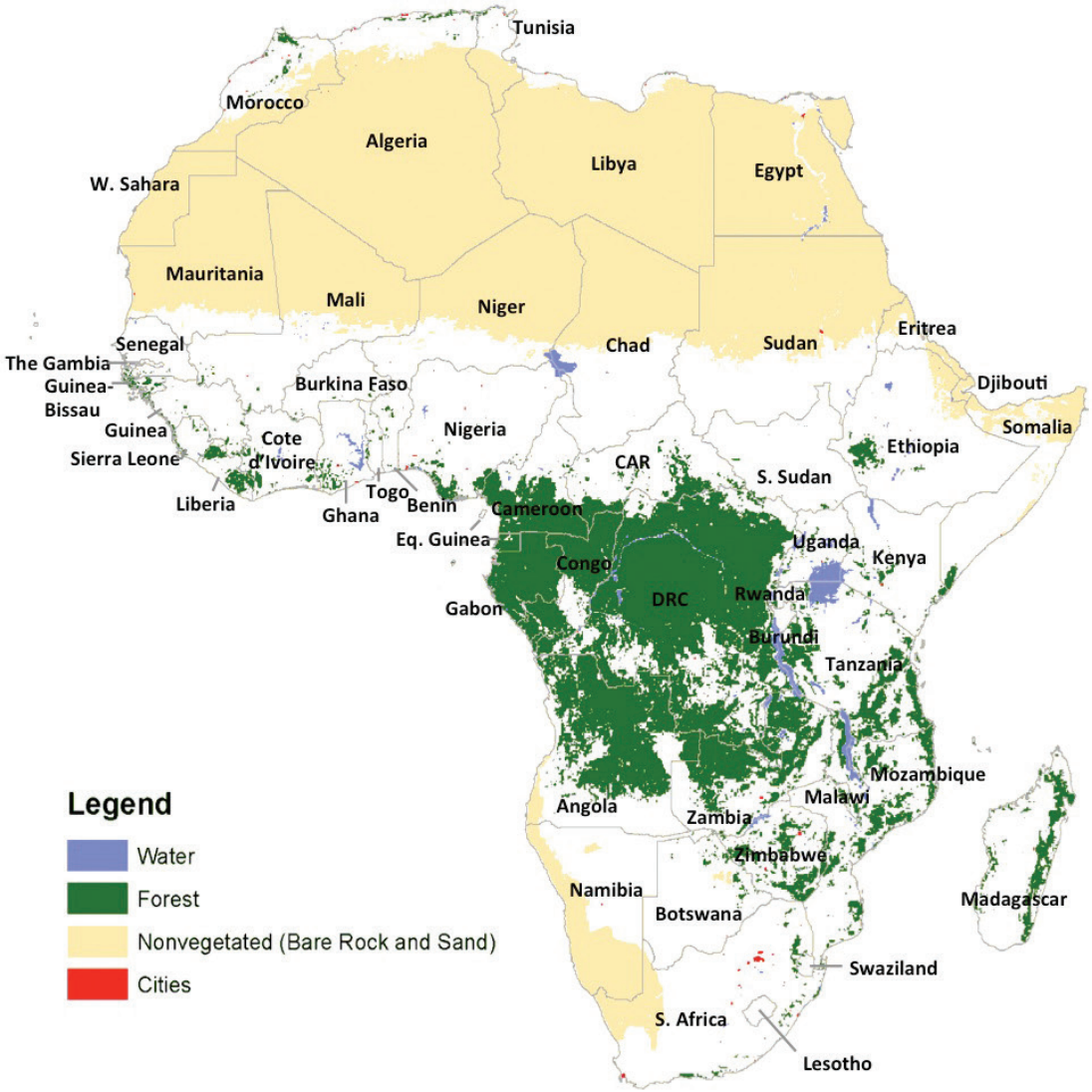
Available & Accessible Farmable land

~14% of African land area is biophysically suitable and accessible for agriculture



Source: GLC2000, GAEZ, UN-WDPA, Lake Partners analysis

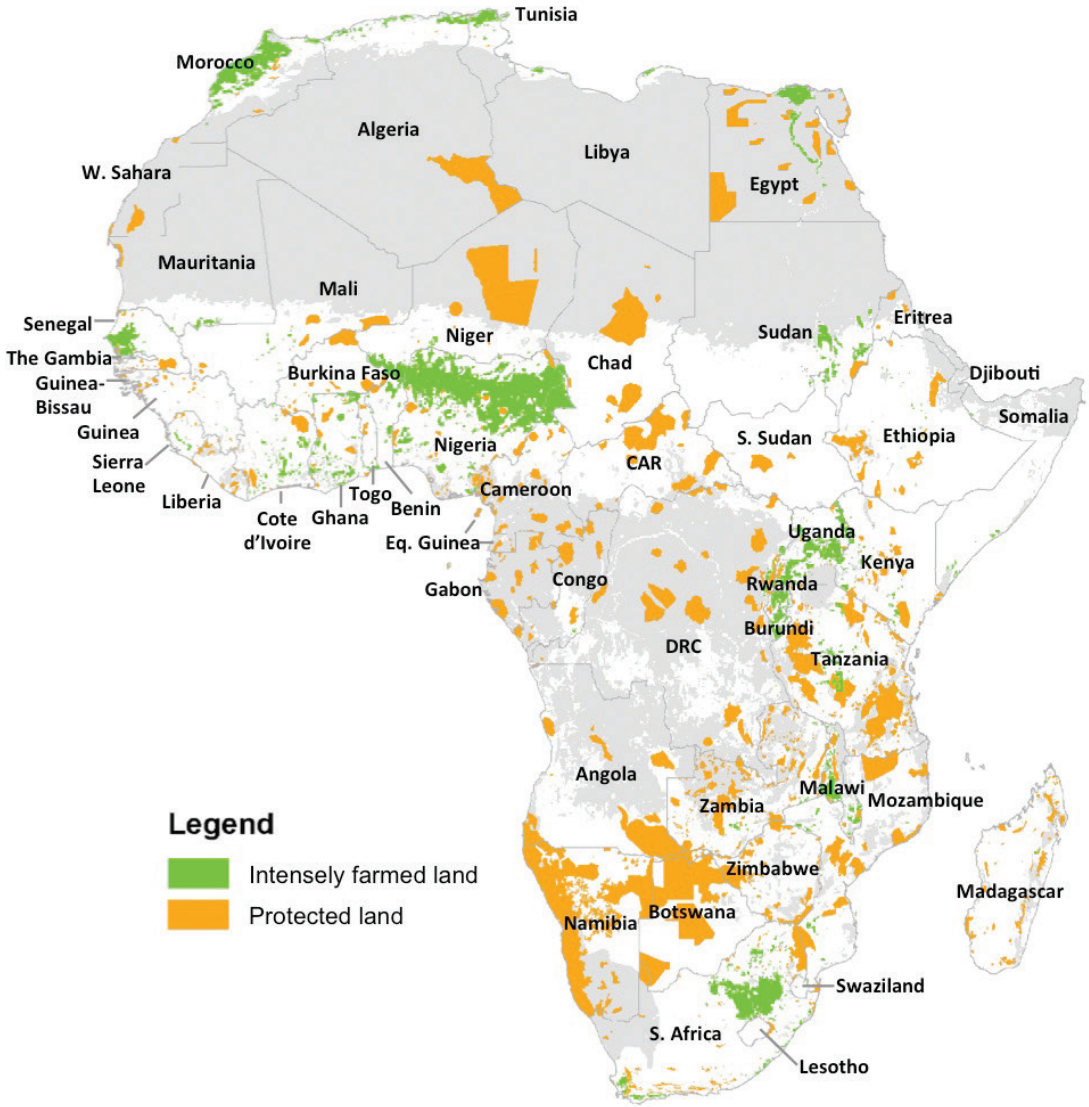
Exclusions: Desert, Forests, Cities and Inland Water



51% of Africa lies in desert, forest, cities or inland water

Source: GLC2000, Lake Partners analysis

Exclusions: Intensely Farmed & Protected Land



An additional 11% of land is existing intensely farmed cropland or designated as protected area

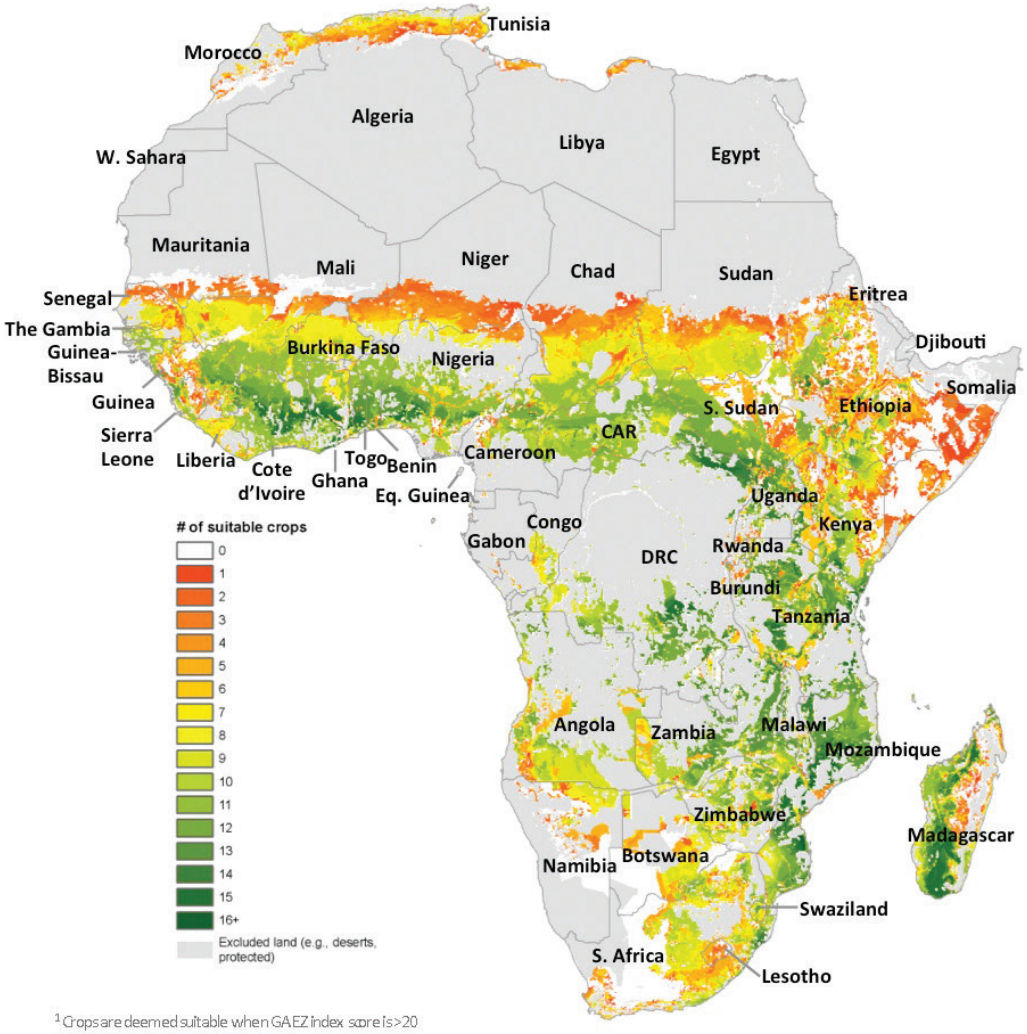
Source: GLC2000 ("Intensely farmed land"), UN-World Database on Protected Areas ("Protected land"), Lake Partners analysis

Suitability of Remaining Land

Most of the suitable land lies in fertile belts across West & Central Africa and along the eastern coast

Suitable Remaining Land

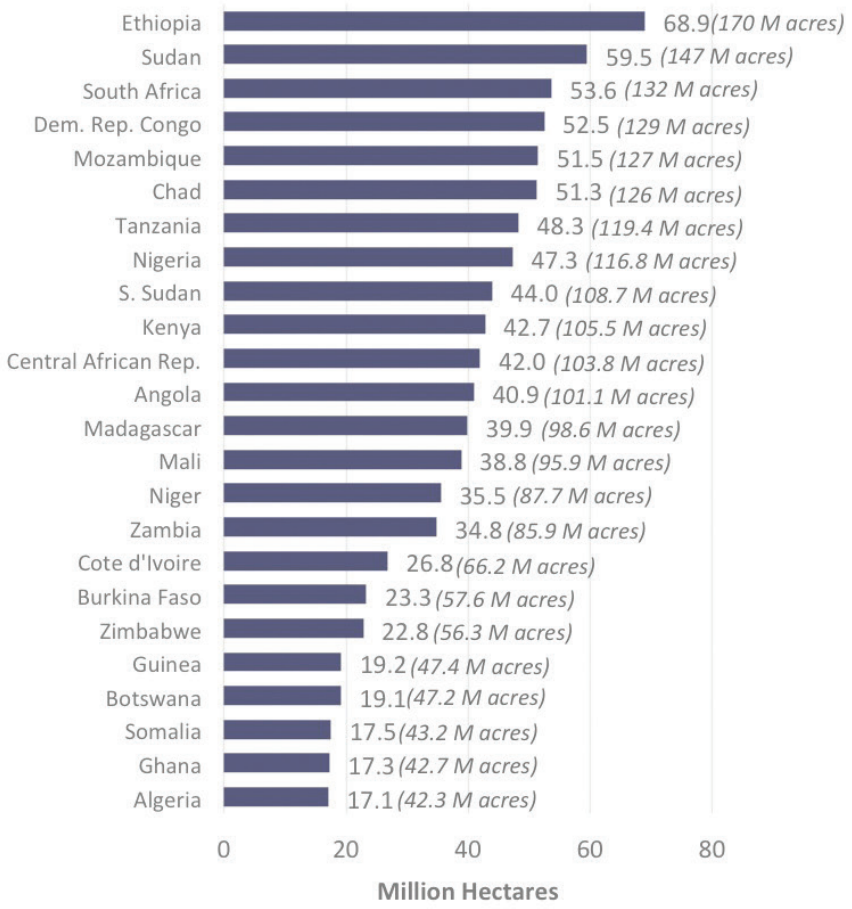
Number of Crops Well-Suited to Land[1] Under Rainfed Conditions



[1] Crops are deemed suitable when GAEZ index score is >20

Source: FAO-GAEZ, Lake Partners analysis

Total Land Suitable for Growing Major Crops

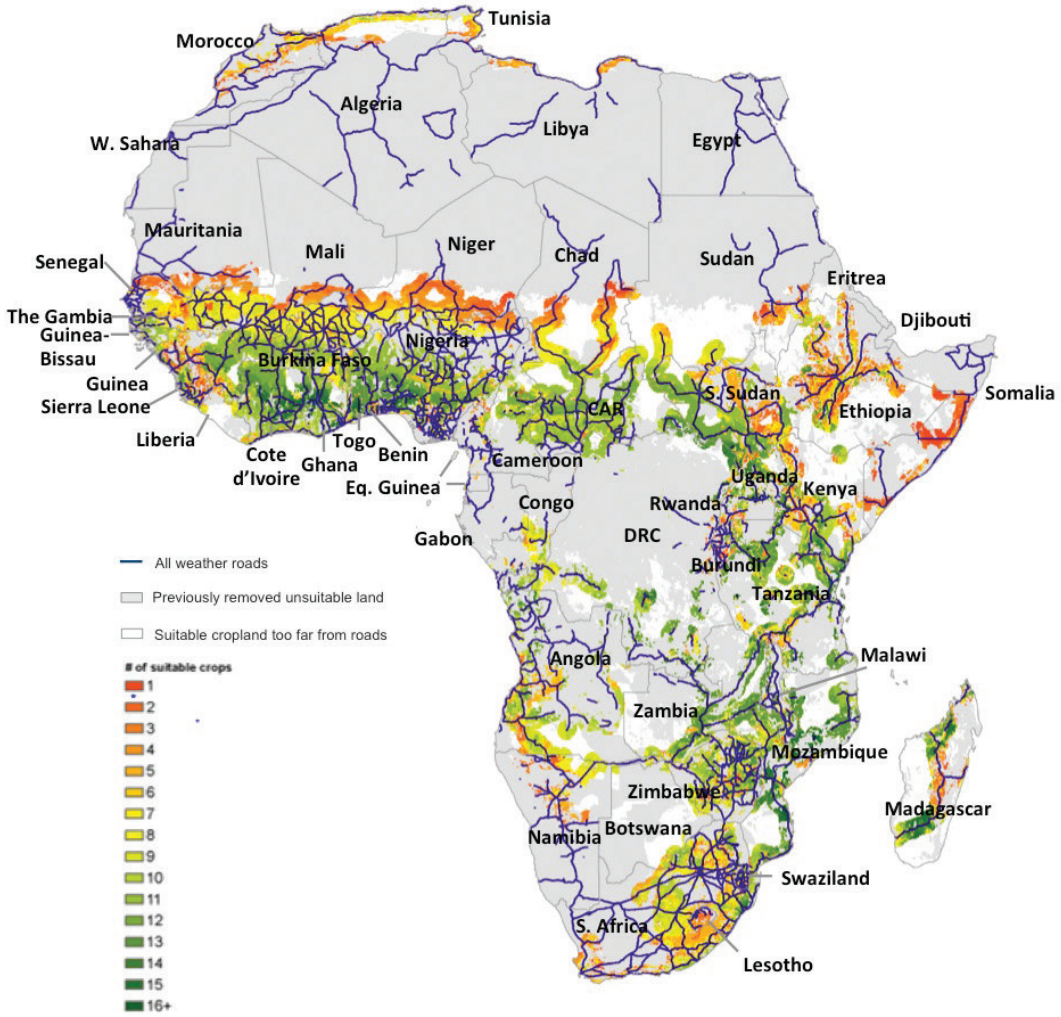


98% of biophysically suitable cropland lies in 24 countries

Access to Road Infrastructure

~70% of farmable land lies within 75 km (47 miles) of an all-weather road

Suitable Remaining Land relative to All-Weather Roads[1]
Number of Crops Well-Suited to Land[1] Under Rainfed Conditions



100% of current heavily cultivated cropland[2] lies within 75 kilometers (47 miles) of an all-weather road

- By comparison, 78% of heavily cultivated land lies within half of that distance (37.5 km/23 miles)
- At the 37.5 km vs. 75 km threshold, practically and politically feasible land decreases 20% to 38 M Ha (94 M acres) and incremental potential production decreases 24% to 512 M maize-equivalent tonnes

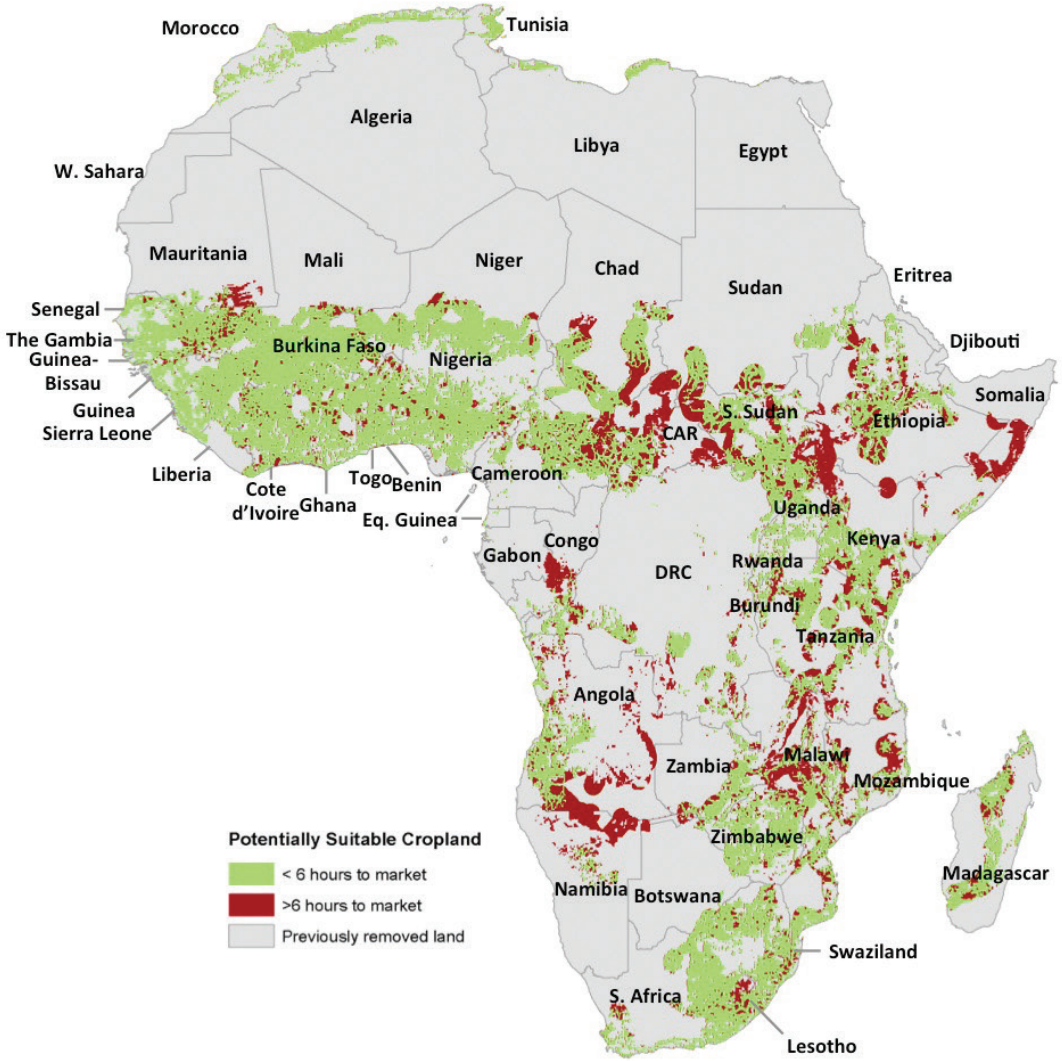
Only 70% of potentially suitable land (730 million Ha or 1.8 billion acres) lies within 75 km (47 miles) of a road

The lack of all-weather feeder roads makes the 75 km (47 mile) distance difficult in many places

[1] "All-weather road": paved road (poor or better condition), gravel road (fair or better condition), earth road (very good condition), unknown roads (poor or better condition); N. Africa roads: "Major roads" (FAO)
[2] > 50% per pixel
Source: FAO-GAEZ ("# of suitable crops"); International Road Federation-AICD/FAO ("All-weather roads"), Lake Partners analysis

Access to Markets

An additional ~20% of biophysically suitable land is >6 hours from markets (cities with 50K+ population)



Source: JRC Land Resource Management Unit (EU) ("Distance to market"), Lake Partners analysis

Access to markets (cities > 50K population) is a major indicator of ability to expand beyond subsistence farming

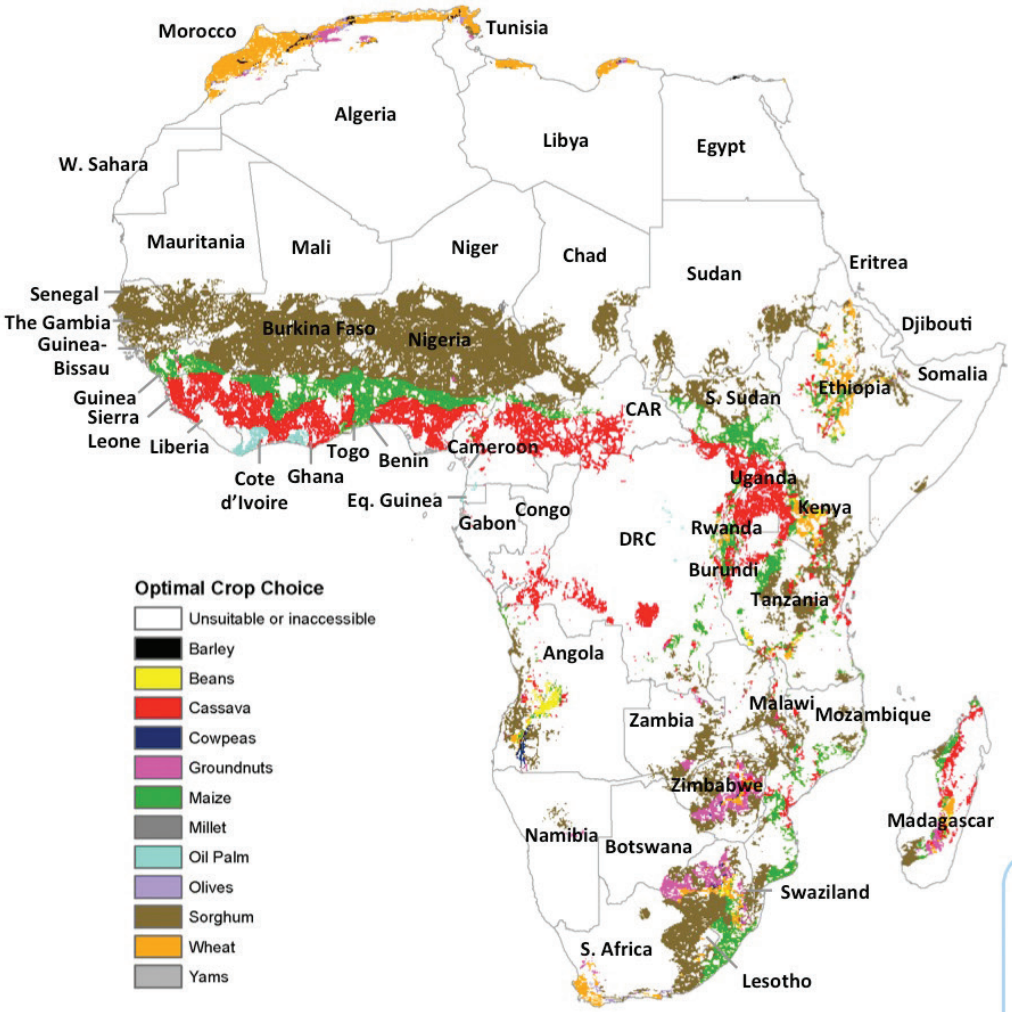
One-way time-to-market of 6 hours is often used as the upper limit by the World Bank and FAO, to preclude a farmer needing to stay overnight at market

Time-to-market includes distance, road & rail quality, major river and open-sea shipping lanes, elevation and slope, type of terrain, and border crossings

Optimal Crops for Consumption

Optimally Nutritious Crop on Current and Potential Farmland

— Farmed at High Inputs —



% of total nutritional balance

Crop	*Current Production*	*Theoretical Production (High Inputs, Optimal Crop Choice)*
Cassava	32.9%	20.0%
Maize	14.9%	14.6%
Yams	12.4%	0.0%
Rice	5.9%	0.0%
Sorghum	5.7%	54.9%
Wheat	5.7%	6.4%
Sweet Potatoes	4.1%	0.0%
Oil Palm	4.0%	0.7%
Banana/Plantain	3.7%	0.0%
Groundnuts	2.4%	2.5%
Millet	2.4%	0.0%
Barley	1.5%	0.1%
Cowpeas	1.1%	0.1%
Beans	1.0%	0.5%
Cottonseed	0.9%	0.0%
Olives	0.7%	0.2%
Cocoa	0.7%	0.0%
Coffee	0.0%	0.0%

While the model does optimize for caloric and protein yield at 10,000 Ha resolution and shows directional suitability, it obviously cannot incorporate all real-world aspects of farming

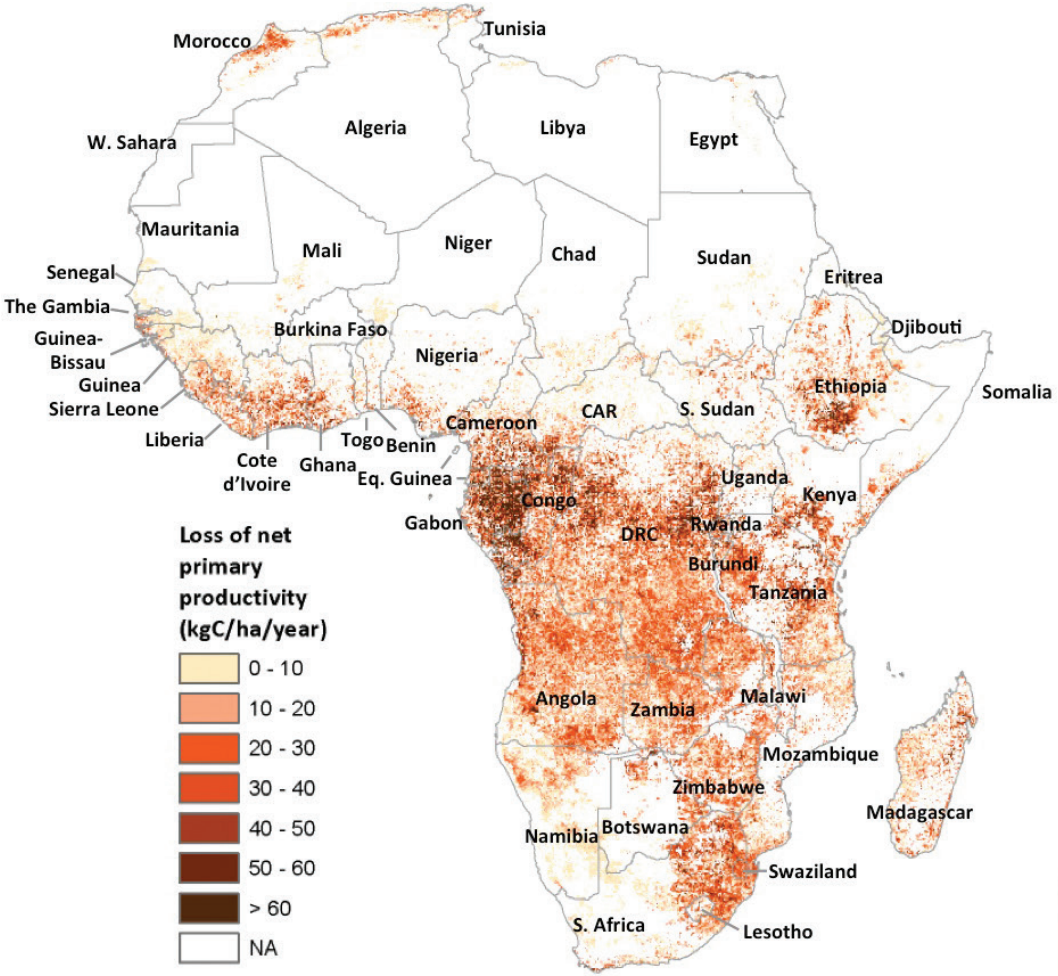
Source: FAO-GAEZ, Lake Partners analysis

Land Loss Through Degradation

Land loss comes from both soil maintenance and urbanization

Loss of Net Primary Productivity[1]

— 1981-2003 —



Soil degradation through erosion and overfarming is lowering productivity by reducing farmland and yields

- An estimated 95 M Ha of land have been degraded to the point that no farming can take place without rehabilitation[2]

In our yield improvement analysis, the GAEZ model accounts for improved conservation farming techniques and nutrient application, which would result in slower degradation

- GAEZ assesses soil erosion, nutrient maintenance and fallow-year requirements (which allow for higher farming intensity in conservation-managed lands) into its yield calculations under medium- and high-input scenarios

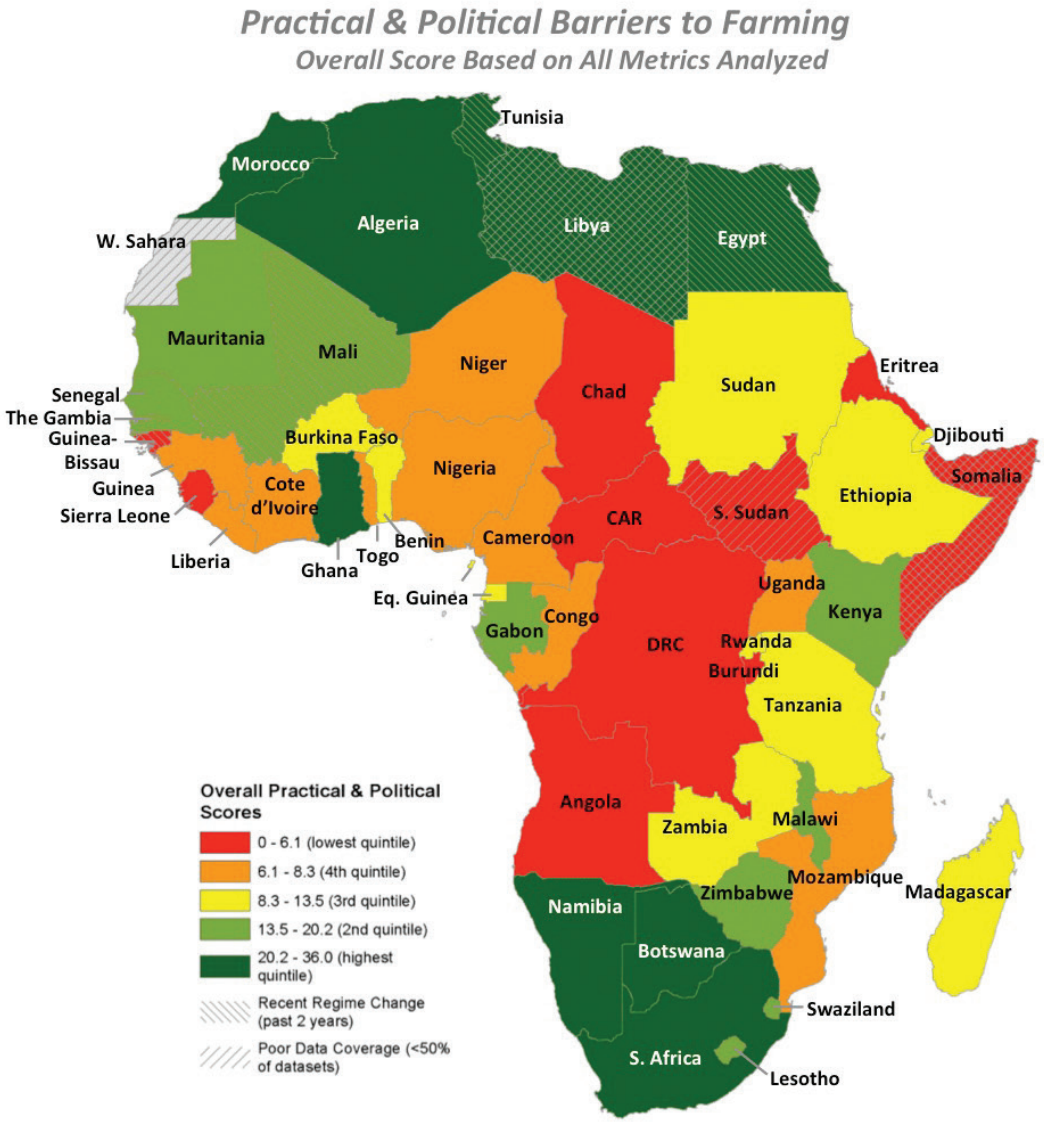
While we don't directly measure land loss, it is indirectly accounted for in the GAEZ model

[1] ISRIC– World Soil Information
[2] Henao & Baanante, "Agricultural Production & Soil Nutrient Mining in Africa" (2006)
Source: Lake Partners analysis

PRACTICAL AND POLITICAL BARRIERS TO FARMING

Practical & Political Barriers to Farming: Overall Score

Even the highest opportunity countries face stiff headwinds to improving productivity in agriculture



— Lowest Barriers to Farming [1] —

Country	Score
South Africa	27.6
Morocco	26.0
Botswana	24.7
Algeria	22.7
Namibia	21.3
Ghana	20.7
Senegal	20.2
Malawi	17.1
Gambia	16.5
Lesotho	15.3

— Highest Barriers to Farming [1] —

Country	Score
Nigeria	6.1
Eritrea	6.1
Guinea-Bissau	5.0
Burundi	3.7
Angola	3.5
Sierra Leone	2.9
Central African Rep.	1.7
Chad	0
Dem. Rep. Congo	0
Somalia	0

[1] Not listed due to very poor data coverage or recent regime change: W. Sahara, S. Sudan, Egypt, Libya & Tunisia

Source: Center for Global Policy (George Mason University), Lake Partners analysis

Potential Production Comparison

With the exception of the most war-torn countries, Maputo targets appear feasible (though not necessarily by 2015)

	2011 Production (M Tonnes)	Theoretical Maximum (M Tonnes)	Politically & Practically Feasible (M Tonnes)	Est. 2015 Maputo Target[1] (M Tonnes)	Maputo Target / Feasible Potential
Nigeria	128.4	572.2	155.7	215.0	138%
South Africa	13.4	365.3	110.5	25.6	23%
Ghana	26.6	313.9	86.1	37.8	44%
Tanzania	21.0	364.5	65.0	22.8	35%
Mozambique	14.7	564.0	60.4	18.0	30%
Cote d'Ivoire	13.4	532.1	50.3	23.3	46%
Mali	7.2	277.6	44.2	8.6	19%
Ethiopia	16.1	200.3	40.9	17.7	43%
Kenya	7.4	217.2	37.2	12.0	32%
Madagascar	9.9	229.9	31.5	12.3	39%
Zimbabwe	2.5	168.9	26.0	3.9	15%
Guinea	5.3	279.9	24.5	9.1	37%
Angola	20.2	122.9	23.7	18.2	77%
Burkina Faso	5.0	206.7	23.3	9.4	40%
Dem. Rep. Congo	19.8	454.2	19.8	37.7	190%
Zambia	5.3	107.4	17.4	5.0	29%
Niger	5.9	137.2	14.5	9.1	63%
Algeria	4.3	47.8	14.2	8.9	63%
Sudan	2.2	90.6	11.3	4.4	39%
Central African Rep.	1.7	424.6	9.1	2.8	30%
Botswana	0.1	14.1	3.5	0.1	2%
Chad	2.6	151.6	2.6	5.2	198%
Somalia	0.5	5.0	0.5	1.1	244%

Zimbabwe & Botswana's targets far underestimate their true potential

[1] Maputo Target Production calculated based on the CAADP target of 6% average annual production increase; calculated from 2003 production data
[2] The former Sudan's 2011 production of 7.9 M tonnes is apportioned to South Sudan (5.7 M tonnes) and Sudan (2.2 M tonnes) using GIS estimates of currently farmed cropland and GAEZ yield estimates
Source: FAO Crop Production Data, Lake Partners analysis

Governance & Socioeconomics Metrics

We use 10 metrics (11 submetrics) to assess the state of governance and socioeconomics in each country

1) Governance & Socioeconomics Metrics & Submetrics	*Units*	*Top Score*	*Source(s)*
1a) Rule of law			
1a.1) Current security risk	0-100 (qualitative)	0 (Iceland)	EIU Risk Briefing
1a.2) Current political stability risk	0-100 (qualitative)	0 (Norway)	EIU Risk Briefing
1a.3) Current government effectiveness risk	0-100 (qualitative)	7 (Denmark)	EIU Risk Briefing
1a.4) State fragility index	0-5 (qualitative)	0 (UK)	State Fragility Index (Center for Global Policy, George Mason University); World Bank
1b) Corruption	0-5 (qualitative)	4.95 (Denmark)	World Governance Indicators, World Bank
1c) Civil & economic freedom	0-60 (qualitative)	60 (Norway)	Freedom House
1d) Social justice for women			
1d.1) Women's political rights	0-3 (qualitative)	3 (Norway)	CIRI Human Rights Data Project
1d.2) Women's economic rights	0-3 (qualitative)	3 (Norway)	CIRI Human Rights Data Project
1e) Cultural heterogeneity			
1e.1) Ethnic fractionalization	Indexed avg share of population (0 = 1 ethnic group in country)	0 (Comoros)	National Bureau of Economic Research
1e.2) Linguistic fractionalization	Indexed avg share of population (0 = 1 major language)	0.002 (S. Korea)	National Bureau of Economic Research
1e.3) Religious fractionalization	Indexed avg share of religious affiliation (0=1 religion)	0.002 (Yemen)	National Bureau of Economic Research
1f) Poverty rate	% people living below $1.25/day (purchasing power parity)	0 (Montenegro)	World Bank (PovCalNet)
1g) Child mortality rate	Under-5 deaths per 1,000 live births	0 (San Marino)	UN Inter-agency Group for Child Mortality Estimation
1h) Literacy rates	% of adults (ages 15+)	100 (Lithuania)	UNESCO/World Bank
1i) Orphans			
1i.1) Orphaned children	Orphans as % of total children	0.03 (Comoros)	UNICEF
1i.2) Children as head-of-household	% orphan households	0 (1st World Estimate)	Multiple Indicator Cluster Surveys (MICS), UNICEF; Demographic and Health Surveys (DHS), Macro International, Lake Partners analysis
1j) Cell phone use	Mobile-cellular telephone subscriptions per 100 people	191.1 (Kuwait)	International Telecommunication Union (UN)

