

Remote Sensing Data for Monitoring Agricultural Production and Economic Activity

Application in Egypt

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This policy note showcases two examples on how remote sensing data can be used for monitoring agricultural production and economic activities. The first case aims to generate granular data on agricultural production, which remain scarce in Egypt and the MENA region. The second case demonstrates the potential of remote sensing data to monitor economic activities during the COVID-19 pandemic. Based on these data and together with other recent findings, we provide the following recommendations to facilitate post-COVID-19 recovery in Egypt:

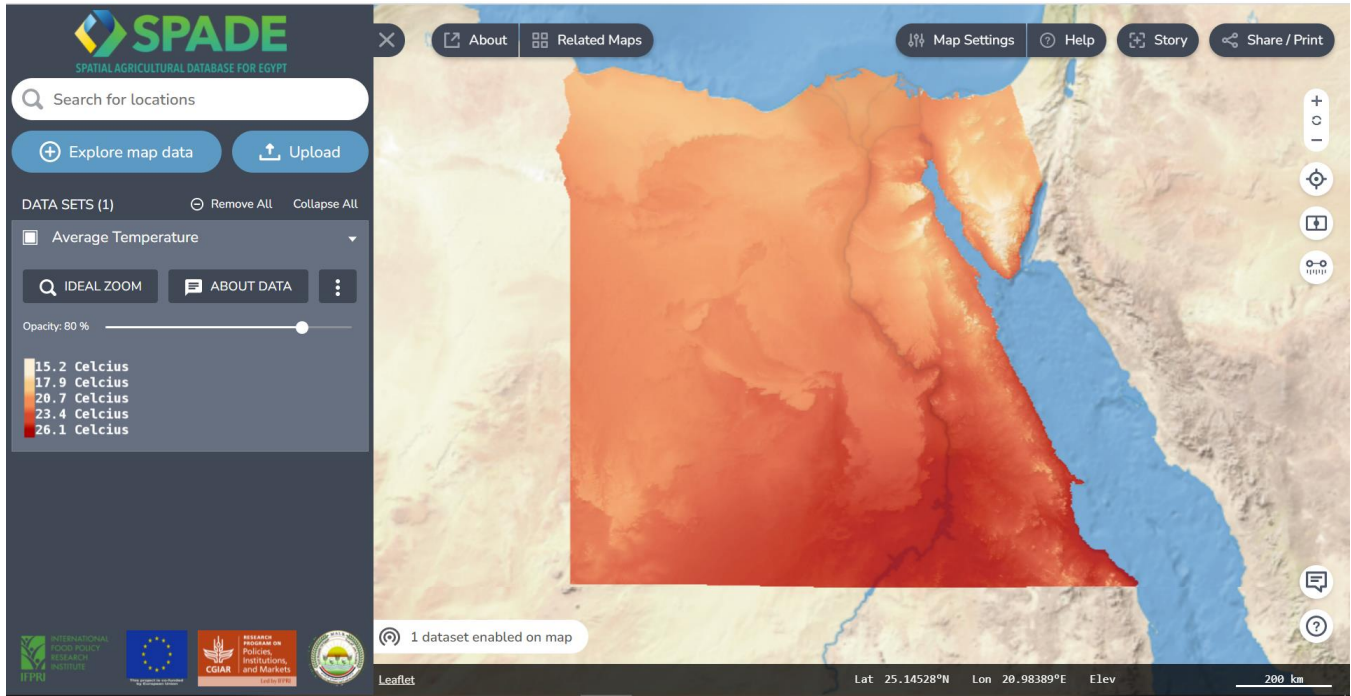
- ▶ Targeting of stimulus and recovery packages based on the economic repercussions experienced across geographies and sectors
- ▶ Identifying and supporting promising value chains which experienced a significant slowdown in economic activities
- ▶ Diversifying economic activities and markets to improve the resilience of agri-food systems.
- ▶ Investment in data infrastructure to monitor and respond to future shocks. This may be supported by scale up of digital solutions, which proved to be effective in sustaining business activities even during the pandemic.

