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Covid-19 Bulletin

Maize Production Forecasts in Northeast Africa: The case of Uganda, Kenya, and Ethiopia.

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The COVID-19 pandemic continues to impact economies around the world. While most countries have lifted restrictions on mobility, protective measures such as mandatory use of masks, COVID-19 screenings for travelers, and bans on large public gatherings remain.

Most governments have revised the countries' estimated economic growth rates downwards due to the pandemic's shocks. As a response, they subsequently provided stimulus packages to support both the private and public sectors.

Policies implemented by countries to mitigate the spread of the COVID-19 pandemic have added to disruptions of national economies. These policies have put a massive strain on different sectors of the economy and communities' livelihoods. One of the biggest fears is that the pandemic and the public health measures taken to mitigate its impacts could also affect agricultural production and could trigger a potential food crisis in many parts of the world, especially in Africa. While on the health side, official data shows that Africa is currently less affected by the Covid-19 pandemic compared to the rest of the world, there have been several impacts on African economies, which are primarily dominated by the informal sector and, as such, are highly dependent on the mobility of their populace.

In the agricultural sector, some undesired consequences on food production include input scarcity, the shortage of agricultural workers, limited access to export markets, and disruptions to the food supply, including imports. For countries with mono-seasonal food crops, late delivery and use of imported seeds and fertilizers can disrupt their agricultural production activities. Good planning by governments and other decision-makers is crucial to anticipate and mitigate the potentially detrimental effects on the agricultural sector to prevent a food crisis. Evaluating how much food is expected to be produced

FINDING A SOLUTION TO THE PROBLEM OF FOOD CROP PRODUCTION DATA

From effects on access to seeds and fertilizers, limited movement of goods, declining demand, to labor shortage, the disruptive impact of Covid-19 on food production systems is real. The challenge here is not only the likely extent and complexity of the disruptions but also the difficulty to identify and track them in real time. Unlike the propagation of the disease itself which can be tracked through testing and tracing, it is impossible, even in normal times, to have accurate information on cropping activities. The introduction of confinement and other measures to control the pandemic make the situation even more difficult. There is no way of knowing whether farmers have access to inputs, in time or in adequate quantities, whether they have been too sick to tend to their farmers or could work only partially. One would eventually find out at the end of the growing season from the impact of harvested quantities. One is then left to play catch up to deal with a crisis situation.
The complete lack of information about growing conditions can be overcome by using today's digital technologies. Remotely sensed data allow to track in real time changes in vegetation cover, weather data and other parameters related to cropping activities. Recent developments in machine learning and computer modeling make it possible to track and predict crop production using these data. The benefits go far beyond the ability to overcome the obstacles to data gathering during crises. The many weaknesses hampering the access to good quality agricultural statistics also can be overcome using the same digital technologies, from measuring arable land, planted areas, crop yields to the spatial distribution of harvested quantities. Our scientists are using these technologies to assess changes in food production systems during the pandemic and thereby provide valuable information to tackle the impact of the pandemic among local communities.

Ousmane Badiane, Executive Chairperson provides a better assessment of food security and allows for a more precise and disaggregated understanding of threats to livelihoods.

The complexity of the pandemic's ramifications and the difficulty of observing changes on the ground in a context of already weak data systems often lead to relatively passive approaches to dealing with production disruptions. One discovers the damage at the end of the growing season when it becomes clear where production has fallen short and where not. Although the Covid-19 pandemic may serve as a trigger, there has been a need for some time for Africa's agricultural sector strategy to shift to harnessing data-driven approaches for better data-gathering techniques and planning. The recent developments in machine learning and the access to disaggregated remotely sensed data have opened a new momentum in tackling complex uncertainties through location-sensitive predictive modeling.

On the one hand, supervised machine learning techniques, in contrast to rule-based approaches, tend to solve problems through "learning" from a large number of examples of historical explanatory variables along with their equally large number of corresponding outcomes, even without initial learning hypotheses. Such characteristics confer learning machines the ability to discover data patterns invisible to humans and use these patterns to predict future states. On the other hand, remote sensing, through satellite images, makes it possible to detect earth features such as agricultural land and vegetation with a relatively high observation frequency. One of the most valuable features of satellite-based, remotely sensed data is their spatial resolution, which allows the availability of highly disaggregated data over time and across space.

