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A woman tends her crops as part of the Kenya Horticulture Competitiveness Project. Photo by Neil Thoma. Source: USAID

CONTRASTING KENYAN RESILIENCE TO DROUGHT: 2011 AND 2017

Executive Summary: Despite repeated severe droughts in 2016/17, the severity of Kenyan food insecurity was substantially less than during the 2010/11 drought and substantially less than might be expected given historical relationships between drought severity and humanitarian need. In line with this, U.S. government expenditures were also substantially less (about half) than what might be expected based on historical relationships.

Key findings that support these observations include:

- Both the extent and depth of food insecurity was much smaller in 2017 than in 2011**. In 2011 the number of severely hungry (IPC 3 or 4) Kenyans was ~2.8 million, in 2017 it was ~1.75 million**.
- Based on the historical relationship between drought severity and humanitarian assistance, an estimated **500,000 fewer people were in need of humanitarian assistance (IPC 3 or 4) in 2017 than would be expected.**
- Despite three severe consecutive droughts, deflated **US Government food aid expenditures for Kenya in 2017 were about half (51% and 40%) of the expenditures during the last two severe crises in 2011 and 2009.**
- Despite a more severe agricultural shock, **maize prices normalized more quickly in 2017 than 2011, however this may reflect market interventions by the Kenyan Government.**

Together these findings suggest that Kenya was substantially more resilient to these types of climatic shocks in 2017 than it was in 2011.

CLIMATE SHOCKS IN 2010/11 AND 2016/17

This report examines two main questions – i) how bad was the 2016/2017 drought in Kenya, compared to the signature recent drought in 2010/11, and ii) given the relative severity of the 2016/17 drought, was the cost and depth of current food insecurity less than what we might expect given historical outcomes? We begin by comparing CHIRPS rainfall data (Figure 1) for 2010/11 and 2016/17. We will then relate these rainfall observations to food security, agriculture and market price outcomes.

Climatically, both 2010/11 and 2016/17 were associated with La Niña-like climate conditions, with relatively warm and cool sea surface temperature conditions in the western and eastern Pacific. The severity of the La Niña was more intense in 2010/11, while the warmth in the western Pacific was greater in 2016/17. **In general, the severity of the back-to-back October-December and March-May rainfall deficits appear generally greater in 2010/11 than 2016/17, especially in the Eastern Kenyan pastoral and agropastoral zone. However it should also be noted that the 2011 October-December rains were above normal, while October-December 2017 rainfall performance was poor in many parts of Kenya**.

Also of note are some exceptionally large deficits (<-150 mm) in 2017 in many of the main crop growing regions of the Rift Valley and Central provinces of Kenya. Crop water requirement satisfaction index analyses for these years (not shown) indicate substantially poorer maize product in this recent year. **We will later show that agricultural outcomes were worse in 2017 than 2011**.

Rangelands water requirement satisfaction index analyses (not shown) show very poor outcomes for 2017. But in 2011, there was no start whatsoever to the long rains season in northeastern Kenya, where emergency, near-famine, conditions broke out.

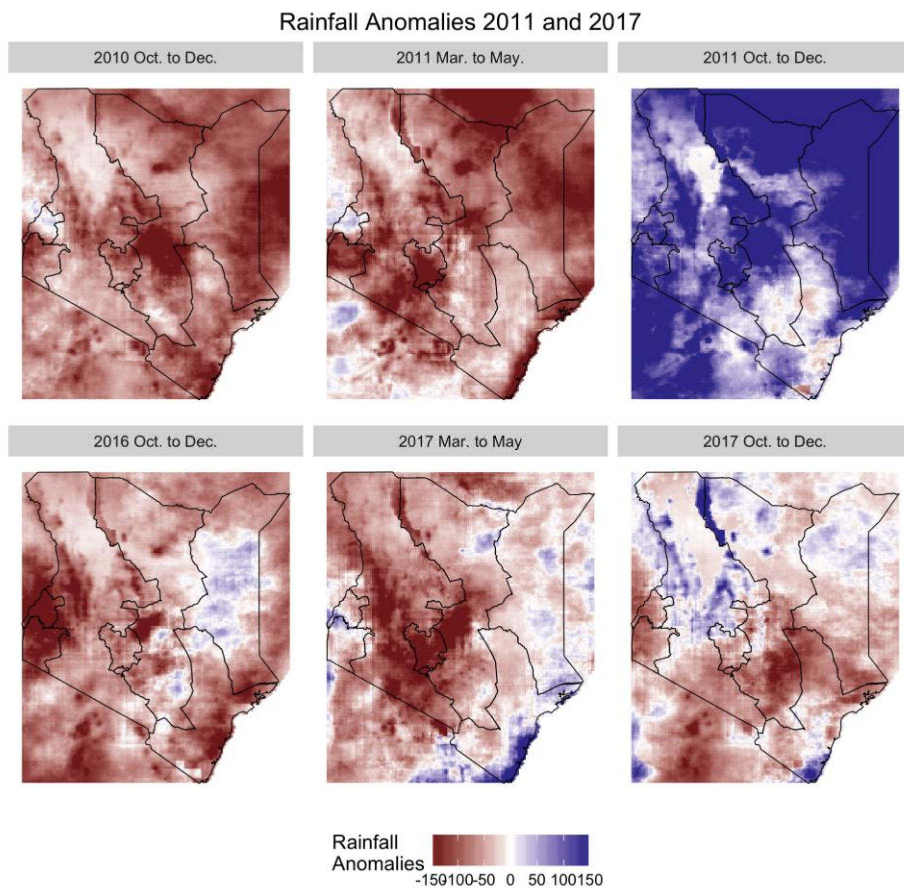

Figure 1. Rainfall Anomalies (the difference between rainfall totals and the long-term mean) for the key months leading up to and during 2011 and 2017.

KENYAN FOOD SECURITY IN 2011 AND 2017

We now use FEWS NET Food Security Outlook (FSO) maps and Food Insecure Population Estimates (FIPE) to quantify the extent and depth of the 2011 and 2017 crises. It should be noted that the FIPE estimation process and estimates are distinct from the IPC process and associated estimates. FIPE values are used in this analysis because they provide a consistent routinely updated data source stretching back to 2011. Given that the 2016/17 drought more severe than 2011 in both the western grain-basket region and during the OND season, was the food security crisis better or worse than we might expect, given historical relationships? Below we present evidence that the 2017 Food Security conditions were relatively less severe than might have been expected, given the severity of the 2016/2017 rainfall deficits.

In late 2011, the FEWS NET Kenya Food Security Outlook indicated extremely high levels of food insecurity (Figure 2, left), with most of the country anticipated to experience crisis or emergency levels of food insecurity. In late 2017, the corresponding FEWS NET Kenya Food Security Outlook indicated widespread food insecurity, but with substantially less severity (Figure 2, right). The 2011 Food Security Outlook estimated a total food insecure population of 3.75 million people. The 2017 Food Assistance Outlook Brief estimated that between 0.5 and one million Kenyans faced IPC Phase 2 conditions, while one to 2.5 million Kenyans faced IPC phase 3 or higher. The mean of these figures yields an approximate total of 0.75+1.75=2.5 million food insecure Kenyans.