Introduction

High-quality agricultural data are critical for measuring countries' progress towards the Sustainable Development Goals (SDG). For example, measuring progress towards SDG2.3 (doubling productivity and income of small-scale food producers) requires repeated and accurate production data. Granular data on agricultural and other economic activities are also equally important for evaluating and monitoring current state of agriculture (e.g., yields, cultivated area and production of different crops). Similarly, understanding the impact of contemporary shocks, including pandemic of the type of COVID-19, on various sectors and portions of households require timely and accurate data on various economic activities. However, the Middle East and North Africa (MENA) region, including Egypt, faces substantial challenges of data scarcity (Hoogeveen, 2022; Rizk et al., 2021; World Bank, 2022). Conventional data sources and nationwide data collection efforts are missing. In those limited cases where some datasets are usually collected, only a fraction is made publicly available (Ekhatior-Mobayode and Hoogeveen, 2021). The COVID-19 pandemic has, additionally, increased the urgency and needs for accurate data on economic activities while also effectively limiting traditional face-to-face data collection methods. This inhibits researchers' and policymakers' ability to understand the sectoral and household-level impact of the pandemic.

The advent of new sources of data, mainly remote sensing data, provides new opportunities to inform monitor agricultural production and economic activities in these data-scarce regions as well as in contexts where and when traditional data collection methods are not feasible. These data are objectively measured, and they are widely available, although most not readily available for end users (e.g., policymakers, researchers, and practitioners). In this note, we showcase two examples on how remote sensing data can be used for assessing agricultural production and economic activities and finally how they may be availed to final users. Using the approaches and data sources we describe below, we built a digital agricultural database, namely the [SPatial Agricultural Database for Egypt \(SPADE\)](#) (Figure 1). SPADE is a comprehensive digital database for agricultural statistics on Egypt, which consolidates publicly available, though often scattered spatial and remote sensing data. As an easy-to-use tool, it allows users to select indicators to overlay on the map, including development over time and all related description information (e.g., time series of climate). Users may also download the underlying data. SPADE's database houses over 1000 datasets and layers organized into the thematic areas of Agriculture, Agroecology, Demographics, Urban Area and Markets, Soil and Water.

Figure 1: The overview of SPADE



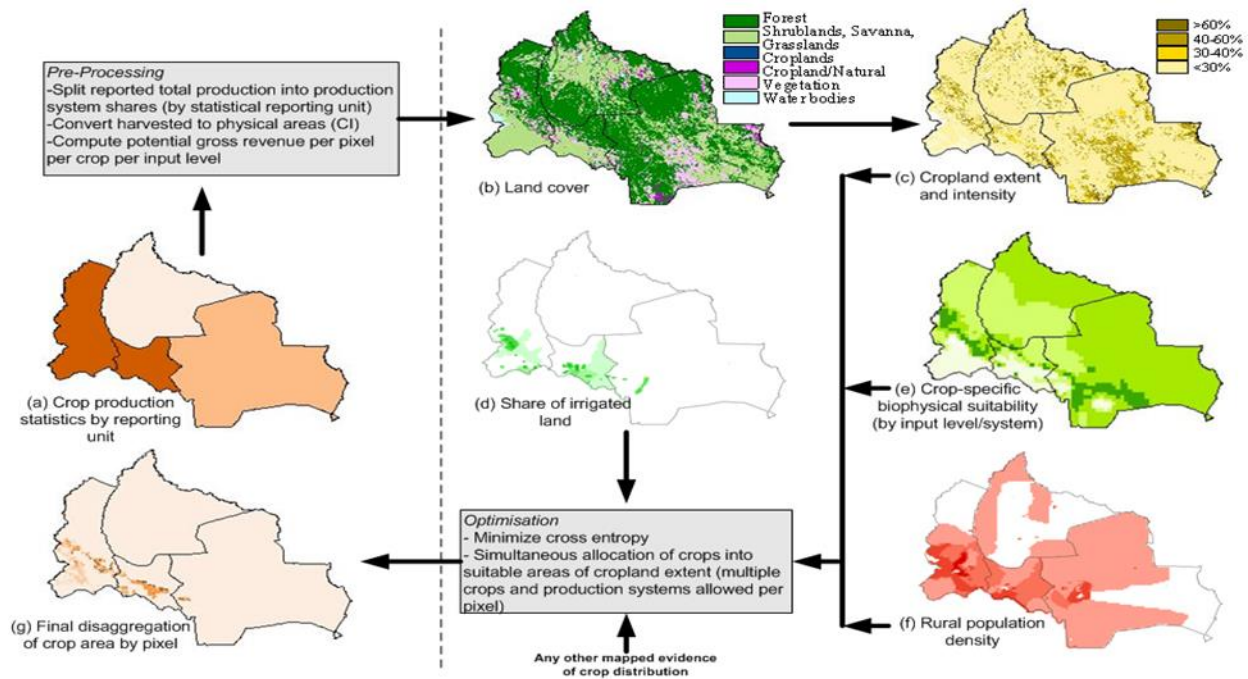
Source: SPatial Agricultural Database for Egypt (SPADE)