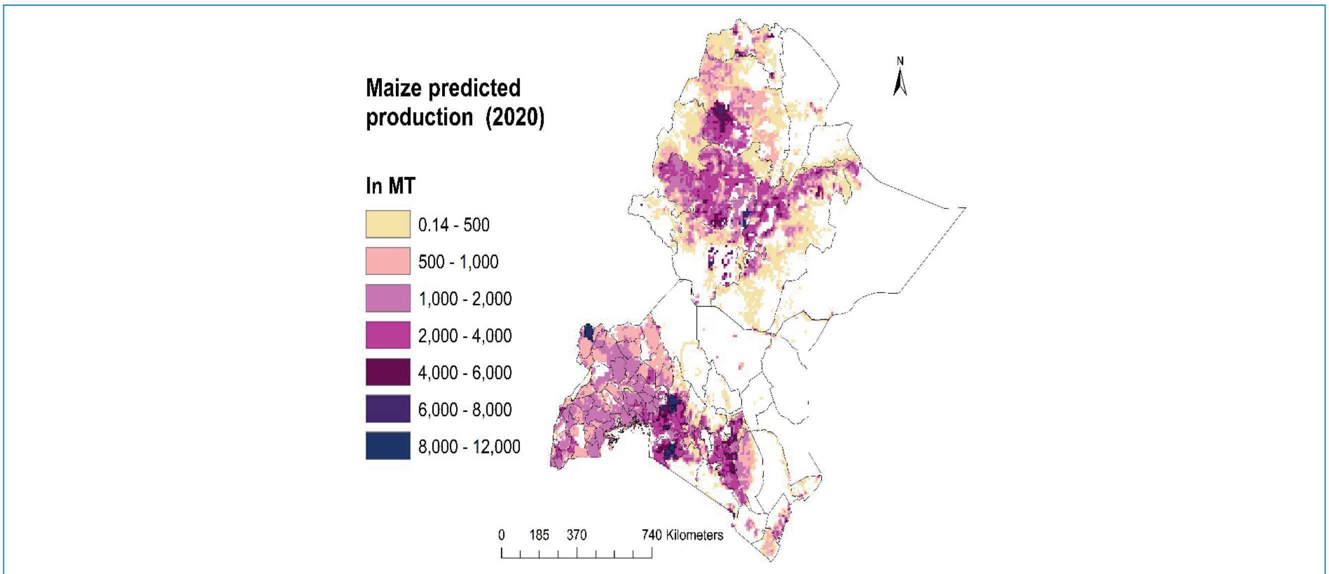
Data scientists at AKADEMIYA2063 assembled remote sensing products and applied machine learning techniques (Ly & Dia, 2020) to estimate maize production for the current agricultural season in Uganda, Kenya, and Ethiopia. The findings show that it is possible to produce accurate production and yield forecasts, for individual crops and large geographic areas, in a relatively short time and use them as inputs in designing and executing agricultural and food policies and programs. Moreover, improved forecasting capacity in the light of possible widespread disruption of production systems from increasingly frequent weather shocks represents a critical component of future readiness to effectively respond to events such as the Covid-19 pandemic and mitigate their effects on local food systems. In its current application, the model examines the spatial distribution of maize production and yields at a pixel level across several countries in Eastern Africa. The findings discussed below illustrate how it can be applied to deal with a larger number of crops and countries to raise our capacity to observe and monitor cropping seasons' progress and detect early signals of shocks or disruptions.

Overview of production and yield estimations in selected countries

Maize is an important staple food in the Northeastern African region and the most widely traded agricultural commodity. Therefore, it has a significant impact on people's welfare, particularly the poor, and is critical to inducing pro-poor growth in Kenya, Ethiopia, and Uganda. In the following sections, we present the results for maize production in 2020 from our forecasting model and contrast them with 2017 production levels to assess the direction of changes. *Figure 1* shows the map of predicted 2020 maize production across the three selected countries. It shows that the highest levels of expected production are located in central Ethiopia, northern Kenya, and western and northern Uganda.