UN Estimates of Kenyan population for 2011 and 2017 are 42.5 and 49.7 million, resulting in 8.8% and 5.0% of the population being classified as food insecure in each year. Using assessments of IPC 3 and 4 populations from 2011, and FAOB Figures from October of 2017 (provided by the FEWS NET data warehouse) we estimate that ~2.8 million Kenyans were classified in IPC Phase 3 or higher in 2011, while only 1.75 million faced such conditions in 2017. From the 2011 report: "*An estimated 1.4 million September 2011 pastoralists residing predominantly in north and northeastern pastoral areas are at Emergency levels (IPC Phase 4) …. an additional 2.35 million pastoralists and marginal agricultural farmers are in Crisis (IPC Phase 3) and Stressed (IPC Phase 2) phases*". This latter assessment led us to assume one million more people were in phase 3. We also added the 400,000 refugees who were in the Dadaab refugee camp. ***In 2011 the number of severely hungry (IPC 3 or 4) people (~2.8 million) was substantially***

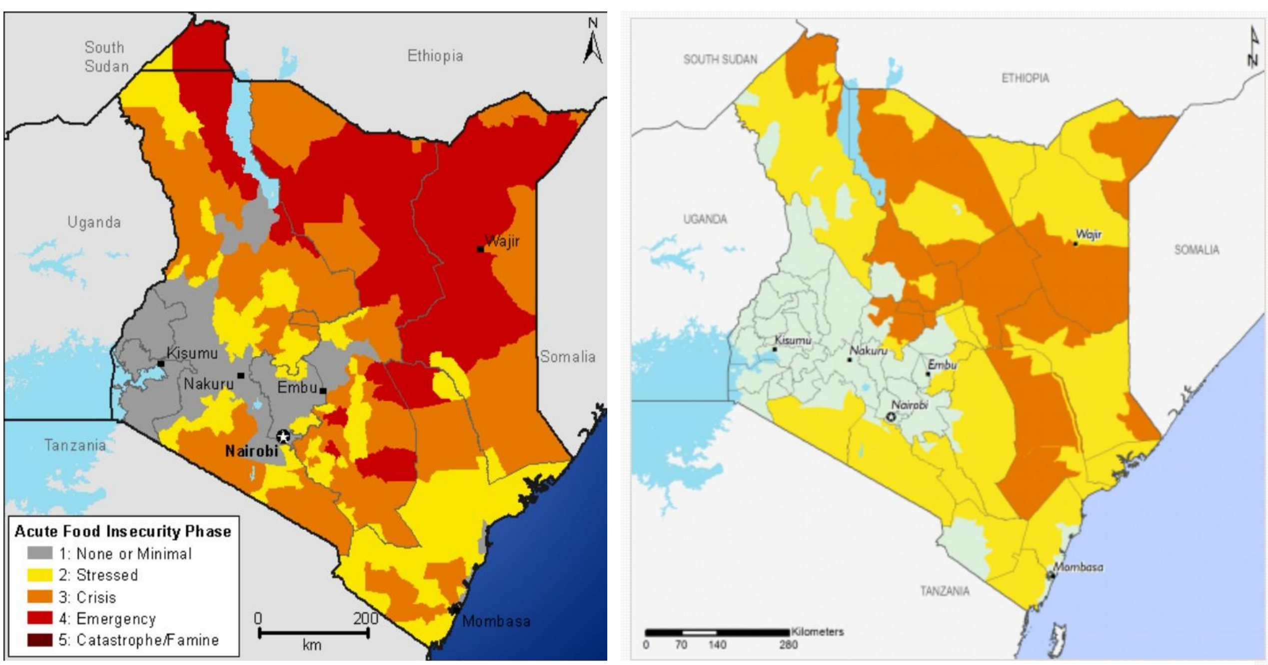

Figure 2. Food Security Outlook assessments made in October of 2011 (left) and October of 2017 (right) for October-January of 2011

larger than the number of severely hungry (IPC3+) Kenyans in 2017 (~1.75 million). However, it should be noted that the reported numbers are estimates, derived from a combination of quantitative and qualitative metrics and that the actual food insecure population might vary.

Food Security Outlook Brief data were graphed for October outlooks between 2011 and 2017 (Figure 3). The blue columns depict the total food insecure population (IPC 2+). The orange columns depict estimates of the very food insecure population (IPC 3+). This data indicates that while Kenyan food insecurity is quite prevalent and persistent in each intervening year, 2011, and to a lesser degree 2017, were substantially worse years. Overall food insecurity (IPC2+) was much more extensive in 2011 and 2017, and the depth (those classified as IPC 3 or above) of food insecurity was also substantially higher in 2011 than in 2017.

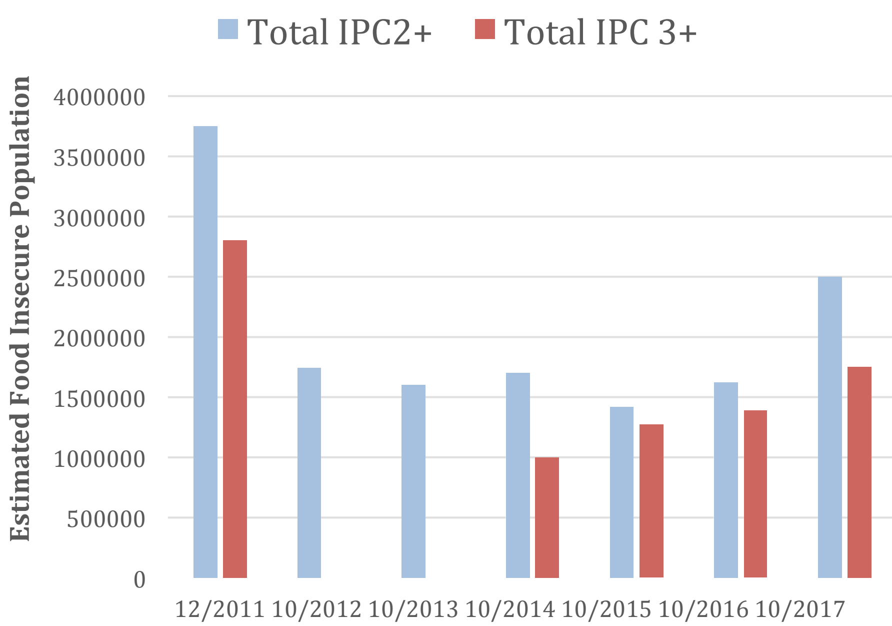

Figure 3. Time series of FAOB Food Insecure Populations for Kenya. IPC Phase 3+ estimates for 2012 and 2013 are not shown, since the data is not broken with this granularity.

We next use our historical October-December/March-May rainfall total time-series (Figure 4) to relate the depth of food insecurity in recent years with historical drought conditions. Estimates of the total number of IPC 3+ plus persons are used to represent the ***depth*** of food insecurity. Figure 4 shows rainfall totals and the number of IPC3+ people in 2011, 2014, 2015, 2016 and 2017. Overall, we find a strong but discontinuous relationship between consecutive seasonal rainfall totals and October Food Security assessments. Note the very large degree of rainfall variability, ranging from 200 mm to more than 500 mm. This corresponds to hydrologic conditions ranging from very poor (annual totals ~200 mm) to semi-humid (annual totals ~500 mm). At consecutive October-December/March-May totals of less than 300 mm, the number of food insecure people increases rapidly, and there appears to be a roughly linear relationship between rainfall and the extent of food insecurity. According to this metric, the total number of stressed or worse-off food insecure populations increased in proportion to rainfall deficits in 2011 and 2017, though we do see greater sensitivity in 2011 (red dot in Figure 4) than in 2017 (yellow dot in Figure 4). While it is hard to untangle all the complex factors that affect herd health, livestock terms of trade, immigration from Somalia, etc., **we would interpret these data as**

evidence of a substantial increase in resilience in Kenya, between 2011 and 2017. While the time-series of FIPE data does not extend back to 2008/09, including this time period might have further corroborated our results. FEWS NET reports from late 2009 indicate similar outlook conditions as shown for 2011 in Figure 3 – MOST of the country is classified as highly or severely food insecure, in stark contrast to 2017. While FIPE estimates and any estimation process will be inherently uncertain, the results from Figure 4 might suggest that an additional ~500,000 might have been in IPC3+, based on the sensitivity found for the 2010/11 crisis.