Source: Lake Partners analysis

Governance & Socioeconomics: Summary of All Metrics

Highest Scores [1]

Botswana	60.7
South Africa	50.4
Namibia	49.0
Algeria	44.9
Gabon	43.8

Lowest Scores [1]

Guinea-Bissau	6.0
Central African Rep.	0.0
Chad	0.0
Dem. Rep. Congo	0.0
Somalia	0.0

[1] Not listed due to poor data or recent regime change: S. Sudan, Egypt & Tunisia

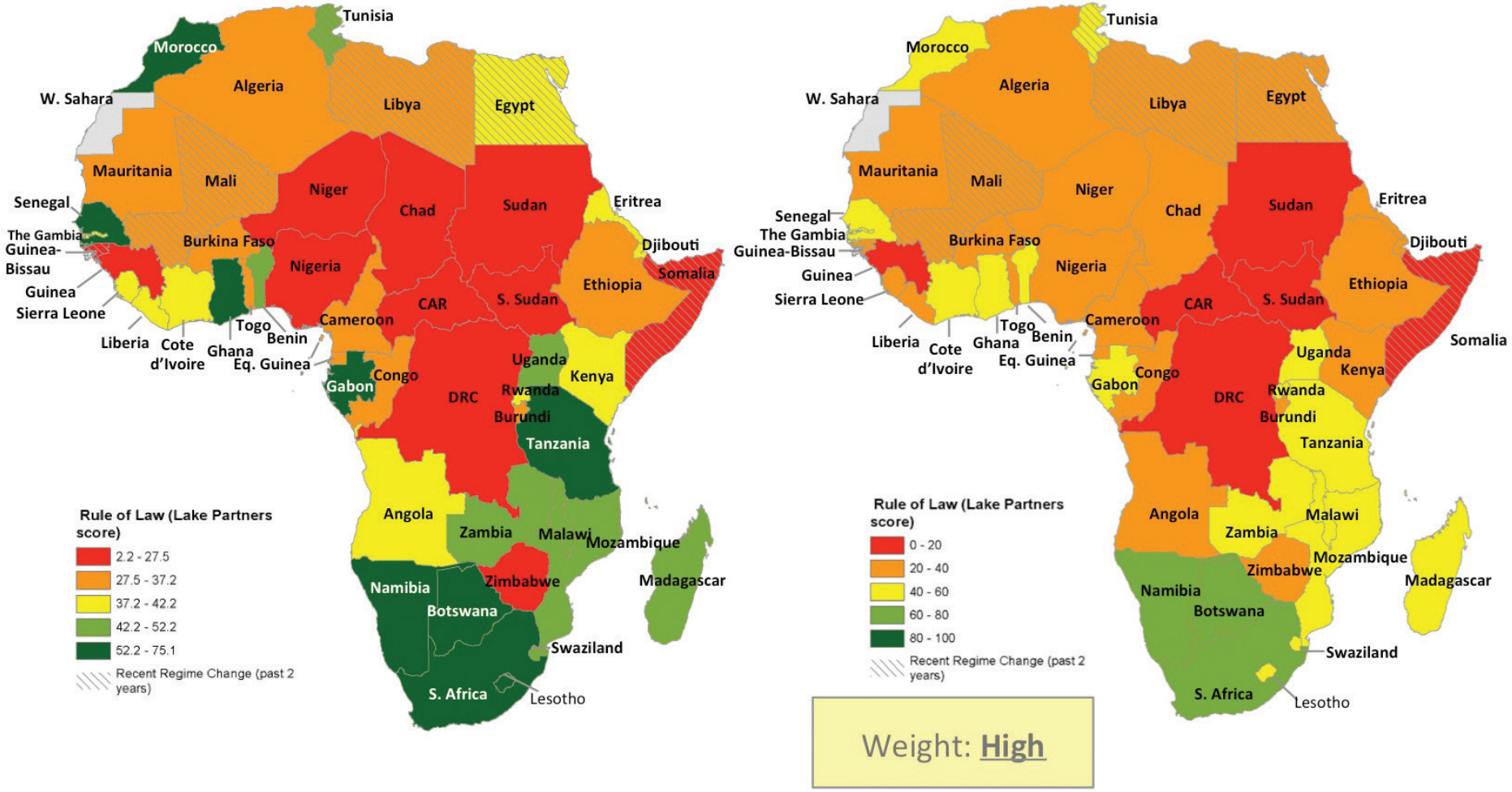
Source: Lake Partners analysis

Rule of Law

Rule of Law (quintiles)

Rule of Law (absolute scale)

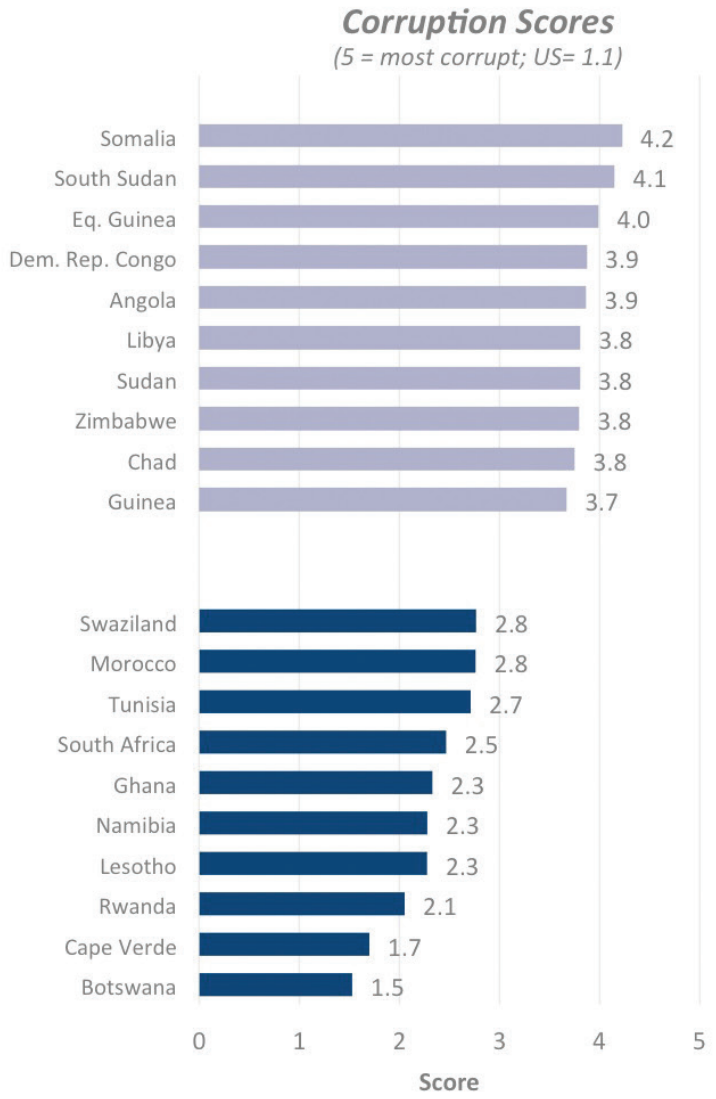
(0 = most unstable; 100 = perfectly stable; US = 84)[1]



Weight: **High**

[1] Lake Partners score is clustered metric based on: State Fragility Index (George Mason University), Current Security Risk score (EIU), Current Political Stability Risk score (EIU), and Current Government Effectiveness Risk score (EIU)
Source: Lake Partners analysis

Corruption



Most Corrupt

Least Corrupt

These data cover both perception of corruption and its practical effect (e.g., number of bribes paid)

Corruption can simply be a tax — the disconnect between perception and reality can be a bigger barrier than corruption itself

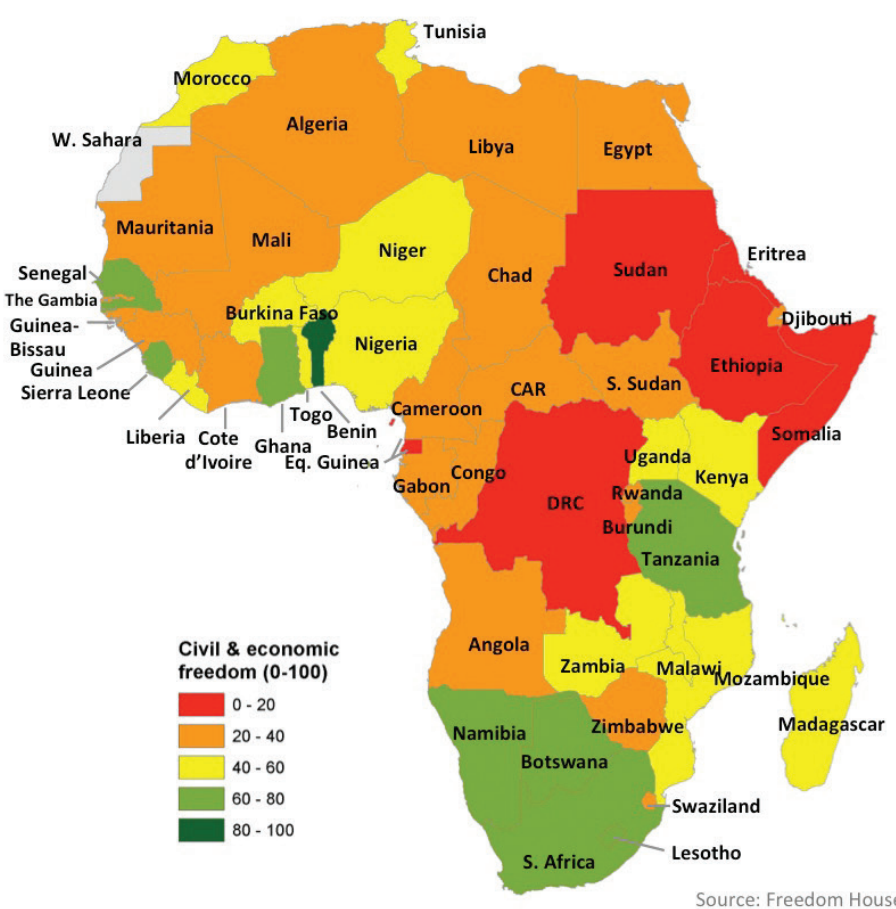
Cultural views of what constitutes corruption and whether it is ever permissible complicates comparisons of corruption across nations

Weight: **Medium**

Source: World Bank – World Governance indicators (Control of Corruption), Lake Partners analysis

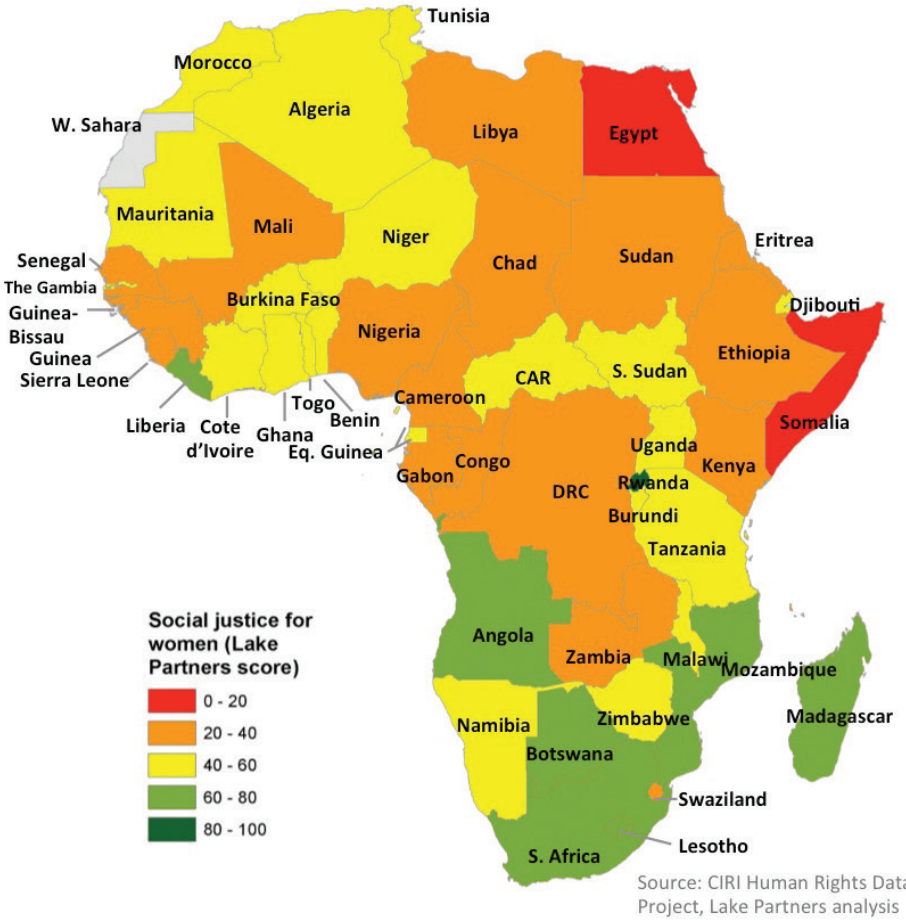
Freedom & Rights

Civil & Economic Freedom
(US = 93)



Source: Freedom House

Social Justice for Women[1]
(US = 83)

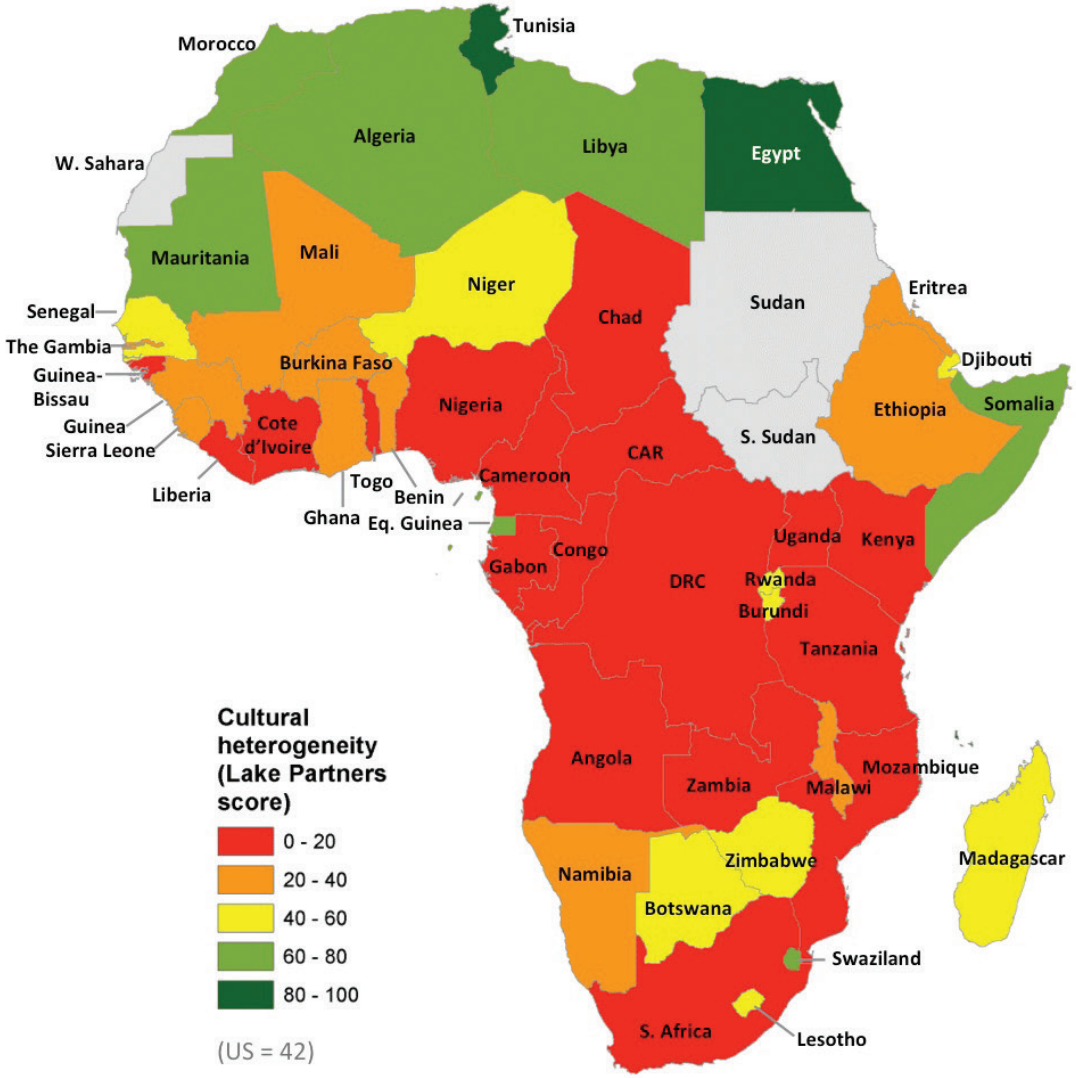


Source: CIRI Human Rights Data Project, Lake Partners analysis

[1] Lake Partners score is clustered metric based on: Women's Political Rights & Women's Economic Rights scores (CIRI Human Rights Data Project)
Source: Lake Partners analysis

Weights: **Medium**

Cultural Heterogeneity[1]



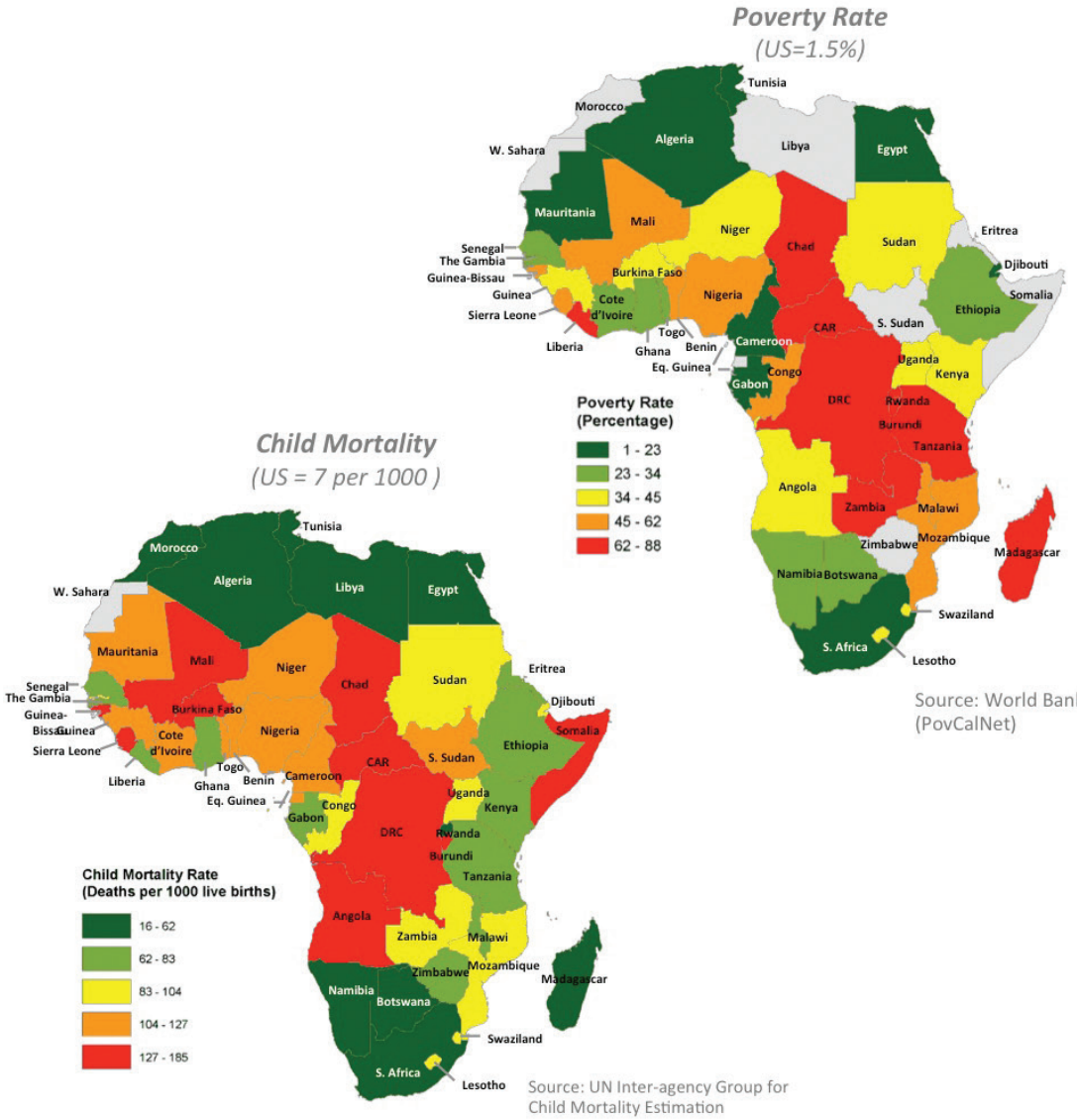
Diversity in language can drive up the cost of government programs due to the burdens of translation

Cultural differences can inhibit free flow of capital and techniques

Weight: **Medium**

[1] Lake Partners score is clustered metric based on: Ethnic, Linguistic, and Religious Fractionalization scores (National Bureau of Economic Research)
Source: Lake Partners analysis

Poverty and Child Mortality Rates



Source: World Bank (PovCalNet)

Source: UN Inter-agency Group for Child Mortality Estimation

Source: Lake Partners analysis

Child mortality rates are a major indicator of public health, which has impacts on productivity and income of agriculture workers

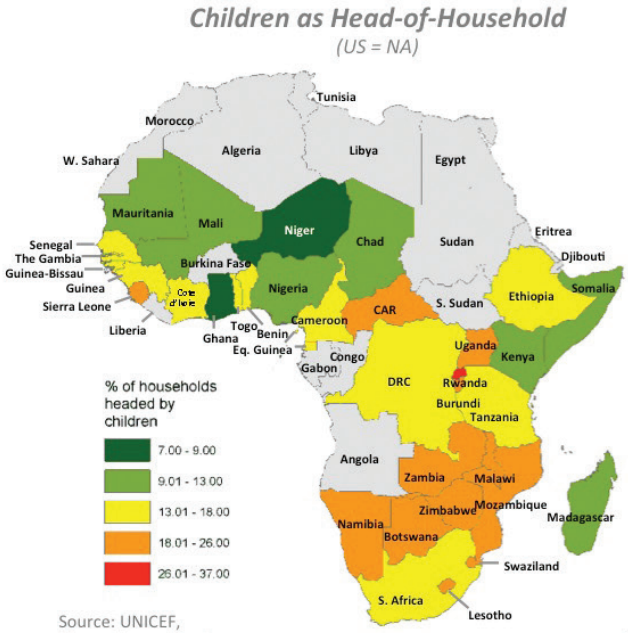
Poverty in Africa is tied closely to agricultural performance due to the large majority of people who work as farmers

Between 1997 and 2003, poverty rates in Mozambique fell 15% and economic growth increased to 8% in part due to active targeting of agriculture sector improvements

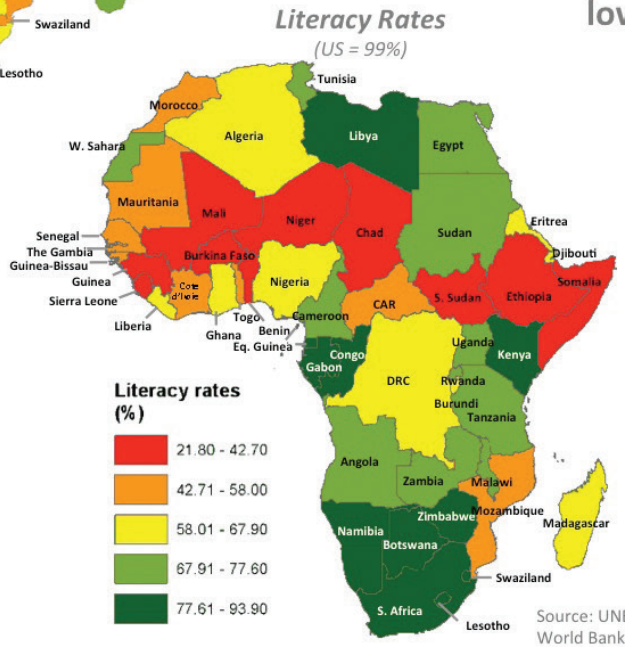
Poverty
Weight: **Medium**

Child Mortality Rates
Weight: **High**

Orphans and Literacy Rates



Source: UNICEF, Macro International



Source: Lake Partners analysis

Source: UNESCO/ World Bank

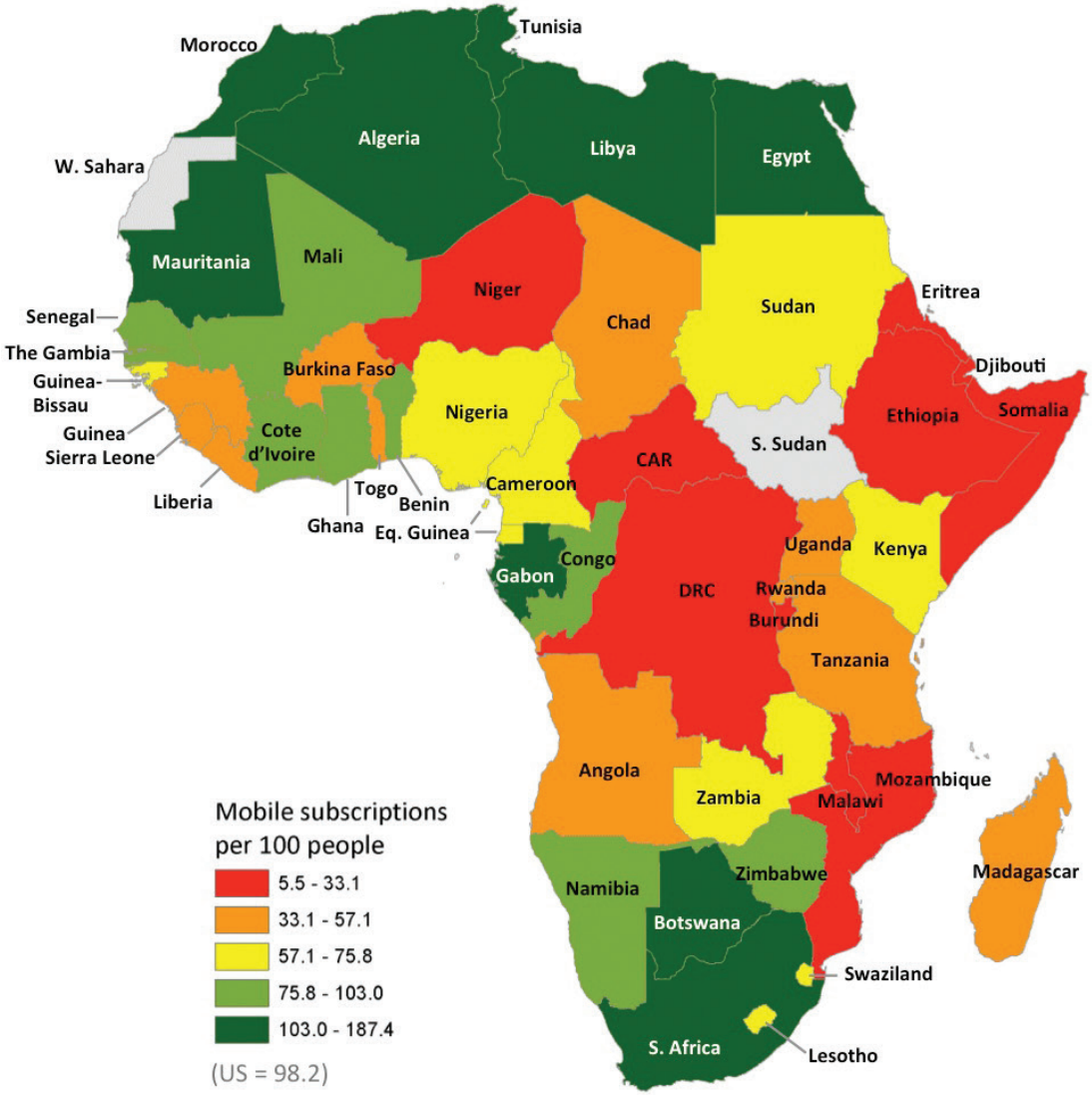
Conflict and HIV deaths have left many countries in central and southern Africa with a high incidence of orphans and a shrinking, less effective agricultural workforce

Literacy has obvious impacts on farming effectiveness — In Tanzania cell phone programs to give farmers access to pricing and other crucial information have been successful in areas of lower literacy

Children head-of-household
Weight: **Low**

Literacy rates
Weight: **Medium**

Cell Phone Use



Cell phone use is a good measure of socioeconomic status of a country

- Rwandan cell phone owners have greater than twice the predicted expenditures as the national average

In addition, cell phones are a useful tool for farmers — they may be used for extension services, crop price information, information on caring for livestock or gaining information about crop insurance

Weight: **Medium**

Source: International Telecommunication Union (UN), Lake Partners analysis

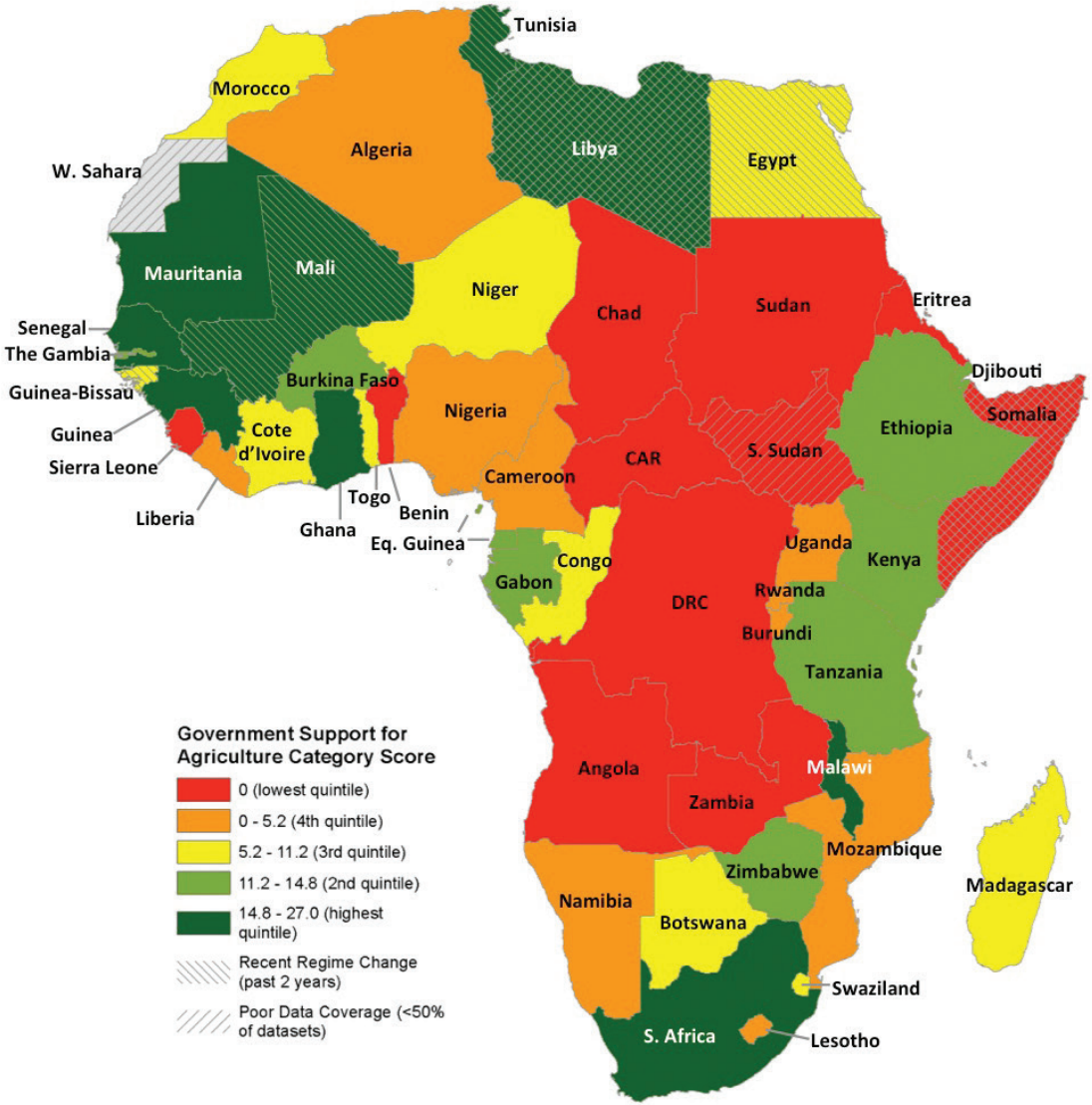
Government Support for Agriculture Metrics

We use 7 metrics (14 submetrics) to assess the state of government support in each country

2) Government Support for Agriculture Metrics & Submetrics	*Units*	*Top Score*	*Source(s)*
2a) Government spending on agriculture	Ag spending % of total public budget	30.2 (Zimbabwe)	ReSAKSS 2013 CAADP M&E Indicators
2b) Extension, research and education			
2b.1) Access to extension services & research	1-6 (qualitative)	7 (1st World Est.)	IFAD/Mo Ibrahim Foundation, Lake Partners analysis
2b.2) Breeding programs (breeders as proxy)	Plant breeders (FTEs) per M Ha of cropland	56 (USA)	FAO-PBBC; Baenzing, 2006
2b.3) Ag researchers	Number of FTEs per 10,000 Ha of cropland	2.4 (USA)	CGIAR DIIVA project; Pardy, Alston, & Chan-Kang 2013
2b.4) Improved seed	% of cropland farmed with improved seed	100 (1st World Est.)	CGIAR DIIVA project; Lake Partners analysis
2b.5) Public agriculture R&D	Public ag R&D as % of agricultural GDP	4.32 (Botswana)	Agricultural Science and Technology Indicators (ASTI)
2b.6) College graduates studying agriculture	Grads per M people	395 (Albania)	UNESCO/World Bank
2c) Regulation of protected seeds			
2c.1) Adoption of UPOV laws (governing plant variety protection [PVP])	0 (No PVP); 1 (in contact with UPOV to implement similar laws); 2 (UPOV accession in progress); 3 (Member of UPOV Convention)	3 (1st World Est.)	International Union for the Protection of New Varieties of Plants (UPOV), Lake Partners analysis
2c.2) History of rejecting GMO food aid	0 (Never reject GM food); 1 (Reject unmilled food only); 2 (Reject all GM food aid)	0 (1st World Est.)	African Centre for Biosafety, "GMOs in Africa" Status Report, Lake Partners analysis
2d) Commodity reserves (year-end stock as proxy)	% grains in year-ending stock vs. annual production	220 (Israel)	USDA-FAS
2e) Trade delays (time to import/export as proxy)			
2e.1) Time to export	days	5 (Denmark)	WTO, Doing Business Project, Trading across borders survey data
2e.2) Time to import	days	4 (Singapore)	WTO, Doing Business Project, Trading across borders survey data
2f) Import tariffs	Avg % import tariffs for most favored nation (MFN)	1.3 (Australia)	Food Security Index by Dupont/Economist: WTO
2g) Water resource management			
2g.1) Access to water for agriculture	0-100 (qualitative)	125 (1st World Est.)	IFAD/Mo Ibrahim Foundation, Lake Partners analysis
2g.2) Resilience to natural variability in water supply	0-100 (qualitative)	97 (India)	Rural Water Livelihoods Index, Oxford University Centre for Water Research & FAO-Water (UN)
2g.3) Secure & equitable water entitlement	0-100 (qualitative)	100 (Austria)	Rural Water Livelihoods Index, Oxford University Centre for Water Research & FAO-Water (UN)
2g.4) Water management regulatory framework	0-3 (qualitative)	4 (1st World Est.)	African Union/African Ministers' Council on Water (AMCOW), Lake Partners analysis

Source: Lake Partners analysis

Government Support for Agriculture: Summary of All Metrics



Highest Scores [1]

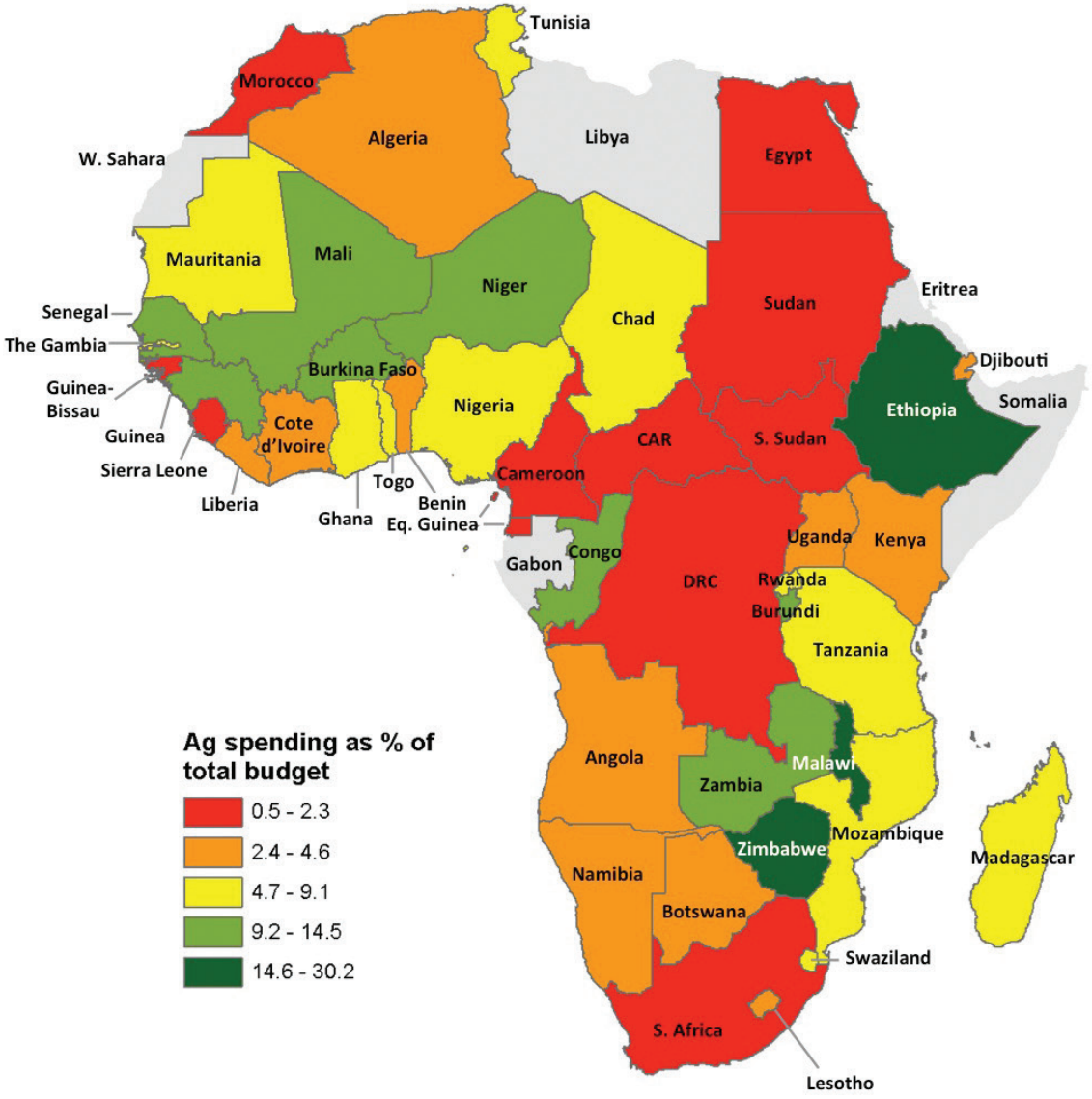
Senegal	27.0
Malawi	26.1
South Africa	23.5
Mauritania	19.2
Ghana	19.0

Lowest Scores [1]

Chad	0.0
Eritrea	0.0
Zambia	0.0
Angola	0.0
Sudan	0.0

[1] Not listed due to poor data or recent regime change: W. Sahara, S. Sudan, Tunisia & Libya
Source: Lake Partners analysis

Government Spending on Agriculture (% of Budget)



Source: ReSAKSS CAADP M&E Indicators, Lake Partners analysis

The track record of centrally distributed subsidies is better than local distribution

Locally distributed subsidies suffer from diversion to well-connected farmers and ineffective local governments

