NASA Harvest: Monitoring Food Security from Space During the COVID-19 Pandemic

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Scientia

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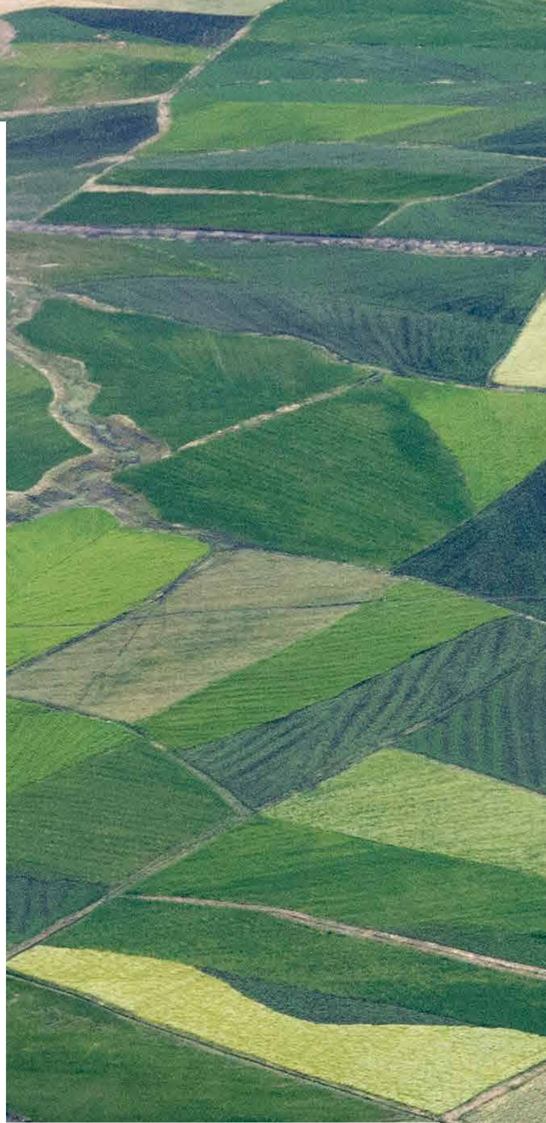

In the face of the combined challenges of climate change and COVID-19, reliable access to accurate information about crop health has never been more crucial. **Dr Michael Humber** at the University of Maryland is the Data Lead of the NASA Harvest project – a global collaboration of researchers from many different backgrounds, who are aiming to provide this data using advanced satellite-based technologies. His team's work has already had an important impact on systems that warn farmers of likely crop failures before they occur, and could be vital for ensuring global food security in the coming decades.

Achieving Food Security

Despite decades of progress towards improving food security for the global population, the recent trend in declining world hunger appears to be slowing down. In 2017, the number of undernourished people increased for the third year in a row to reach over 820 million – a statistic that now threatens the ambitious United Nations goal to eradicate world hunger by 2030.

Among the main drivers of this worrying observation is an increase in extreme weather, widely attributed to climate change. As global temperatures rise, events including droughts, floods, and storms are increasingly coming to damage and destroy crops, particularly in the developing world.

On top of this threat, the COVID-19 pandemic has made the future of global food security even more uncertain. Because of the increased costs of labour created by travel restrictions, many farmers have made the difficult decision that their crops would be more expensive to harvest than to leave in the ground. With communities in many developing nations relying heavily on exports of these crops, the risk of reversing the previous trend in world hunger is now at its highest in decades. Clearly, such an all-encompassing problem requires coordinated and highly advanced solutions.

A Need for Early Warning Systems

Ultimately, there are two key aspects to the challenges faced in tackling these issues. In the developing world, crops are generally far more vulnerable to failure, due to lower-yielding crop varieties, limited access to seeds and fertiliser, and a lack of reliable irrigation infrastructure. Because of this, farmers are far less able to protect their crops during extreme weather events or economic disruption.

In addition, many nations don't rely on the crops they grow themselves to sustain their populations, but instead rely on imports. One particularly clear example is Egypt – which has a large, dense population, but very little arable land suitable for growing wheat. As a result, the country is the world's largest importer of the crop – sourcing most of it from Russia, where wheat supplies are abundant. Similar supply chains are now widely used in both poorer and developed countries, meaning crop failures can have severe knock-on effects across the globe.