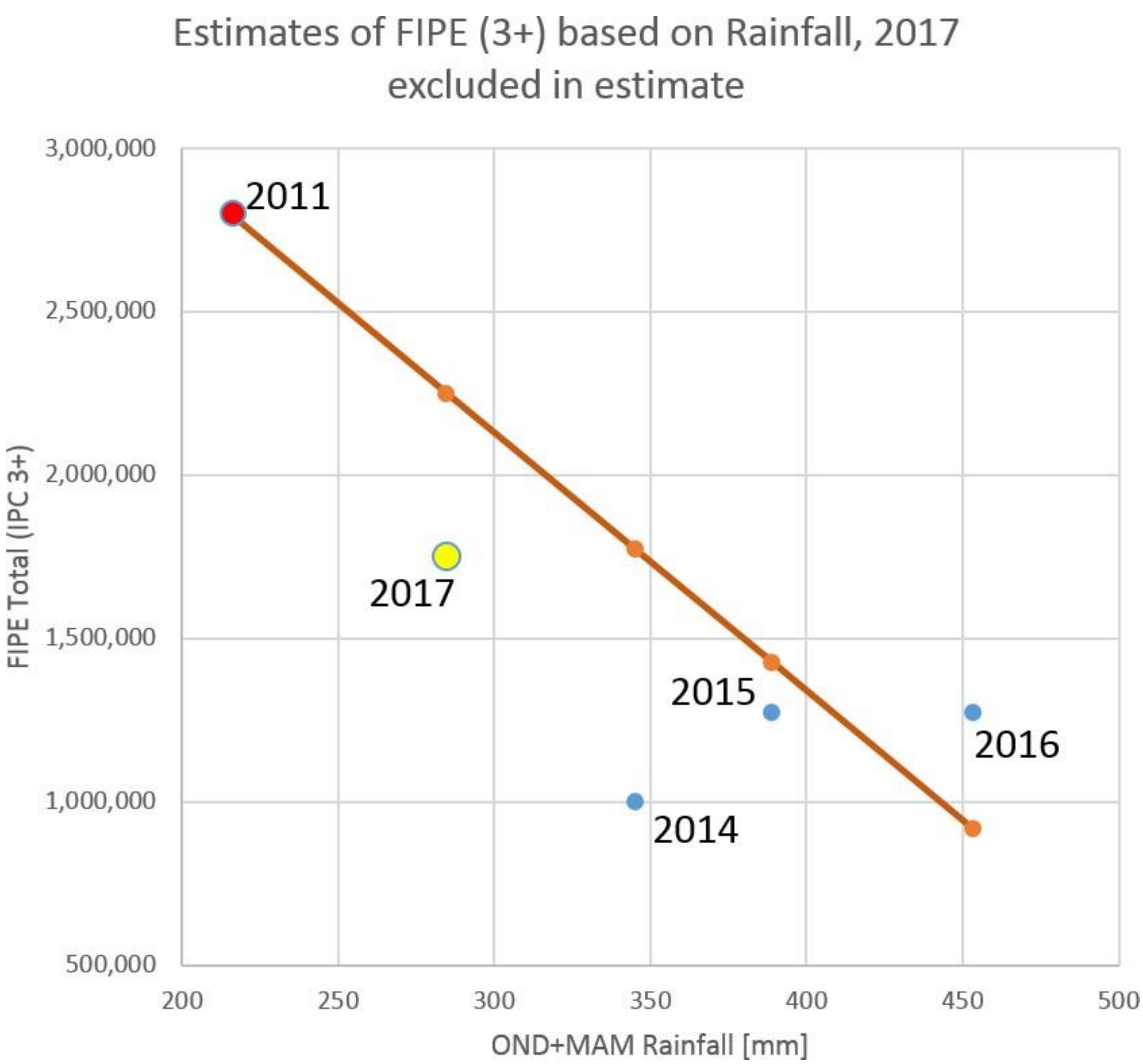

Figure 4. FIPE totals for IPC phase 3 or greater and back-to-back OND+MAM rainfall totals.

EXPENDITURES ON KENYAN FOOD SECURITY IN 2011 AND 2017

We now plot standardized rainfall time-series alongside deflated US government emergency relief expenditures in Kenya to show that the spending on the 2016/17 food emergency was much less than what might have been expected, given the relative severity of the drought. To represent drought intensity, we use analyses from October-December and March-May CHIRPS rainfall in the polygon shown in Figure 5. This region covers vulnerable arid and semi-arid land (ASAL) counties, as well as climatically exposed maize growing regions.

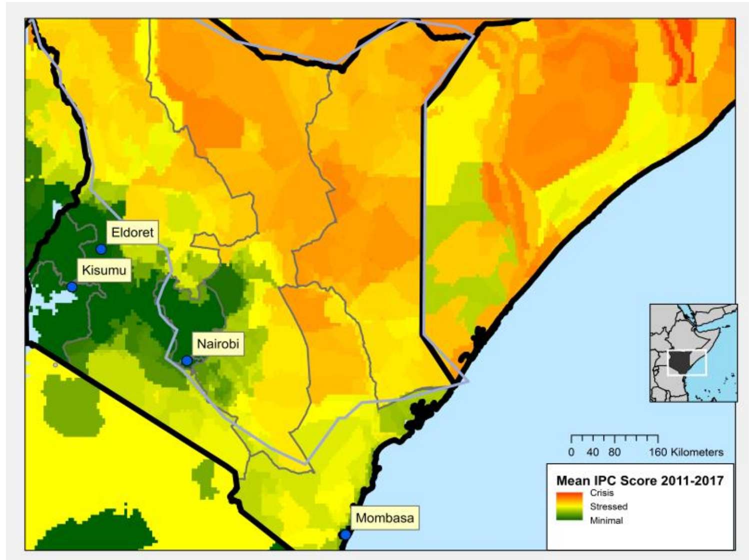

Figure 5. Average Integrated Phase Classification Scores from 2011-2017. The labeled points are the locations of major maize wholesale markets. The blue grey polygon shows the rainfall region used to characterize drought stress.

The spending data were derived from 2003-2015 International Food Assistance reports, updated for 2016 and 2017 using Food for Peace [emergency assistance figures](). These annual figures were deflated to 2009 levels using inflation estimates from the Kenya Statistical Agency. The years 2009, 2011 and 2017 clearly stand out as severe drought years that initiated substantial donor response expenditures. In US dollars the responses were \$134, \$125 and \$96 million in in 2009, 2011 and 2017, respectively.

After accounting for inflation, the corresponding expenditures were \$131, \$101 and \$52 million. Humanitarian responses require local grain purchases, logistics, transportation, and coordination – expenses which will scale with inflation in Kenya, which has been, on average, 8.6% since 2003. In inflation adjusted dollars, the overall magnitude of the US government humanitarian response in 2017 was relatively low (\$52 million).