Weight: **High**

Extension, Research, and Education

	Access to extension services & research	Breeding programs (breeders as proxy)	Ag researchers	Improved seed	Public agricultural R&D	College graduates in agriculture
	1 – 6 (qualitative)	*Plant breeders (FTEs) per M Ha of cropland*	*Number of FTEs/ 10,000 Ha of cropland*	*% of cropland farmed with improved seed*	*Public ag R&D as % of ag GDP*	*Grads per M people*
	1st World (est.) = 7	*US = 56 FTE / M Ha*	*US = 2.4*	*1st World (est.) = 100%*	*Botswana = 4.3%*	*Albania = 395 Grads/M*
Top 5 Overall Performers						
Ethiopia	4.3	12.8	0.07	18.8	0.3	90.5
Nigeria	3.3	1.9	0.04	51.5	0.4	ND
Kenya	4.0	2.4	0.21	25.8	1.3	ND
Ghana	4.0	2.9	0.05	30.4	0.9	94.9
Benin	4.5	5.5	0.11	50.0	0.7	12.2
Bottom 5 Overall Performers						
Niger	4.0	0.3	0.01	21.2	0.3	17.9
Mozambique	4.3	0.6	0.07	11.7	0.4	18.1
Burundi	3.3	ND	0.06	7.6	1.8	14.5
Sierra Leone	4.0	2.1	0.10	5.7	0.3	ND
Togo	3.0	3.0	0.08	15.1	0.5	ND
Source:	UN-IFAD/Mo Ibrahim Foundation	FAO-PBBC	CGIAR-DIIVA Project	CGIAR-DIIVA Project	CGIAR-ASTI	UNESCO

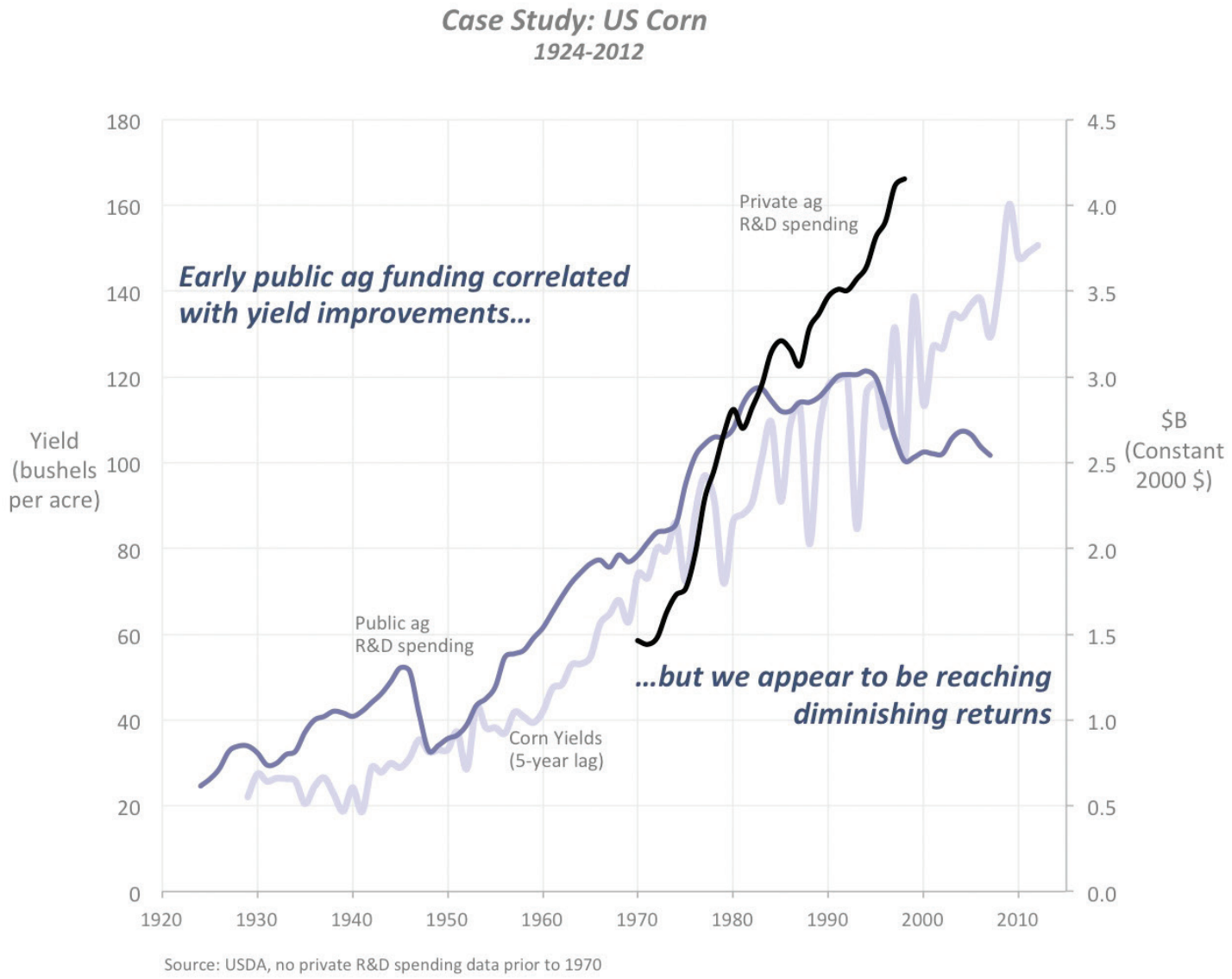
Many breeding and R&D programs are highly dependent on unstable funding sources, (e.g. temporary funds from aid organizations) so sustaining a long-term R&D program has proven difficult for many countries

Weight: **High**

Source: Lake Partners analysis

Agriculture R&D and Impact on Yields

While private R&D generally follows public spending, the impact on yields is becoming less clear



Source: USDA, no private R&D spending data prior to 1970

Source: Lake Partners analysis

Regulation of Protected Seeds

Source: UPOV, Lake Partners analysis

The International Union for the Protection of New Varieties of Plants (UPOV) is a convention governing the certification of protected hybrid and improved seeds

- Members of UPOV can use seeds that have been certified in other countries without undergoing the process internally
- UPOV membership allows easier adoption of protected improved seeds

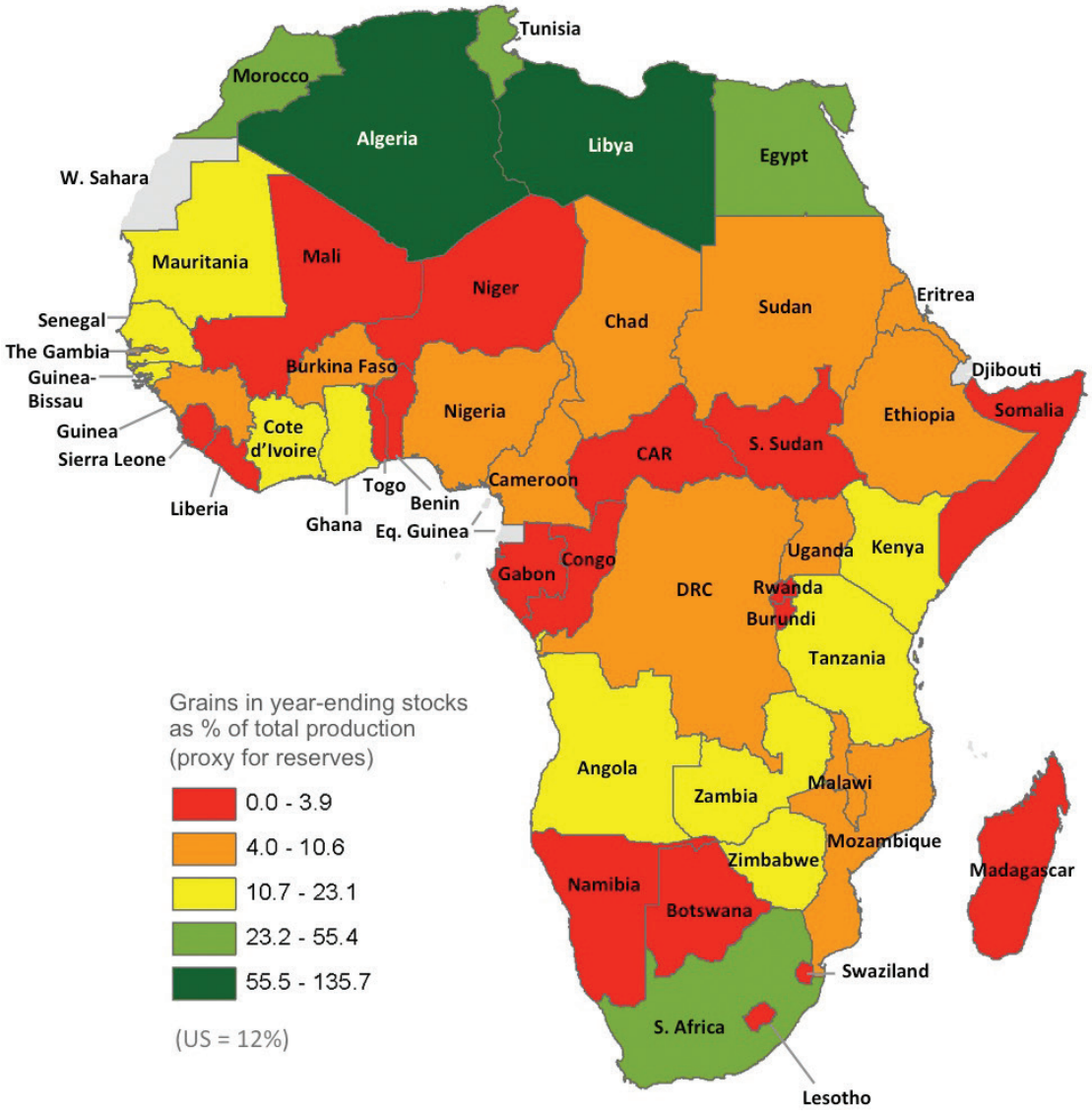
For example, Kenya increased the number of maize varieties from 7 to 60 following adoption of UPOV

- Most of these were improved varieties (e.g., pest- and drought-resistant)

Weight: **Medium**

Grains in Year-Ending Stocks

We use year-ending stocks as a proxy for commodity reserves



Source: USDA-FAS, Lake Partners analysis

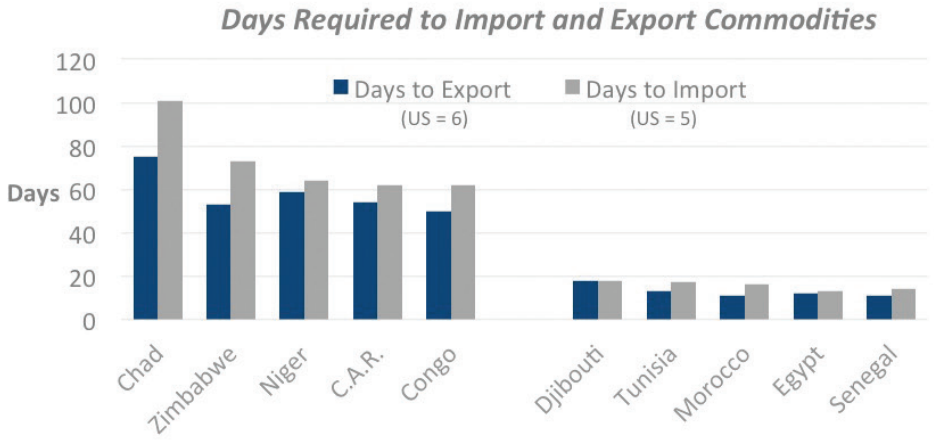
Many smallholder farmers are unable to sell crops at optimal prices due to poor storage and access to markets following harvest times, when prices dip due to surplus

Commodity reserve programs are able to purchase grains from farmers at higher prices and store them until prices rise later in the year

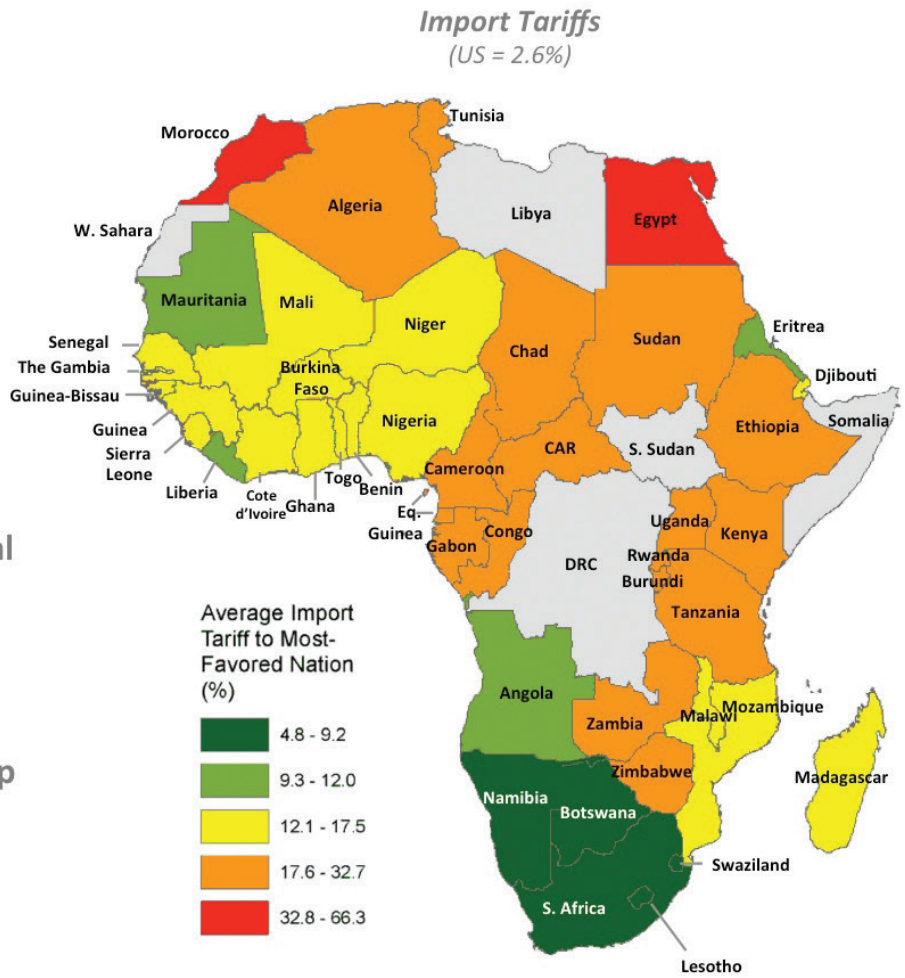
- Several countries, including Ethiopia and Rwanda, have recently established commodity exchanges to stabilize the flow of commodities to international buyers and prices for farmers

Weight: **Medium**

Import Tariffs and Trade Delays



Source: WTO Doing Business Survey, Trading Across Borders survey data



Source: WTO

Countries like Tanzania help buffer the variability in global pricing of inputs by reducing tariffs

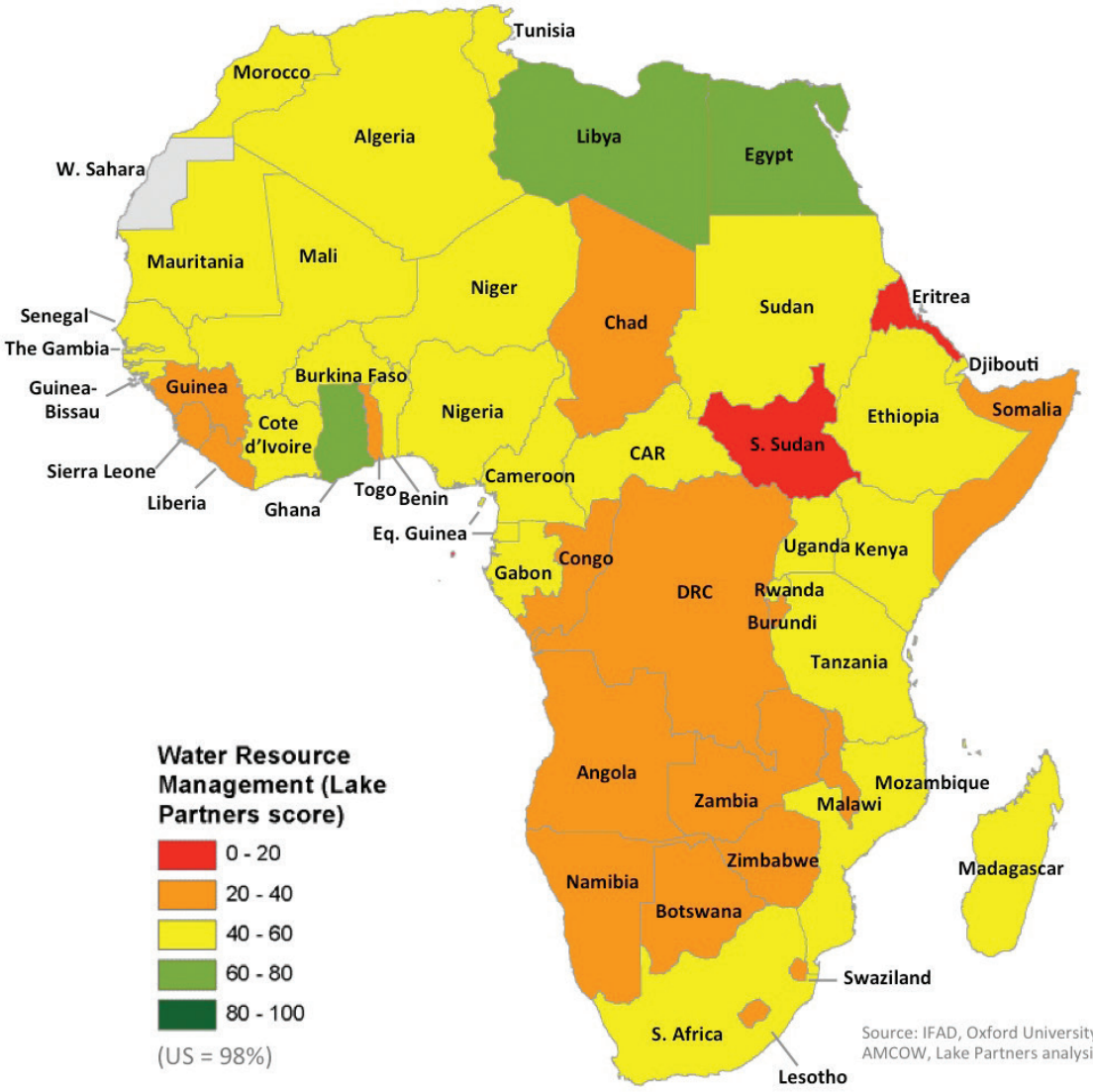
Ethiopia's input tariffs magnify the problem

Export restrictions lead to local oversupply and lower crop prices, which prevent farmers from sustaining profits

Weights: **Medium**

Source: Lake Partners analysis

Water Resource Management[1]



Source: IFAD, Oxford University (Rural Water Livelihood Index), AMCOW, Lake Partners analysis

Because irrigation is so expensive, successful regions have focused on water policy over irrigation infrastructure

The two main issues are equitable distribution and policies for drought resilience

Weight: **Medium**

[1] Lake Partners score is a clustered metric based on: Access to Water for Agriculture score (IFAD/Molbrahim), Resilience to Natural Variability in Water Supply score (Rural Water Livelihoods Index), Secure & Equitable Water Entitlement score (Rural Water Livelihoods Index), and Water Management Regulatory Framework score (African Union/AMCOW)
Source: Lake Partners analysis

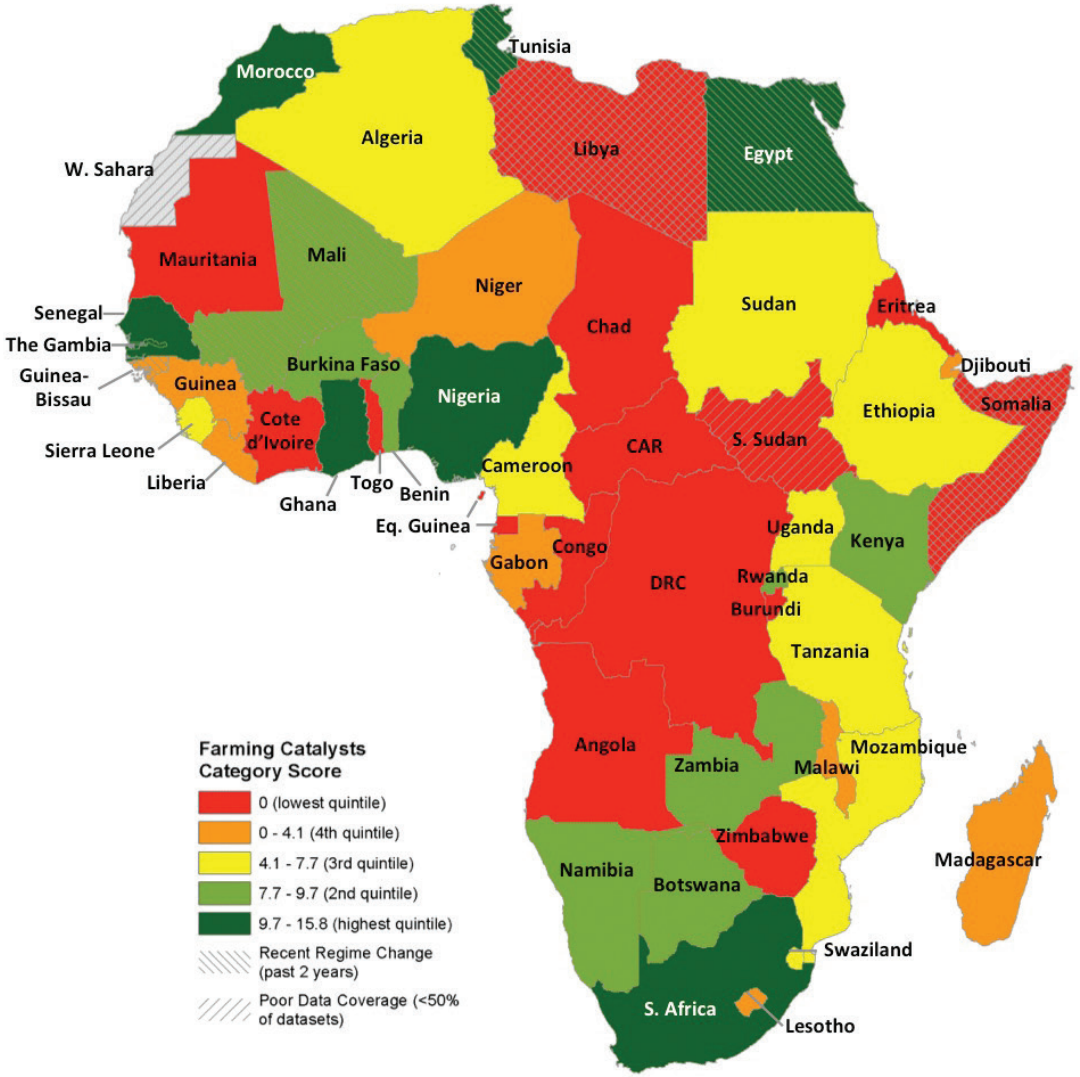
Farming Catalysts Metrics

We use 14 metrics (20 submetrics) to assess the catalysts for farming in each country

3) Farming Catalysts Metrics & Submetrics	*Units*	*Top Score*	*Source(s)*
3a) Availability of fertilizer (usage as a rough proxy for availability)			
3a.1) Nitrogen	tonnes/1,000 Ha of cropland	461 (New Zealand)	FAOSTAT-UN
3a.2) Phosphate	tonnes/1,000 Ha of cropland	162 (Jordan)	FAOSTAT-UN
3a.3) Potash	tonnes/1,000 Ha of cropland	136 (Belarus)	FAOSTAT-UN
3b) Pesticide use	tonnes/1,000 Ha of cropland	17.8 (China)	FAOSTAT-UN
3c) Mechanization (tractors in use as a proxy)	Number of tractors per 1,000 Ha of cropland	251 (Switzerland)	FAOSTAT-UN
3d) Access to capital			
3d.1) Growth in agricultural physical assets (in-use)	% (change from 2001-07)	52.7 (Sierra Leone)	FAOSTAT-UN
3d.2) Investment climate for rural businesses	1-6 (qualitative)	7 (1st World Est.)	IFAD/Mo Ibrahim Foundation, Lake Partners analysis
3d.3) Crop insurance programs	0 (no program); 1 (pilot); 2 (has program)	2 (1st World Est.)	*Government Support to Agricultural Insurance*, World Bank 2010
3e) Access to agricultural input and produce markets	1-6 (qualitative)	7 (1st World Est.)	IFAD/Mo Ibrahim Foundation, Lake Partners analysis
3f) Entrepreneurial opportunity			
3f.1) Entrepreneurial Climate	1-142 (qualitative)	1 (Denmark)	Legatum Institute Prosperity Index
3f.2) New business density	New registrations/1,000 people	14.5 (New Zealand)	World Bank
3f.3) Time to start a business	Days	1 (New Zealand)	World Bank, Starting a business survey
3f.4) Startup costs	% of income per capita	0.2 (Denmark)	World Bank, Starting a business survey
3g) Water resources (freshwater withdrawals as proxy)	Freshwater withdrawals as % of renewable water	0 (DRC)	FAO-AQUASTAT/World Bank
3h) Rural organizations (co-ops)			
3h.1) Policy & legal framework for rural organizations (co-ops)	1-6 (qualitative)	7 (1st World Est.)	IFAD/Mo Ibrahim Foundation, Lake Partners analysis
3h2) Dialogue between government and rural organizations	1-6 (qualitative)	7 (1st World Est.)	IFAD/Mo Ibrahim Foundation, Lake Partners analysis
3i) Land rights			
3i.1) Access to land (rural sector performance assessment)	1-6 (qualitative)	7 (1st World Est.)	IFAD/Mo Ibrahim Foundation, Lake Partners analysis
3i.2) Insecure tenure and property rights	0-7 (qualitative)	0 (Source defined)	USAID-ARD, Inc. (Land Tenure & Property Rights Regional Reports)
3i.3) Inequitable access to land and natural resources	0-7 (qualitative)	0 (Source defined)	USAID-ARD, Inc. (Land Tenure & Property Rights Regional Reports)
3i.4) Poor land market performance	0-7 (qualitative)	0 (Source defined)	USAID-ARD, Inc. (Land Tenure & Property Rights Regional Reports)
3j) Women farmers	% of agricultural workforce	3.2 (Belize)	FAOSTAT-UN
3k) Foreign Direct Investment (FDI)			
3k.1) Inward FDI per capita	FDI per capita ($USD)	104 (Liberia)	UN Conference on Trade and Development; Dupont/EIU Food Security Index
3k.2) Preferential target of global investment	Rank (0-177) of Inward FDI Potential	0 (Source defined)	UN Conference on Trade and Development; Dupont/EIU Food Security Index
3l) Orphan crops	% of total harvested land	82 (Namibia)	FAOSTAT-UN; International Centre for Underutilized Crops
3m) Farm size			
3m.1) Farmland per ag worker	Ha per person employed in agriculture	147 (Canada)	FAOSTAT-UN
3m.2) Average farm size	Ha per farm	3,232 (Australia)	FAO Agricultural Censuses; CSFVAs; country-level reports; Chand, Prasamma, Singh 2011
3n) Availability of skilled workforce (change in ag workforce as proxy)	Avg annual % change in ag workforce	4.2 (Bhutan)	FAOSTAT-UN

Source: Lake Partners analysis

Farming Catalysts: Summary of All Metrics



Highest Scores [1]

Ghana	15.7
South Africa	14.9
The Gambia	13.0
Morocco	11.8
Senegal	11.6

Lowest Scores [1]

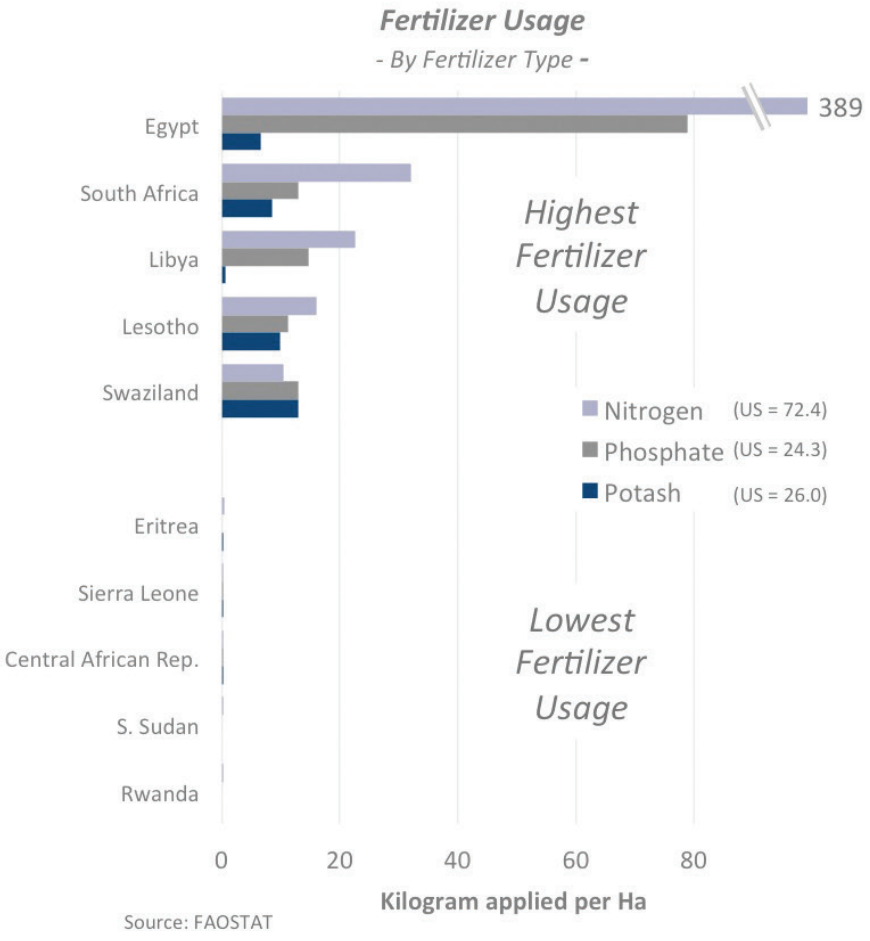
Congo	0.0
Chad	0.0
Somalia	0.0
Central African Rep.	0.0
Zimbabwe	0.0

[1] Not listed due to poor data coverage or recent regime change: W. Sahara, S. Sudan, Egypt, Mali & Tunisia

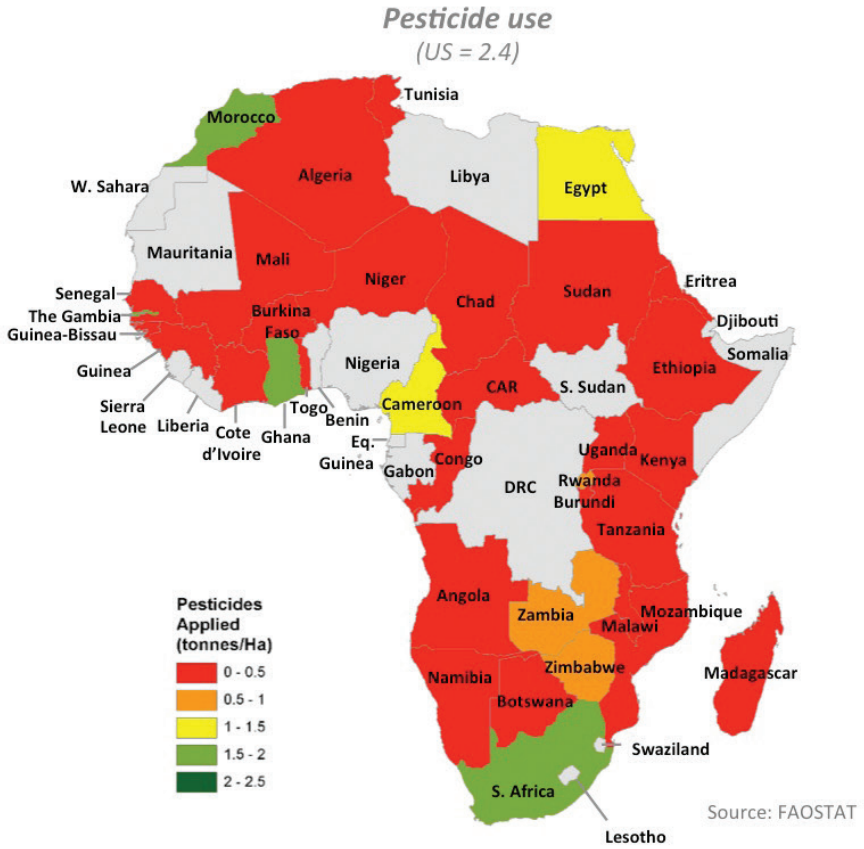
Source: Lake Partners analysis

Fertilizer & Pesticide Availability

We use fertilizer usage as a proxy for fertilizer availability



Weight (Fertilizers): **High**
Weight (Pesticides): **Medium**



Sophistication and density of local fertilizer use drives down input prices and increases effectiveness of improvement programs

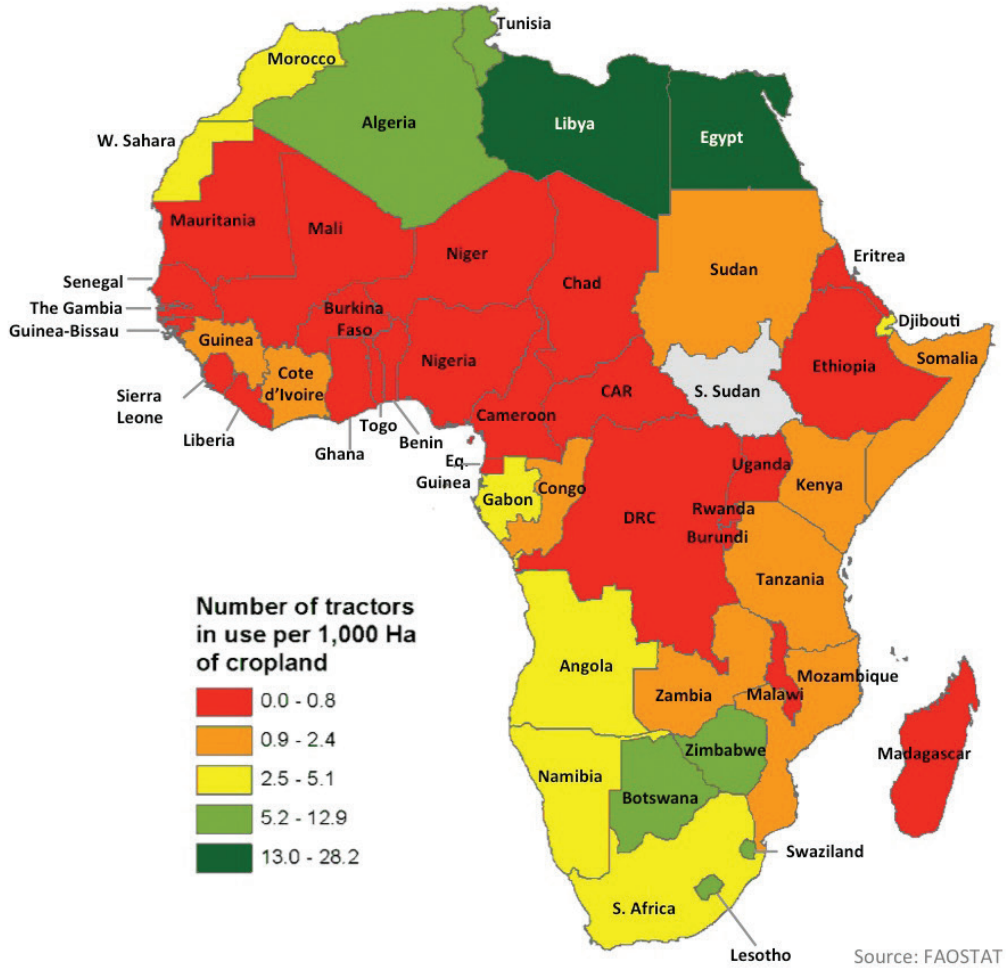
The use of pesticides could have substantial upside for the productivity of farmers, especially women who are responsible for 90% of hand weeding [1]

[1] Ukekje, 2004, Modernizing Small-holder Agriculture to Ensure Food Security and Gender Empowerment: Issues and Policy, Intergovernmental Group of Twenty Four
Source: Lake Partners analysis

Mechanization

We use number of tractors in use as a proxy for mechanization

Tractor Density
(US = 27.3)



Source: FAOSTAT

Over the past 40 years, tractor usage in Africa has declined while it has increased ten-fold in developing counties in Asia

As a result 50-80% of cropland is cultivated manually in central and southern Africa[1]

Weight: **Medium**

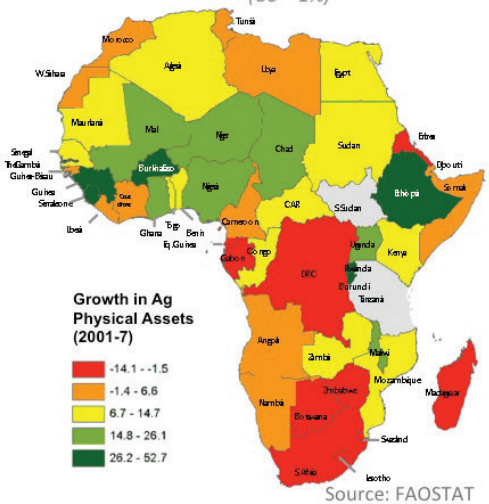
[1] Ashburner & Kienzle, Investment in agricultural mechanization in Africa, FAO Ag and Food Engineering technical report 8, 2011
Source: Lake Partners analysis

Source: FAOSTAT

Access to Capital[1], Inputs & Markets

Growth in Agricultural Physical Assets

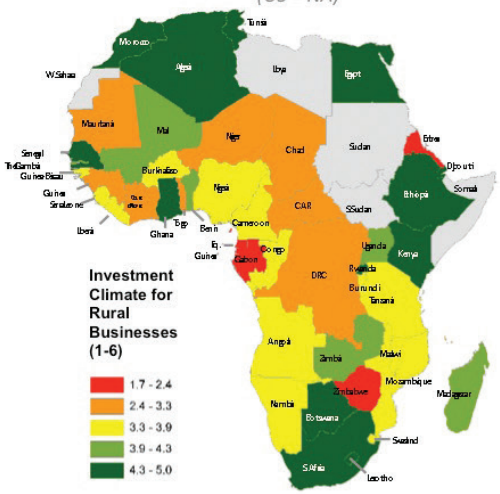
(US = 1%)



Source: FAOSTAT

Investment Climate for Rural Businesses

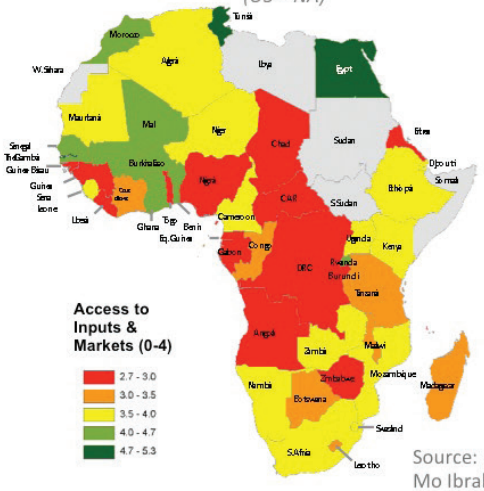
(US = NA)



Source: IFAD/
Mo Ibrahim Foundation

Access to Inputs & Markets

(US = NA)



Source: IFAD/
Mo Ibrahim Foundation

The shift to market-based farming is a hallmark of progress in both agricultural development and improved food security.