According to the United Nations Food and Agriculture Organization (FAO), the three countries' aggregated

Figure 1. *2020 predicted maize production for Ethiopia, Kenya and Uganda. Pixels are 10 by 10 km in size. Predicted data and map source: Authors*



maize production was around 14.3 million metric tons in 2017. The most significant contributor is Ethiopia (54.2%), followed by Kenya (25.8%) and Uganda (20.0%). Our model suggests an aggregated maize production of close to 13.4 million metric tons for the same countries in 2020, which corresponds to a decrease of 6.0% compared to 2017. However, the contribution of each country remains similar to what has been observed in 2017. Indeed, based on our forecasts, Ethiopia, Kenya, and Uganda account for 52.7%, 26.7%, and 20.6% of total production, respectively.

When it comes to projected yields (*Figure* 2), which have been estimated as the ratios between predicted 2020 production levels and MapSPAM harvested areas, it appears there is a different geographical distribution compared to that of production. Maize yield variability can be affected by initial conditions such as the suitability of the farming method. However, exogenous factors, such as national policies, agro-ecological zones, and foreign market conditions, often directly influence farm yields. In most areas, predicted maize yields in 2020 range between 2 and 4 MT/ha. However, for most countries, there is some spatial variation in yield levels. Yields are particularly high, in relative terms, in some parts of northern and southern Uganda. For Ethiopia, high-yield areas represent small, sparse spots. The lowest forecasted maize yield is located in Kenya.

Figure 2. *Estimated maize yield for the 2020 agricultural season. For each pixel, the production value is divided by the corresponding harvested areas retrieved from the MapSPAM database. Map and data source: Authors*

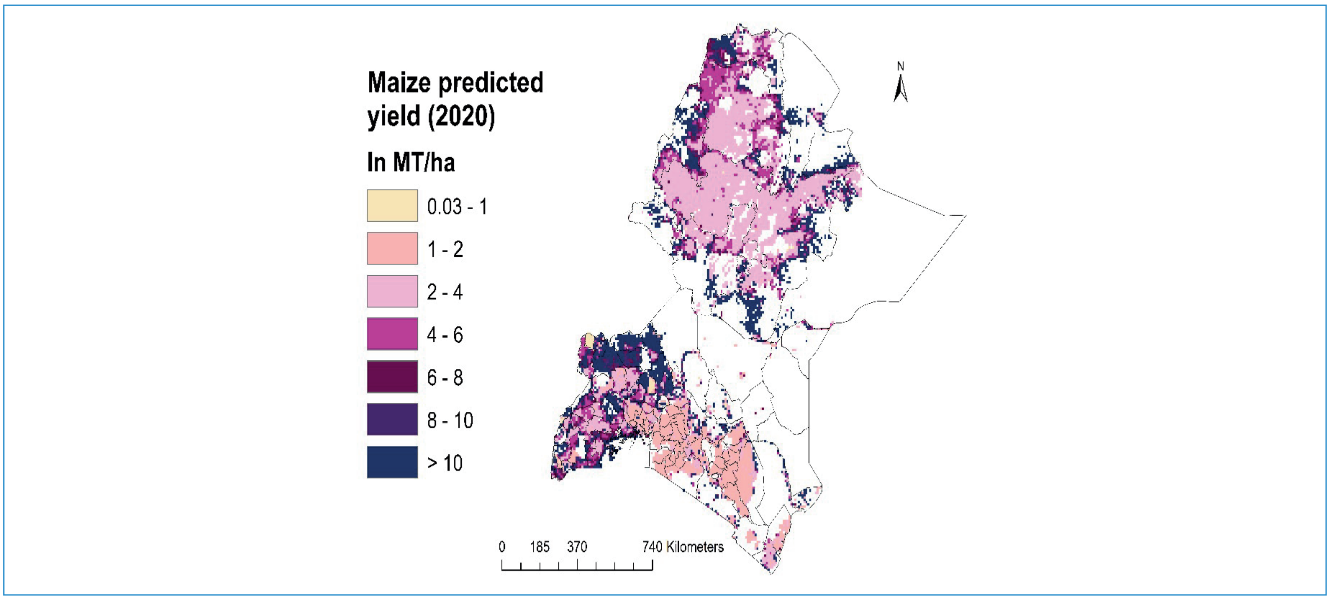
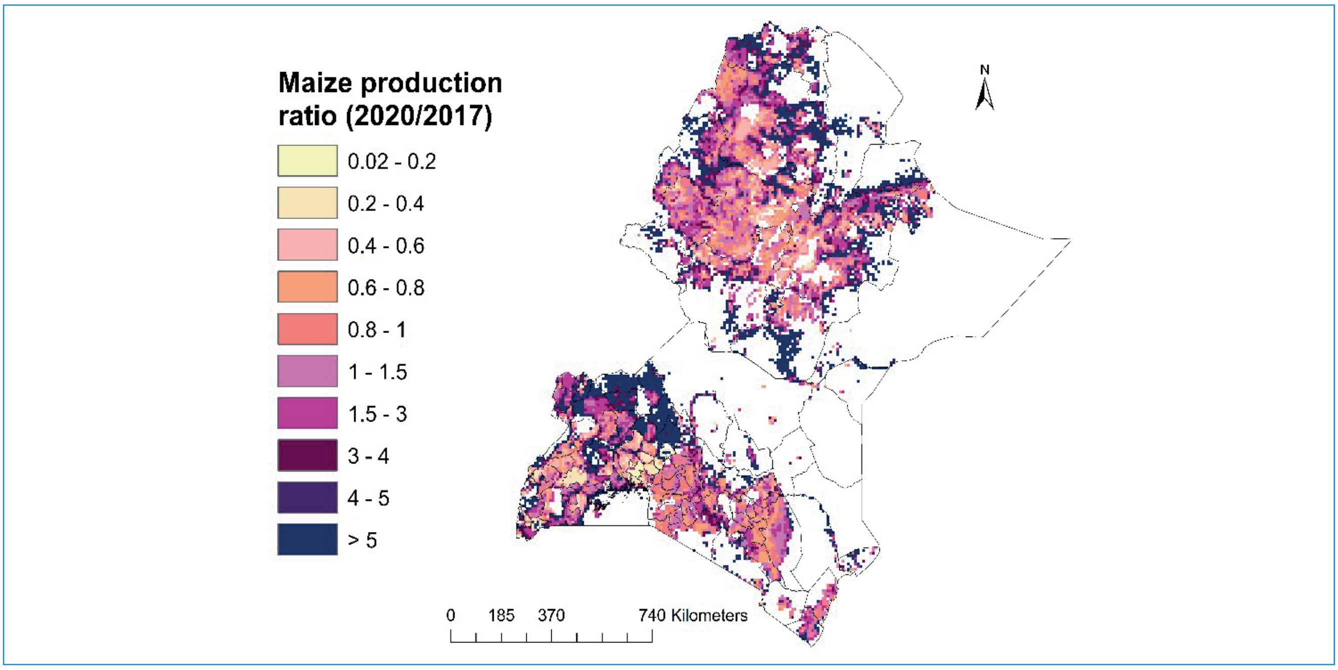