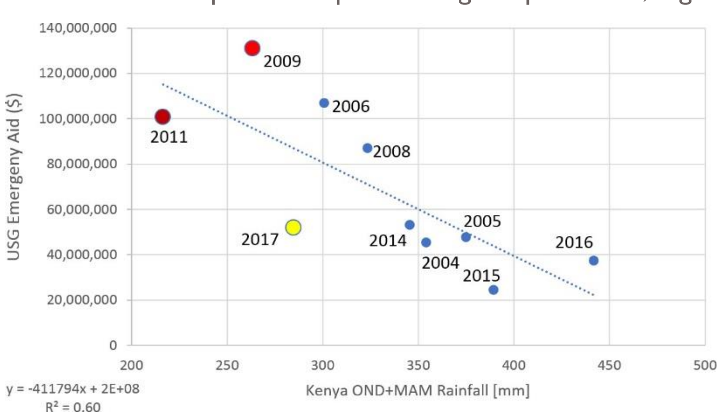

Figure 6. Inflation-adjust USG emergency responses and CHIRPS rainfall

Screening wet years (OND+MAM rainfall > 480 mm), and examining the relationship between inflation-adjusted USG responses and rainfall (Figure 6), we find a strong linear relationship (R^2~0.6). This relationship was estimated without using 2017 values. **This historical relationship indicated an expected ~$95 million US dollar response (in 2009 Kenya shillings), whereas the actual USG response was ~$52 million.**

SUMMARIZING INCREASED RESILIENCE OUTCOMES

Before turning to a brief analysis of crop production and maize prices, we recap our findings to this point. In deflated dollars, 2017 US government emergency food aid cost $52 million US dollars. Historic relationships (Figure 6) indicate that it 'should' have been about $90 million. Similarly, historic relationships (Figure 3) indicate that some 2.3 million people 'should' have been in IPC phase 3+, as opposed to the ~1.75 million identified by FEWS NET in 2017. Much of Kenya is still exposed to the impacts of severe drought, and the 2016/17 period pushed an expected number of people into some level of food insecurity, but **the depth and cost of this insecurity was substantially less than what we might have expected given the severity of the drought.**

MAIZE YIELDS, PRODUCTION AND PRICES

In order to better understand how drought translated into food access and food availability shocks, we now examine trends in two key indicators of Kenyan food security: maize production and maize prices. Given the magnitude and location of the 2016/17 drought, did the corresponding impacts on production and prices seem commensurate? Production and yields provide a rough indicator of food availability while prices can serve as a proxy for food access, while also aggregating perceptions about supply and demand. Both can be sensitive to climate shocks, but both are also functions of numerous other local and global socioeconomic factors.

MAIZE YIELDS AND PRODUCTION

In Figure 7 we plot maize yields (left panel) and maize production (right panel) for the six main maize producing provinces in Kenya. In each plot we highlight the periods from 2010-2011 and 2016-2017 and show the percent change in each of those periods. Changes from the prior year, during the 2011 to 2017 period, were not homogenous across all regions. For example, the Rift Valley, which covers the largest portion of Kenya and accounts for the majority of national grain production, saw a prior year production decrease of 20% in 2011 compared with 9% in 2017. On the other hand, the total level of maize production in the Rift Valley province was very low in 2017, and much lower than in 2011. When compared with the percent change from the prior year however, 2016-2017 was better than 2010-2011 in every region except for the Central. In the case of the Central region we believe that this due to the above average short rains in 2011, and below-average short rains in 2017.

These results may suggest that Kenya's agricultural resilience remains relatively low, which should not be too surprising, given that almost all agricultural production is rainfed. While crop production in Western Province is increasing, Rift Valley maize production may actually be falling off. Figure 8 presents national USDA maize production and harvested area estimates for Kenya, expressed as a function of United Nation population totals. By a per capita metric, 2011 crop production appears substantially better than 2017. Note that the overall level of crop production is very low (60 kg per person per year).

This low level of production is, in turn, a function of low yields, combined with very low and decreasing per capita harvested areas. More detailed sub-national analyses could explore regional differences in crop water use efficiency.

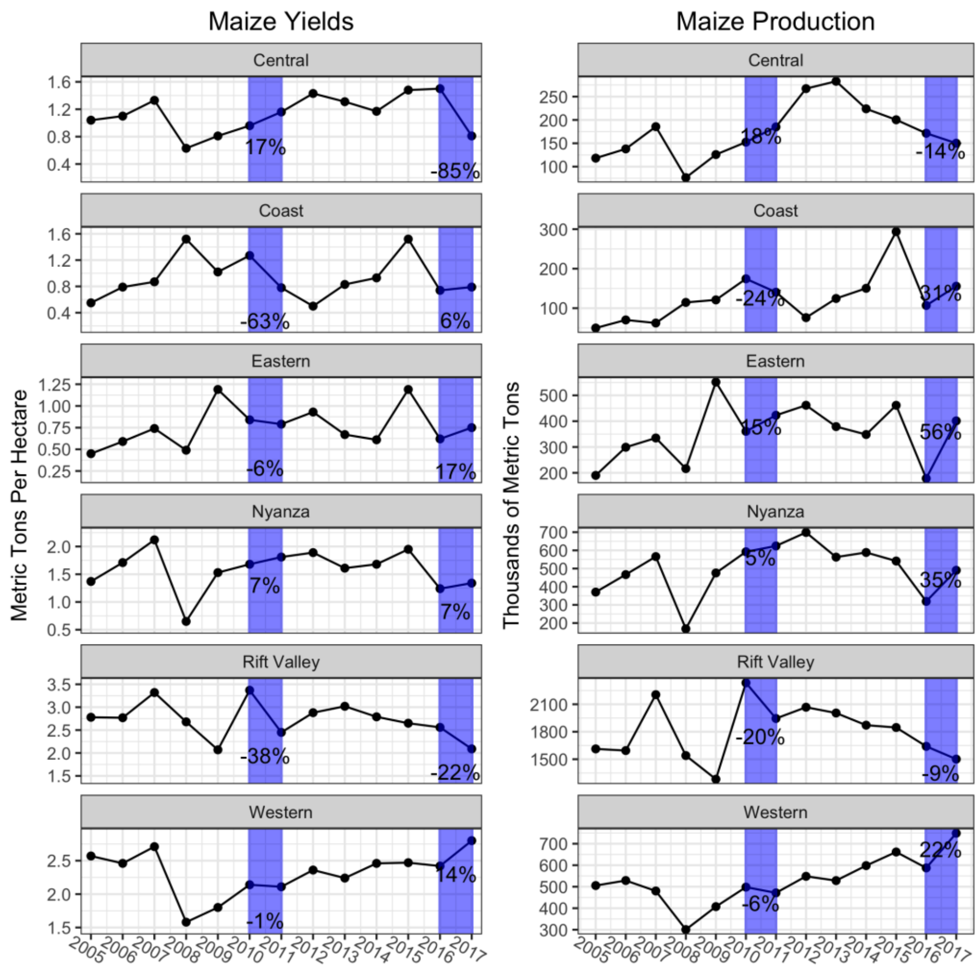

Figure 7. Maize Yields and Production 2005 to 2017. Note the range on the y-axes vary across panels to reflect the varying production and yield values across regions.

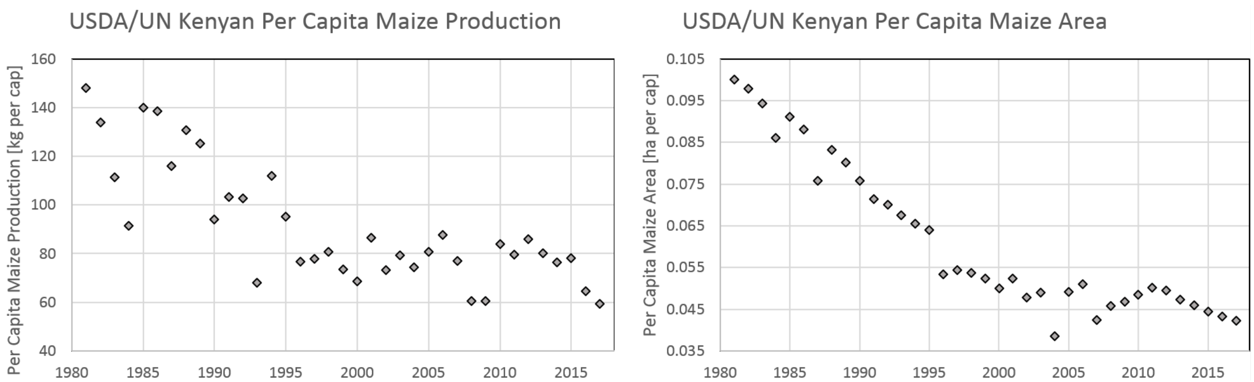

Figure 8. Kenya per capita maize production and harvested area.