Remote Sensing Data for Monitoring Spatial Distribution of Agricultural Production

Although national and high-level aggregate production data are usually available, the enormous gaps and diversities in the geographic and crop coverage makes these data not adequate to provide spatially disaggregated insights into the location of production (Carter et al., 1992; Ladha et al., 2000, IFPRI 2001). To address this challenge, the approach described in this note seeks to generate plausible estimates of the distribution of crop production at the scale of individual pixels, through judicious triangulation amongst a range of accessible evidence. The Spatial Allocation Production Model (SPAM) (You et al., 2014) combines subnational aggregate data with high-resolution (pixel-level) remote sensing land cover data. By facilitating spatial disaggregation, this approach addresses one of the major analytical weaknesses of meso- and macro-scale agricultural studies – the inability to objectively re-aggregate production statistics into any other geography than the national or sub-national administrative boundaries for which published statistics exist. This has been a thorn in the flesh of most attempts to analyze production and productivity by agro-ecological zones or watersheds. Such disaggregation is important to inform agricultural investment decisions across governorates and communities. Figure 2 shows an overview of SPAM. It starts with the administrative (geopolitical) statistical reporting units (SRUs) for which we have been able to obtain production statistics. In the case of Egypt, this starts with aggregate data at governorate level (Figure 2(a)). We then reinterpret the already classified land cover imagery (Figure 2(b)) into crop land and non-crop land (Figure 2(c)). This crop land surface provides valuable information on where and how much agricultural land is at the pixel level. Figure 2(d) shows the crop-specific suitability (maize in the figure) judging from local climate and soil conditions. The SPAM then utilizes all these input data and applies a cross-entropy approach to obtain the final estimation of crop distribution (e.g., Golan et al.,

1996; You and Wood, 2004; 2005). SPAM predictions have been validated in various settings (e.g., You and Wood, 2006). Other studies have shown that recent advances in satellite technologies facilitate successful prediction of agricultural yield even at smaller spatial units (e.g., plot level) (e.g., Lobell et al., 2019). These encouraging results suggest that remote sensing and image processing data and tools could be used more extensively to assess and monitor spatial heterogeneities in agricultural production.