Weights: **High**

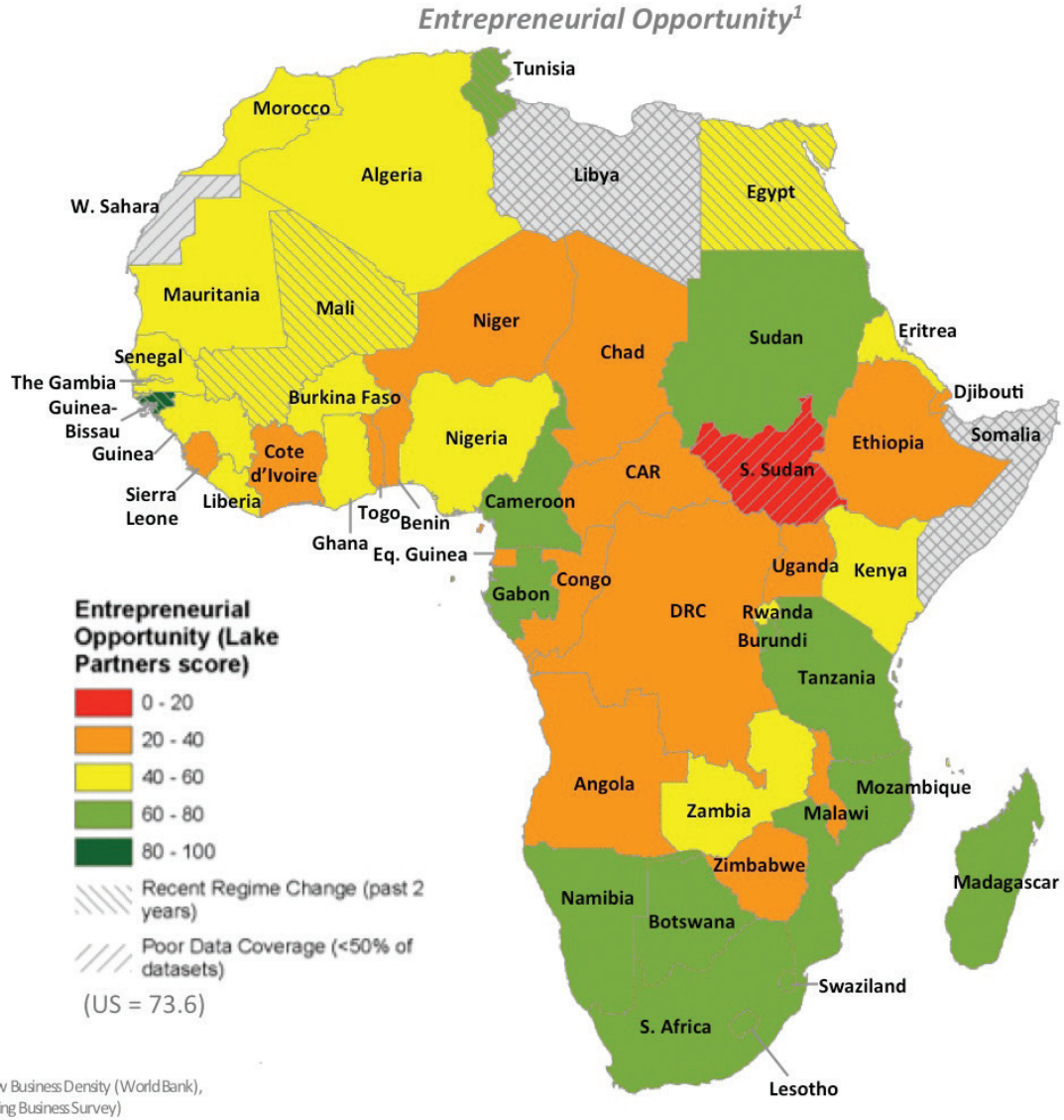
[1] Access to Capital is a clustered metric based on sub metrics: Growth in Agricultural Physical Assets (FAOSTAT-UN), Investment Climate for Rural Business (IFAD/Mo Ibrahim Foundation) & Crop Insurance Programs (World Bank)
Source: Lake Partners analysis

Entrepreneurial Opportunity

The ability to cheaply and easily start a new business allows for the rapid deployment of new technologies.

For example, to lower the production cost of maize, newly available mobile compact mills are currently being rapidly acquired by entrepreneurs, NGOs and the government in South Africa.[2]

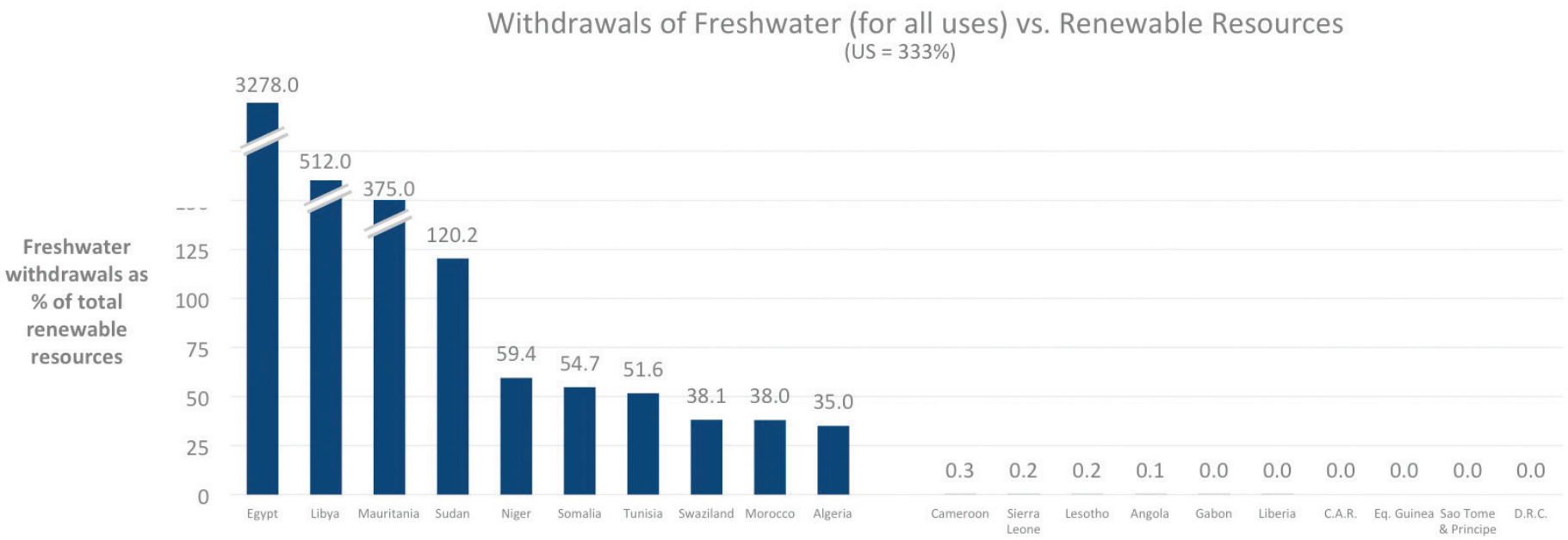
Weight: **Medium**



[1] Lake Partners score is a clustered metric based on: Legatum Index Entrepreneurial sub-score (Legatum Institute), New Business Density (World Bank), Time to start a new business (World Bank-Ease of Doing Business Survey) and Startup costs (World Bank-Ease of Doing Business Survey)
[2] S. African Engineering News: http://www.engineeringnews.co.za/article/bhler-south-africa-launches-compact-mobile-maize-milling-plant-2013-04-12
Source: Lake Partners analysis

Water Resources

We use freshwater withdrawals as a proxy for a country's water resources



Source: FAO-AQUASTAT, Lake Partners analysis

Countries with strained water resources are more susceptible to droughts, which can have long-term effects on agricultural production

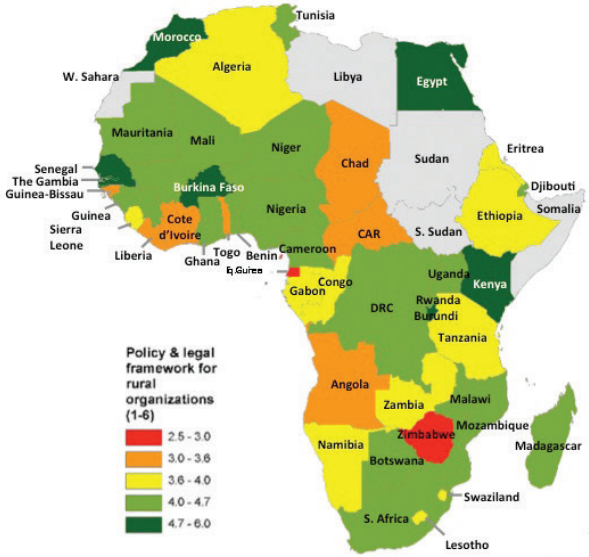
- South Africa's maize yields fell by 72% following a 1991 drought, and took several years for agricultural GDP to recover

Weight: **Medium**

Source: Lake Partners analysis

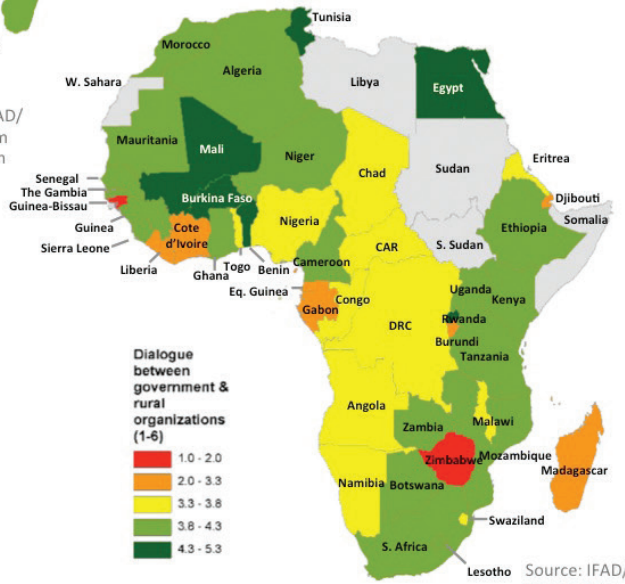
Rural Organizations (Co-Ops)

Policy & Legal Framework for Rural Organizations (Co-Ops)



Source: IFAD/ Mo Ibrahim Foundation

Dialogue between Governments & Rural Organizations (Co-Ops)



Source: IFAD/ Mo Ibrahim Foundation

Rural co-ops provide a link between government organizations and farmers

- Co-ops are often used to disseminate funding and inputs from central governments to farmers, functioning as on-the-ground support network
- Co-ops can be used in lieu of inefficient government ministries to gain greater access to remote areas

Co-ops also allow farmers to join and find benefits from scaled input purchases and crop sales

Weight: **Medium**

Source: Lake Partners analysis

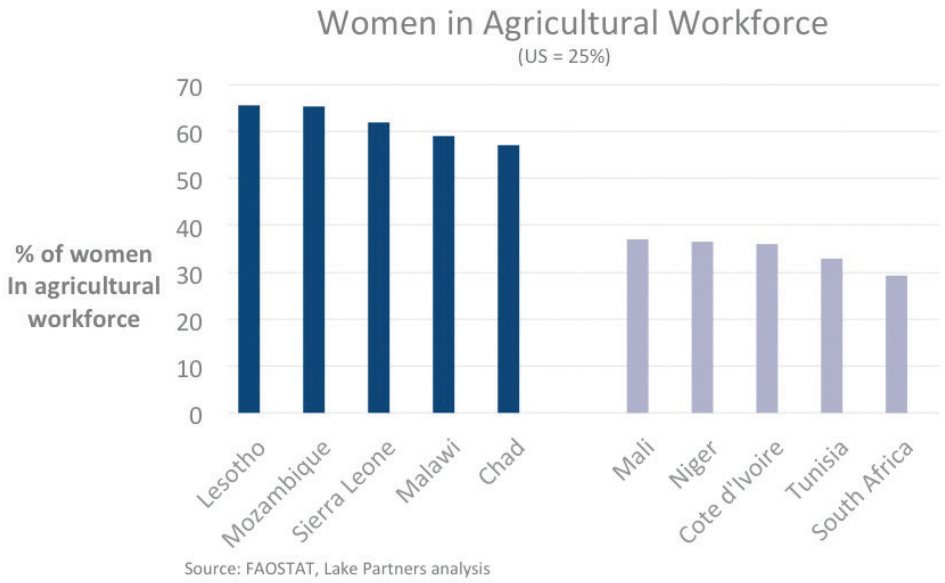
Land Rights & Women Farmers

Secure access to land is a necessary component of increasing agricultural investments needed to increase productivity

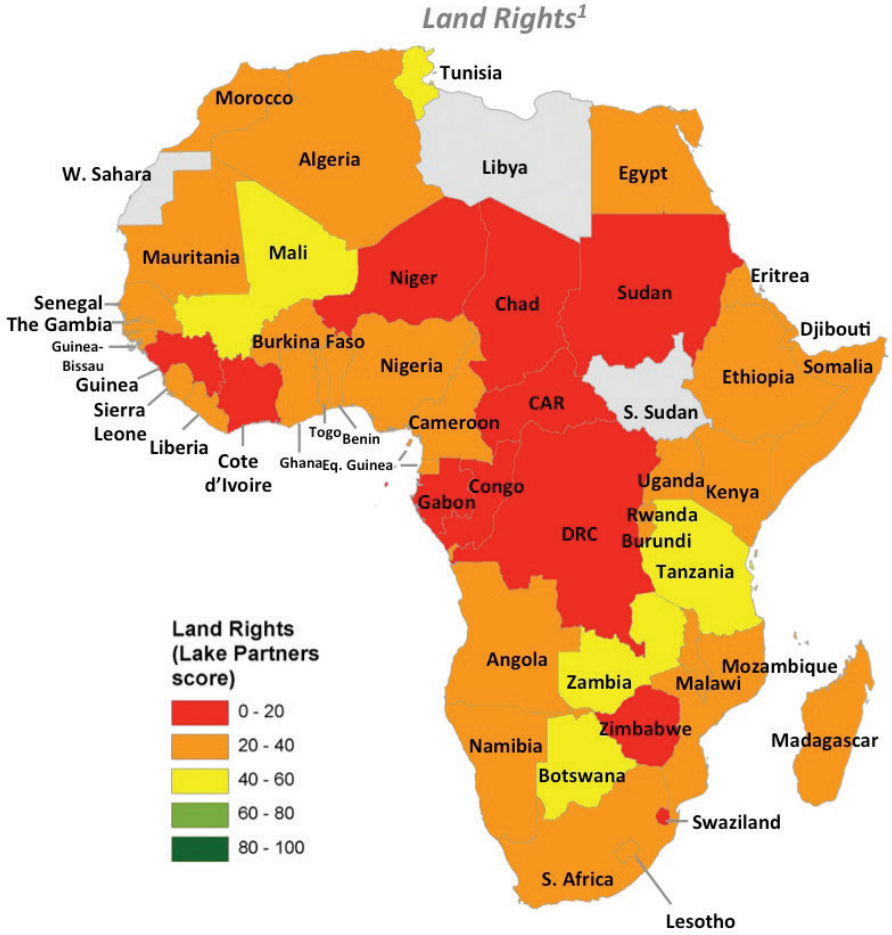
- Titled land can be used as collateral for loans
- Farmers who own their land are more likely to make long-term investment decisions in that land
- Small farm size limits the impact of interventions such as increased extension services and training programs

Women farmers commonly have less access to land, credit and subsidies

In Malawi, studies have shown that women receive less fertilizer, farm fewer cash crops and receive fewer extension visits than men



Source: FAOSTAT, Lake Partners analysis

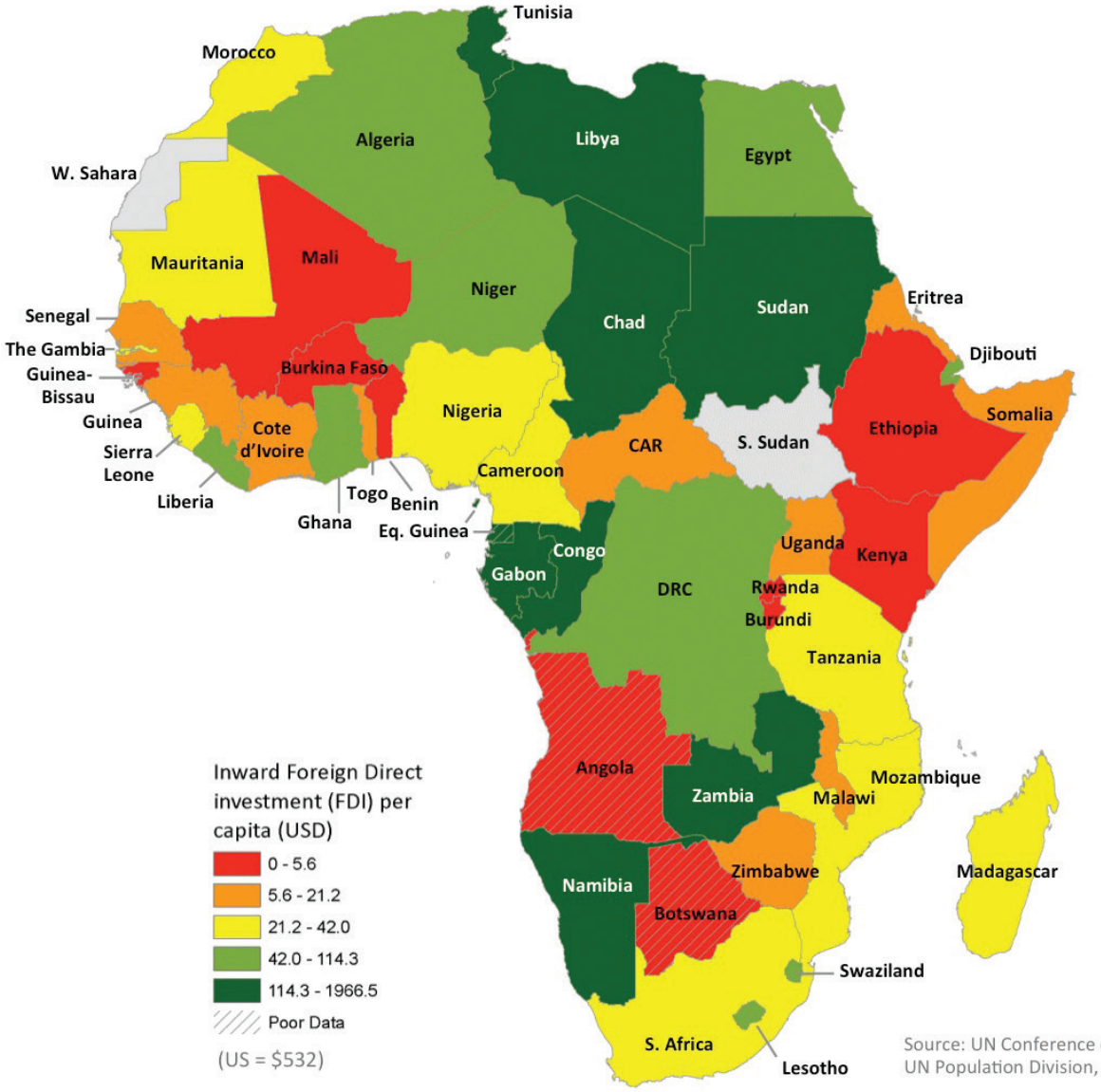


Source: USAID, IFAD/Mo Ibrahim Foundation, Lake Partners analysis

Weights: **Medium**

[1] Lake Partners score is a clustered metric based on: Access to Land score (IFAD/Mo Ibrahim Foundation), Insecure Tenure and Property Rights Score (US-AID), Inequitable Access to Land and Natural Resources score (US-AID), and Poor Land Market Performance score (US-AID)
Source: Lake Partners analysis

Foreign Direct Investment



Source: Lake Partners analysis

Foreign Direct Investment measures only private commercial investment and does not account for "land grab" investments – long-term lease deals where agricultural production is primarily for export

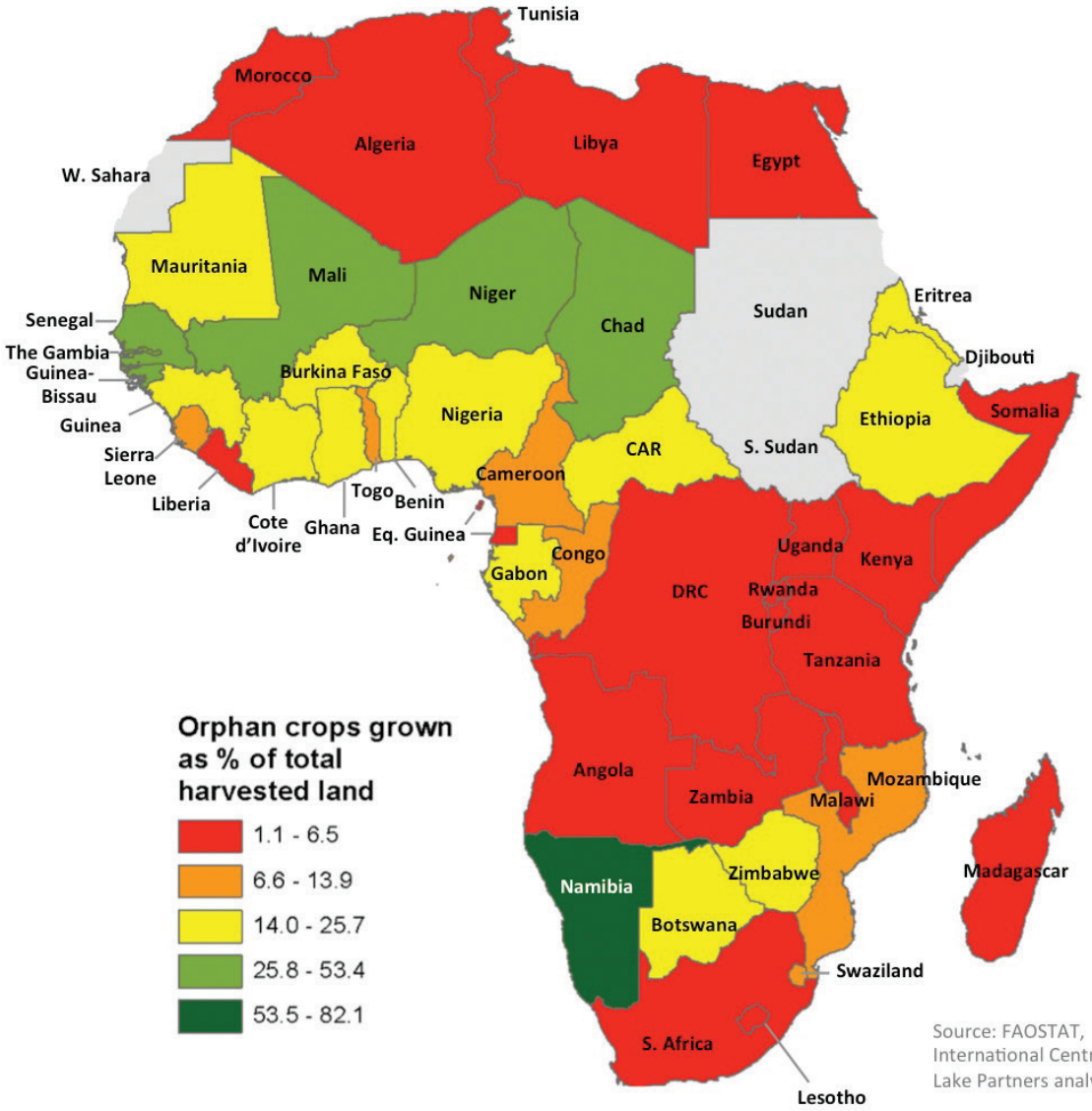
Ownership of agricultural land by foreign interests is barred or restricted in Kenya and other nations

Investments by mining companies in the DRC allow for infrastructure improvements that indirectly benefit agricultural production and the training of a more skilled construction sector lowering the cost of future projects

Weight: **Medium**

Source: UN Conference on Trade and Development, UN Population Division, Lake Partners analysis

Orphan Crops



Source: Lake Partners analysis

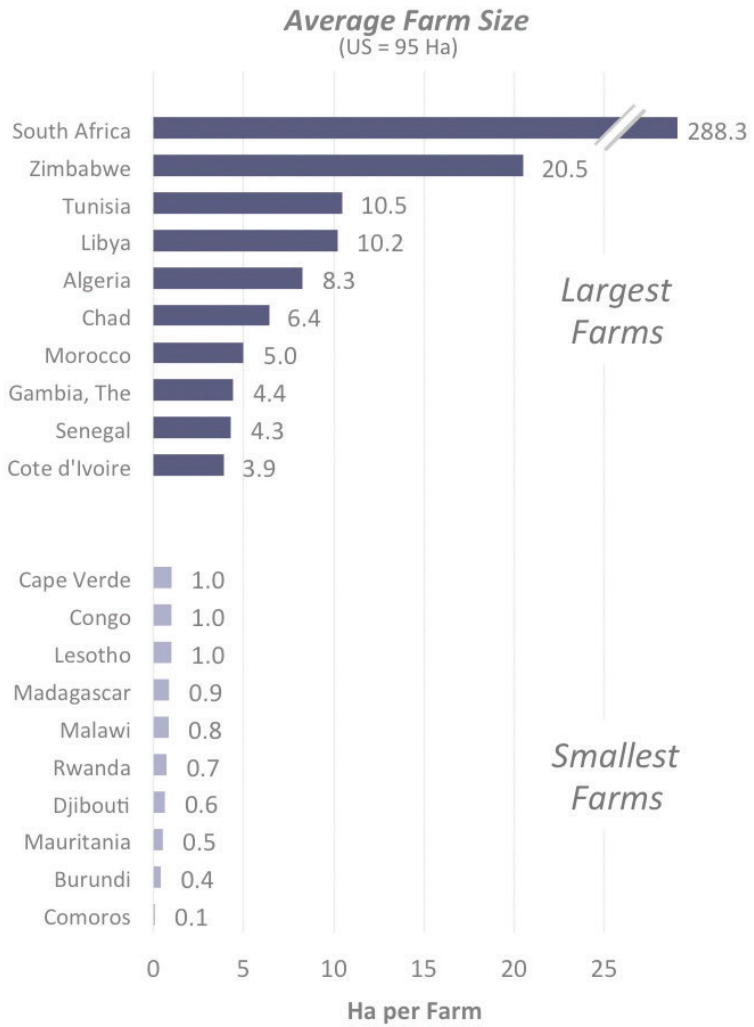
In theory, orphan crops (like amaranth, yams and taro) require fewer inputs and can be good options for subsistence farmers and food security due to their accessibility and adaptability to local conditions

However, due to their poor economic value they have been less intensely studied and have fewer improved varieties, limiting their potential yields, nutrition density and marketability

Weight: **Low**

Source: FAOSTAT, International Centre for Underutilized Crops, Lake Partners analysis

Average Farm Size



Growth in average farm size may be indicative of a country's shift from subsistence farming to commercial-scale farms

In some countries (e.g., Zimbabwe), the desire for more local ownership has been shifting farm sizes lower

However, most data collected here is from agricultural censuses from as far back as 1990, and may not be representative of present-day conditions

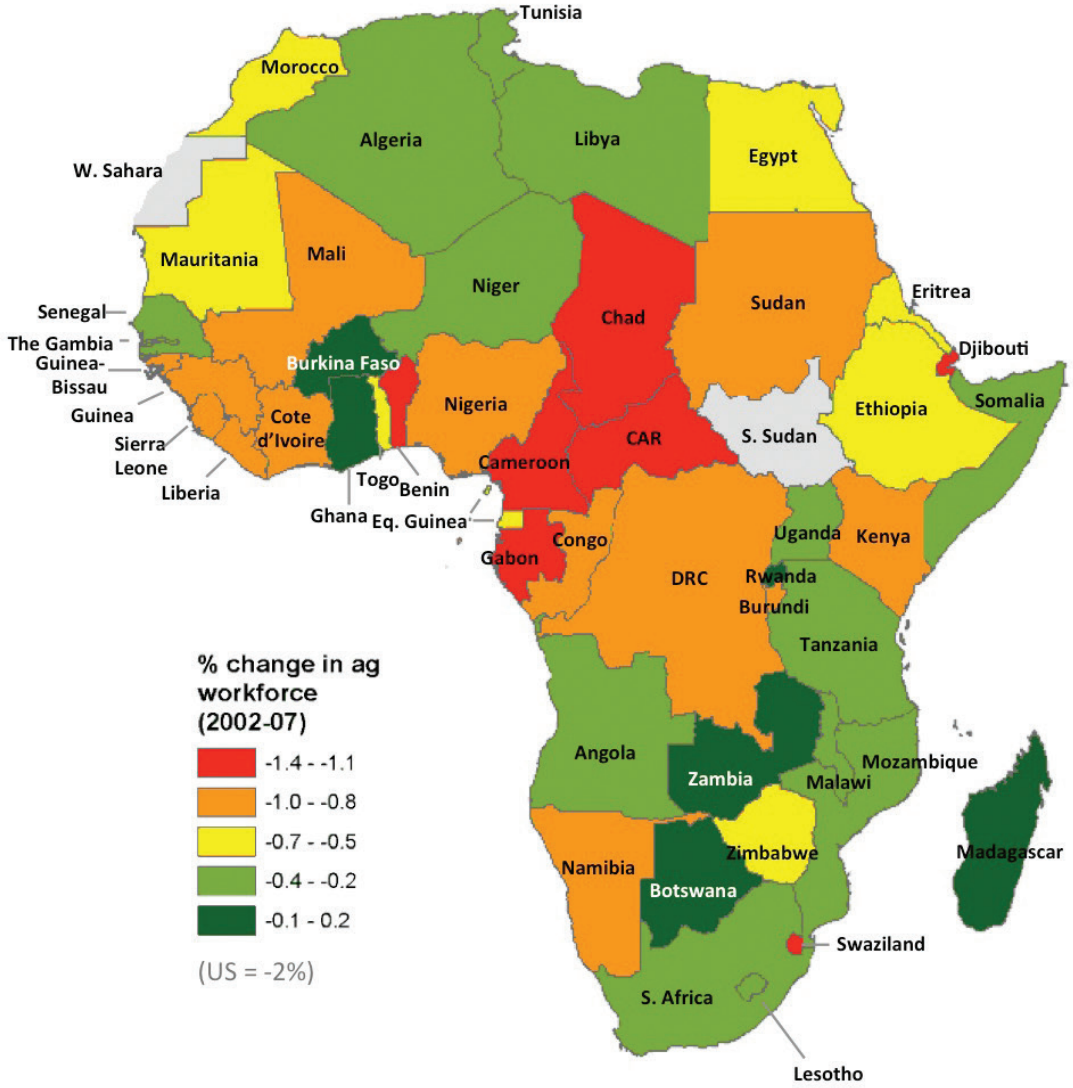
- Data should therefore be taken as directional, but not definitive

Weight: **Medium**

Source: FAO agricultural censuses, World Food Program Comprehensive Food Security and Vulnerability Analyses, country-level surveys, Lake Partners analysis

Availability of Skilled Workforce

We use the change in agricultural workforce as a proxy for worker availability



Source: FAOSTAT, Lake Partners analysis

In countries with strong non-agricultural sectors such as mining and oil, high reservation wage rates have reduced the affordability of ag workers

Youth (15–34) unemployment in many countries remains high or has reached "epidemic" levels (e.g. Kenya), ensuring plenty of excess labor is available despite upward pressures on the reservation wage in countries with significant petroleum and mining sectors.

Weight: **Medium**

Infrastructure Metrics

We use 5 metrics (10 submetrics) to assess the state of infrastructure in each country

4) Infrastructure Metrics & Submetrics	*Units*	*Top Score*	*Source(s)*
4a) Public investment in infrastructure			
4a.1) Public resources for rural development	1-6 (qualitative)	7 (1st World Est.)	IFAD/Mo Ibrahim Foundation
4a.2) Public infrastructure spending	% of GDP	12.6 (Cape Verde)	African Development Bank - AICD
4b) Road condition			
4b.2) Roads paved	%	100 (USA)	International Road Federation/World Bank
4b.1) Extent & quality of road infrastructure	0-4 (qualitative)	7 (Sweden)	EIU Risk Briefing/Mo Ibrahim Foundation
4c) Rural electrification			
4c.1) Access to electricity	0-4 (qualitative)	7 (Sweden)	EIU/Mo Ibrahim Foundation
4c.2) Time required to get electricity	days	17 (Germany)	World Bank - Doing Business Project
4c.3) Rural population with electricity	%	100 (USA/1st World Est.)	International Electricity Agency
4d) Grain storage			
4d.1) Production loss through poor storage & transportation	% annual cereal production as waste	2 (N American Avg.)	FAOSTAT-UN, FAO Global Food Losses and Food Waste Report 2011
4d.2) Post-harvest losses of maize	% of harvest lost	2 (N American Avg.)	African Postharvest Losses Information System (APHLIS), FAO Global Food Losses and Food Waste Report 2011
4d.3) Access to adequate storage	0-1 (qualitative)	1 (Binary Score)	Dupont-EIU Global Food Security Index
4e) Rail condition	0-4 (qualitative)	7 (Sweden)	EIU/Mo Ibrahim Foundation

Source: Lake Partners analysis

Infrastructure: Summary of All Metrics

Highest Scores [1]

Morocco	41.6
Algeria	38.0
Namibia	23.7
Sudan	22.1
South Africa	21.8

Lowest Scores [1]

Chad	0.0
Liberia	0.0
Dem. Rep. Congo	0.0
Gabon	0.0
Somalia	0.0

[1] Not listed due to poor data or recent regime change: W. Sahara, S. Sudan, Egypt, Libya, & Tunisia
Source: Lake Partners analysis

Public Investment in Infrastructure[1]

Top 10 Performers (0-100)[1]	
Egypt	61.4
Algeria	60.5
Tunisia	59.0
Morocco	50.0
Namibia	49.9
Lesotho	48.3
Gambia	44.5
Benin	43.3
South Africa	42.9
Kenya	42.8
Bottom 10 Performers (0-100)[1]	
Togo	27.3
Burkina Faso	27.1
Congo	24.4
Liberia	22.7
Cote d'Ivoire	21.4
Nigeria	19.8
Dem. Rep. of Congo	15.9
Chad	14.1
Gabon	9.1
Zimbabwe	0

For many African countries, years of conflict and post-colonial decay have left infrastructure in disrepair

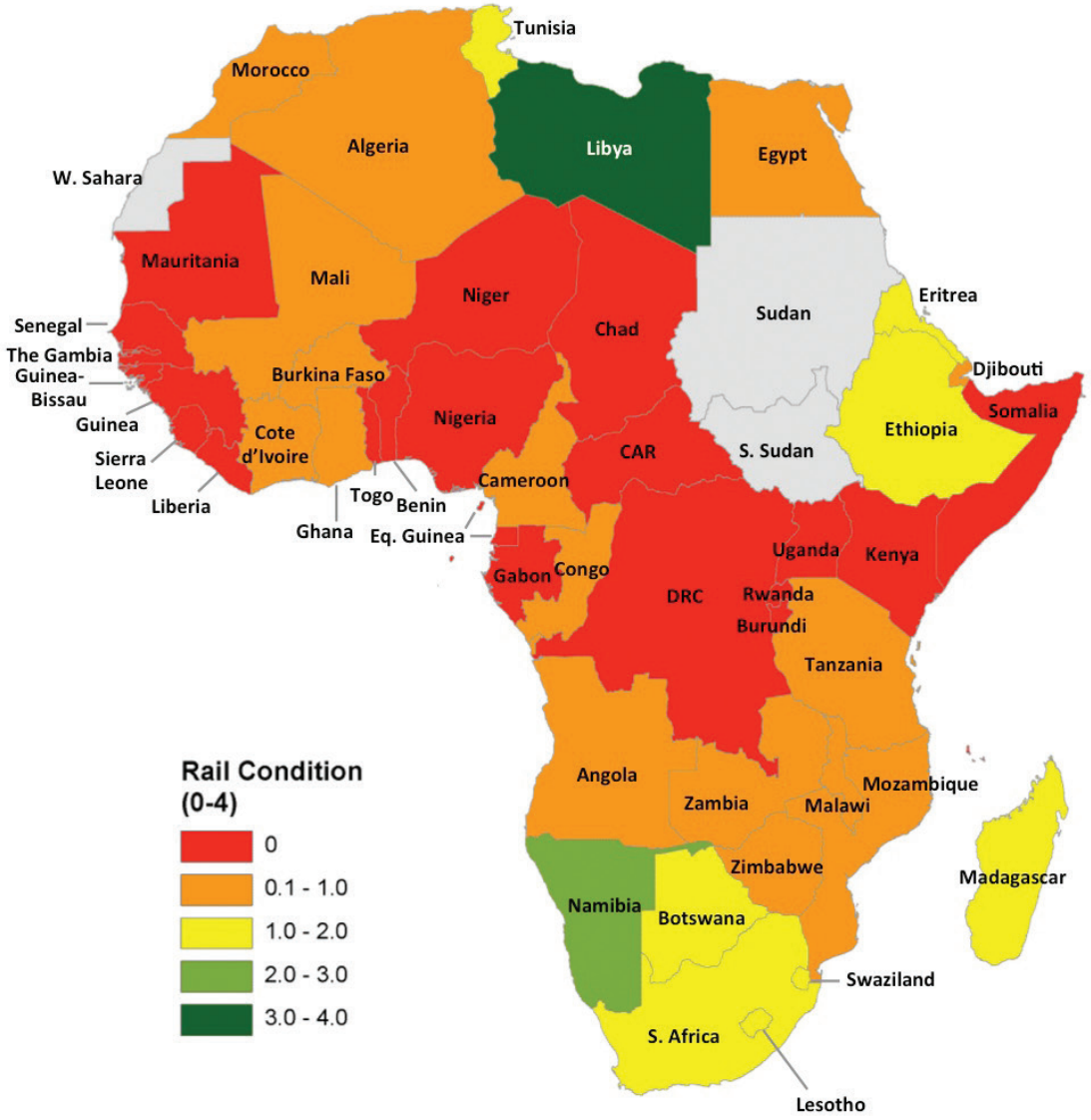
However, private investment from foreign countries has begun to increase rapidly — China recently surpassed the World Bank as the greatest foreign donor to infrastructure projects

However, nearly two-thirds of infrastructure funding still comes from public spending, and a country's investment in infrastructure ensures access to rural areas that are not lucrative for private investors

Weight: **High**

[1] Lake Partners score is a clustered metric based on: Public Resources for Rural Development score (IFAD/Mo Ibrahim) and Public Infrastructure Spending (African Development Bank)
Source: UN-IFAD/Mo Ibrahim Foundation, African Development Bank/AICD, Lake Partners analysis

Rail Conditions



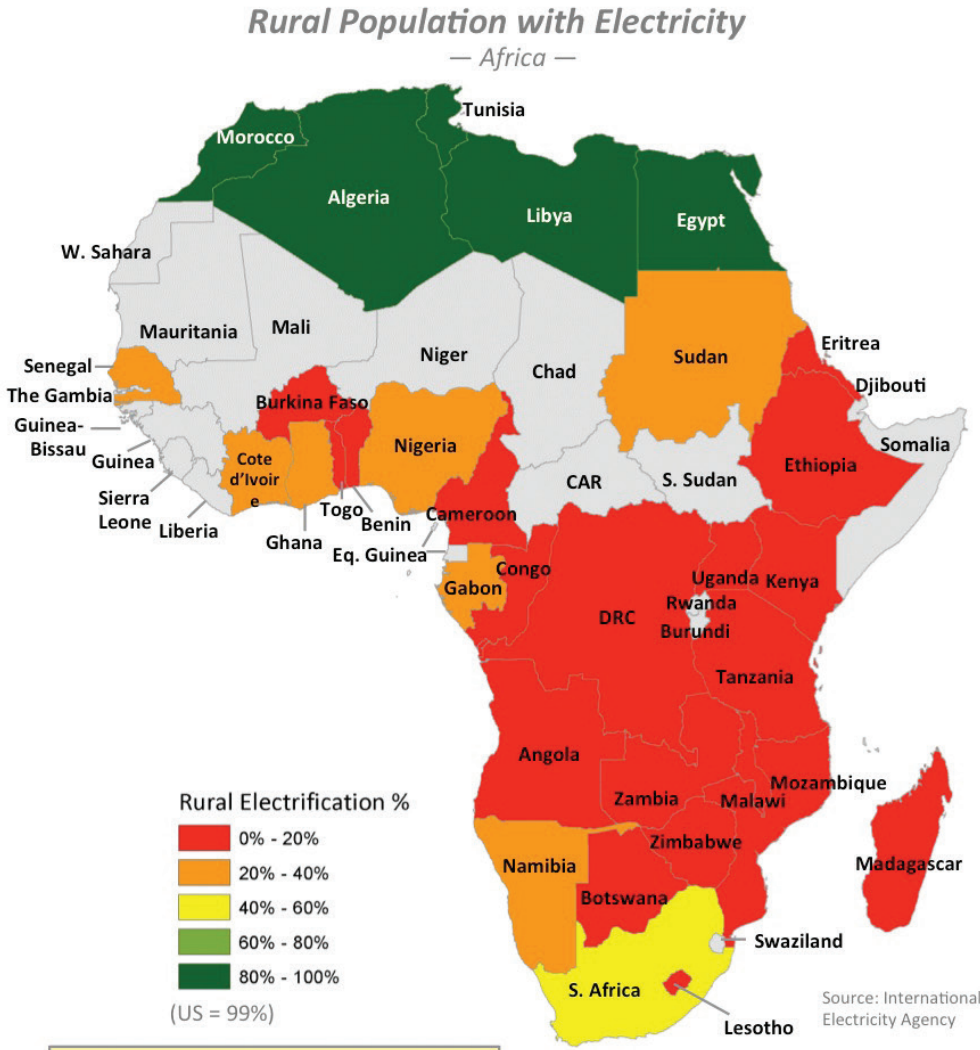
Source: EIU/Mo Ibrahim Foundation, Lake Partners analysis

Rail infrastructure is extremely poor throughout Africa; roads are much more common for transporting crops to market

However, for those near rail lines, prices for rail freight shipping often set the base price for local road transport as well, benefiting farmers with lowered transport costs through competition