MAIZE PRICES

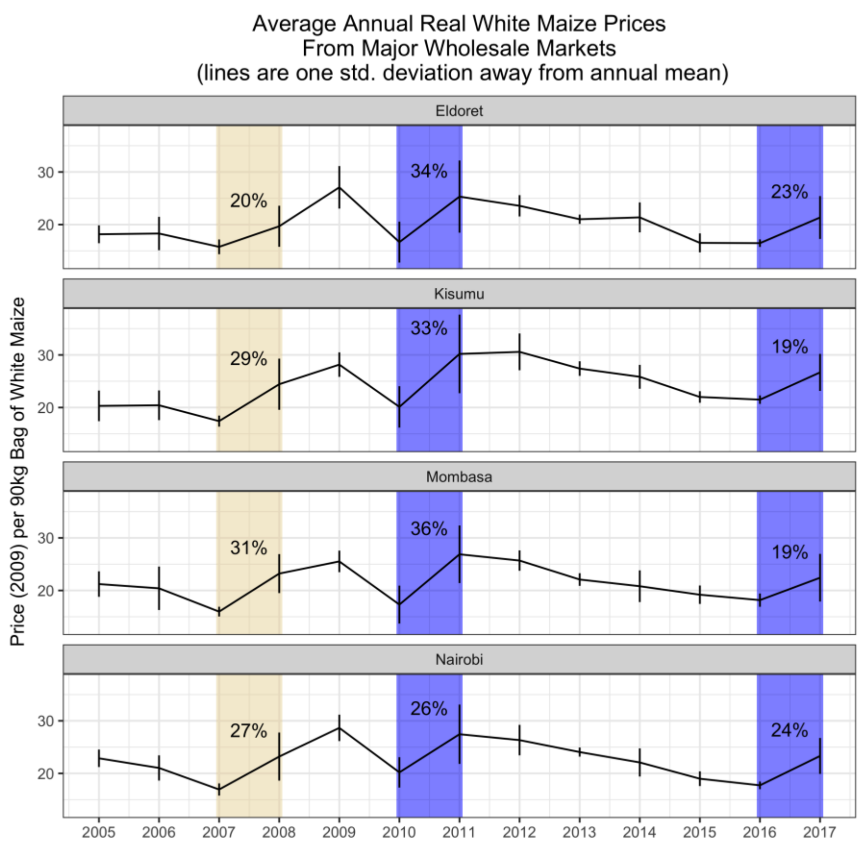

Figure 9. Average Annual White Maize Prices

We now examine relative changes in white maize prices from 2010 to 2011 and 2016 to 2017. In theory, wholesale maize prices should reflect supply and demand shocks from most of Kenya, and incorporate additional factors other than weather, such as imports and food-stock carry over. Figure 9 shows average annual deflated (to 2009) Kenya white maize prices from 2005 to 2017 in four major wholesale markets. Points show the average price over a calendar year while the lines show the standard deviation over the same period. The periods of interest (2010 to 2011 and 2016 to 2017) are highlighted in blue. For additional context we also highlight in tan another period of global price increase, 2007 to 2008. Percent changes in average annual price for each period of interest are also labeled on the graph.

Figure 9 illustrates several relevant facts.

- There was a large jump in average price in all markets in all three drought periods. But the 2010-2011 period saw the steepest jumps (ranging from 26%-36%) across the major wholesale markets.
- The relatively wide standard deviation of prices in 2007, 2011 and 2017 also reflect greater than average deviation as markets reacted with uncertainty to weather and other food security related shocks.
- It took several years for prices to recover after the price increase in 2011.

Considering that 2017 was climatically worse in key maize growing regions than 2011, the smaller price increases from 2016 to 2017 (relative to 2007/2008 and 2010/2011) suggest that markets were better equipped to deal with weather shocks in that period than in prior periods. We can explore this further by examining monthly price behavior within those calendar years. The top panel of Figure 10 shows the average maize price (across the wholesale markets) during each month of 2010, 2011, 2016, and 2017. The black line area shows the average price across all markets and years, and the shaded area is one standard deviation away from this line. Prices in 2011 were highest in both absolute terms (the highest spike in 2011 occurred in July at 37 KS per kilo) while the highest spike in 2017 occurred in April at 29 KSD. More importantly, by the end of 2017, prices had returned to the prior year lows, but by the end of 2011, prices remained above the mean and in fact, remained high for several years. The bottom panel of Figure 10 illustrates this point further by plotting the percent change from one year prior (this figure also includes the 2007-2008 period for additional context). As noted above, by the end of 2017 (dashed blue line, bottom panel of Fig. 10), prices appear to have recovered to prior norms while at the end of both 2007 and 2011 prices remained well above average levels. **The rapid normalization of prices in the recent period may indicate substantially greater market resilience to a national production shock than in 2011. However, other factors including government maize subsidies may also have played a role in price stabilization.**