Figure 2: The overview of spatial allocation

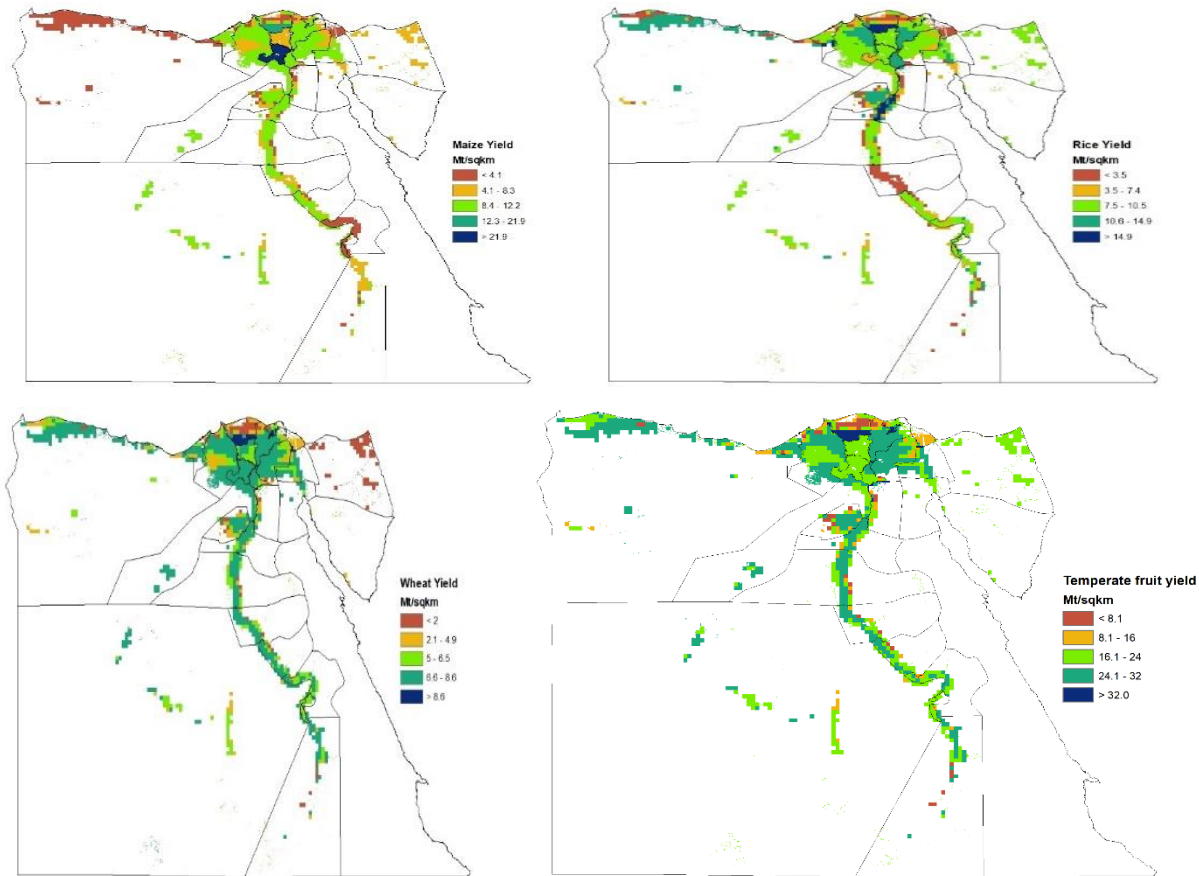


Source: Authors' compilation of the SPAM modeling process.

Here we adapted the SPAM and modified it to assess crop production and production systems in the context of Egypt. We collected aggregate production quantities of main cereal crops, including wheat, rice, and maize at the governorate level for the years 2017, 2018, 2019 (MALR, 2019); These data were then averaged over the 2017–2019 period and recalibrated so that the aggregated subnational data equaled the corresponding 2017–2019 FAOSTAT national totals. Biophysical constraints on crop production were modeled by interacting three pixelated datasets (cropland, irrigated land and agro-ecological suitability). Finally, the allocation process also considered additional suitability information including soil types, climate data and additional socio-economic variables such as population density.