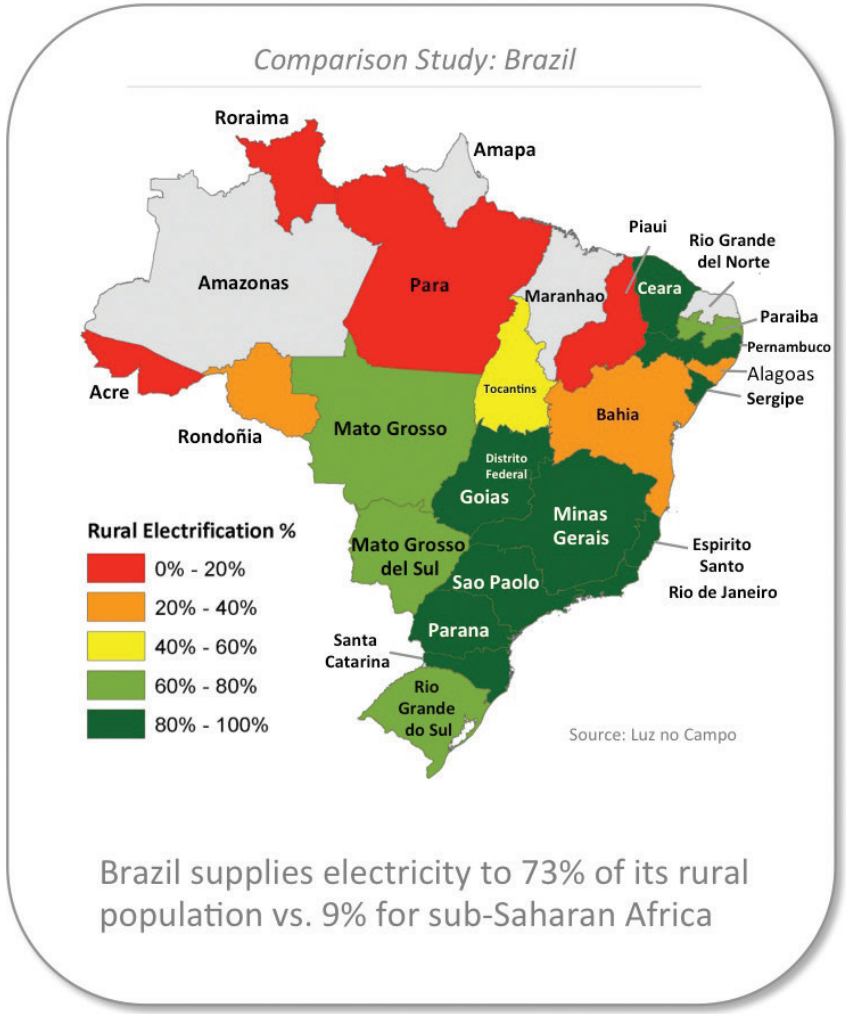
Weight: **Low**

Rural Electrification



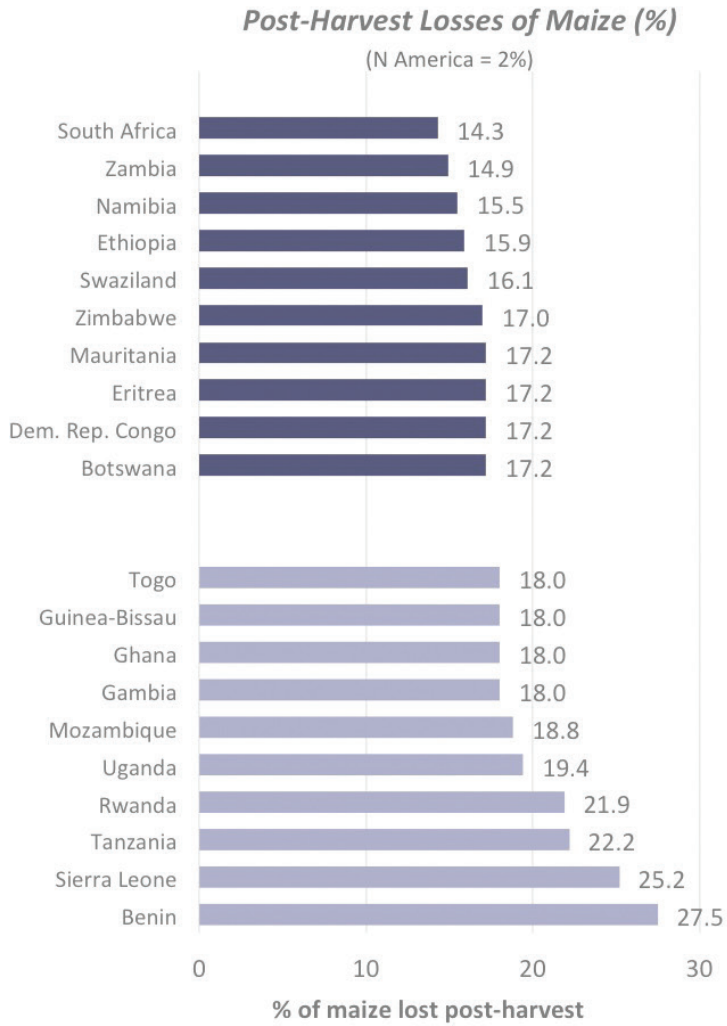
Weight: **Medium**

Source: Lake Partners analysis



Brazil supplies electricity to 73% of its rural population vs. 9% for sub-Saharan Africa

Adequate Grain Storage



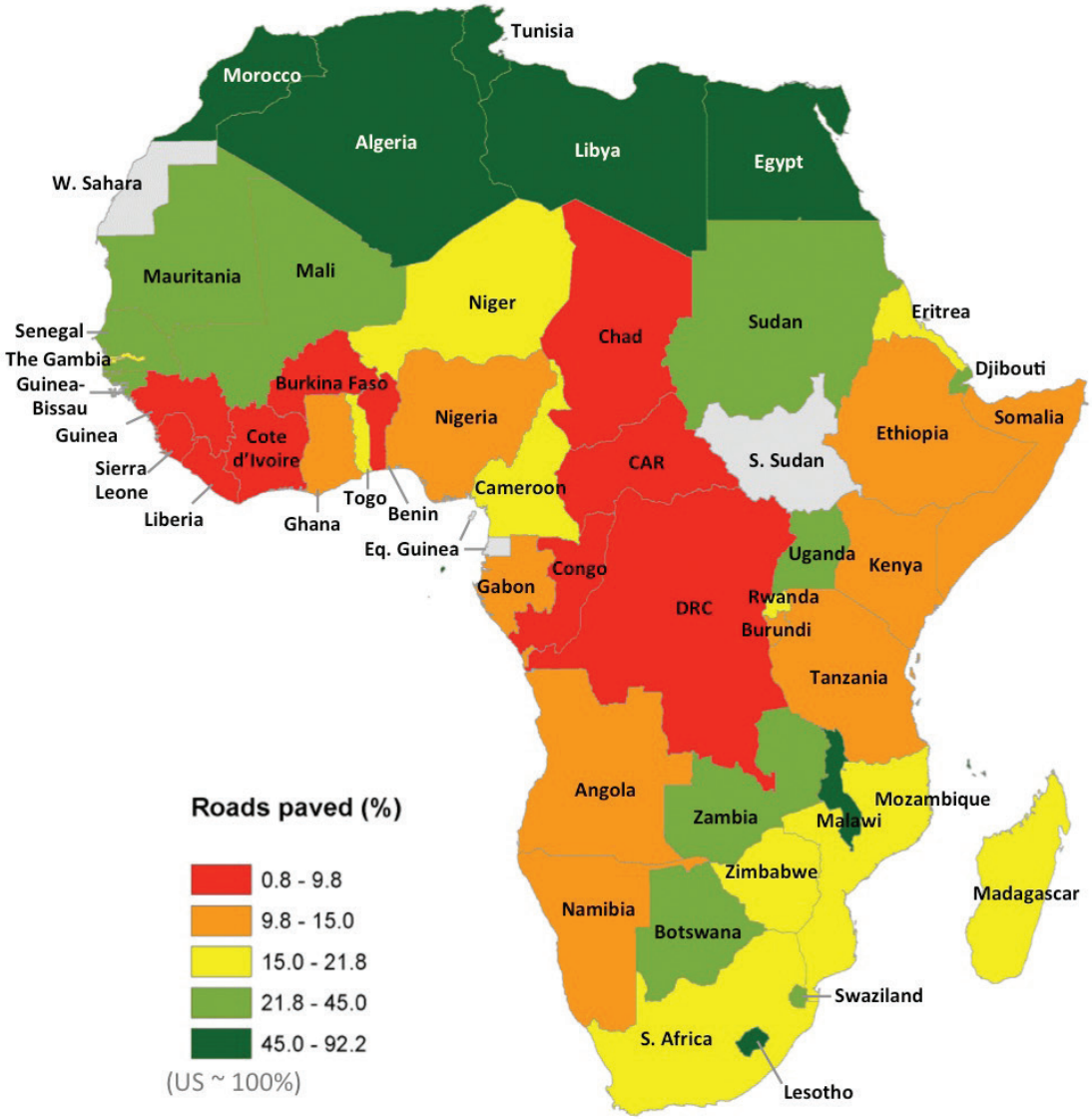
Currently, 10-20% of grain production spoils from bacteria and pests

A continent-wide African Post-Harvest Loss Information System (funded by the European Union) is targeting this aggressively

Weight: **Medium**

Source: EU/African Post-Harvest Loss Information System (APHLIS), Lake Partners analysis

Road Conditions



Source: International Road Foundation, Lake Partners analysis

The African Development Bank estimates that doubling rural accessibility requires a quadrupling of the length of road networks

Because of poor quality and access to many rural areas, costs of transporting produce may increase from $0.10 to $2.00 per ton-km, compared to more accessible farms

Weight: **High**

COUNTRY CASE STUDIES: PRACTICAL BARRIERS TO FARMING

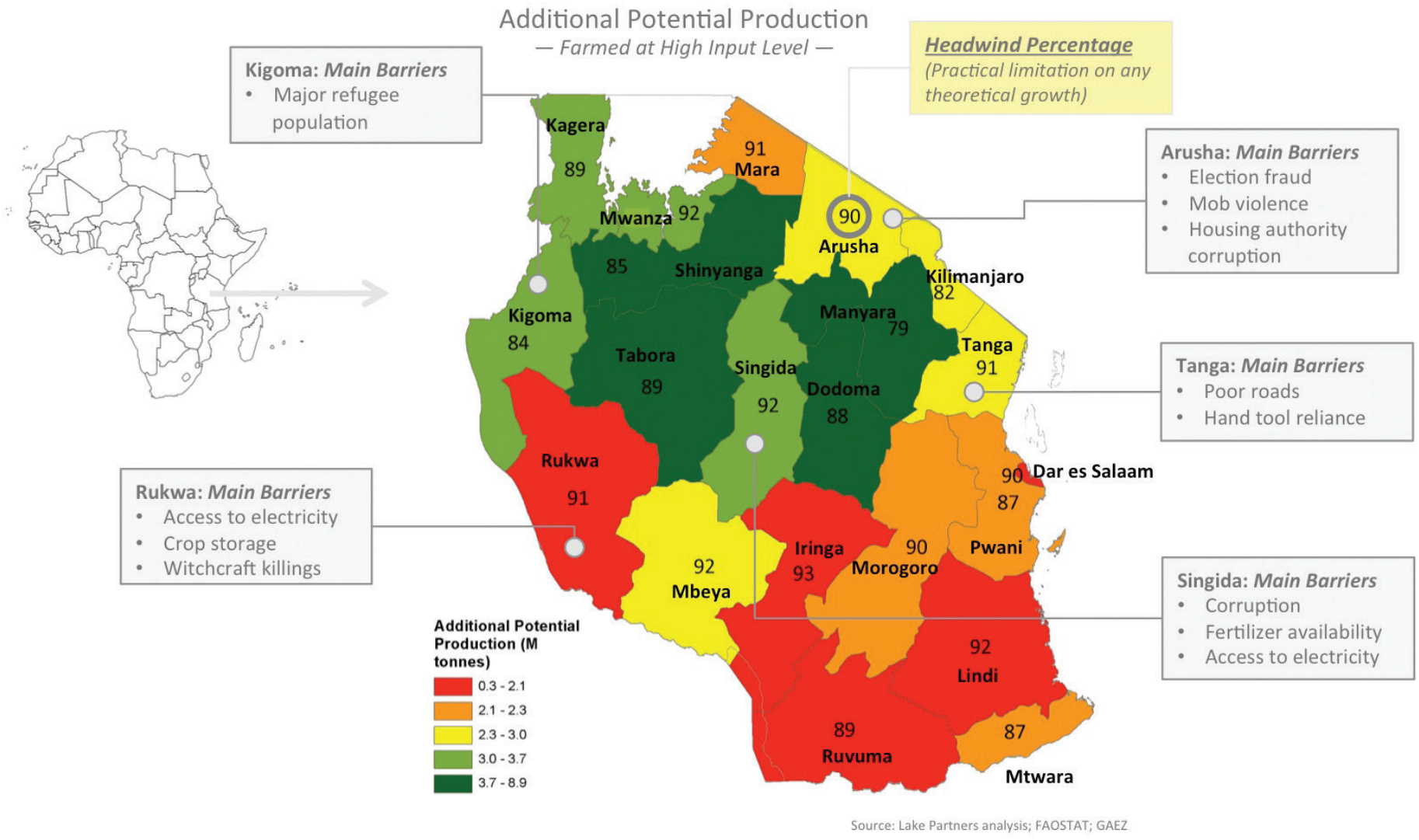
Introduction to Select Country Case Studies

While in-country regional-level data are sporadic, they provide reasonable accuracy on variations in practical and political barriers

	Regional-level Data on Practical and Political Barriers					Headwind Percentage	
	Governance & Socioeconomics	Government Support for Agriculture	Farming Catalysts	Infrastructure	Confidence in Regional Scoring[2]	Weighted Average of Regions[1]	Country-Level
Tanzania	• No data available • Use subjective +/- relative to country average based on Lake Partners research on regions	• Area under ag subsidy • % ag HH with access to extension programs • % farmland planted with improved seed • % villages with water council	• Women % head of farm household • % of ag households • Hours to town >20K • % planted area under organic fertilizer • % farms that buy, borrow, rent land • % Tractors/hand hoes	• % ag HH w/ electricity • % accessing credit • Travel time to town • Co-ops/1000 workers • % using fertilizer • # of ag workers	Medium	87.9%	87.2%
Ethiopia	• No data available • Use subjective +/- relative to country average based on Lake Partners research on regions	• Gov't spend on ag and natural resources • % visited by extension agents • % farmers using improved seed	• Women % of ag workforce • % accessing credit • Hours to town >20K • Co-ops/1000 workers • % using fertilizer • # of ag workers	• % ag HH w/ electricity connection • Avg % crop lost • Km all weather roads/ 1000 people • Per capita spend on rural development	Medium (No data on land rights)	88.0%	86.5%
Ghana	• No data available • Use subjective +/- relative to country average based on Lake Partners research on regions	• # of Ministry of ag district offices • % rating local water and sanitation services "very well"	• Women % of ag workforce • % farms w/ loans • Hours to town >20K • % farms without market stalls • % of co-ops • Input dealers/Ha farmed • % workforce in Ag	• % farms w/ access to electricity • Crop loss % • % rating road maintenance as "good"	Med-Low (Limited data on Gov't Support, none on land rights)	82.2%	79.3%
Kenya	• No data available • Use subjective +/- relative to country average based on Lake Partners research on regions	• Distance to crop extension service provider • % rating local water and sanitation services "very well"	• % ag HH receiving ag credit • Hours to town >20K • % farms without market stalls	• % ag survey respondents w/ electricity • Maize & sorghum loss % • % rating road maintenance as "good"	Low (Limited/no data on Gov't Support, input use, land rights)	76.8%	85.8%
DRC	• No data available	• No data available	• No data available	• No data available	N/A	N/A	N/A

[1] Weighted by potential production using GAEZ high-level inputs
[2] Combination of coverage, source reliability and comparability to country-level metrics
Source: Regional census data, local surveys and studies, Lake Partners analysis

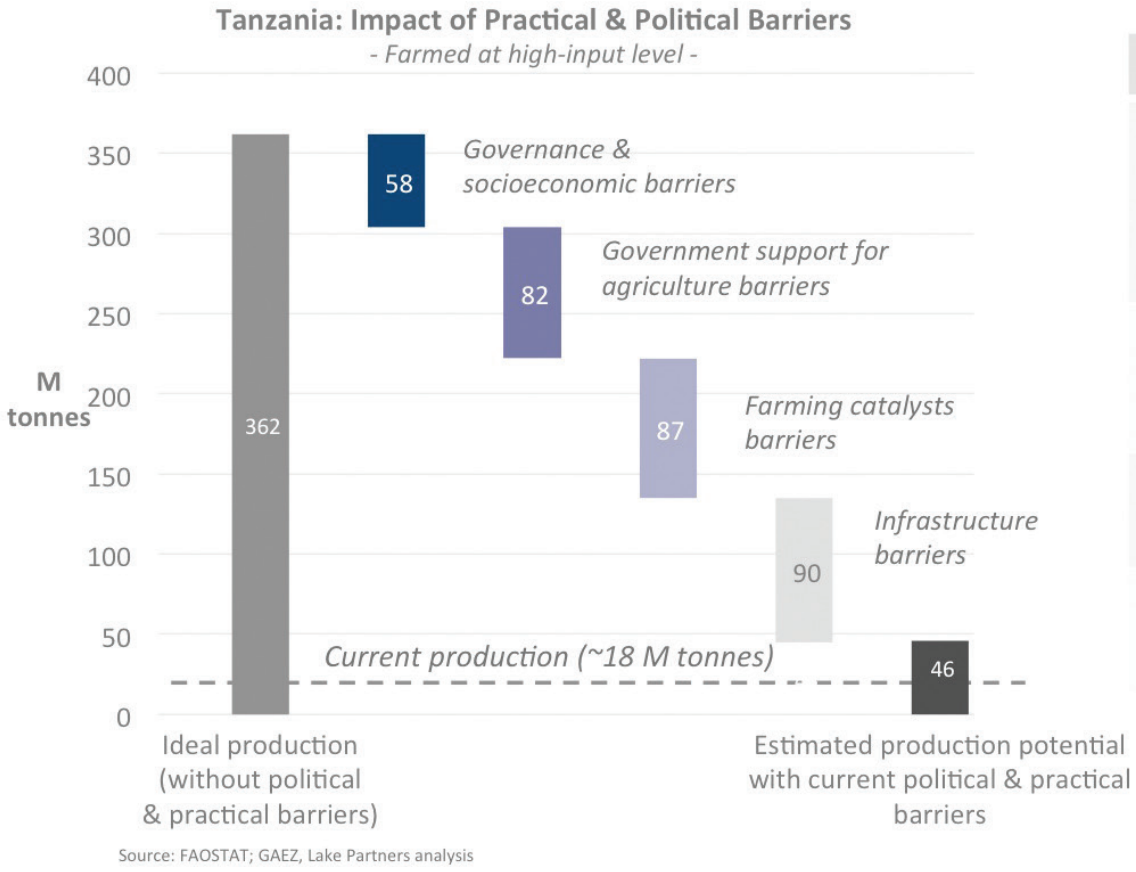
Case Study: Tanzania



Source: Lake Partners analysis

Case Study: Tanzania

Practical and Political Barriers to Production Potential



Source: FAOSTAT; GAEZ, Lake Partners analysis

Barriers	Strengths	Weaknesses
Governance & socioeconomics	CAADP Tanzanian development goals focus on market access and liberalization as well as land and water management	Corruption is widespread and Tanzanians feel it is getting worse
Government support for agriculture	Funded National Agriculture input voucher scheme (NAIVS; e.g. input subsidies)	National Agriculture Research System (NARS) has unpredictable funding
Farming catalysts	Percentage of farmers accessing credit has increased annually	Hand tools are still the farming implements used by most farmers
Infrastructure	Crop storage is encouraged via expanded extension programs	Rural road connectivity and availability of power are low

Government-led market-driven improvements have fueled strong agricultural growth and put Tanzania on a path toward self-sufficiency

Source: Lake Partners analysis

Case Study: Tanzania's "Bread Basket"

Despite structural disadvantages, Mbeya's local focus on credit has helped it outperform neighboring Morogoro

Barrier Categories	Mbeya	Morogoro
Governance & Socioeconomics	*39.2*	*39.2*
Infrastructure	*23.2*	*35.8*
Farming Catalysts	*28.9*	*28.8*
Government Support for Agriculture	*35.7*	*28.6*

Change in area under cultivation (2005-10) [1]	47%	2.8%
Change in avg. yield per acre (2005-10) [1]	9%	(23%)

Morogoro has better roads, closer markets, more tractors and fewer women farmers than Mbeya…

…however Mbeya's government offers better access to extension programs and water councils while more effectively utilizing opportunities to expand credit …

…which has allowed Mbeya to significantly outperform Morogoro in farmland growth and yield

Mbeya's government support for agriculture is major lever on agricultural production growth

[1] Tanzanian Agricultural Survey
Source: Lake Partners Analysis

Case Study: Tanzania Credit and Input Programs

- Credit is more heavily utilized in Mbeya, improving inputs, technology and production growth
  - Mbeya has been successful in using aid from Federal and NGO sources to expand the availability of credit, especially among poor and female farmers
  - Through Mbeya's government-run Rural Financial Services Programme, the number of lending co-ops grew from 11 in 2003[1] to 28 by 2006[2]
  - Officials in Morogoro have struggled to introduce micro-financing schemes for poor, subsidy-reliant smallholders who produce the majority of food

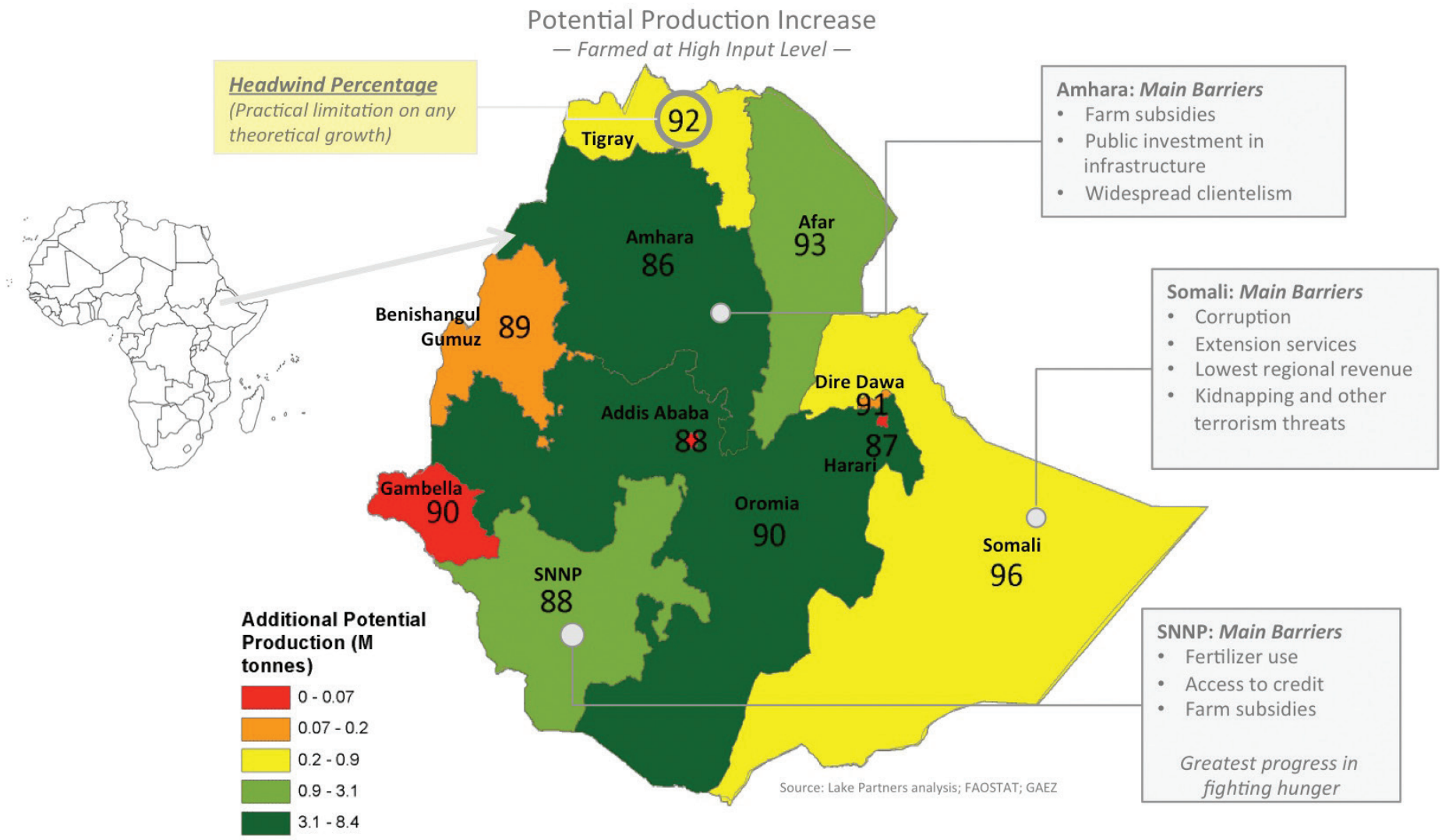
- Pervasive corruption in managing subsidies makes direct credit to farmers relatively more effective as a catalyst to farm production
  - ~It is estimated that 60% of input subsidies are captured by village officials[3], never reaching farmers
  - Mbeya is more aware of corruption than Morogoro, with Morogoro citizens 3.5x more likely to believe that their officials are "not corrupt" (14% vs. 4%)[4]

	Farmers using 2+ lines of credit[5]	Farms using improved seed[5]	Farms using chemical fertilizer[5]	Farms using irrigation[6]	Change in production for all crops, 2005-10 (1,000 tons)[5]
Mbeya	1.1%	25%	35%	10%	1050
Morogoro	0.5%	16%	13%	9%	(313)
Mainland Average	0.7%	24%	13%	7%	N/A

Access to improved inputs has been critical to agricultural improvement but subsidies are less efficient than credit in increasing production

[1] CRDB Bank of Tanzania, Piprek, 2007
[2] Shekilango, 2012, MA Thesis Lund Univ. Sweden
[3] World Bank Report, Pan & Christiaensen
[4] Tanzanian Research Into Use Program, Morogoro Region Report, 2008
[5] Tanzanian Agricultural Survey
[6] Tanzanian Min. of Water Statistics
Source: Lake Partners analysis

Case Study: Ethiopia



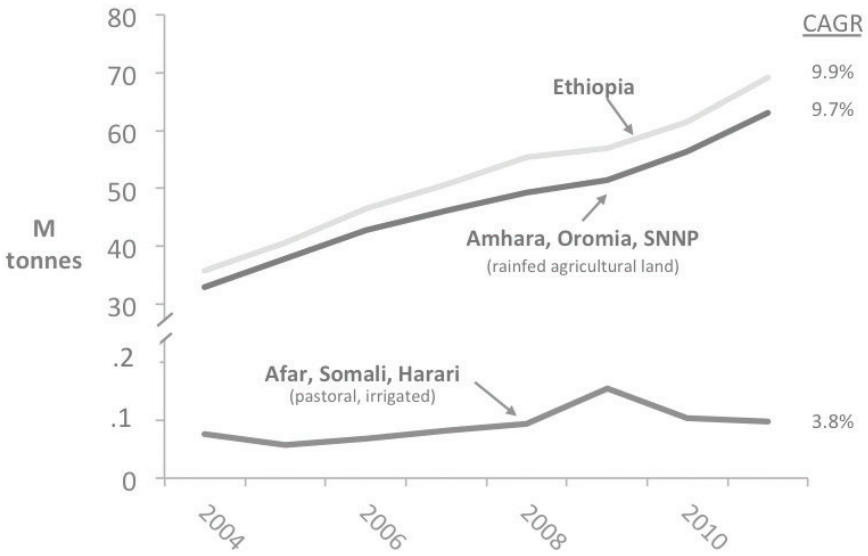
Source: Lake Partners analysis

Case Study: Ethiopia's Strategy For Agriculture

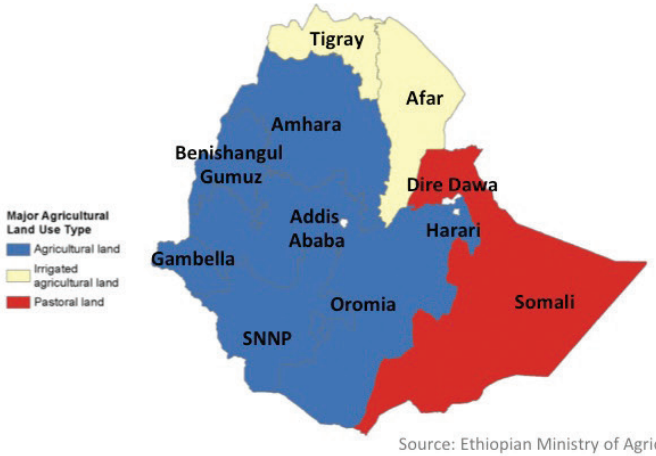
State-directed agriculture is the "long game" for development

- Ethiopia has a highly planned food production sector
  - Agriculture development is focused in areas with sufficient rainfall, while pastoral activities are focused in arid and water-stressed areas
  - A controversial program to relocate villages within the Gambella region and other fertile areas is underway
  - Large-scale farming has been encouraged with contentious land lease programs that may displace small landholders
- Development is targeted to highest-impact regions
  - Semi-arid areas have been targeted for irrigation
  - Fertilizer and advanced inputs are encouraged in areas with long growing seasons and damaged soils
  - Road improvements are focused on poorly connected rural areas
  - Electrification is targeted at unconnected rural areas

Resources within the agricultural sector are targeted at the regional, district and village level to maximize production and meet other national goals



Source: FAOSTAT 2012; Ethiopian Min. of Agriculture

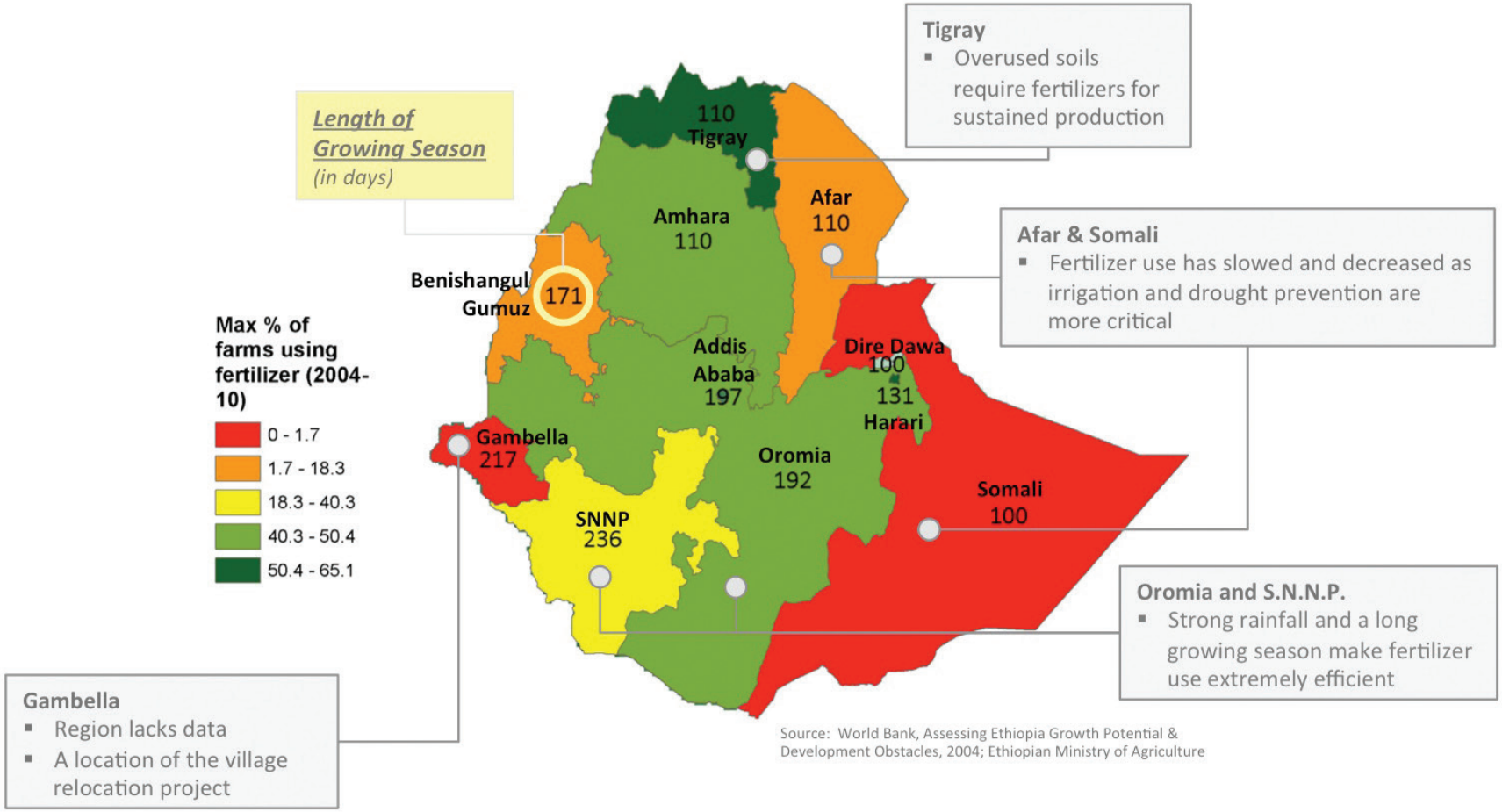


Source: Ethiopian Ministry of Agriculture

Source: Lake Partners analysis

Case Study: Ethiopia's Improved Inputs

Increased fertilizer use has been targeted where it will be of most use



Source: World Bank, Assessing Ethiopia Growth Potential & Development Obstacles, 2004; Ethiopian Ministry of Agriculture

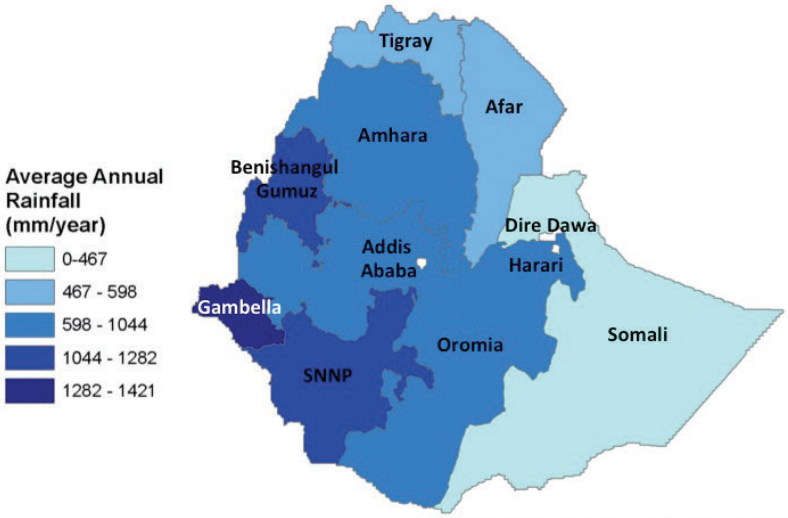
Fertilizer and other inputs are generally underutilized but efforts to direct greater use in areas of greatest return are underway

Source: Lake Partners analysis

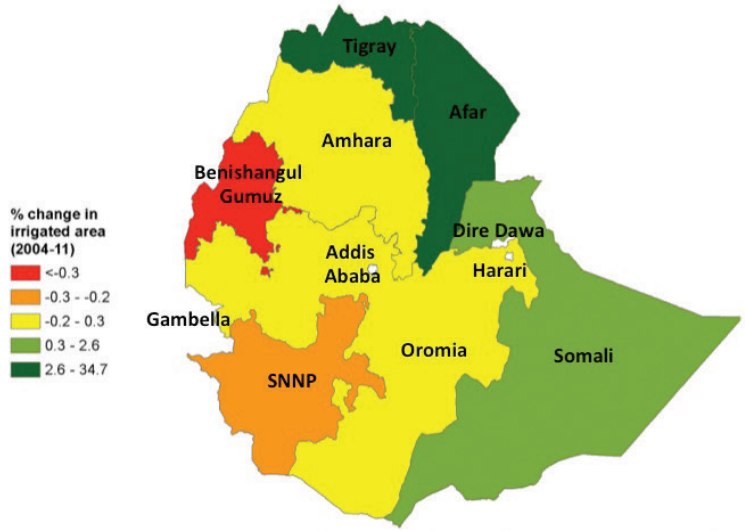
Case Study: Ethiopia Water and Land Use

Semi-arid areas are targeted for irrigation and more arid areas set aside for livestock production

- Ethiopia seeks to limit the impact of droughts through prioritization of water resources
  - In the semi-arid northern regions, irrigation and drought resilient farming techniques/technologies have been the focus of government investment
  - The government has supported shifting agriculture from the most drought-prone areas to similar eco-zones
- Rangeland has been isolated due to limited water resources for other agricultural production
  - Somali region has been primarily set aside for additional grazing land because it is prone to water shortages
  - Water resources in Somali are preferentially set aside for pastoral use rather than agriculture



Source: Ethiopian Central Statistical Agency 2011



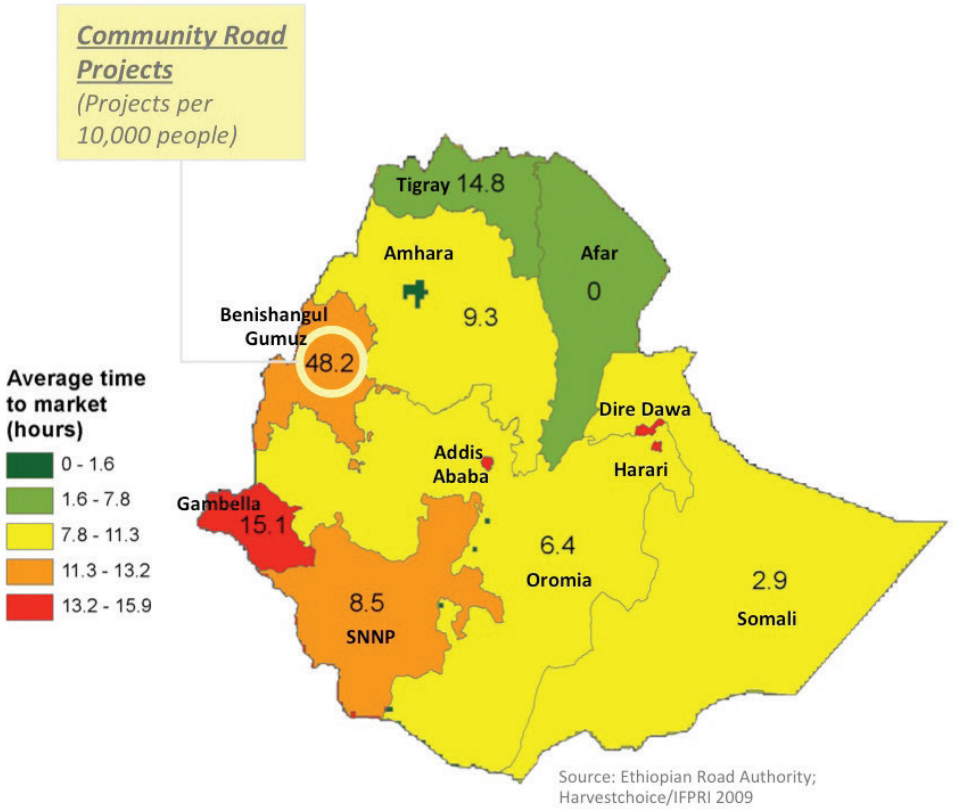
Source: Ethiopian Central Statistical Agency, Lake Partners analysis

Government policy seeks to minimize the impact of drought through water and land resource management

Source: Lake Partners analysis

Case Study: Ethiopia Rural Roads

Few to no rural roads led to broad and aggressive investment in the transportation sector



- Ethiopia has been aggressive in building its road infrastructure for decades
  - Infrastructure investments prior to 2000 focused primarily on trunk routes and regional connectivity
  - Numerous and spread out villages lacked connections to main highways (e.g. "last mile" problem)
  - From 1997 to 2010 the average distance to an all-weather road has been cut in half, while the percentage of asphalt roads in good condition has increased from 17% to 70%[1].
- Universal Rural Roads Access Project (URRAP) aims to improve market access through improvement of feeder roads
  - The goal of the project is to increase road accessibility from <30% to 80% nationwide [1], focusing on agriculturally significant areas and regions with poor market access
  - Success has been mixed as some regions slated for improvement have had difficulty finding consultants and contractors for all approved projects
  - Ethiopia's Rural Access Index Score increased from 17% to 32% from 2002 to 2004[2]