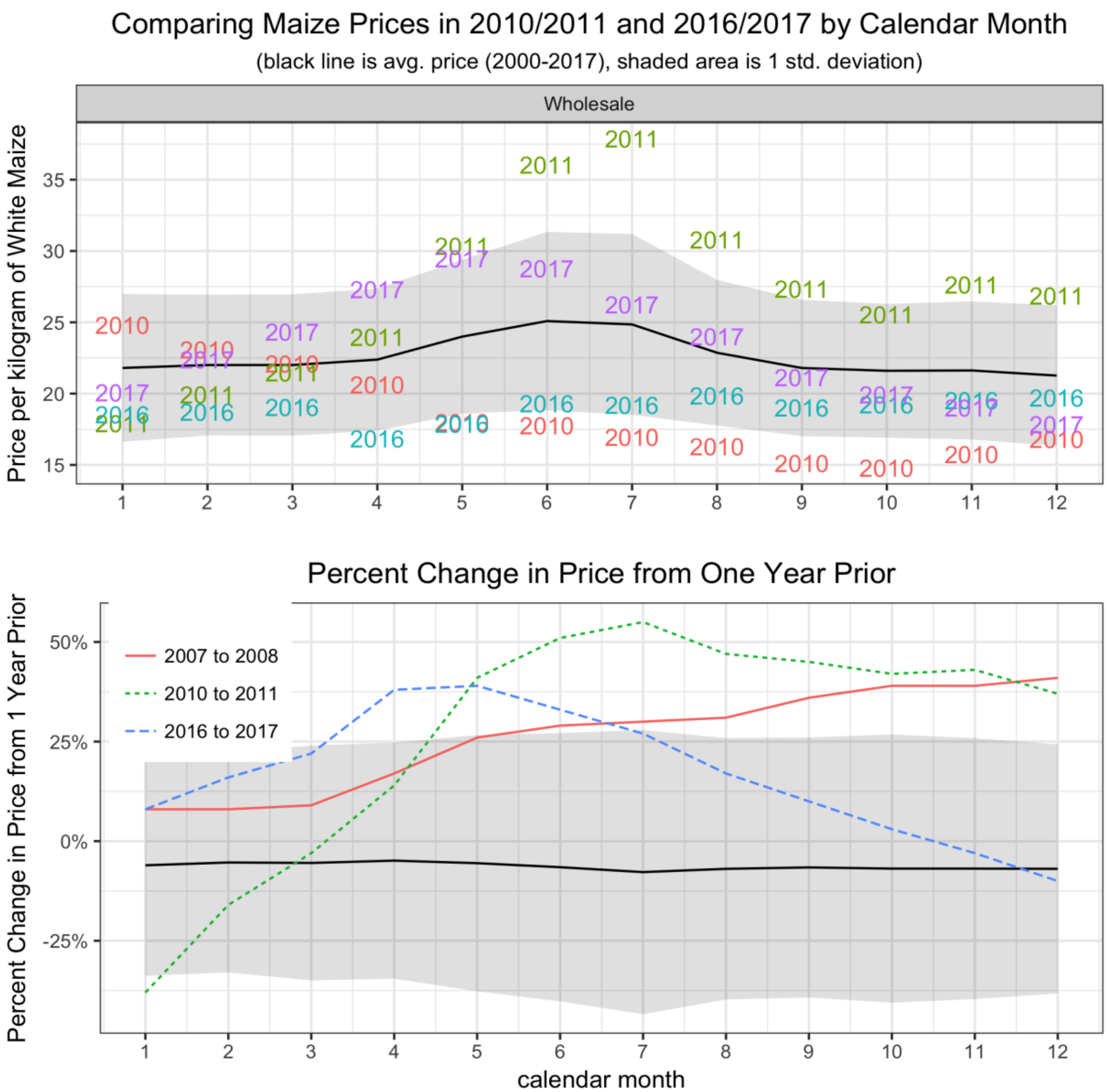

Figure 10. Top Panel: Maize prices in 2010/2011 and 2016/17 during the calendar year. Bottom Panel: Percent change from 1 year prior for each calendar month in 2007/2008 (solid red line), 2010/2011 (dotted green line), and 2016/2017 (dashed blue line).

SUMMARY AND DISCUSSION

Overall, these results appear to indicate a substantial, but partial, increase in Kenyan resilience to severe back-to-back hydrologic shocks. Poor Kenyans, and perhaps especially pastoralists, maintain high levels of exposure to consecutive severe droughts, which impact pasture conditions, food prices and terms of trade. In climatically bad years like 2010/11 and 2016/17, we see substantial increases in the **prevalence** of food insecurity, and overall prevalence rates still seem roughly proportional to the relative severity of the associated drought impacts. But, there also appear to be dramatic **reductions in the relative**

depth or intensity of the increases in food insecurity. While the exact estimates of FIPE values for IPC class 3 and 4 are volatile and uncertain, it seems fairly safe to conclude (as seen in Figure 1) that the intensity of food insecurity in 2011 was far greater than in 2017. The extent of food insecurity was quite similar in both years, but the depth was much greater in 2017.

Of course, there are a great many factors complicating this comparison. In 2011, global price shocks and the Somali famine and Somali refugee crisis certainly added to Kenyan food pressures. In 2017, however, Somalia, and now South Sudan, faced severe food crises. Eastern Kenya also experienced poor 2016 long rains, and poor 2017 October-December rainfall as well.

What these data may suggest is that Kenya still faces a fairly high level of chronic severe food insecurity, with more than one million people typically classified as IPC phase 3 or higher. Furthermore, Kenya still faces serious climate-food access coupling, especially when consecutive droughts strike. On the other hand, the ability to cope with these shocks, at a household, community or national level, appears to have increased. The specific mechanism for why this is the case remains a topic for further inquiry. In 2017, a proportional increase in the severely food insecure might have resulted in some 2 million severely food insecure people, but the FIPE numbers suggest that by far the largest response was a ~2.4 million increase in the number of people classified as stressed (IPC Phase 2).

Our analysis of price, crop production and disaster relief responses aligns fairly well with our results based on FIPE figures. The price and agricultural data do suggest that in 2017 Kenyans again faced major food access problems, with large price increases and severe long rains crop production deficits. Yet while 2017 maize production deficits may have been greater than in 2011, the corresponding price response was much shorter lived and smaller in magnitude. This suggests improvements in Kenyan markets and food transport systems, with better flows of commodities within the country and between countries, and also direct market interventions from the Kenyan government. Further analyses could investigate the effectiveness of government intervention for price stabilization as well as account for the impact of regional and global price volatility. The Kenyan economy is growing rapidly, with a 2003-2017 average inflation rate of 8.6%. Once this inflation is taken into account, there is a strong correspondence between rainfall deficits in normal-to-below-normal years and US government disaster relief payments (R^2=0.6). Inflation-adjusted 2017 relief payments were low ($52 million USD), and about half of what might have been expected given the severity of the drought ($97 million USD). Adjusting this number for inflation to produce an estimate of the 2017 USG emergency response in 2017 dollars, given the historical rainfall-response relationship, suggests that a larger response, akin to that required in 2011 or 2009, might have cost $175 million USD. Kenya appears to be more resilient in 2017 than 2011.

While these results are hopeful, it does warrant noting that Kenya's national agricultural situation continues to be concerning. This situation begins with Kenya's unique geography, with a large population dependent on limited highland growing areas, where cultivation has to compete with other forms of land use. This results in one of the lowest per capita harvested areas in Africa, just 0.04 hectares per person in 2017, with this value declining from ~0.05 in 1998. Small farm plot size may make innovation and increases in yields difficult. In Western Province agricultural statistics indicate modest increases in production, but these appear to be offset by decreases in production in the Rift Valley.

While the data analyzed here suggests that socio-economic resilience seems to be increasing, we do not seem to find evidence for large scale increases in agricultural resilience. While a detailed analysis of agricultural outcomes is beyond the scope of this study, we note that a continued reliance on rainfed agriculture, combined with agricultural extensification into drier warmer and more exposed growing areas might account for some of this lack of resilience. Kenya's agricultural expansion has been mostly in the drier central and eastern parts of the country, and analyses of plot level data suggest that the use of improved crop varieties and fertilizer can only partially offset Kenya's tendency towards drier and warmer conditions[1].

One goal of this study was to evaluate how new FEWS NET data products, namely the FSO maps, FIPE data, price time-series, and agricultural statistics, might inform questions surrounding resilience. The results appear promising. While the spatial and temporal granularity of FIPE and FSO assessments are probably inadequate to fully support measuring 'resilience' when defined as a dynamic response to shocks, they do appear adequate to denote the prevalence and magnitude of food insecurity. Using this data, we suggest that Kenya has become more resilient to severe climate shocks, especially when measured based on depth. The depth of food insecurity was much greater in 2009 and 2011 than in 2017, and the inflation-adjusted USG disaster responses were proportionally much greater as well.

While also imperfect, market price data and agricultural statistics provide independent sources of information with higher spatial and temporal resolution. This data provides a convergent picture of how 2011 and 2017 evolved. The agricultural data suggest a 2017 climate shock on par, or perhaps worse, than 2011, while the price time-series suggest a market response with substantially lower price volatility.

More detailed sub-national spatial analysis of price and agricultural data could be carried out. Recent analyses have explored, for example, the adoption of fertilizer and seeds in Kenya (Davenport et al. 2018), and more analysis of the sub-national agricultural statistics might highlight regions where more 'crop-per-drop' seems plausible. This study also showed that the majority of agricultural expansion appears to be in the central and eastern parts of the country, where rainfall is more variable and the long rains are declining. Sub-national analyses of market prices have also indicated regions (like Marsabit and Mandera) which appear to be uncoupled to the national markets, potentially indicating places where improved transportation and market infrastructure could decrease prices and price volatility (Davenport et al. 2015). There appear to be many ways in which FEWS NET data resources can contribute to analyses of resilience. Similar analyses could be replicated in other countries.