Figure 3. *Predicted 2020 maize production as a fraction of 2017 production. Values under unity mean that 2020 production is less than 2017 production. Pixels are 10 by 10 km in size. Map and (computed) data source: Authors*



Maize production changes in 2020 across the countries of interest

Figure 3 shows the ratio between predicted maize production for the 2020 season and levels in 2017. The map suggests disparities in maize production for the 2020 season compared to 2017. Indeed, maize production is likely to decrease by 8.7% in Ethiopia, 2.4% in Kenya, and 3.1% in Uganda from 2017 to 2020. However, the disaggregation at pixel level reveals disparities within each country, with higher production zones alongside those projected to have lower production levels in 2020.

The above findings illustrate the promise of combining machine learning algorithms and remote sensing to augment available data and produce valuable insights into the behavior of agricultural production systems. While data gathering remains a significant challenge in regular times and significantly more so during crises such as the current pandemic, the recourse to remotely sensed data and information changes how data scarcity can be tackled in Africa. More importantly, applications such as machine learning make it possible to extract a large amount of useful information and knowledge otherwise hidden in the data. AKADEMIYA2063 is harnessing this opportunity to leverage data-driven approaches to solve the agricultural sector's most pressing issues. Through the Covid-19 publication series, the AKADEMIYA2063 team of data scientists takes a holistic approach—with available datasets—to treat and provide policy-relevant data for policymaking processes. The team does this by predicting food crop production, assessing changes in growing conditions, and analyzing shifts in yields. This bulletin is the second to focus on several countries in the same region.

Note

The boundaries, names and designations shown on maps do not imply official endorsement or acceptance by AKADEMIYA2063.

Background documents

Ly, R., & Dia, K. (2020). *Application of Remote Sensing and Machine Learning for Crop Production Forecasting During Crises.* AKADEMIYA2063. Kigali: AKADEMIYA2063.

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