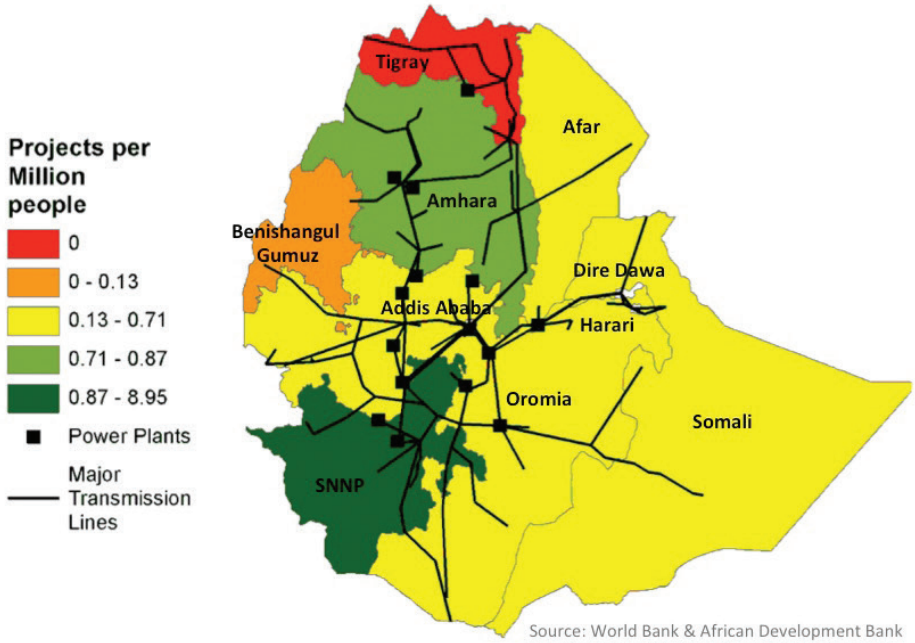
Critical yet uneven progress has been made in increasing rural transportation connectivity

[1] Ethiopian Road Authority
[2] World Bank Transport Sector Board
Source: Lake Partners analysis

Case Study: Ethiopia Electrification

Investments in electrification are targeted beyond agriculture

- Ethiopia seeks to be a regional energy leader through investment in expanding its grid
  - Government goal is to become a regional exporter of power due to the country's large hydropower potential
  - However, Ethiopia currently loses 21% of power during distribution, and low power usage has hindered necessary maintenance
  - Rural population has had little access to power despite spending on hydroelectric power plants
- Agriculture will see some benefit from expansion of rural electricity
  - Ethiopia is targeting increased production potential: more efficient irrigation systems to allow for bigger farms, greater reach of extension services with multimedia, and greater mechanized farming
  - Additional benefits are closer food processing facilities (e.g., grinding mills) and refrigeration for perishable crops
  - Local studies find that rural firms in electrified villages are 40% more productive[1]

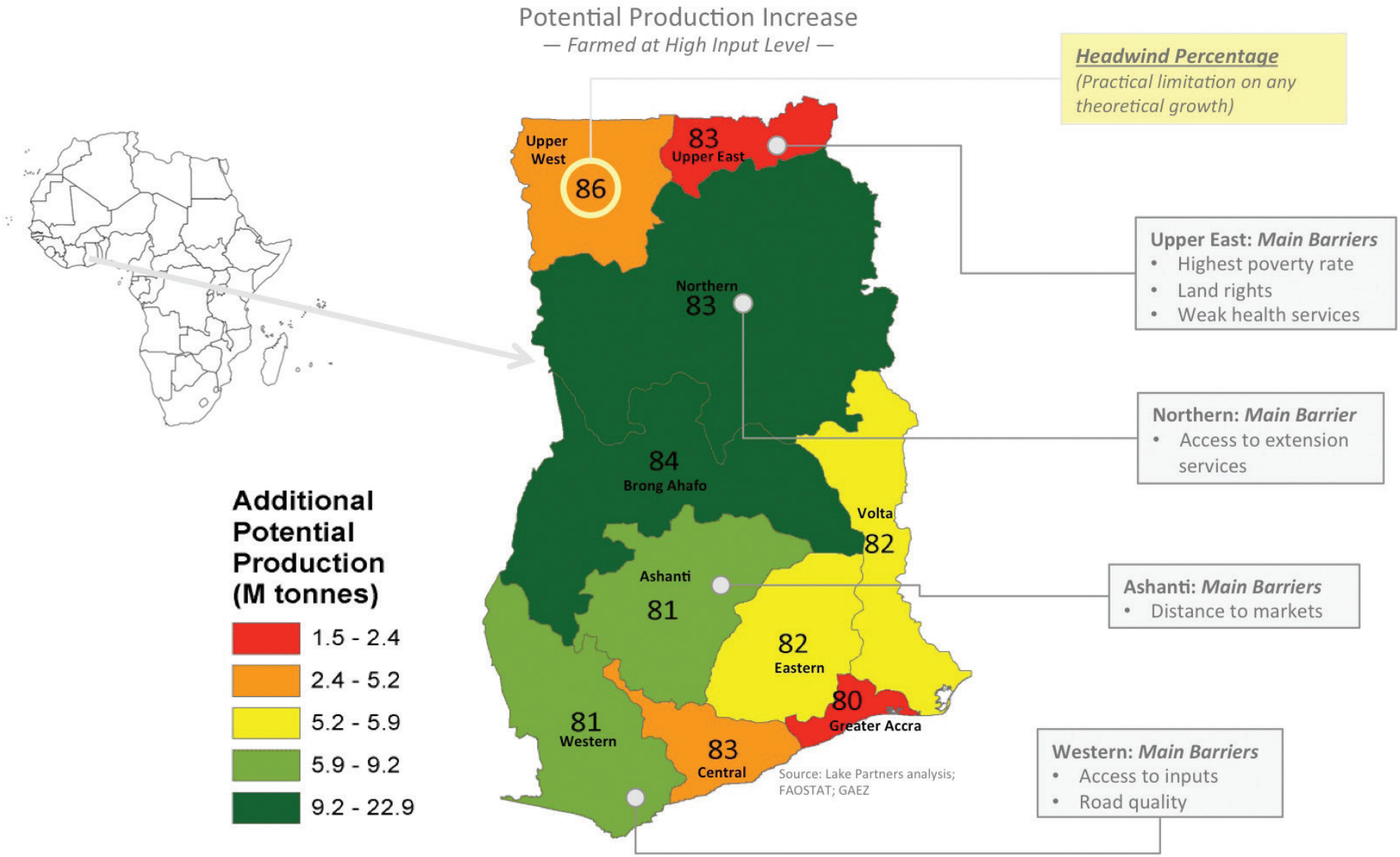


Source: World Bank & African Development Bank Infrastructure Project Reporting; AICD database

Rural access to power lags behind other development indicators and requires targeted investment in extremely underserved and widely dispersed rural areas

[1] Ayele et al. 2009
Source: Lake Partners analysis

Case Study: Ghana

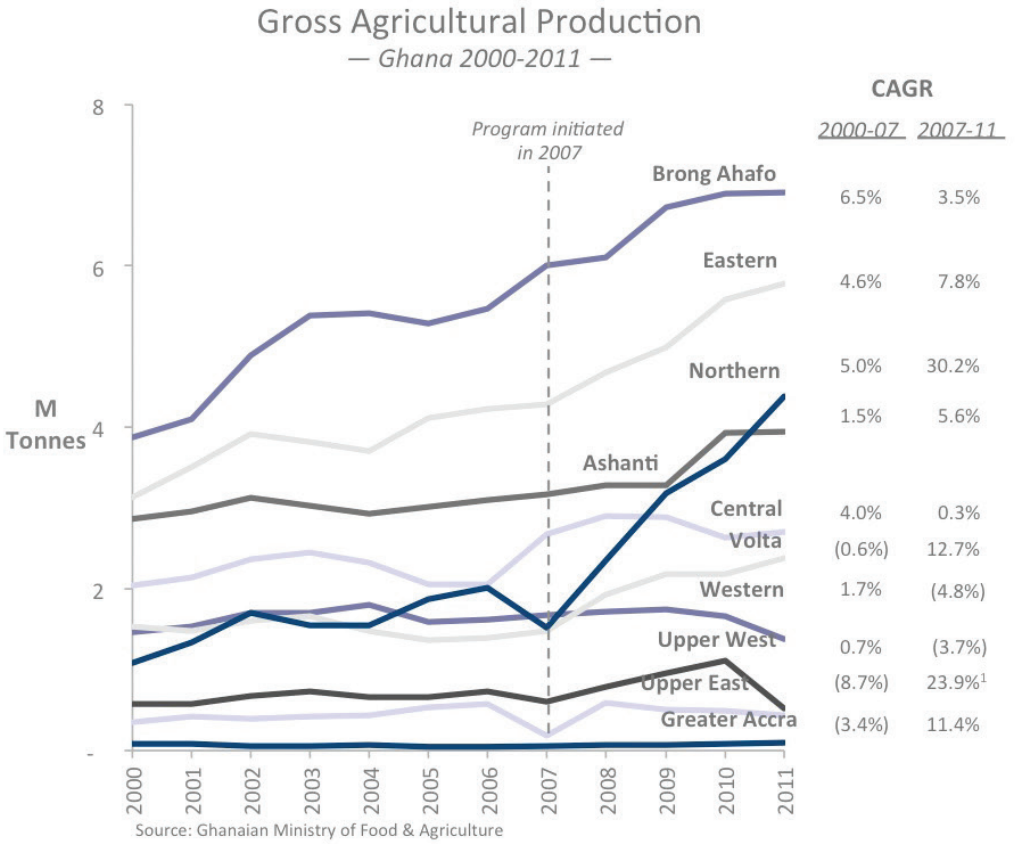


Source: Lake Partners analysis

Case Study: Ghana Production Increases

Ghana's market-based agricultural initiatives have exacerbated economic disparities

- In 2007, Ghana launched an agriculture program to improve output
  - Promoted land expansion via credit availability
  - Added emphasis on high-value cash crops
  - Focused on large industrial farms
  - Some infrastructure improvements, but not a priority
- Output growth accelerated, but unevenly
  - Regions with higher income and larger farms (e.g. Northern, Eastern, Central) saw huge gains, almost entirely from land expansion
  - Poorer areas (e.g. Upper West, Upper East) saw little benefit as farmers didn't have collateral for credit and market access for cash crops



Source: Ghanaian Ministry of Food & Agriculture

Ghana is a story of the rich getting richer and the poor getting poorer

[1] Upper East growth skewed by 2007 drought and subsequent recovery; for comparison 2000-06 CAGR was 8.6% while 2006-11 CAGR was (5.3%)

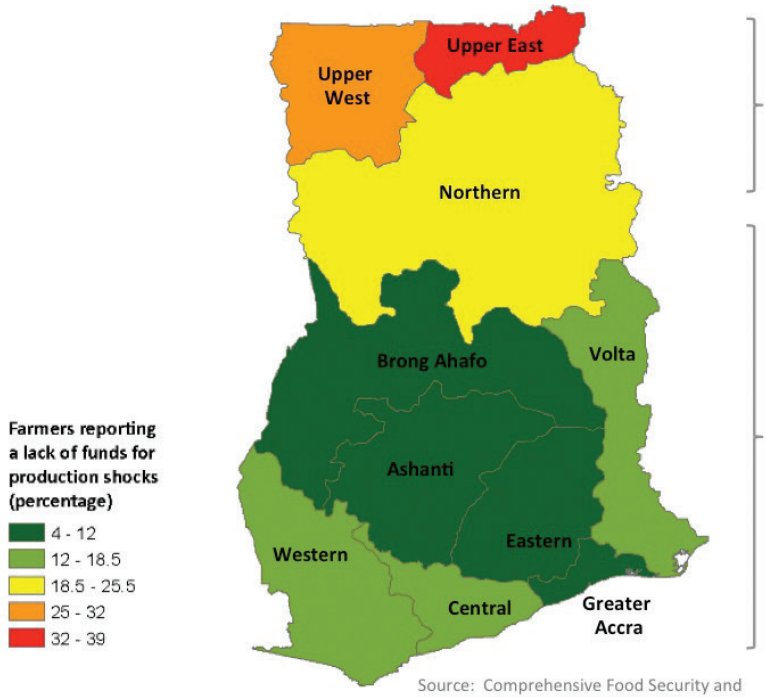
Source: Lake Partners analysis

Case Study: Ghana Credit Programs

Poverty & land ownership customs in the far north have stifled credit programs

Availability of Funds for Production Shocks

– Proxy for Credit Access –



Historically poor, and land is either government-owned or communally owned, restricting use of land as collateral for credit

Mineral wealth historically was used to fund large private landowners, allowing credit for large commercial farms

Source: Comprehensive Food Security and Vulnerability Analysis (CFSVA) 2009

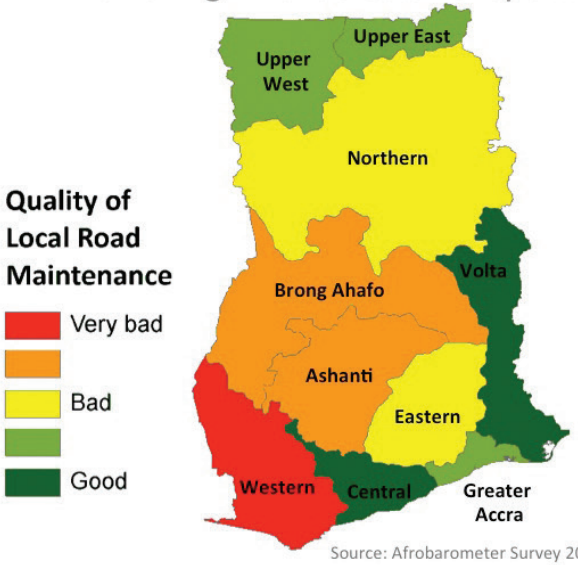
Credit programs have struggled where private land tenure is uneven

Source: Lake Partners analysis

Case Study: Ghana Market Access

Access to markets is crippling for northern Ghana

Despite reasonably good roads and high-value cash crops…

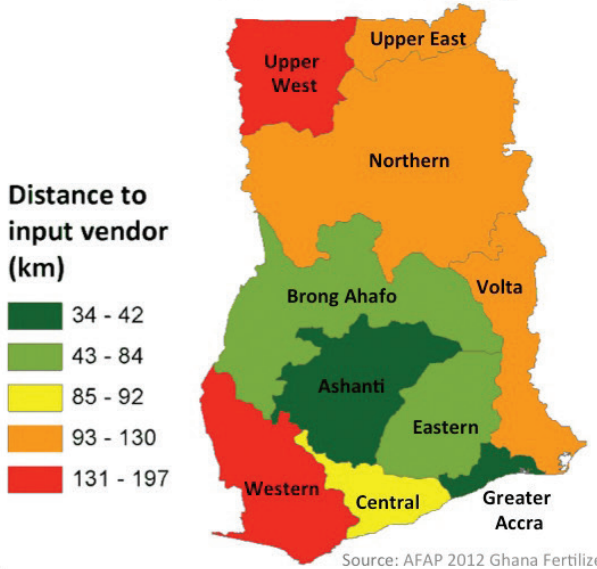


Source: Afrobarometer Survey 2012

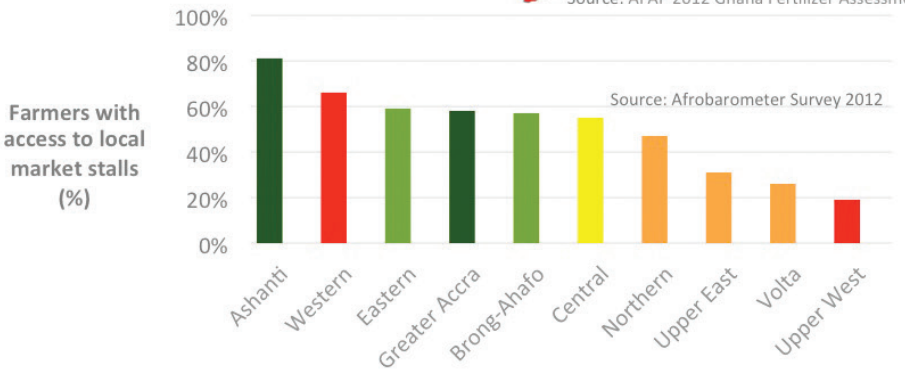
Top Crops, 2010 Price (GH¢/mt) & Percentage of Production (tonnes)	
Upper East	Rice (1041) – 25% & Maize (487) – 17%
Upper West	Groundnut (1529) – 31%, Cowpea (~1000) – 16%
Northern	Yam (508) – 45%, Cassava (224) – 30%
Brong-Ahafo	Cassava (224) – 41%, Yam (508) – 31%
Volta	Cassava (224) – 70%, Yam (508) – 17%
Ashanti	Cassava (224) – 48%, Plantain (554) – 25%
Eastern	Cassava (224) – 63%, Plantain (554) – 14%
Western	Cassava (224) – 40% , Plantain (554) – 37%
Greater Accra	Cassava (224) – 75%, Rice (1041) – 20%
Central	Cassava (224) – 81% , Maize (487) – 8%

Source: Ghanaian Ministry of Food & Agriculture

…distance to markets limits economic viability



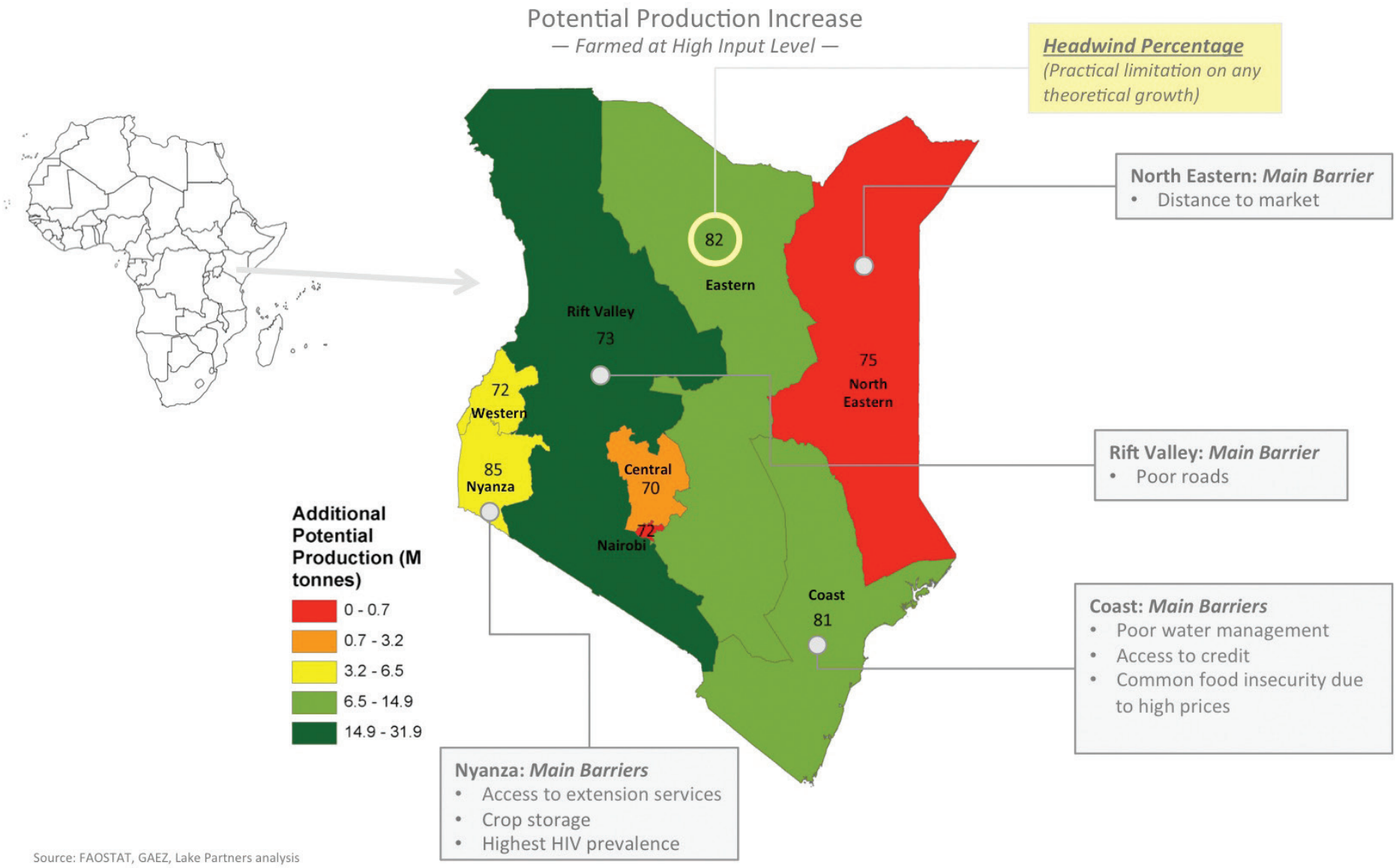
Source: AFAP 2012 Ghana Fertilizer Assessment



Despite manageable practical & political barriers, Ghana's north suffers poverty & food insecurity

Source: Lake Partners analysis

Case Study: Kenya

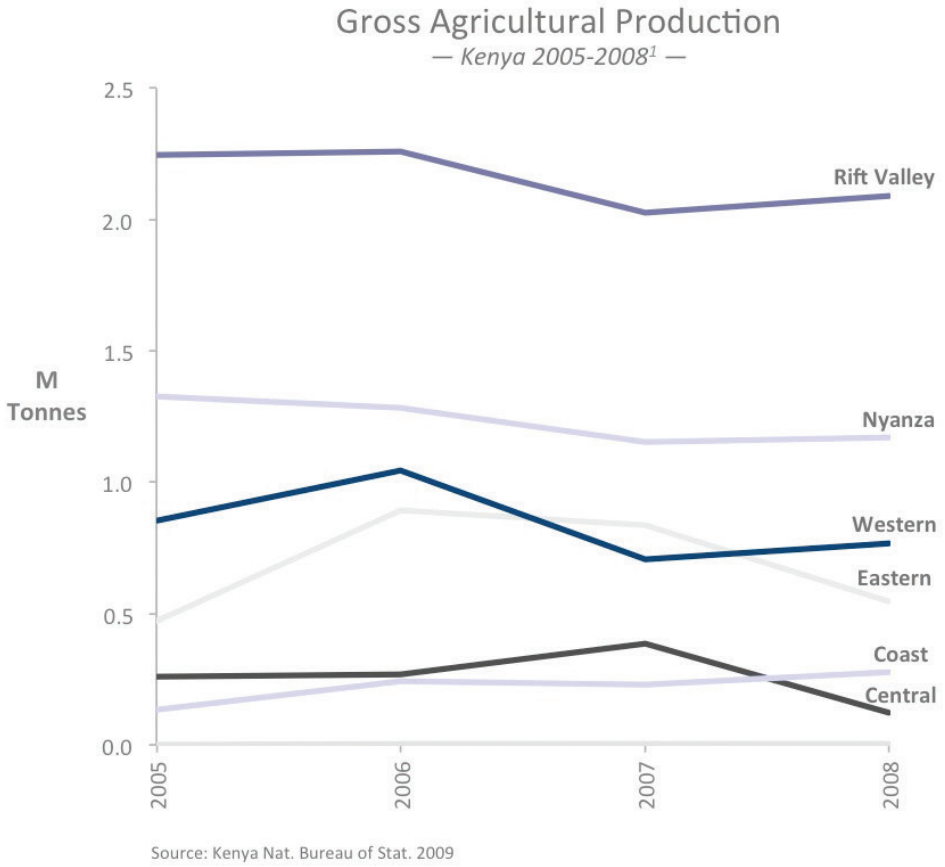


Source: FAOSTAT, GAEZ, Lake Partners analysis

Case Study: Kenya Agricultural Strategy

Kenyan agricultural production saw little improvement despite lofty plans for increases

- Kenya went big
  - The Strategy for Revitalizing Agriculture (SRA) was adopted in 2004
  - Focus was on large scale projects like irrigation dams, feeder roads, research & extension projects
  - SRA relied on local implementation and private market inputs/outputs
- Poor implementation led to few improvements
  - Focus on broad goals over specific policies (e.g. "irrigation and roads" vs. water management and market access plans) prevented most investment from taking root
  - In areas where focus was targeted (e.g. extension programs), lack of qualified personnel and gross mismanagement prevented gains



Source: Kenya Nat. Bureau of Stat. 2009

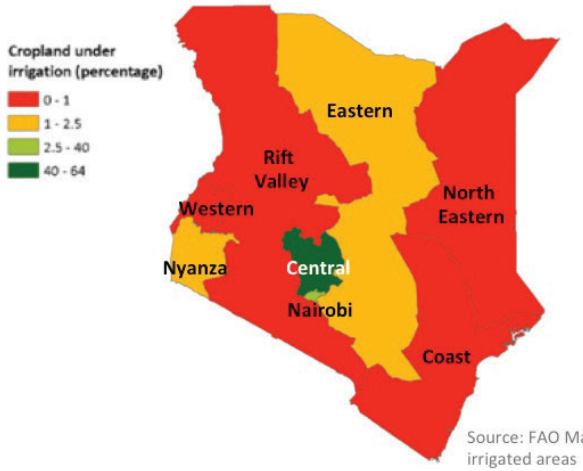
By 2008, Kenya admitted failure and re-centralized the program

[1] Production in Nairobi and North Eastern provinces was negligible (<.003 and <.001 metric tonnes respectively in 2008)
Source: Lake Partners analysis

Case Study: Kenya Water Management

Despite massive investment, water policy is still lacking

Despite huge investments in water infrastructure, little of the country benefits from better irrigation…



Source: FAO Map of irrigated areas

…in large part because water policy has been grossly mismanaged

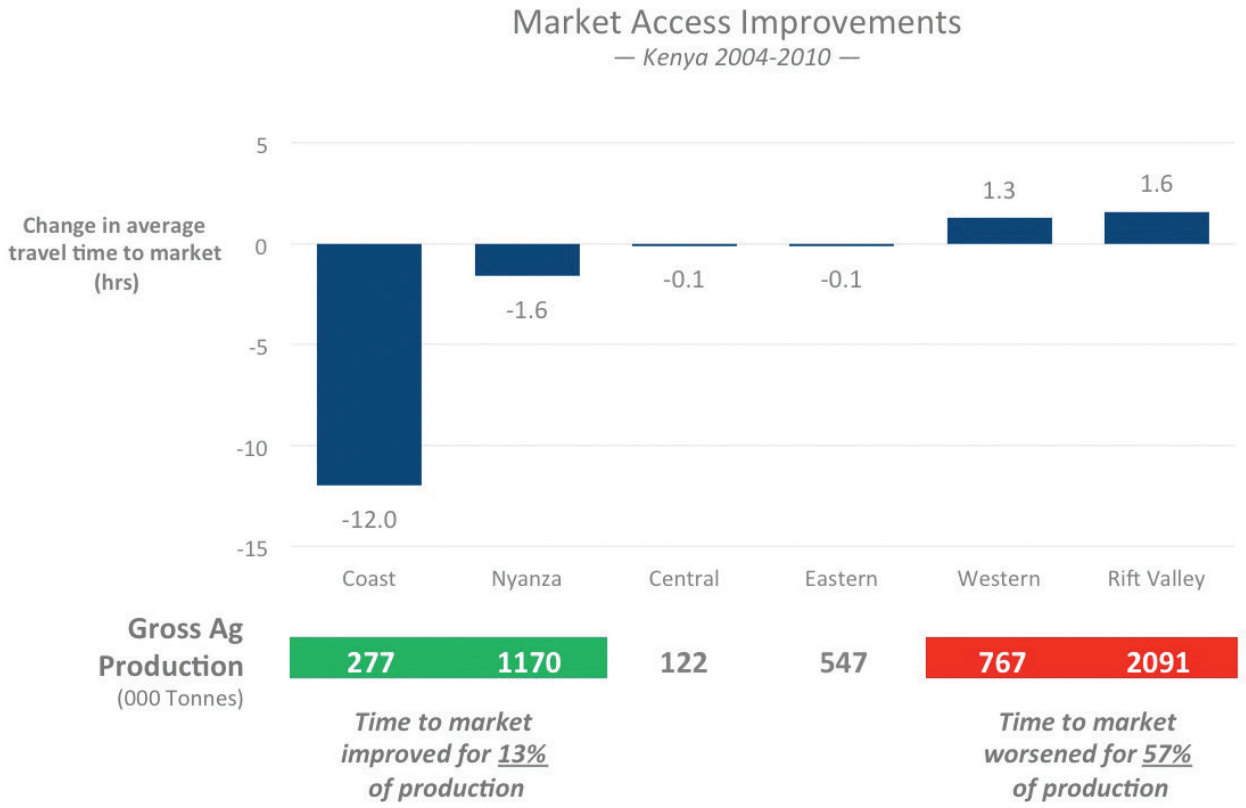
- Ongoing maintenance costs and unpredictable water rationing make irrigation a tough sell in traditionally pastoral systems
  - *"[Investments in large scale irrigation] fail to recognize the investments in developing, and then maintaining, the highly capital-intensive inputs that irrigation requires is extremely expensive, especially for food production."* – International Institute for Environment and Development[1]
  - *"60% of water tankering was also conducted [before the crisis period of the 2008/2009 drought], which is surprising given that this might be considered more of an emergency response."*[2]
- Water reserves are not managed sufficiently for frequent droughts
  - *"According to the inventory, very few water resource assessments were carried out which suggests that adequate preparedness for drought emergency water supply may not have been appropriately undertaken"*[2]
  - 80% of district development directors conceded that monitoring and compliance of local authorities and their projects were weak[3]
- Even the recent discovery of a vast aquifer in Northwest Kenya is met with realism and skepticism
  - *"Abou Amani, Unesco's Africa hydrologist, urged caution and said it was important not to 'overexploit' the aquifers. 'We need to put in place a sound management system,' he said."* [4]
  - *The head of the NGO Friends of Lake Turkana…said…'It is critical for governments to realise they don't… come up with programmes without community ownership… and linking it to economic development'"*[4]

[1] http://reliefweb.int/report/kenya/irrigation-scheme-locks-horns-kenyas-pastoralists
[2] http://eeas.europa.eu/delegations/kenya/documents/more_info/assessment_of_the_response_2008_en.pdf 4.6.1
[3] Harmonization of Decentralized Development In Kenya – KRHC & SPAN 12/2010
[4] BBC - http://www.bbc.co.uk/news/science-environment-24049800
Source: FAO Map of irrigated areas, Afrobarometer survey 2012, Lake Partners analysis

Case Study: Kenya Infrastructure Investment

Kenya's focus on new feeder roads over road maintenance produced mixed results

Kenya spent 8% of its national budget ($120B[1]) on road construction from 2004-2010…with little benefit to agriculture



Source: Sheahan et al. 2013 Agricultural & Applied Economics Association Presentation; Kenya Nat. Bureau of Statistics

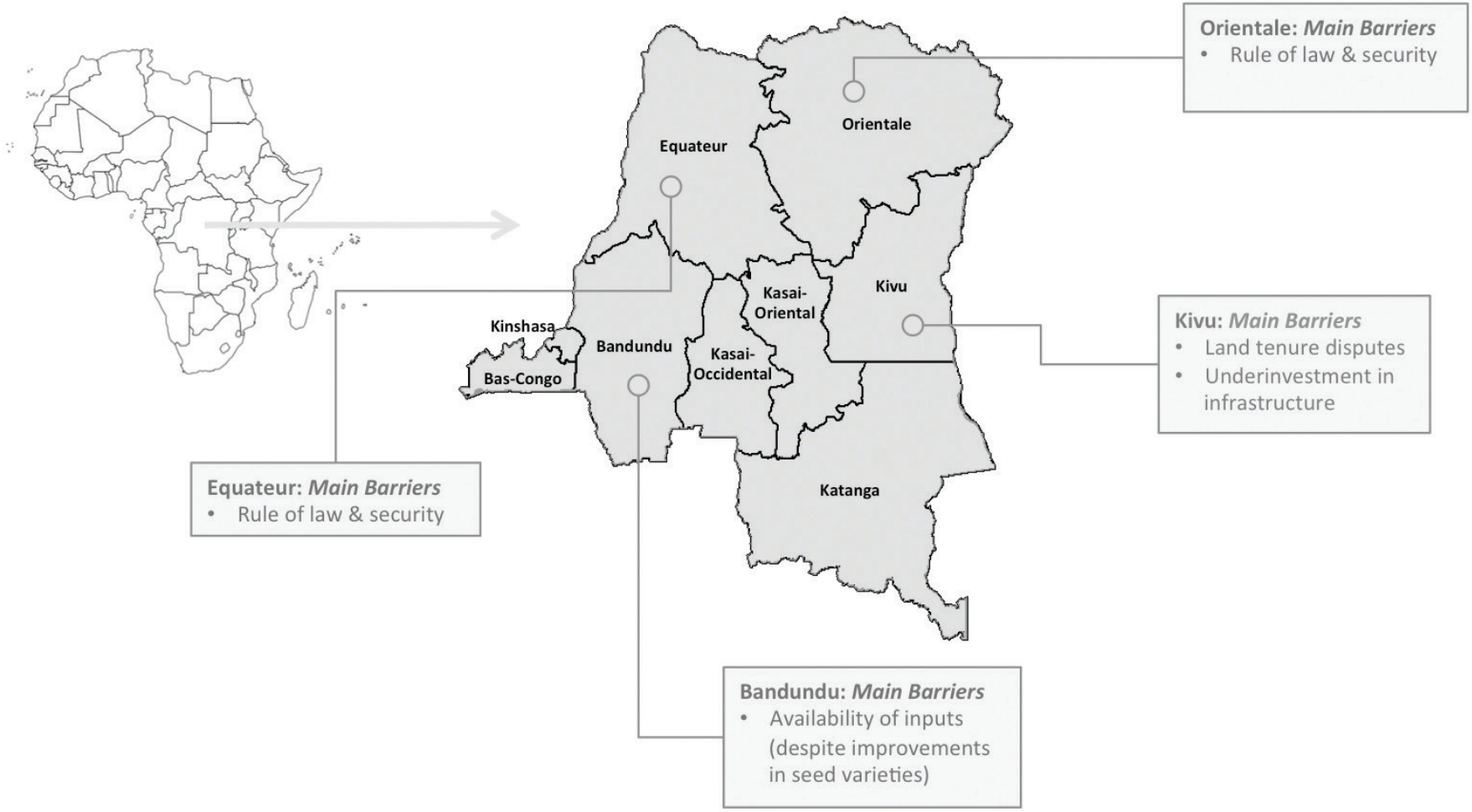
[1] 60B KSh adjusted for 2008 PPP; Kenya Nat. Bureau of Statistics
Source: Lake Partners analysis

Case Study: DRC

Government dysfunction and lawlessness hamper progress

Potential Production Increase

— INSUFFICIENT REGIONAL DATA AVAILABLE—



Source: BTI Report 2012, IMF Poverty Reduction Progress Report 2010, IFPRI Discussion Paper #01066 2011, Lake Partners analysis

Case Study: DRC Outreach

DRC's agricultural efforts are in the broader context of local stability

- There are claims that the government of the DRC is spending money on agricultural outreach, but little is verifiable
  - Focus on rural councils for stability and extension services for agriculture
- History of privatization with mineral companies does not appear to be a sustainable model for agriculture
  - 50% of infrastructure is in need of rehabilitation, with no indication that agriculture is a priority
  - The resulting limited market access has led to highly segmented, opaque agriculture markets *"…Farmers have great difficulty in selling any surplus, while food prices in urban centers are high. Interregional connections are often limited to minimal air transport; as a result the country has essentially broken down into a set of economic enclaves"*[1]
- It appears that the primary traction is from NGOs
  - E.g., improved seed programs for orphan crops
  - E.g., mediation of local and farmland disputes

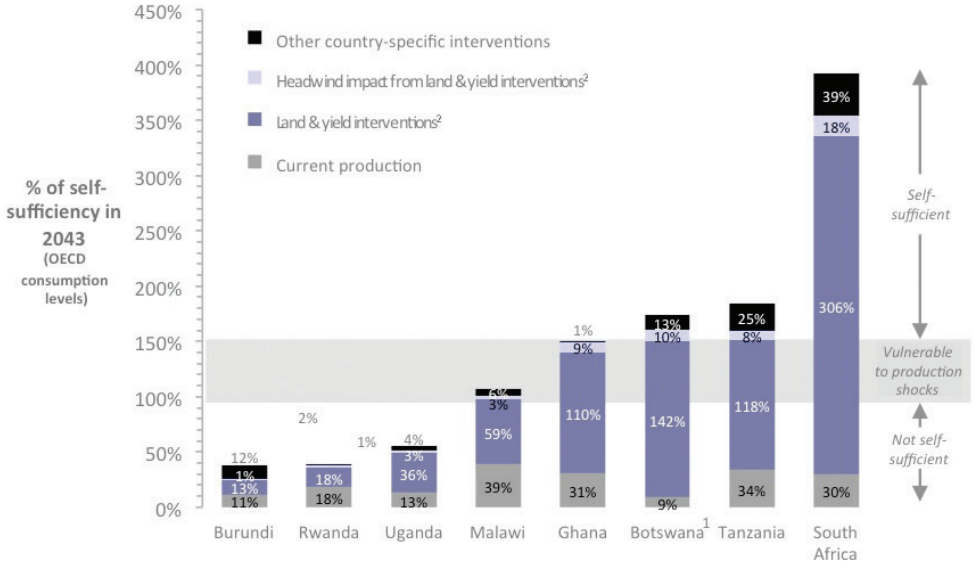
[1] World Bank 2010, Diagnostic Trade Integration Study, Kinshasa: Democratic Republic of Congo, Ministry of Trade, Small and Medium-sized Enterprises p94
Source: AICD DRC Infrastructure Report 2010, IFPRI Discussion Paper #01066 2011, Lake Partners analysis

ECONOMICS OF SELECT INTERVENTIONS

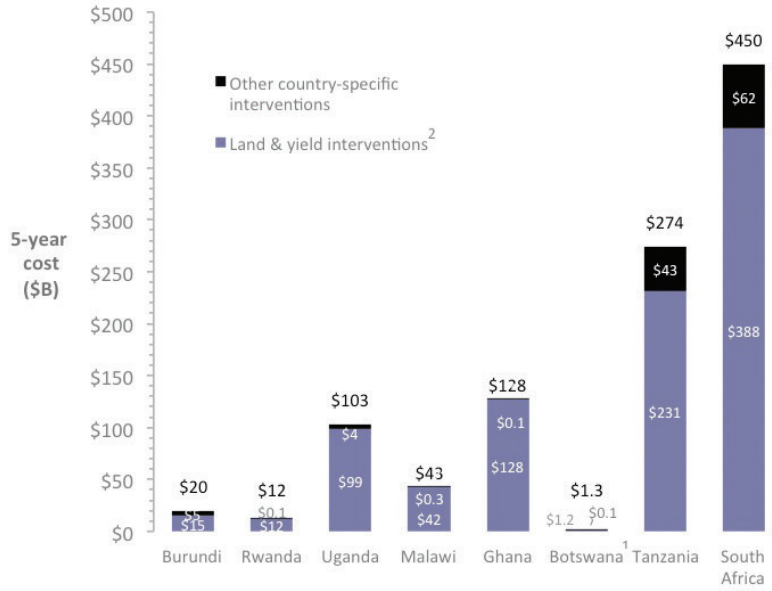
Cost of Self-Sufficiency

For most countries, reaching self-sufficiency in 2043 requires billions of dollars in investment

Impact on self-sufficiency



Estimated Program costs



Production increases from land & yield interventions have a huge impact, but reducing practical & political barriers is critical for self-sufficiency

[1]Excludes bringing additional farmland online due to very high costs
[2]Includes bringing additional farmland online, optimal crop choice, improved farming (with conservation ag) and improved grain storage
Source: FAOSTAT, Lake Partners analysis

Impact on Production

The multiplicative effect of combined interventions is large

Botswana

	Production (maize-equivalent tonnes)
Current Production:	92K
Additional land	147K
Optimal crop choice	275K
Improved farming	920K
Grain storage	16K
Trade barriers	1K
Water management	1K
Time to start a business	0.1K
Multiplicative effect	6,223K
Potential Production	**7,584K**
Self-Sufficiency (Current Levels)	**805K**
Self-Sufficiency (OECD levels)	**1,045K**

Burundi

	Production (maize-equivalent tonnes)
Current Production:	1,696K
Additional land	227K
Optimal crop choice	159K
Improved farming	584K
Grain storage	323K
Market access	88K
Trade barriers	21K
Multiplicative effect	2,642K
Potential Production	**5,739K**
Self-Sufficiency (Current Levels)	**9,670K**
Self-Sufficiency (OECD levels)	**15.051K**