Representative questions might include:

[1] Davenport et al. (2017) https://link.springer.com/article/10.1007/s10584-018-2149-7

- How much food assistance is required to "replace" crop production lost to the recent drought?
- What is the best metric, or combination of metrics, that can be used to provide gauge the food secure status of predominantly pastoral populations?
- Where did the drought actually occur, and where not, and where should crop insurance pay-out?
- Which populations have become more or less resilient to weather induced production shocks?
- To what degree are food prices being driven by local growing conditions, versus global price drivers?
- To what degree is water scarcity driving malnutrition?
- How might the aggregate cost of droughts drive programming priorities?

The 2010/11 drought was more intense or severe compared to 2016/17, and, only comparable to 1984/85 and 2000/1, which were the most devastating droughts in recent history for Kenya. The 2016/17 drought, however, was more geographically extensive and prolonged. The drought penetrated into key agricultural areas of Kenya, which are highly productive and relatively more populous than those affected in 2010/11 (Figure 11). Prevailing Land Surface Temperatures (LSTs) were on average much warmer during the 2016/17 droughts, as opposed to the 2010/11 dry spells, accelerating crop, rangelands and water-resources stresses and losses (Figure 12). The population of Kenya, has increased by 8M people (20%), from about 41M in 2010/11, compared to about 49M people in 2016/17, with highly populous areas falling under the 2016/17 drought epicentre. As shown earlier, the data indicate that the 2016/17 drought should have been costlier and more damaging. While more exploration into the factors averting such a crisis will be needed, it seems likely that i) improved EWS (Forecasting & Monitoring Systems), ii) more frequent and targeted drought assessments, iii) well informed/sensitized and targeted subsidies for maize prices that facilitated increased access to food, and iv) effective long-term development programs in support of resilience planning/building played an important and positive role. Even though Kenya is becoming drier and hotter (Figure 13), resilience appears to be improving.

Because FEWS NET has an on-going technical interest in understanding the concept, and human and humanitarian implications, of resilience, FEWS NET can examine these issues from a unique data-driven perspective. Most of the evidence used in this study is a product of FEWS NET's own labor and investment of resources, and it therefore constitutes an accessible and low-cost pathway for regular assessments of these conditions in Kenya in the future, as well as in many other countries with FEWS NET coverage.