Figure 3 shows the yields of the summer crops, maize, wheat, rice and fruits. As expected, the production of cereal crops is concentrated around the Nile. However, we can clearly observe some spatial differences in the distribution of yield across crops which can provide important contributions towards informing agricultural investments, including decisions on the location of agro-industries. For example, some areas in the Northwestern part of Egypt which are characterized by low maize yield are yet associated with higher wheat yield. Similarly, some areas in the Northeastern part of Egypt with low wheat yield are characterized by higher yield for fruits. These can inform the location of agro-processing factories which use various types of agricultural products as raw material. These can also inform potential yield gaps across space and hence allocation of investments to address these yield gaps.

Figure 3: Yield of maize, wheat, rice and fruits, 2019



Source: SPAM results.

Remote Sensing Data for Monitoring Economic Activities During Pandemic

A second case we aim to demonstrate in this note is the potential of remote sensing data to monitor economic activities during the COVID-19 pandemic. The COVID-19 pandemic has significantly curtailed economic activities while also affecting economic agents' behavior, from lifestyles to the economic activities of consumers and firms (Barua, 2021). In Egypt, national GDP is projected to have decreased by 1.1 percent in the last quarter of the 2019/2020 fiscal year, compared to previous the fiscal year, due to the pandemic (Breisinger et al., 2020). The services sector has been struck the most, with a drop of 10.9 percent, followed by industry, which has dropped by -8.3 percent. Agriculture has been shown to be the most resilient industry (e.g., Breisinger et al., 2020). At the industrial level, from mid-March until 1 July 2020, the tourist sector, which contributes about 5.5 percent of GDP and 9.5 percent of jobs, was shut down. Because of persistent deterioration in net exports, mostly tourist receipts, real GDP growth was predicted to decelerate to 3% in 2021. Tourism revenues, which accounted for 25% of exports in 2019, were projected to significantly fall in 2020 owing to the shutdown of international airports and limitations on local travel (OECD Economic Outlook, 2020). The informal sector constitutes a large part of the Egyptian economy keeping a large segment of society living in a vulnerable state.

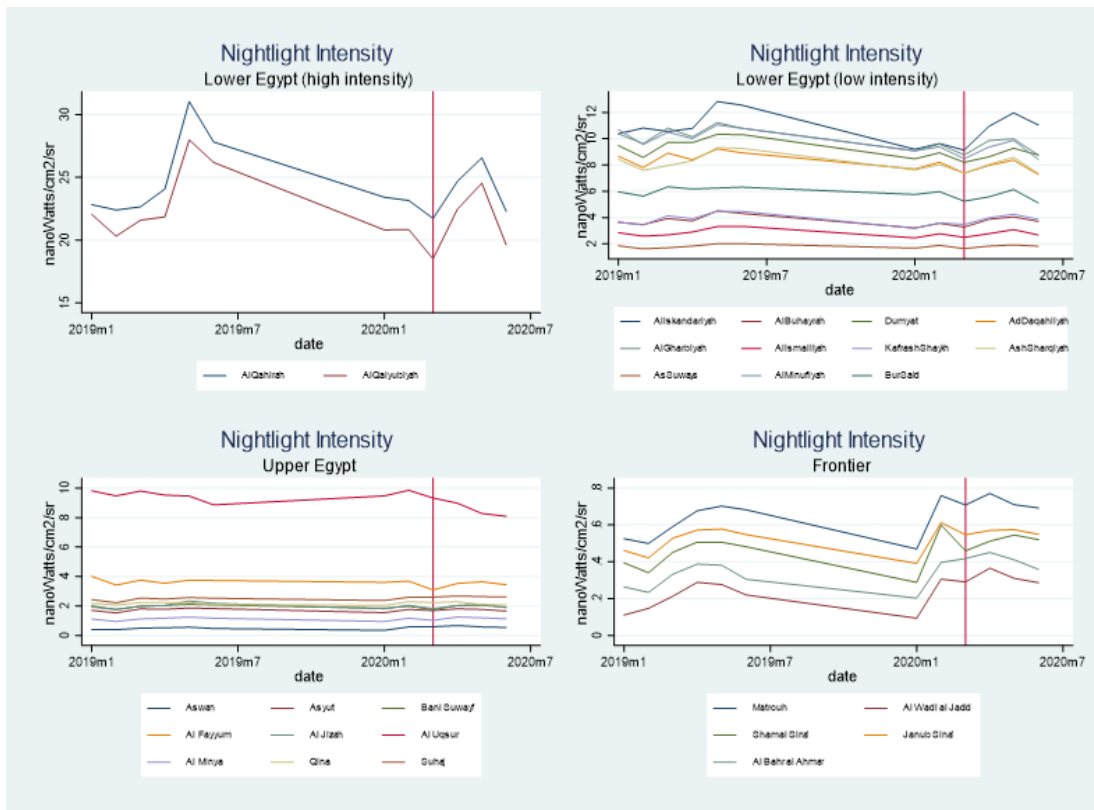
Despite these aggregate predictions and forecasts, the impacts of the pandemic at governorate or lower levels remain unknown. To fill this gap, we propose using remote sensing data, mainly nightlight intensity to capture economic activities at the governorate level. The night Day/Night Band (DNB) detectors from