Ghana

	Production (maize-equivalent tonnes)
Current Production:	13,036K
Additional land	7,449K
Optimal crop choice	2,267K
Improved farming	9.049K
Grain storage	2,433K
Market access	37K
Multiplicative effect	38,584K
Potential Production	**63,815K**
Self-Sufficiency (Current Levels)	**42,398K**
Self-Sufficiency (OECD levels)	**42,398K**

Malawi

	Production (maize-equivalent tonnes)
Current Production:	6,875K
Additional land	1,646K
Optimal crop choice	987K
Improved farming	3,730K
Grain storage	1,157K
Soil Erosion	25K
Resilience to drought	60K
Women farmers	42K
Multiplicative effect	4,420K
Potential Production	**18,942K**
Self-Sufficiency (Current Levels)	**16,345K**
Self-Sufficiency (OECD levels)	**17,716K**

Rwanda

	Production (maize-equivalent tonnes)
Current Production:	2,898K
Additional land	602K
Optimal crop choice	437K
Improved farming	829K
Grain storage	596K
Commodity reserves	3K
Water management	39K
Multiplicative effect	893K
Potential Production	**6,297K**
Self-Sufficiency (Current Levels)	**14.047K**
Self-Sufficiency (OECD levels)	**16.061K**

South Africa

	Production (maize-equivalent tonnes)
Current Production:	14,132K
Additional land	60,364K
Optimal crop choice	18,653K
Improved farming	17,436K
Grain storage	2,280K
Road condition	329K
Cultural heterogeneity	80K
Water resources	77K
Multiplicative effect	72,308K
Potential Production	**185,659K**
Self-Sufficiency (Current Levels)	**47,287K**
Self-Sufficiency (OECD levels)	**47,287K**

Tanzania

	Production (maize-equivalent tonnes)
Current Production:	14,985K
Additional land	8,887K
Optimal crop choice	4,322K
Improved farming	14,704K
Grain storage	2,781K
Access to capital	88K
Rural electrification	182K
Research & education	258K
Multiplicative effect	36,186K
Potential Production	**82,393K**
Self-Sufficiency (Current Levels)	**36.805K**
Self-Sufficiency (OECD levels)	**44,593K**

Uganda

	Production (maize-equivalent tonnes)
Current Production:	8,331K
Additional land	3,371K
Optimal crop choice	1,843K
Improved farming	5,477K
Grain storage	1,920K
Market access	45K
Farmers co-ops	45K
Cellphones	16K
Multiplicative effect	14,982K
Potential Production	**36,030K**
Self-Sufficiency (Current Levels)	**56,133K**
Self-Sufficiency (OECD levels)	**65,013K**

Source: Lake Partners analysis

Impact on Headwinds

Interventions that effectively improve production also have the greatest impact on reducing headwinds

Botswana

Current Headwind:	75%
▪ *Additional land*	(0.6%)
▪ *Optimal crop storage*	(0.3%)
▪ *Improved farming*	(3.3%)
▪ *Grain storage*	(3.1%)
▪ *Trade barriers*	(1.4%)
▪ *Resilience to drought*	(1.1%)
▪ *Time to start a business*	(0.2%)
Potential Headwind	**65%**
Add'l Production from 1% Improvement[1]	**1K**

Burundi

Current Headwind:	96%
▪ *Additional land*	(0.4%)
▪ *Optimal crop storage*	(0.2%)
▪ *Improved farming*	(3.5%)
▪ *Grain storage*	(3.7%)
▪ *Market access*	(4.6%)
▪ *Trade barriers*	(1.7%)
Potential Headwind	**82%**
Add'l Production from 1% Improvement[1]	**17K**

Ghana

Current Headwind:	79%
▪ *Additional land*	(0.3%)
▪ *Optimal crop storage*	(0.0%)
▪ *Improved farming*	(2.7%)
▪ *Grain storage*	(4.3%)
▪ *Market access*	(0.3%)
Potential Headwind	**72%**
Add'l Production from 1% Improvement[1]	**111K**

Malawi

Current Headwind:	83%
▪ *Additional land*	(0.3%)
▪ *Optimal crop storage*	(0.1%)
▪ *Improved farming*	(3.1%)
▪ *Grain storage*	(1.5%)
▪ *Soil erosion*	(0.4%)
▪ *Resilience to drought*	(1.0%)
▪ *Women farmers*	(0.7%)
Potential Headwind	**76%**
Add'l Production from 1% Improvement[1]	**59K**

Rwanda

Current Headwind:	87%
▪ *Additional land*	(0.3%)
▪ *Optimal crop storage*	(0.0%)
▪ *Improved farming*	(3.1%)
▪ *Grain storage*	(4.1%)
▪ *Commodity reserves*	(0.1%)
▪ *Water resources*	(1.5%)
Potential Headwind	**78%**
Add'l Production from 1% Improvement[1]	**25K**

South Africa

Current Headwind:	72%
▪ *Additional land*	(0.5%)
▪ *Optimal crop storage*	(0.5%)
▪ *Improved farming*	(3.5%)
▪ *Grain storage*	(1.2%)
▪ *Road condition*	(2.6%)
▪ *Cultural heterogeneity*	(0.7%)
▪ *Water resources*	(0.7%)
Potential Headwind	**63%**
Add'l Production from 1% Improvement[1]	**119K**

Tanzania

Current Headwind:	87%
▪ *Additional land*	(0.2%)
▪ *Optimal crop storage*	(0.0%)
▪ *Improved farming*	(3.9%)
▪ *Grain storage*	(2.5%)
▪ *Access to credit*	(0.7%)
▪ *Rural electricity*	(1.4%)
▪ *Research & education*	(1.9%)
Potential Headwind	**77%**
Add'l Production from 1% Improvement[1]	**131K**

Uganda

Current Headwind:	92%
▪ *Additional land*	(0.2%)
▪ *Optimal crop storage*	(0.0%)
▪ *Improved farming*	(2.4%)
▪ *Grain storage*	(4.0%)
▪ *Market access*	(0.6%)
▪ *Farmers co-ops*	(0.6%)
▪ *Cell phones*	(0.2%)
Potential Headwind	**84%**
Add'l Production from 1% Improvement[1]	**76K**

[1]Maize equivalent tonnes, based on today's yields
Source: Lake Partners analysis

Highest Impact, Highest Return Interventions

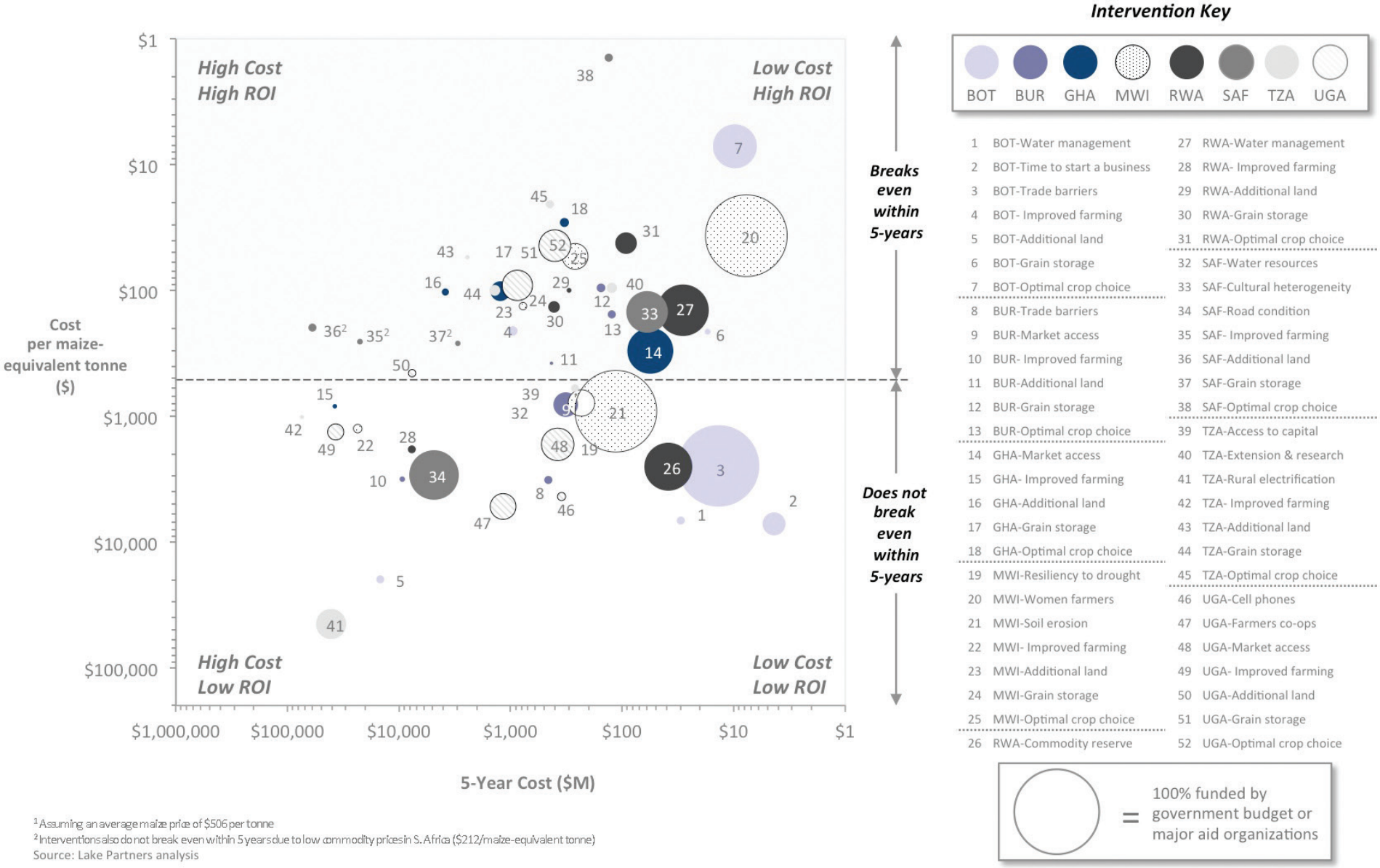
- In general, the highest-production and highest-ROI interventions are bringing unfarmed land into production, optimal crop choice and grain storage, while improved farming takes longer to pay back
  - An exception is Botswana where moving to improved farming techniques pays off more quickly due to less available farmland
  - Bringing additional land into production breaks even in five years or less except in Botswana, where lucrative cattle ranching makes farming a tougher sell
  - Optimal crop choice has low-medium confidence because it is based on 10,000 Ha GIS mapping, not on-the-ground experience
- If it's important to demonstrate the power of reducing country-specific headwinds, then there are several high priority candidates
  - Increasing the effectiveness of women farmers in Malawi ($8M) has a high ROI at low cost
  - Water resource management improvements in Rwanda ($28M) are much needed to protect future resources
  - Market access improvement in Ghana ($56M) builds facilities for selling/processing, trains local officials and builds feeder roads
  - Addressing South African cultural heterogeneity by increasing farmer group participation ($60M) improves access to services for underserved minority groups
- Having developed and well-funded government plans brings other programs to the top
  - Malawi is dedicated to improving its soil health by reducing degradation and nutrient runoff ($114M)
  - Botswana has a well-formed plan to reduce trade barriers by training officials and making policy improvements ($14M)
  - Rwanda has prioritized improving its commodity reserve program by beginning the installation of several strategic grain silos ($39M)

While the cost for most programs is in the billions, nearly all are scalable to the district (or equivalent) level

Source: Lake Partners analysis

Return on Investment

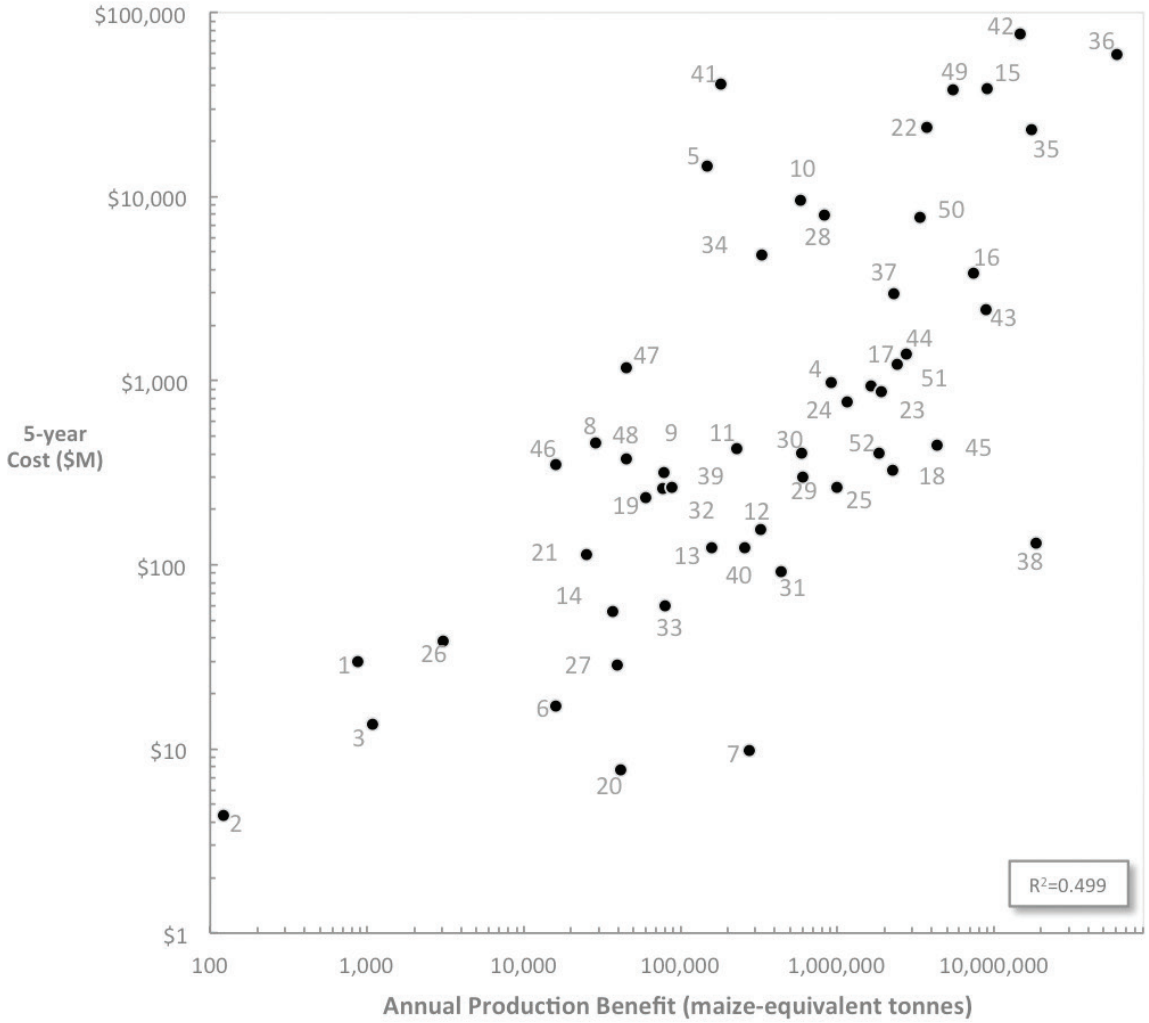
The vast majority of interventions pay back within 10 years



[1] Assuming an average maize price of $506 per tonne
[2] Interventions also do not break even within 5 years due to low commodity prices in S. Africa ($212/maize-equivalent tonne)
Source: Lake Partners analysis

Cost of Increased Production

There are few inexpensive interventions that meaningfully move the needle on production potential



Intervention Key

1	BOT-Water management	27	RWA-Water management
2	BOT-Time to start a business	28	RWA-Improved farming
3	BOT-Trade barriers	29	RWA-Additional land
4	BOT- Improved farming	30	RWA-Grain storage
5	BOT-Additional land	31	RWA-Optimal crop choice
6	BOT-Grain storage	32	SAF-Water resources
7	BOT-Optimal crop choice	33	SAF-Cultural heterogeneity
8	BUR-Trade barriers	34	SAF-Road condition
9	BUR-Market access	35	SAF-Improved farming
10	BUR-Improved farming	36	SAF-Additional land
11	BUR-Additional land	37	SAF-Grain storage
12	BUR-Grain storage	38	SAF-Optimal crop choice
13	BUR-Optimal crop choice	39	TZA-Access to capital
14	GHA-Market access	40	TZA-Extension & research
15	GHA-Improved farming	41	TZA-Rural electrification
16	GHA-Additional land	42	TZA-Improved farming
17	GHA-Grain storage	43	TZA-Additional land
18	GHA-Optimal crop choice	44	TZA-Grain storage
19	MWI-Resiliency to drought	45	TZA-Optimal crop choice
20	MWI-Women farmers	46	UGA-Cell phones
21	MWI-Soil erosion	47	UGA-Farmers co-ops
22	MWI-Improved farming	48	UGA-Market access
23	MWI-Additional land	49	UGA-Improved farming
24	MWI-Grain storage	50	UGA-Additional land
25	MWI-Optimal crop choice	51	UGA-Grain storage
26	RWA-Commodity reserve	52	UGA-Optimal crop choice

Source: Lake Partners analysis

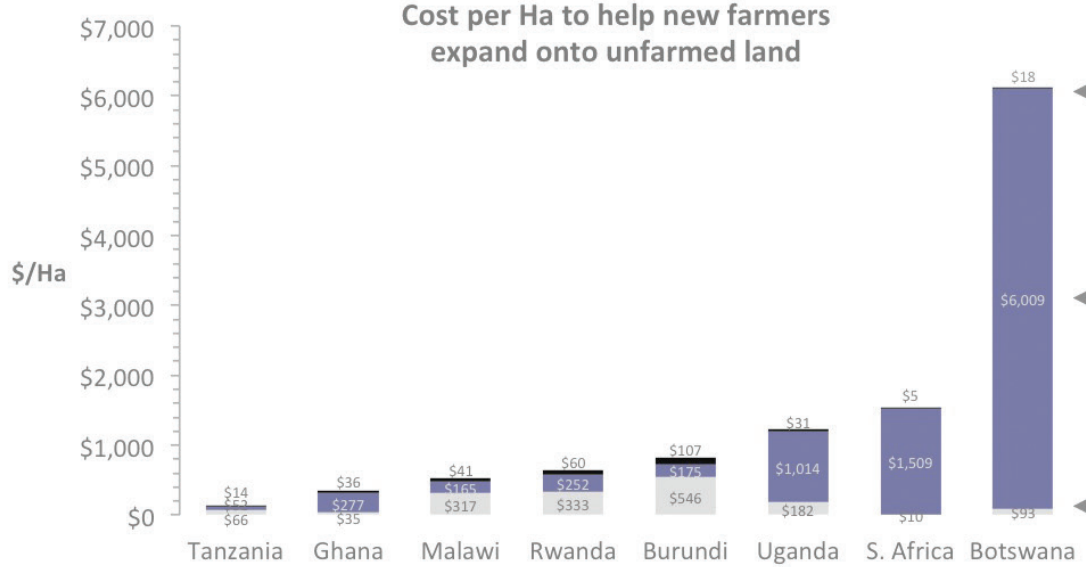
Bringing Unfarmed Land into Production

All countries have substantial unfarmed communal or underused private land

Most land remains unfarmed because of three main barriers[1-3]:

1. *Farming is too financially risky for first-timers*
2. *Buying or negotiating access to the land is expensive or complicated due to poor land laws*
3. *Potential farmers cannot afford start-up costs (e.g., tools, inputs, labor)*

Cost per Ha to help new farmers expand onto unfarmed land



	Tanzania	Ghana	Malawi	Rwanda	Burundi	Uganda	S. Africa	Botswana
Unfarmed arable land (MHa)	18.5	11.0	1.8	0.5	0.5	6.3	39.0	2.4
5-year cost of expanding farmland	$2.4B	$3.8B	$0.9B	$0.3B	$0.4B	$7.7B	$59.5B	$14.7B

Barrier #1: Alleviating financial risk of switching to farming through cash awards (~10% of cost[3])

Barrier #2: Giving grants to local farmers to negotiate use or purchase of unfarmed land from willing parties, and build/reinforce national land surveying and titling institutions (~60% of cost[3])

- Grant amounts are based on current ag land prices
- Assumes 0% of current landowners want to farm

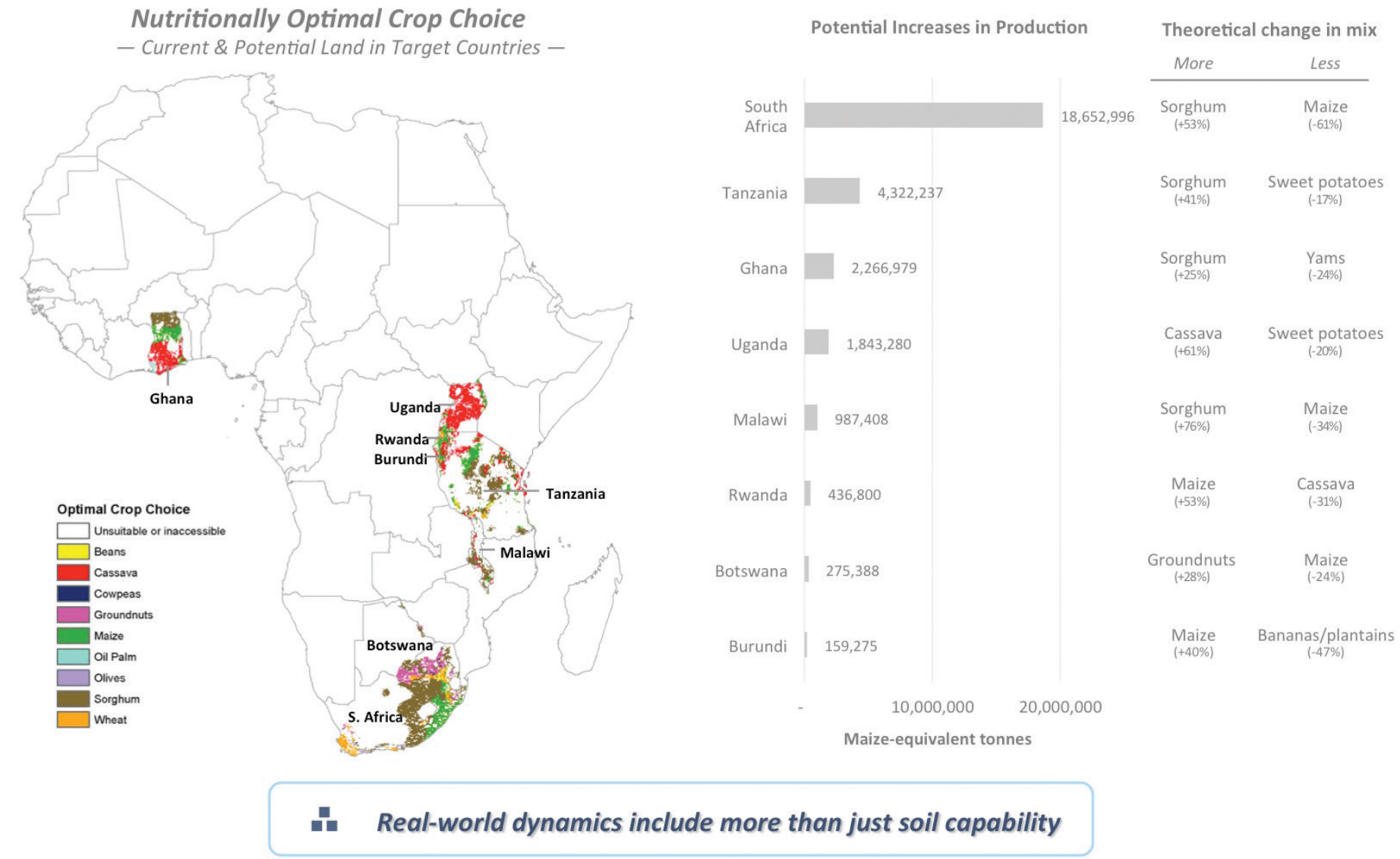
Barrier #3: Covering costs of training, equipment and basic necessities for new wave of farmers (~30% of cost[3])

- New farmers receive tools, training, inputs, food and housing materials for new farms & homesteads
- Costs are scaled based on local input prices

Most countries could see a 150-300% expansion of farmland by bringing unfarmed arable land into production

[1]Momagri: http://www.momagri.org/UK/focus-on-issues/Unfarmed-arable-land-Enough-is-available--to-achieve-long-lasting-food-security-for-mankind-_710.html
[2]IRIN/UN Office for the Coordination of Humanitarian Affairs: http://www.irinnews.org/report/74399/sierra-leone-why-don-t-people-farm-the-land
[3]World Bank: Malawi Community-Based Rural Land Development Project: http://www.worldbank.org/projects/P075247/community-based-rural-land-development-project?lang=en
Source: Lake Partners analysis

Theoretically Optimal Crops



Real-world dynamics include more than just soil capability

Source: World Bank, FAOSTAT, Lake Partners analysis

Improved Farming: Fertilizer, Pesticides, Extension & Soil Testing

		Botswana	Burundi	Ghana	Malawi	Rwanda	S. Africa	Tanzania	Uganda
Fertilizer ($/Ha)	Conservation Ag	$163	$98	$112	$265	$172	$115	$247	$156
	Traditional Ag	$254	$212	$137	$283	$230	$208	$251	$210
Pesticides ($/Ha)	Conservation Ag	$54	$63	$51	$95	$56	$15	$52	$62
	Traditional ag	$83	$97	$82	$146	$87	$24	$80	$95
Extension & soil testing	Conservation Ag	$3M	$302M	$130M	$199M	$179M	$476M	$164M	$238M
	Traditional ag	$3M	$291M	$122M	$189M	$174M	$472M	$155M	$227M
Total 5-year Cost	**Conservation Ag**	**$199M**	**$1,221M**	**$4,547M**	**$5,263M**	**$1,475M**	**$2,638M**	**$14,697M**	**$5,506M**
	Traditional ag	**$307M**	**$2,052M**	**$6,058M**	**$6,217M**	**$1,968M**	**$4,304M**	**$16,231M**	**$7,597M**

Conservation vs. Traditional Ag

Fertilizer reductions of 40 – 70%

- Cover crops can replace 30 – 75% of the nutrients provided by fertilizers[1,2]
- Conservation ag (e.g. low-tillage) can reduce runoff leading to 5-7% reduction in fertilizer use[3]

Pesticide savings of >30%

- Cover crops and residues inhibit weed growth resulting in a 65% reduction in herbicide use[4]

Costlier training and support

- Complicated conservation ag methods require more training for extension officers
- Farmers require more support to utilize these methods in the iterative manner necessary for long-term soil improvements

Because of the lower costs and comparable yields of conservation ag, we use it as our base case for improved farming techniques

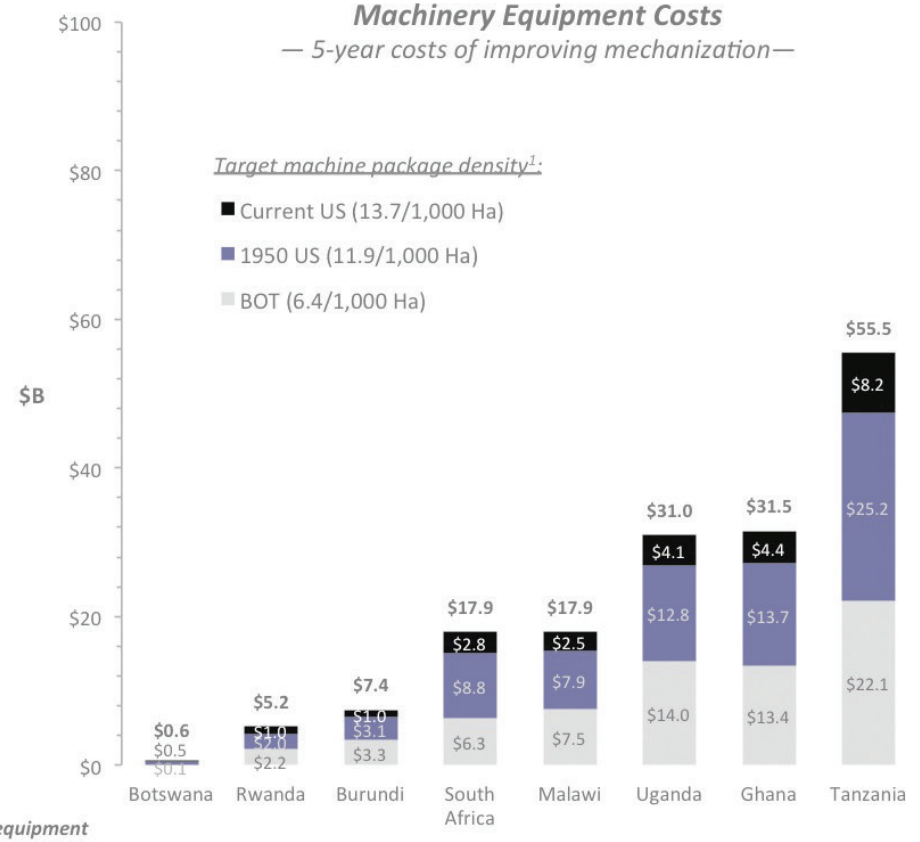
[1] Average of Nitrogen (N), Phosphate(P), and Potassium (K) needs are taken from global usage data collected by the International Fertilizer Industry Assoc. –See World Fertilizer Use Manual (2014) Int. Fertilizer Industry Assoc. Accessed Jan 2014: http://www.fertilizer.org/ifa/HomePage/LIBRARY/Our-selection2/World-Fertilizer-Use-Manual/by-common-names

[2] 50% of nutrients left as crop residue are assumed to be available to the following planted crop (Sustainable Agriculture Network (2000) Managing Cover Crops Profitably 2nd Edition: http://www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition). An average of 75 kg/Ha of Nitrogen and 10 kg/Ha Phosphate is provided by cover crops: (a) Mississippi soybean promotion board (2013) Cover Crops: www.MSSOY.org; (b) Florentin et al. (2011) ICM – Green manure/cover crops & crop rotation in Conservation Agriculture on small farms FAO: http://www.fao.org/fileadmin/user_upload/agp/icm12.pdf. An average of 75 kg/Ha of Potassium is provided by cover crops: Sullivan (2003) Overview of Cover Crops and Green Manures, ATTRA Pub: http://www.clemson.edu/sustainableag/IP024_covercrop.pdf

[3] An estimated 17% of N and 19% of P applied as fertilizer are loss to run off (USDA - CEAP Cropland modeling team (2010) Assessment of the Effects of Conservation Practices on Cultivated Practices on Cultivated Cropland in the Upper Mississippi River Basin), which may be reduced 70% by cover crops (Tonitto et al. (2006) Replacing bare fallows with cover crops in fertilizer-intensive cropping systems: A meta-analysis of crop yield and N dynamics, Agriculture Ecosystems & Environment, 112:58-72) and an additional 53% by buffer strips (Fawecett & Smith, A review of BMPs for managing crop nutrients and conservation tillage to improve water quality, CTIC: www.conservationinformation.org); P loss to runoff may be reduced 74% by cover crops 63% by buffer strips and 86% due to reduced tillage (Fawecett & Smith)

[4] Relative to the manufacturer recommended usage of fungicide, herbicide & insecticide 2.7 kg/Ha of fungicide, herbicide & insecticide with a 65% reduction herbicide (9.24 kg/Ha); Liebman et al. (2008) Agronomic and Economic Performance of Characteristics of Conventional and Low-External-Input Cropping systems in the Central Corn Belt, Agron, J 100: 600-610: http://www.wallacechair.iastate.edu/PDF/MarsdenFarm_Agron_J_2008.pdf

Improved Farming: Mechanization



Add'l equipment packages required	Botswana	Rwanda	Burundi	South Africa	Malawi	Uganda	Ghana	Tanzania
Current US	1.3K	15.3K	15.4K	36.4K	37.4K	64.0K	72.6K	123.7K
1950 US	1.0K	13.4K	13.4K	30.7K	32.6K	55.6K	63.2K	106.9K
Botswana (best in Africa)	0	7.2K	7.2K	12.9K	17.4K	29.5K	34.0K	54.5K

Farm Machinery Packages
-- Retail price[2] & description --

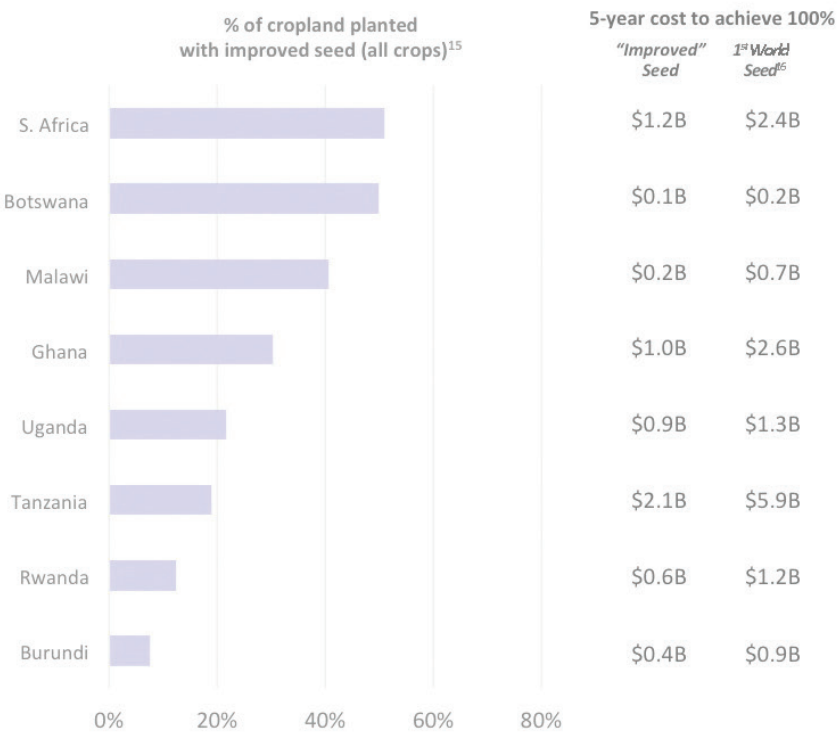
	Conservation ag (base case)	Traditional ag
Tractor	$21,939 (55 hp, 4WD)	$21,939 (55 hp, 4WD)
Plow /roller-crimper	$2,400 (roller/crimper)	$2,332 (3-furrow disc plow)
Combine harvester	$226,303 (9.1 m, self-propelled)	$226,303 (9.1 m, self-propelled)
Planter	$15,455 (4-row, 900 mm depth, mounted)	$12,157 (4-row, 900 mm depth, mounted)
Fertilizer spreader	$37,142 (4,000 l)	$37,142 (4,000 l)
Boom sprayer	$3,851 (12 m)	$3,851 (12 m)
Total package cost	**$307,090**	**$303,724**

While mechanization doesn't meaningfully impact yields, it is critical for scale

[1]Machine density includes both tractors & combines (FAOSTAT: http://faostat.fao.org/)
[2]South African Guide to Machinery Costs: http://www.daff.gov.za/docs/statsinfo/Guidemach1213.pdf

Improved Farming: Improved Seeds

	Current African "Improved" seed (50 lb bag)	1st-world seed (50 lb bag)	Average seeding rate (Bags/Ha)[1,2]	1st-world seed cost per Ha
Maize	$65 – $185 Varies by country (Pioneer hybrid[3])	$445 (DKC 62-80 BR + "Refuge-in-a bag"[4])	0.6	$286
Wheat	$20 (Rwandan avg[5])	$25 (Syngenta Southwind[6])	4.9	$123
Sorghum	$22 (Ugandan avg[7])	$126 (Pannar 8816[8])	0.2	$31
Groundnuts	$57 (Serenut 4 [Pearl Seeds][9])	$69 (Serenut + CruiserMaxx seed treatment)[10]	6.9	$480
Cassava	Program to propagate stem cuttings on locally accessible plots[11]			$9-26[11]
Beans	$50 (Kholoplethe – SUG-131[12])	$252 (Syngenta Carson[13])	3.7	$932
Cowpeas	$38 (Ghanaian avg[5])	$69 (AATF Bt cowpea[14])	0.9	$63



[1] Maize, Sorghum & Beans (Michigan State University Revised extension bulletin E-2017: http://fieldcrop.msu.edu/uploads/documents/E2107.pdf); Wheat (UC Davis Small grain production manual: http://anrcatalog.ucdavis.edu/pdf/8208.pdf)
[2] Groundnuts (Univ. of GA 2013 Peanut production guide: http://www.caes.uga.edu/commodities/fieldcrops/peanuts/documents/2013UGAPeanutProductionGuide.pdf); Cowpea (IITA – Farmer's guide to Cowpea production in W. Africa: http://www.icrisat.org/tropicallegumesII/pdfs/Cowpea.pdf)
[3] $120 and $65 are the prices of a 50lb bag of Pioneer hybrid in S. Africa and Malawi respectively. Price vary depending on the maturity of the improved seed market (Pioneer, 2014)
[4] SA Grain: http://www.senwes.co.za/files/main_articles/2011/10/7/mielie_monsanto.jpg; Est. price from best available seed to an improved variety with better refuge requirements based on a 15% price change from Monsanto VT3 ($295/unit) to SmartStax corn ($340/unit)
[5] Price data from AGRA: http://www.agra.org/
[6] Reisig Seeds, LLC, Russel KS Price quote (Feb 2013)
[7] AMITSA: http://amitsa.org/Home.aspx
[8] SA Grain: http://www.senwes.co.za/files/main_articles/2011/10/7/sorghum_pannar.jpg
[9] IFDC: api.ning.com/files/.../gender study_gulu_hub_report_march2011.doc
[10] Serenut (Growing Georgia: http://growinggeorgia.com/news/2011/10/georgia-peanuts-saving-seed-2012-three-considerations-and-word-caution/); CruiserMaxx (Pioneer Field Facts: http://www.chappellseeds.ca/Information%20for%20website/Soybean%20Agronomy/Soybean%20tech%20sheet/Field_Facts_Soybean_Seed_Trmt_Pop.pdf)
[11] Catholic Relief Services Great Lakes Cassava Initiative (cost vary by country): http://www.crsprogramquality.org/storage/pubs/agenw/glci-final-report.pdf#5
[12] CIAT: http://communityeds.org/59ee3fb9/Common%20bean%20varieties.pdf
[13] Johnnie's Selected Seeds: http://www.johnnyseeds.com/p-6952-carson.aspx
[14] Based on a current price of $0.76/lb (UC Davis Agriculture and Natural Resources Publication 8030: http://anrcatalog.ucdavis.edu/pdf/8030.pdf) with a price increase to account for the utilization of Bt technology (See AATF, "Maruca-Resistant Cowpea project Progress Report" 2011: http://www.aatfafrica.org/userfiles/cowpea-2011-progress-report.pdf) based on the price change from Monsanto's RR1-Brazil ($0.75/unit) to their RR2-Intacta variety ($1.36/unit)
[15] CGIAR-DIVA Project: http://www.asti.cgiar.org/diva
[16] Assumes new seeds are required every year. Assumes both improved and non-improved seed is upgraded to 1st world

Small Scale Grain Storage Needs: PICS Bags Case Study

Post-harvest loss of maize range from 14% to 30% in Sub-Saharan Africa

Purdue PICS Post-Harvest Loss Program (2007-2012)