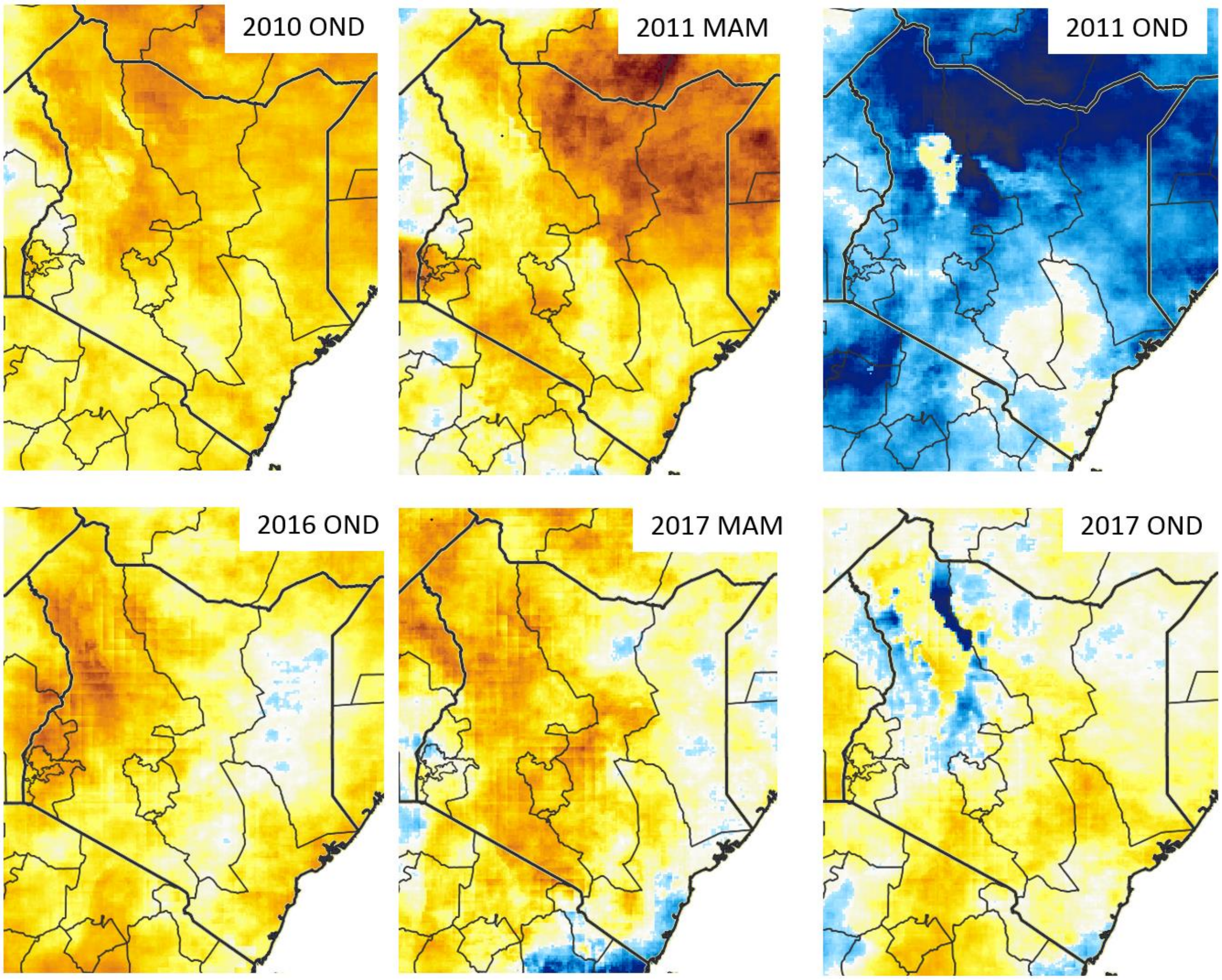

Figure 11. Meteorological Drought Dimensions based on CHIRPS/z-Scores

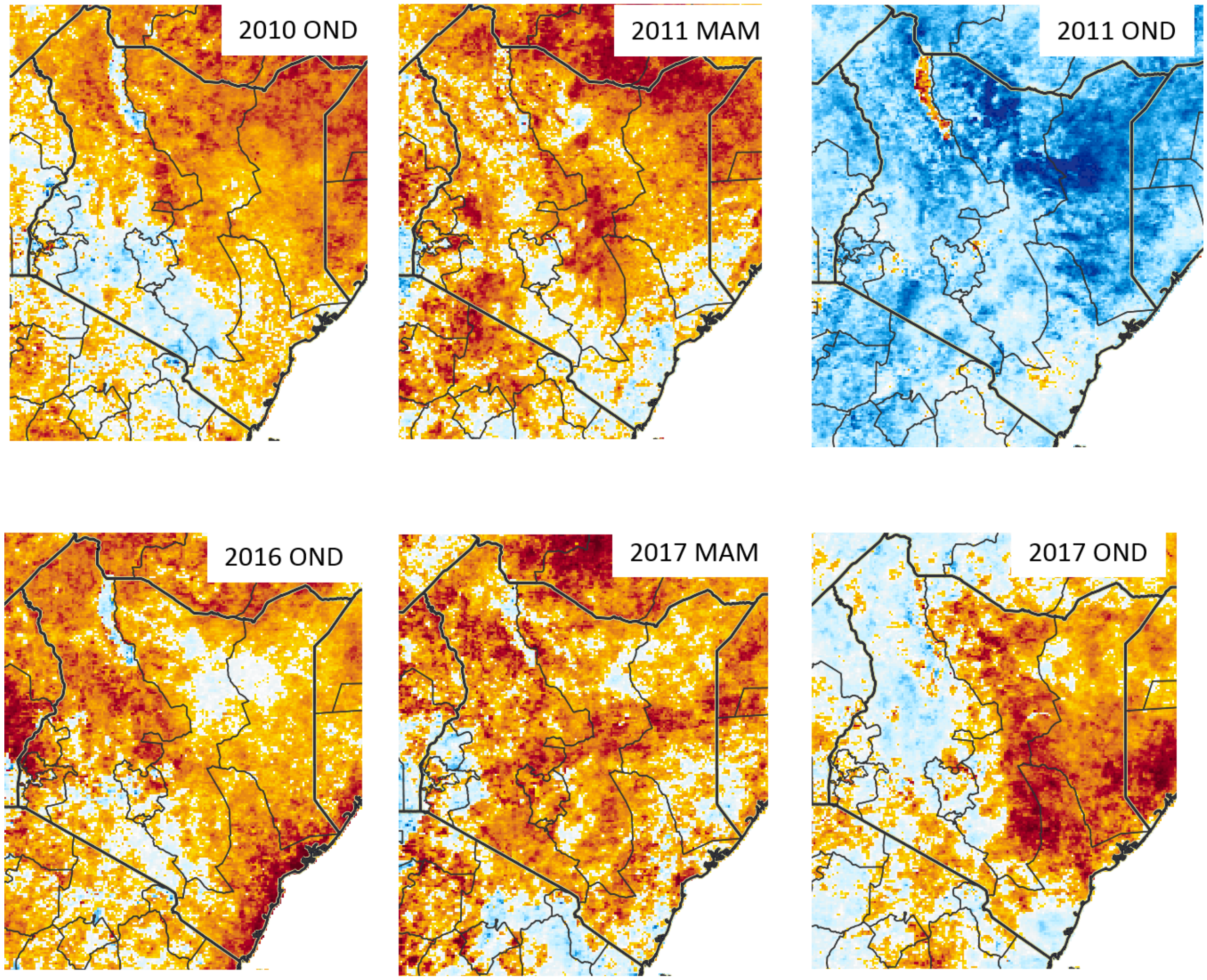

Figure 12. Meteorological Drought Dimensions based on Land Surface Temperature Z-Scores

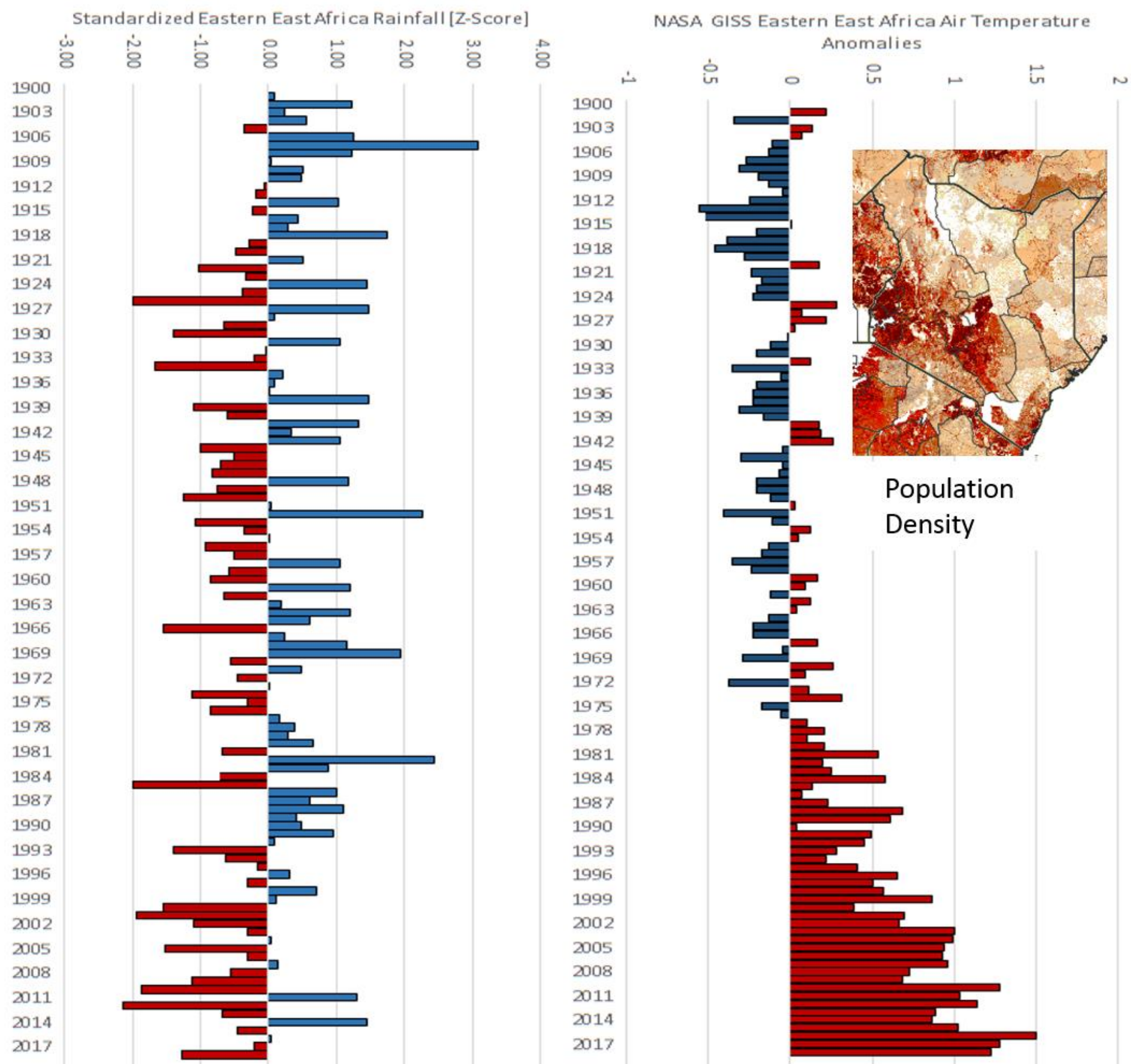

Figure 13. March-May standardized rainfall for central-eastern Kenya (left) and annual air temperature anomalies (right). Also shown are Landscan population densities.

Relevant Publications

Funk, C., Eilerts, G., Davenport, F., and Michaelsen, J., (2010) A Climate Trend Analysis of Kenya-August 2010, USGS Fact Sheet 2010-3074: http://pubs.usgs.gov/fs/2010/3074/pdf/fs2010-3074.pdf

Williams P. and C. Funk (2011) A westward extension of the warm pool leads to a westward extension of the Walker circulation, drying eastern Africa, Climate Dynamics, V37.11-12, p. 2417-2435. http://www.springerlink.com/content/u0352236x6n868n2/fulltext.pdf

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Funk, C., Hoell, A., Shukla, S., Bladé, I., Liebmann, B., Roberts, J. B., and Husak, G. (2014). Predicting East African spring droughts using Pacific and Indian Ocean sea surface temperature indices. Hydrology and Earth System Sciences Discussions, 11(3), 3111-3136.

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