the Suomi-NPP Visible Infrared Imaging Radiometer Suite (VIIRS) are a new generation of satellite products that provide global observation of visible and near-infrared light that are used for Earth science studies.¹ The nightlight series used in the study provides monthly composite generated from daily atmospherically and lunar-BRDF corrected nightlight radiance to remove the influence of extraneous artifacts and biases. The monthly series is uniquely able to capture human activity from space. The VIIRS-DNB can capture and measure nighttime light intensity from all sources of lights on the ground including city lights, and vehicle headlights. It is widely used to capture human civilization, urbanization and economic activities (Sutton et al., 2001; Doll et al., 2006; Henderson et al., 2009; Amare et al., 2021; Abay et al., 2022).

The analysis is based primarily on two sets of monthly cloud-free composites: one is monthly nightlight images before the pandemic in 2019, the other is monthly nightlight images during and after the pandemic in 2020. Monthly images with the full coverage of Egypt in both years are produced for the analysis. The analyses are performed at various spatial resolutions.

Figure 4 shows average monthly nightlight intensities at the governorate level for 2019 and 2020. Major economic governorates show a decrease in nightlight over the analysis period, specifically Cairo and Qalyubiyah. Major SMEs and industrial clusters are in these governorates indicating that the COVID19 had a negative impact on the regional economies. Frontier governorates were less affected due to the small size of economic activities and population density.

Figure 4: Trends in mean nightlight intensity across governorates



Source: Visible Infrared Imaging Radiometer Suite (VIIRS) Satellites.

¹ The VIIRS/DNB has a spectral range of 500–900 nm and is sensitive to low-light conditions compared to previous product from the Defense Meteorological Satellite Program's (DMSP).

Conclusion

Overall, our findings indicate that the Covid19 has negatively impacted economic activities in Egypt. Despite the care and reluctance by the Egyptian government to keep businesses open, the pandemic has significantly reduced economic activities, more so, in some governorates. Some governorate known for hosting many agri-food SMEs have experienced significant slowdown in economic activities. This justifies effective targeting of stimulus and recovery packages (McKee and Stuckler, 2020). In this sense and together with other recent findings, we provide the following recommendations to policy makers in Egypt:

- ▶ Targeting of stimulus and recovery packages based on the economic repercussions experienced across geographies and sectors
- ▶ Identifying and supporting promising value chains which experienced a significant slowdown in economic activities
- ▶ Diversifying economic activities and markets to improve the resilience of agri-food systems.
- ▶ Investment in data infrastructure to monitor and respond to future shocks. This may be supported by scale up of digital solutions, which proved to be effective in sustaining business activities even during the pandemic.

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