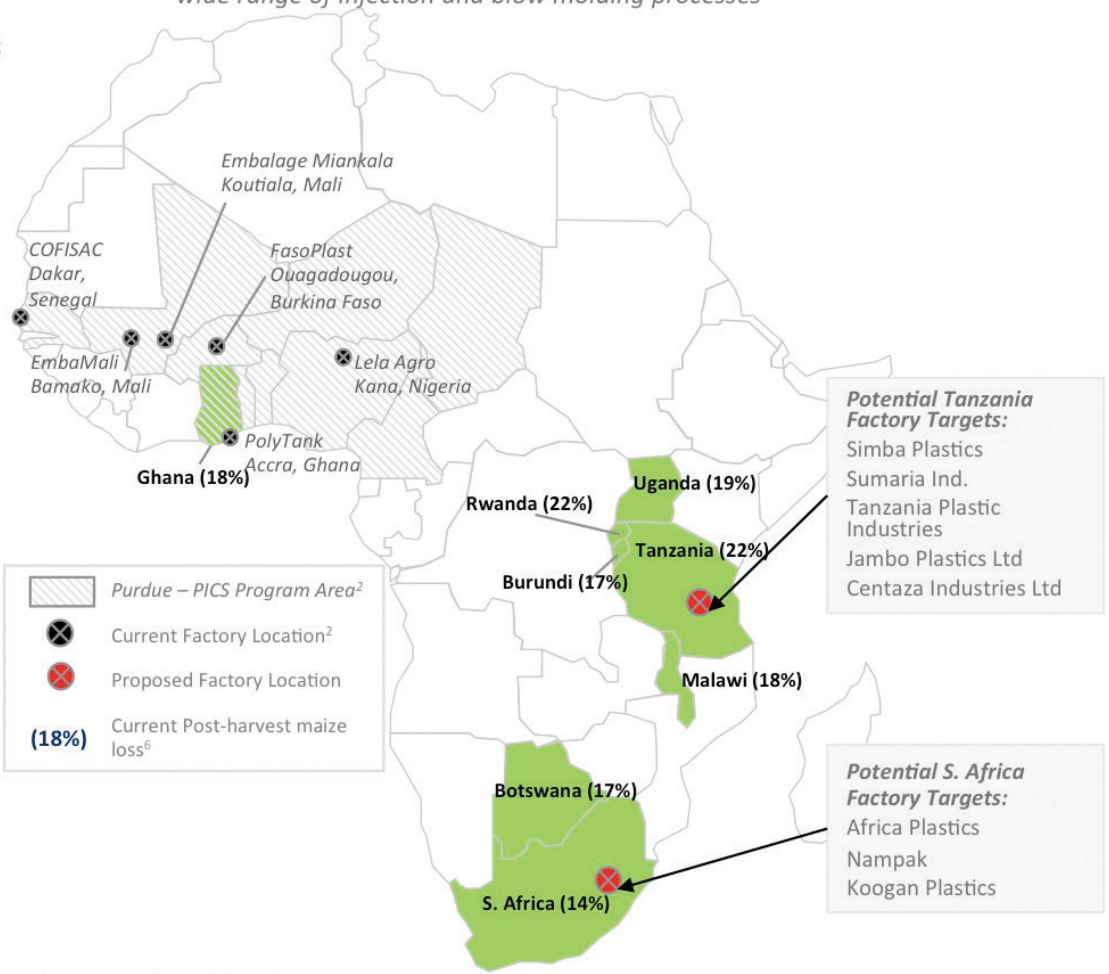
- Purdue Bags are 3-layer plastic bags capable of hermetic storage and can last for 3 years[1]
- Current distribution to 28,000 villages[2]
- Require little training or upkeep and no silos[1]
- Annual incomes for 1.6 million farmers increased an average of $32 using "Purdue Bag" storage for their cowpea harvest[3]

Intervention Idea to Improve Grain Storage

- Build two regional suppliers by partnering with large plastics manufacturers in Tanzania and South Africa to set-up bag fabrication equipment ($1.2M - 2.4M per factory[4])
- Distribute bags through regional supply chains and local input dealers
- Provide bag vouchers to farmers for $3/bag ($30 per tonne)[5]

Manufacturing Requirements

Large plastics firm with the ability to utilize a wide range of injection and blow molding processes



[1]Baributsa, D and others (2013), Purdue Improved Cowpea Storage (PICS) Technology, Purdue Extension: http://extension.entm.purdue.edu/publications/E-262.pdf
[2]Project Overview, Purdue Improves Storage (PICS) Project, Purdue University: https://ag.purdue.edu/ipia/pics/Pages/ProjectOverview.aspx
[3]Impact update, Purdue Improved Cowpea Storage (PICS) project, Purdue University: https://ag.purdue.edu/ipia/pics/Style%20Library/new_pics/PICS/impact.html
[4]Based on equipment needs for current yields – See Data book for costs break-down
[5]Jones, M and others (2011) Profitability of Hermetic Purdue Improved Crop Storage (PICS) Bags for African Common Bean Producers: http://ageconsearch.umn.edu/bitstream/117708/2/11-6.pdf
[6]African Post-harvest Loss Information System (APHLIS): http://www.aphlis.net/
Source: Lake Partners analysis

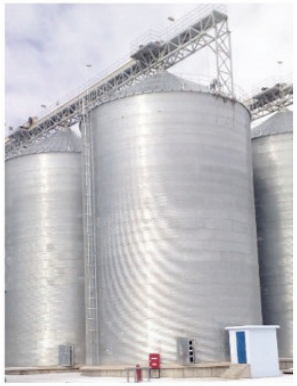
Large Scale Grain Storage Needs: On Farm & Commercial Silos

Silos are needed to scale production

1st world large scale storage is a combination of on farm and commercial…

On Farm Storage (60%)[1]

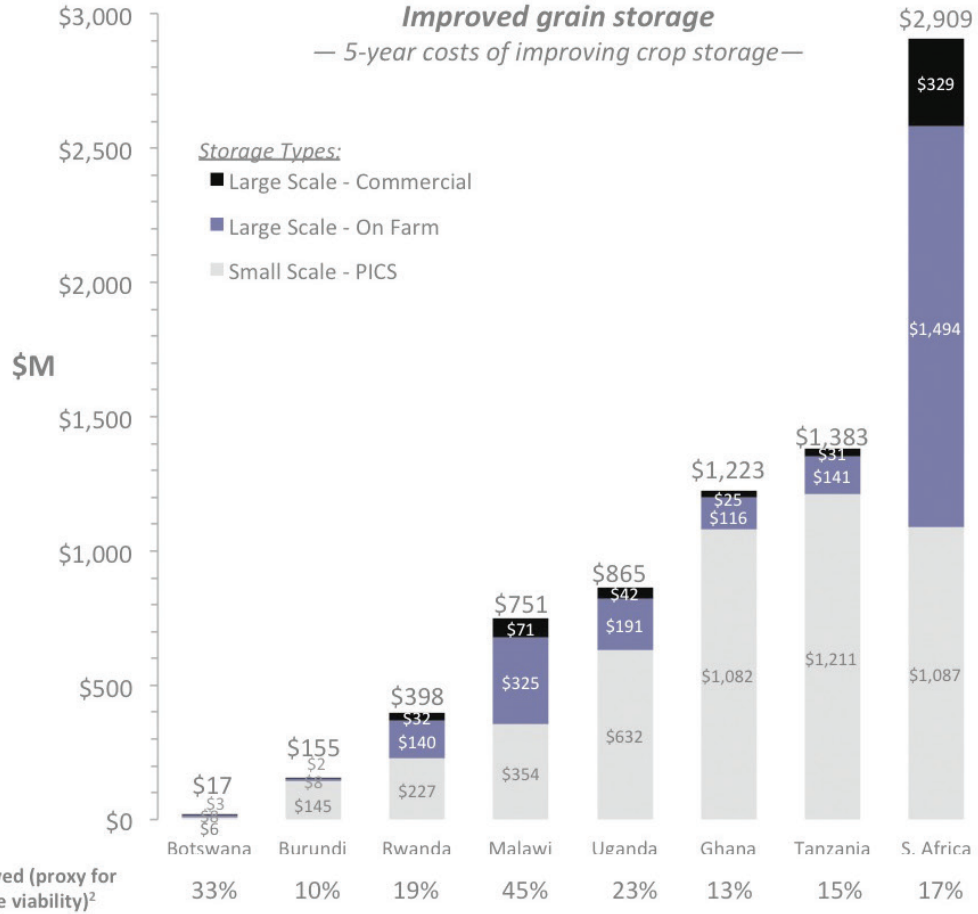
- *Steel or cement construction*
- *One to two tonne capacity*
- *Construction costs vary based on local wage rates*
- ***Cost of one tonne silo: $61 (Burundi) - $880 (S. Africa)***
- ***Effective cost/tonne: $12 (Burundi) - $175 (S. Africa)***



Commercial Storage (40%)[1]

- *Steel construction*
- *10k tonne capacity*
- *Construction and annual maintenance and receipt costs vary based on local wage rates:*
- ***Construction cost: $203k (Burundi) - $2.8M (S. Africa)***
- ***Service cost: $21k (Burundi) - $287k (S. Africa)***
- ***Effective cost/tonne: $5 (Burundi) - $58 (S. Africa)***

…but these are only viable if road infrastructure exists



[1]Based on current US storage conditions - USDA Grain Stocks reports (1991-2010): http://usda.mannlib.cornell.edu/MannUsda/homepage.do
[2]FAOSTAT: http://faostat.fao.org/

Market Access

Rural infrastructure initiatives in Burundi, Ghana & Uganda remove market barriers with high ROI

For each market:

- Link goods to market by investing in basic rural infrastructure (~93% of cost)
  - Construct or repair rural markets in underserved communities:
  - Rehabilitate ~70 km of all-weather gravel roads per market, reducing access time for ~170 families per km[1]
- Improve value chain through agro-processing[2,3] (~2%)
  - Provide agro-processing machinery (avg. 1-2) per market (e.g. warehouse, slaughterhouse, cassava processing plant)
- Train local officials to insure proper maintenance & operations[3,4] (~5%)
  - Instruct local officials in road maintenance, market processes
  - Fund annual infrastructure rehabilitation projects (e.g. village trail restoration, market cleaning, etc.)

Total Costs

	Burundi	Ghana	Uganda
5-year cost per market	$1.1M	$90K	$400K
# of markets	300	611	927
Tot. 5-year cost	$318M	$56M	$378M
Additional 5-year production (maize eq. tonnes)	438K	183K	226K

Farmers impacted by similar programs have seen incomes rise 116%[3]

[1]Ugandan Bureau of Statistics: http://www.ubos.org/
[2]AFDB's Ugandan CAAIP Program: http://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/UG-2008-077-EN-ADF-BD-WP-UGANDA-CAIIP-II.PDF
[3]World Bank's Ghanaian Village Infrastructure Project (VIP): http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2005/02/18/000012009_20050218132224/Rendered/PDF/31016.pdf
[4]Burundi Agro-Pastoral Productivity & Markets Development, Project Appraisal, April 2010: http://documents.worldbank.org/curated/en/2010/04/12085777/burundi-agro-pastoral-productivity-markets-development-project
Source: IFAD, World Bank, Ghana CAADP Budget, AFDB, Lake Partners analysis

Major Infrastructure

Road paving (SAF) and traditional rural electrification projects (TZA) are costly and have low direct ROI

Road Paving

— South Africa —

- Only 17.3% of South Africa's major roads are paved[1], and 50% of all gravel roads are in poor or very poor condition[2]
  - Unpaved roads are concentrated in ag-heavy southeastern provinces[2]
  - In 1999, the backlog in necessary road funding was $10.6B[2]
- Increasing from 17.3% paved to 32.6% (Botswana-level) requires $4.8B over five years in construction & maintenance costs
  - Average road paving costs of $150K/km make new paving projects very costly

km of roads to pave	28,277
Cost per km	$149,226
Annual cost of maintenance per km	$4,251
Total 5-year cost	*$4.8B*
Cost per maize-eq. tonne	*$4,220*
Years to break even ($212 maize)[6]	*Never*

Rural Electrification

— Tanzania —

- Tanzania's rural electrification rate (2-4%[3,4]) is among the lowest in Africa
  - Tanzania's grid has expanded slowly due to financial and technical constraints
- Reaching 75% electrification would be on par with most southeast Asian and central American countries
  - Even for the simplest province of Singida, this program would cost $926M

Target electrification %	75%
Power plants required[5]	29
Transmission systems required[5]	43
Total 5-year cost	*$40.9B*
Cost per maize-eq. tonne	*$40,918*
Years to break even ($414 maize)[6]	*545*

Major infrastructure projects are useful, but require a very long-term ROI view

[1]International Road Federation: http://data.worldbank.org/indicator/IS.ROD.PAVE.ZS
[2]Development Bank of South Africa: http://www.dbsa.org/Research/Documents/DBSA%20State%20of%20SA%20Economic%20Infrastructure%20Report%202012.pdf
[3]International Electricity Agency: http://www.worldenergyoutlook.org/resources/energydevelopment/accesstoelectricity/
[4]Tanzania's Rural Energy Agency: http://www.esmap.org/sites/esmap.org/files/4b.%20TANZANIA_Innovation%20in%20Delivery%20of%20Services.pdf
[5]Tanzania Electrification Master Plan: http://www.mem.go.tz/Portals/0/EasyDNNNewsDocuments/1059/0062_10072013-Power_System_Master_Plan_2012.pdf
[6]Based on current cost of one tonne of maize in specified country – FAOSTAT
Source: Lake Partners analysis

Water & Soil Management

While expensive, some programs can pay back in the mid- to long-term

	Program Elements: Intervention	Typical 5-year cost per district	Program Focus: Malawi	Botswana	S. Africa	Rwanda
Water Management	Water conservation & drought monitoring[1]	$112K – $720K	◒	◒	◒	◒
	Soil moisture management[1]	$0.9M - $11.3M	●	●	○	○
	Local government water management training[1]	$0.4M - $0.7M	◒	◒	○	●
	Rain-water harvesting[2]	$0.4 - $14.8M	○	○	●	●
	Drylands planting techniques (e.g. no till farming)[1,2]	$0.9M - $13.2M	●	●	●	○
	Drought crop management[1]	$0.9M - $11.3M	●	●	○	○
Soil Conservation[3]	Conservation agriculture training	$1.5M	●	○	○	○
	Sustainable land management practices	$66K	◒	○	○	○
	Increase land under agroforestry	$2.5M	●	○	○	○
Integrated Water Resource Management (IWRM)	Regionally focused IWRM practices[4]	$3.0M	○	○	○	●
	Promote water efficiency and fair resource allocation[4]	$1.2M	○	○	○	●
	Capacity building in water resource fields[4]	$1.1M	○	○	○	●

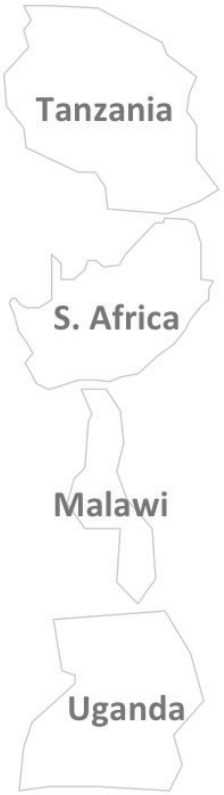
Symbol Key

○ Intervention not present ◒ Minor Program Component ● Major Program Component

Impact					
	Country cost (5-year)	**$347M**	**$30M**	**$258M**	**$25M**
	Headwind impact	**1.4%**	**1.1%**	**0.7%**	**1.5%**
	Increased production (maize-eq. tonnes)	**87,400**	**875**	**77,100**	**39,305**
	Years to payback	**8**	**88**	**16**	**1.5**

[1]South Eastern Dry Areas Project Report, Republic of Zimbabwe/IFAD, Sep. 1995: http://operations.ifad.org/web/ifad/operations/country/project/tags/zimbabwe/435/project_overview
[2]South African Water Resource Commission: http://www.wrc.org.za/Knowledge%20Hub%20Documents/Research%20Reports/1176-1-03.pdf
[3]Malawi Agricultural Sector Wide Approach, Republic of Malawi, September 2011: http://www.moafsmw.org/ocean/docs/Key%20Documents/ASWAP%20Revised%2023Sept2011.pdf
[4]Water Resources Management sub-sector Strategic Plan (2011-2015), Ministry of Natural Resources, Dec 2011: http://mra.rw
Source: World Bank, Malawi CAADP Budget, Botswana National Agricultural Plan, South African Water Resource Commission, Lake Partners analysis

Extension, Outreach & Education



	5-year Cost ($M)	Benefit (Maize eq. tonnes)
■ Target undergraduate & advanced degree agricultural education improvements[1,2] ▪ Fund 8,000+ university scholarships ▪ Endow ~30 professorships/staff	$123	257,500
■ Help cultural divisions by forming co-ops[3] ▪ Create 68,000+ minority cooperative marketing groups ▪ Provide annual training, capacity building and ongoing extension services	$60	80,300
■ Improve women farmers' welfare programs[4] ▪ Combine direct production support, extension services and gender awareness campaigns ▪ Improve number of local female leaders by forming women farmers' groups	$8	41,800
■ Boost farmer productivity through outreach & extension[3] ▪ Create 360K co-ops ▪ Provide 5.3M cell phones with plans for market, weather & crop disease information	$1,170 $351	45,000 16,100

Extension, outreach & education interventions rank among top initiatives for ROI and net production increase

[1]Based on programs by African Center of Excellence (ACE): http://www.worldbank.org/projects/P126974/strengthening-tertiary-education-africa-through-africa-centers-excellence?lang=en
[2]Based on the Innovative Agricultural Research Initiative (iAGRI): https://docs.google.com/file/d/0B0xzyGXEhwS2bW9JRVhkQkNzTDg/edit
[3]Based on the World Bank's Ugandan National Agricultural Advisory Program (NAADS): http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2010/08/11/000333038_20100811014210/Rendered/PDF/ICR14210P044691IC0disclosed08191101.pdf
[4]Based on the Malawian Ministry of Agriculture's Gender, HIV & AIDS Strategy from the Malawi CAADP: http://www.caadp.net/pdf/Investment%20plan%20-%20Malawi.pdf
Source: Lake Partners analysis

Commerce & Trade

Improvements to commerce and trade are costly over the short term and should be considered late-stage interventions

- High transport costs and weak value chains necessitate trade improvements in **Botswana**[1] and **Burundi**[2]
  - Focus on improving trade laws and opening new markets to create demand
  - Train producers and co-operatives to create and utilize value chains
  - Reduce travel and border crossing times via infrastructure improvements (Burundi) and ITC solutions (Botswana & Burundi)
  - A similar program in Mozambique resulted in farm gate sales increasing from $6.1M in 2010 to $41M in 2012 due to higher prices and better market access[3]
  - Total 5-year costs: $13.6M (BOT) & $460.8M (BUR)

- **Botswana** should target its lengthy time to start a business to improve rural commerce
  - Streamline and computerize business registration procedures
  - Decentralize process through online and district level registration centers
  - Program based on a Guyana USAID project that reduced business permitting from 64 days to 12 days for electronic/online registration[4]
  - Total 5-year costs: $3.9M

- A distributed commodity reserve program in **Rwanda** should stabilize prices, increase food security and combat post-harvest losses
  - Construct, staff and manage three major grain warehouses
  - Purchase maize and beans to feed the food insecure (29% of pop.) for three months
  - Create a cash reserve capable of funding a month of crop purchases for the food insecure
  - Total 5-year costs: $38.8M

[1]Interventions based on the Botswana National Export Strategy, 2010; URL: http://www.mtigov.bw/webfm_send/178
[2]Interventions based on the Plan National D'Investissement agricole (PNIA) 2012-17, Ministrere De L'agriculture et de l'elevage, Republique du Burundi; URL: http://www.gafspfund.org/sites/gafspfund.org
[3]Performance Evaluation of the USAID/Mozambique Agriculture Portfolio, Jan. 2013; URL: http://pdf.usaid.gov/pdf_docs/PDACU951.pdf
[4]Guyana Threshold Country Plan/Implementation Program, 2008-2010 Final Report, Feb. 2010; URL: http://pdf.usaid.gov/pdf_docs/pdacs950.pdf
Source: Lake Partners analysis

ANALYSIS OF SELECT CAADP PLANS

CAADP Plan Comparison

	Current priorities	Recommended priorities	Scope of current plan	Likelihood of implementation	Gov't funding for recommended priorities
Botswana (not CAADP)	• Improved farming (input subsidies & mechanization) • Optimal crops • Trade barriers	• Optimal crops • Improved farming[1] • Grain storage	**Targeted** Focused on growing an undersized ag sector	**High** Strong government support	3%
Burundi	• Input subsidies • Rehabilitate rural roads	• Grain storage • Expanding to unfarmed land • Market access	**Specific, but mixed priorities** Targets market access, but focuses on input subsidies for bad soil	**Low** Small government discretionary budget	3%
Ghana	• Rural infrastructure • Value chain development • Food security	• Grain storage • Expanding to unfarmed land • Optimal crops	**Specific, but broader priorities** Focus on food security and increased incomes	**Low-Medium** Too many priorities with limited funds	1%
Malawi	• Women farmers • Input subsidies • Water & soil management	• Women farmers • Grain storage • Optimal crops	**Broad** Ag-sector wide budget	**Low-Medium** High government awareness of problems, but limited funds	4%
Rwanda	• Intensification of production • Promote agribusinesses • Strengthen institutions in support of ag	• Grain storage • Expanding to unfarmed land • Water management	**Broad, with ambitious targets** Focus on ag productivity & poverty	**Medium** Plan is currently 40-60% funded	3%
South Africa (not CAADP)	• Promote profitable production • Improve management and regulatory services • Diversity in ag sector	• Optimal crops • Cultural heterogeneity • Grain storage	**Incremental growth** Targets commercial growth and empowers disadvantaged farmers	**Medium-High** Advanced economy & well-developed ag sector	<1%
Tanzania	• Input subsidies • Local official training • Access to capital	• Expanding to unfarmed land • Grain storage • Research & education	**Targeted** Focus on public-private investments in ag production	**Medium** Dedicated to improvement, but has persistent corruption	1%
Uganda	• Agricultural research • Optimal crops • Expanding rural co-ops	• Grain storage • Optimal crops • Expanding to unfarmed land	**Broad** Targets capacity building and food security through education & improved farming techniques	**Low-Medium** Overly dependent on external funds	2%

[1] 1st-world farming with conservation ag
Source: Lake Partners analysis

Country Level Plans: Botswana

The ag sector lags behind other segments of the economy and improvements are focused on reducing imports

Botswana has a well-developed plan with a high likelihood of successful implementation

- Botswana's Agriculture Development plan provides inputs, mechanization and crop advice to increase production of smallholders[1]
  - Their plan focuses on commercial farming to replicate the success seen with livestock
  - It has replaced plans focused on dryland agriculture with general input support
  - Funded primarily by the Government of Botswana
- Because of Botswana's low yields and low absolute production, multiple interventions are needed to break even
  - Optimal crops and improved farming techniques are prerequisites for any program of interventions
- Current production levels (maize-eq. tonnes): 0.1M
  - Self-sufficiency in 2043 (OECD consumption levels): 1.6M

	Potential Interventions								
	Program Costs ($M)		Bite-Size (5-year Costs)		Gov't acting on plan?	% Funded by Nat'l Ag Plan	Cumulative add'l production (maize-eq. tonnes)	Stand alone years to break even[2]	Cumulative years to break even[2]
	One-Time	Annual	District-level ($M)	Village-level					
Optimal Crop	$9.8	$-	$1.1	$10,400	✓	100%	0.3M	<1	<1
Improved Farming (Conservation Ag)	$399	$116	$109	$-	✓	2%	1.2M	2	1
Grain Storage	$12.9	$0.9	$1.9	$18,200		0%	1.6M	2	1
Trade Barriers	$13.6	$-	$-	$-	✓	100%	1.7M	32	1
Water Resource Mgmt.	$29.8	$-	$3.4	$132,200		0%	1.7M	88	1
Additional Land	$14,650	$-	$1,628	$15,472,700		0%	7.5M	256	18
Time to start a business	$2.9	$0.2	$1.4	$-	✓	8%	7.5M	Never	18

Decreasing ROI

[1]National Master Plan for Arable Agriculture and Dairy Development (NAMPAAD), Ministry of Agriculture, Republic of Botswana
[2]Rounded to the nearest year and calculated using $387/tonne of maize
Source: Lake Partners analysis

Country Level Plans: Burundi

Poor connectivity, isolated farms and low capacity markets require investment to grow the ag sector

Burundi's poorly prioritized plan lacks the funding necessary for sector-wide agricultural improvements

- Burundi's CAADP plans focus on increased production using costly input subsidy programs while poor market access results in food failing to make it to market regularly[1]
  - Input subsidies target large populations of rural poor
  - Rehabilitate rural roads to improve market access
  - Funded by both the Government and development partners (USAID, World Bank, etc.)
- Because of Burundi's poor soil, even with all interventions it does not achieve self-sufficiency
  - Burundi's plan is wide in scope, covering our targeted interventions, but lacks funding and prioritization[1]
- Current production levels (maize-eq. tonnes): 1.7M
  - Self-sufficiency in 2043 (OECD consumption levels): 22.6M

	Potential Interventions								
	Program Costs ($M)		Bite-Size (5-year Costs)		Gov't acting on plan?	% Funded by Nat'l Ag Plan	Cumulative add'l production (maize-eq. tonnes)	Stand alone years to break even[2]	Cumulative years to break even[2]
	One-Time	Annual	District-level ($M)	Village-level					
Grain Storage	$64	$18	$9.1	$5,500	✓	0%	0.3M	<1	<1
Optimal Crop	$124	$-	$7.3	$4,400		0%	0.4M	1	<1
Additional Land	$431	$-	$25.3	$15,200		0%	0.6M	2	1
Market Access	$318	$-	$19.1	$436,000	✓	9%	1.2M	5	2
Trade Barriers	$461	$-	$-	$-		0%	1.4M	20	2
Improved Farming (Conservation Ag)	$4,779	$950	$561	$-	✓	<1%	4.0M	Never	8

Decreasing ROI

[1]Plan National D'Investissement agricole (PNIA) 2012-17, Ministrere De L'agriculture et de l'elevage, Republique du Burundi
[2]Rounded to the nearest year and calculated using $792/tonne of maize
Source: Lake Partners analysis

Country Level Plans: Ghana

Inspired rural infrastructure, value chain development and food security sub-programs lack funds

Ghana's ag plan has right priorities, but insufficient funding

- Ghana's CAADP plan addresses our top-three recommended interventions by targeting rural infrastructure, strategic commodities value chain development and food security (79% of budget)
  - The plan's prioritization of rural infrastructure (29%) directly complements our emphasis on increasing rural markets and reducing market access times across Ghana
  - CAADP plan significantly funds value chain development of specific national crops (13%) and food security (12%), firmly aligning with our goals of optimizing crops and improving grain storage
- Although the Ghanaian CAADP sub-programs strategically align with our key interventions, substantial additional funding is required
  - Current CAADP budget only covers 32% of our rural market access intervention
  - Ghana's national ag plan funds a mere 1.2% of optimal crops and 5.8% of grain storage interventions
- Current production levels (maize-eq. tonnes): 13.0M
  - Self-sufficiency in 2043 (OECD consumption levels): 63.6M

	Potential Interventions								
	Program Costs ($M)		Bite-Size (5-year Costs)		Gov't acting on plan?	% Funded by Nat'l Ag Plan	Cumulative add'l production (maize-eq. tonnes)	Stand alone years to break even[1]	Cumulative years to break even[1]
	One-Time	Annual	District-level ($M)	Village-level					
Optimal Crops	$327	$-	$32.7	$11,500	✓	1%	2.3M	<1	<1
Additional Land	$916	$581	$382	$134,500		0%	9.1M	<1	<1
Grain Storage	$547	$136	$123	$43,240	✓	6%	13.0M	<1	<1
Market Access	$52.1	$0.7	$5.6	$225,000	✓	32%	13.2M	3	<1
Improved Farming (Conservation Ag)	$22,439	$3,250	$3,869	$-	✓	<1%	50.1M	15	5

Decreasing ROI

[1]Rounded to the nearest year and calculated using $523/tonne of maize

Source: World Bank, IFAD, FAO, Ghanaian CAADP budget, Lake Partners analysis

Country Level Plans: Malawi

Safeguarding natural resources and ensuring gender equity in ag are the keys to a sustainable food-secure future

Malawi's ag plan is overly broad and fails to prioritize the most efficient improvements

- The Malawi agricultural sector-wide approach focuses on risk management and food security in addition to market development and sustainability[1]
  - There is conflict between expensive maize yield improvements, through irrigation and increased input use, and the development of a sustainable, diversified crop sector
  - Plan prioritizes commercial agriculture focused on high value export crops
  - Supported via a combination of government and foreign aid funds
- Malawi's focus on inputs and maize irrigation is not supported by our analysis of ROI for various interventions
  - Despite strong laws to protect women in the civic sphere, relieving economic and social barriers for women farmers will boost productivity at a low cost
  - Malawi can also benefit from simple, efficient interventions, such as water and soil conservation
- Current production levels (maize-eq. tonnes): 6.9M
  - Self-sufficiency in 2043 (OECD consumption levels): 26.6M

	Potential Interventions								
	Program Costs ($M)		Bite-Size (5-year Costs)		Gov't acting on plan?	% Funded by Nat'l Ag Plan	Cumulative add'l production (maize-eq. tonnes)	Stand alone years to break even[2]	Cumulative years to break even[2]
	One-Time	Annual	District-level ($M)	Village-level					
Women Farmers	$7.7	$-	$2.1	$-	✓	100%	0.1M	<1	<1
Optimal Crop	$265	$-	$9.5	$8,000	✓	10%	1.0M	<1	<1
Grain Storage	$529	$47.7	$27.4	$23,100	✓	<1%	1.3M	1	1
Additional Land	$936	$-	$33.4	$28,200		0%	2.7M	1	2
Resilience to Drought	$233	$-	$8.3	$46,700	✓	11%	2.8M	8	2
Soil Erosion	$114	$-	$4.1	$-	✓	100%	2.9M	9	2
Improved Farming (Conservation Ag)	$11,605	$2,466	$855	$-	✓	1%	12.0M	Never	12

Decreasing ROI

[1]Malawi Agricultural Sector Wide Approach, Republic of Malawi, September 2011
[2]Rounded to the nearest year and calculated using $493/tonne of maize
Source: Lake Partners analysis

Country Level Plans: Rwanda

Poverty and food insecurity are the primary drivers of Rwandan agricultural policies

This well-developed plan has a moderate likelihood of successful implementation due to limited resources

- The Rwandan agricultural sector investment plan[1] is robust and consists of nearly all of our priced interventions and more
  - The agricultural investment plan as envisioned is only 40-60% funded
  - Rwanda's agricultural plan is broader, targeting systemic poverty as well as increased production
- Due to Rwanda's poor soil, the country cannot reach self-sufficiency using all studied interventions
  - Production can be increased to 45% of self-sufficiency at current consumption levels, and 39% at OECD consumption levels
- Current production levels (maize-eq. tonnes): 2.9M
  - Self-sufficiency in 2043 (OECD consumption levels): 24.1M

	Potential Interventions								
	Program Costs ($M)		Bite-Size (5-year Costs)		Gov't acting on plan?	% Funded by Nat'l Ag Plan	Cumulative add'l production (maize-eq. tonnes)	Stand alone years to break even[2]	Cumulative years to break even[2]
	One-Time	Annual	District-level ($M)	Village-level					
Optimal Crop	$91.5	$-	$18.3	$5,900	✓	7%	0.4M	<1	<1
Additional Land	$195	$20.9	$60.0	$19,200		0%	0.7M	1	1
Grain Storage	$256	$29.9	$80.1	$25,900	✓	2%	1.2M	1	1
Water Resource Mgmt.	$28.5	$-	$-	$-	✓	40%	1.3M	2	1
Commodity Reserves	$36.8	$0.4	$9.4	$-	✓	35%	1.3M	35	2
Improved Farming (Conservation Ag)	$4,753	$632	$1,583	$-	✓	1%	3.4M	Never	12

Decreasing ROI

[1]Agriculture Sector Investment Plan, Ministry of Agriculture and Animal Resources, Government of Rwanda, 2009
[2]Rounded to the nearest year and calculated using $470/tonne of maize
Source: Lake Partners analysis

Country Level Plans: South Africa

A well-developed ag economy continuing broad-based ag improvements to increase exports and profits

Costly interventions in South Africa limit the reach of plans to improve agriculture

- South Africa has a broad plan that seeks to increase agricultural profits while improving social and economic conditions for previously disadvantaged individuals[1]
  - Sustainable management of natural resources is a major component of the sector wide strategy
  - An improved agricultural sector is needed to pull poor smallholders out of poverty
- Our interventions fit well into the South African agricultural plan
  - Despite much available land, the costs associated with bringing these areas into production is high compared to benefit (57% improvement in yields on new land vs. 175% for existing farmland)
  - Both the South African plan and ours prioritize interventions that reduce the burden caused by cultural heterogeneity
- Current production levels (maize-eq. tonnes): 14.1M
  - Self-sufficiency in 2043 (OECD consumption levels): 70.9M

Potential Interventions									
	Program Costs ($M)		Bite-Size (5-year Costs)		Gov't acting on plan?	% Funded by Nat'l Ag Plan	Cumulative add'l production (maize-eq. tonnes)	Stand alone years to break even[2]	Cumulative years to break even[2]
	One-Time	Annual	District-level ($M)	Village-level					
Optimal Crop	$132	$-	$14.7	$44,700		0%	18.7M	<1	<1
Cultural Heterogeneity	$59.7	$-	$6.6	$20,200	✓	26%	19.1M	4	<1
Additional Land	$59,459	$-	$6,607	$20M		0%	76.6M	5	4
Grain Storage	$2,229	$152	$332	$1.0M		0%	95.2M	7	4
Improved Farming (Conservation Ag)	$11,260	$2,345	$2,554	$-	✓	1%	156.5M	8	176
Water Resources	$258	$-	$29.4	$0.9M		<1%	159.5M	16	122
Road Condition	$4,220	$120	$542	$1.6M	✓	37%	171.5M	Never	1,730

Decreasing ROI

[1]Strategic Plan for the Department of Agriculture, Forestry and Fisheries 2012-17, Republic of South Africa
[2]Rounded to the nearest year and calculated using $212/tonne of maize
Source: Lake Partners analysis

Country Level Plans: Tanzania

With a strong and growing ag sector, only a few interventions are needed for significant improvement

Despite frequent shifts in plans and priorities, Tanzania continues to make steady improvement

- Tanzania's agricultural development plan is focused on increasing farm incomes and profitability in the agriculture sector[1]
  - Corruption remains a problem in the country's expensive input subsidy programs calling for capacity building and reform at the local level
  - Improving access to capital is a long-standing goal of the Tanzanian government
- Our interventions are similar to those developed by the Tanzanian government but with lower prioritization of costly & poorly distributed input subsidies
  - Continuing to bring more land into production is critical for food security and production increases
  - Both plans target boosting Tanzania's lagging agricultural research and education systems by revitalizing universities
- Current production levels (maize-eq. tonnes): 15.0M
  - Self-sufficiency in 2043 (OECD consumption levels): 66.9M

	Potential Interventions								
	Program Costs ($M)		Bite-Size (5-year Costs)		Gov't acting on plan?	% Funded by Nat'l Ag Plan	Cumulative add'l production (maize-eq. tonnes)	Stand alone years to break even[2]	Cumulative years to break even[2]
	One-Time	Annual	District-level ($M)	Village-level					
Optimal Crop	$447	$-	$17.2	$11,800		0%	4.3M	<1	<1
Grain Storage	$627	$153	$53.4	$36,600	✓	2%	6.2M	<1	<1
Additional Land	$2,433	$-	$93.6	$64,100		0%	15.5M	<1	<1
Research & Education	$82.7	$8.1	$-	$-	✓	14%	17.3M	1	<1
Access to Capital	$265	$-	$10.2	$-	✓	1%	18.0M	7	<1
Rural Electrification	$40,918	$-	$926	$-	✓	2%	19.3M	545	6
Improved Farming (Conservation Ag)	$38,264	$7,578	$2,929	$-	✓	<1%	67.4M	Never	32

Decreasing ROI

[1]Tanzania Agriculture and food security investment plan (TAFSOP) 2011-12 to 2020-21, Main document 18th October 2011, United Republic of Tanzania
[2]Rounded to the nearest year and calculated using $414/tonne of maize
Source: Lake Partners analysis

Country Level Plans: Uganda

Uganda adequately funds ag advisory services & technology development while neglecting infrastructure

Uganda's CAADP plan emphasizes research, but neglects infrastructure

- Uganda's CAADP plan prioritizes research to utilize modern farming technologies & practices, aligning with our recommendations
  - Agricultural advisory services & technology development, increased value addition, and pest & disease control account for 57% of Uganda's CAADP budget
  - Agricultural advisory services & technology development sub-programs align well with our optimal crops, cell phones and farmers' co-ops interventions
- However, the Ugandan plan underfunds infrastructure, a key sub-component of our intervention plan
  - Our market access intervention is only 16% funded by the current CAADP allocation, largely due to an insufficient national investment in rural roads
- Current production levels (maize-eq. tonnes): 8.3M
  - Self-sufficiency in 2043 (OECD consumption levels): 97.5M

	Potential Interventions								
	Program Costs ($M)		Bite-Size (5-year Costs)		Gov't acting on plan?	% Funded by Nat'l Ag Plan	Cumulative add'l production (maize-eq. tonnes)	Stand alone years to break even[1]	Cumulative years to break even[1]
	One-Time	Annual	District-level ($M)	Village-level					
Optimal Crop	$404	$-	$5.2	$3,600	✓	15%	1.8M	<1	<1
Grain Storage	$471	$81	$11.4	$7,700	✓	14%	3.3M	<1	<1
Additional Land	$7,684	$-	$99.8	$67,900		0%	7.2M	3	2
Market Access	$353	$4.9	$4.9	$-	✓	16%	7.6M	12	2
Farmers co-ops	$1,170	$-	$15.2	$10,000	✓	10%	7.7M	35	2
Cell Phones	$338	$2.6	$4.6	$3,100		0%	8.1M	35	2
Improved Farming (Conservation Ag)	$19,799	$3,596	$491	$-	✓	3%	27.7M	37	5

Decreasing ROI

[1]Rounded to the nearest year and calculated using $755/tonne of maize

Source: World Bank, IFPRI, AGRA, AFDB, IFAD, FAO, Ugandan CAADP budget, Lake Partners analysis

CLOSING THOUGHTS

BY HOWARD G. BUFFETT

This report presents a large volume of information and analysis to draw some significant conclusions about Africa's real vs. theoretical potential for agriculture. Like any report of this complexity, certain well-considered assumptions were made. We anticipate that not everyone will agree with every assumption, or even the methodology of trying to illustrate complex dynamics in a way that is accessible. We are making available online a data book (http://www.brownrevolution.org/) of the detailed assumptions underlying this analysis, but we recognize that some people will still take issue with the fact that we did not create a 500-page narrative to accompany this work and did not enlist academics to run statistically significant models.

However, we felt it was important to do three things: 1) to produce an honest and complete effort to identify a more realistic expectation of available and appropriate agricultural production potential in Africa; 2) to produce a report that people could easily understand; and 3) to produce a report that people would actually read. The world is littered with hundreds of well-intentioned academic papers that are rarely read or understood.

We started with a relatively objective view of potential arable land using basic physical characteristics. The headwinds we describe are by their nature more subjective. *But it is these headwinds that are responsible for the majority of hunger in Africa* so we put a stake in the ground to try to capture their effects.

It is politics, conflict, corruption and underinvestment that contribute to the challenge of feeding millions of people. This isn't just our opinion; it is shared by others, including the Food and Agriculture Organization of the United Nations in the 2014 "State of Food Insecurity in the World" and the ONE Campaign in "Trillion Dollar Scandal."

For example, conflict has a significant and devastating effect on agriculture, production potential and hunger. Africa is comprised of 54 countries, with nearly half actively experiencing armed conflict or recently emerging from armed conflict.[1] The World Bank estimates that poverty rates are 20 percentage points higher and people are twice as likely to be undernourished in countries experiencing repeated cycles of conflict. Displacement from people fleeing violence only increases the likelihood that agricultural production is interrupted and people suffer from increased food insecurity. It is critical to capture the effects of conflict and other difficult to measure factors when considering a country's potential for agriculture.

One reason that it is so important that we understand Africa's real potential for agriculture – and real barriers – is so we get the solutions right. Unrealistic goals keep people hungry. They contribute to the idea that untenable solutions are solutions, when in reality they displace efforts that could be successful.

Another reason it is important to be realistic is because industrialized agriculture in the developed world cannot possibly feed a large portion of Africa. American farmers will continue to become more efficient, but it is unlikely they will significantly increase the roughly 20 percent[2] of agricultural commodities they currently export, mostly to other developed nations. Production and exports will increase, but it will most likely remain relative to population increases.

The majority of food globally, about 70 percent, is produced by small-scale farmers, and mostly for their own household consumption.[3] These farmers have challenges and limitations in terms of adaptation of the technologies used in developed countries like the United States. The solution to world hunger will be increasing production in the local and regional areas where the consumption is needed. It will be further achieved by better regional trade (which requires stability and peace) and by bolstering local and regional markets.

International exports will not feed poor hungry people in rural areas with limited infrastructures and incomes. Increasing their production will. To get this right we need solutions that fit the circumstances and to be realistic about when and where scale is possible. We do not need more blanket solutions that fit a Westernized view of industrialized agriculture or strategies designed by bureaucrats, economists and politicians.

No strategy will work if it is built on the wrong set of assumptions. Therefore, we hope this analysis adds to the debate of what is possible in Africa, and ultimately contributes to developing realistic solutions to addressing hunger by improving agricultural productivity among smallholder farmers.

[1]"Africa's Forever Wars," Jeffrey Gettleman, Foreign Policy Magazine, 22 February 2010.

[2] U.S. Census Bureau, Statistical Abstract of the United States, 2012, p.548.

[3] Karla D. Maass Wolfenson, Food and Agriculture Organization of the United Nations, "Coping with the Food and Agriculture Challenge: Smallholders' Agenda," revised July 2013, p. 29.









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