To fully understand the combined impacts of climate change and COVID-19 on global food security, it is critical for agricultural stakeholders to accurately assess levels of crop damage, well before they are harvested. Furthermore, these assessments must take place across a wide range of scales – from regions where communities depend on locally-produced crops, to entire nations, which depend on

international supply chains. If achieved, advanced early warning systems would give these populations critical time to prepare for oncoming food shortages. Currently, however, the human and technological networks required for such high-quality monitoring are not being widely applied.

Monitoring Crops from Space

So far, early warning systems have widely relied on ground-based methods for monitoring crops, including information taken directly from farmers and field surveyors, combined with weather models to estimate the likely impacts of weather on food production. Although this data can be crucially important, efforts to collect it must be carried out by many different institutions and organisations, from regional to international scales. Naturally, it is incredibly challenging to then coordinate this data, enabling relevant communities to be informed about future food shortages.

This challenge has been exacerbated by the COVID-19 pandemic, which has limited the ability of organisations around the world to conduct field operations. As a result, remote sensing has emerged as a highly effective method for observing and forecasting crop production. From space, these instruments can monitor a wide variety of factors – on scales ranging from several centimetres to thousands of kilometres.

From their visualisations alone, satellites can determine how green a patch of land is, due to the density of vegetation growing there. In addition, they can monitor weather, soil moisture, and the amount of water being evaporated from leaves – all of which are relevant to crop health.

These measurements are now benefiting from a growing number of space-based satellites, with sensor resolutions high enough to assess differences in crop quality between different parts of the same field. By coordinating these observations with ground-based measurements, early warning systems could soon improve rapidly. Dr Michael Humber at the University of Maryland and his colleagues play a key role in supporting these efforts.

Launching GEOGLAM

In 2011, heads of state from the G20 forum endorsed the launch of the Group on Earth Observations Global Agricultural Monitoring (GEOGLAM) initiative. Today, GEOGLAM aims to provide widely accessible transparency for assessments of global food markets, enabling nations and communities to better coordinate their activities during food shortages created by crop failures.

To support the objectives of GEOGLAM, NASA launched the NASA Harvest program – an international collaboration including researchers and international stakeholders from over 50 institutions worldwide, whose collective efforts are led by Dr Inbal Becker-Reshef, Director of the NASA Harvest Program and Associate Research Professor at the University of Maryland.

By taking data from space-based satellites, and analysing them using the latest available techniques, these researchers are now taking important steps towards improving global food security in the coming decades. Since 2013, the team has coordinated monthly assessments of the health of four staple

crops, including wheat, rice, maize and soy, within many of the world's most important agricultural regions to achieve an international consensus on monthly crop conditions. Many of Dr Humber's colleagues have now gone on to apply their gathered data in a variety of innovative projects.

Successes so Far

One of these projects, led by Dr Humber's colleague Dr Hannah Kerner, focused on cropland mapping in Togo, West Africa. Using NASA Harvest satellite imagery alongside poverty and census data, the team created a system that can rapidly identify priority areas. This system allows the Togolese Government to protect farmers from shocks triggered by the COVID-19 pandemic that could negatively impact the country's food security.

In another recent project, Dr Mehdi Hosseini from the University of Maryland developed an approach that can quickly assess crop damage over vast regions spanning millions of acres. In August of 2020, a series of windstorms, known as a 'derecho', caused widespread damage to about one-third of soybean and corn crops in the state of Iowa. The NASA Harvest researchers combined different types of satellite data to develop maps that show the overall damage caused for each crop type. The team's approach to identifying damaged areas and assessing the extent of the damage is critical to enabling government agencies and insurance companies to rapidly respond to the disaster, even in the midst of the pandemic.

A final example is a study led by Dr Catherine Nakalembe, head of the African Program for NASA Harvest. Using satellite observations, her team identified the early stages of a drought in Uganda in 2017. This information was used by government agencies to act proactively to an impending production shortfall rather than acting reactively to a food crisis. Since then, these systems have been used to inform farmers and local governments that crop yields are likely to be lower in the near future – giving them crucial time to prepare for potential threats to food security.

Continuing Measurements During COVID-19

This work comes at a particularly critical time, as travel restrictions imposed by COVID-19 have made it extremely difficult for researchers to gather data on the ground. At the same time, the pandemic is causing significant disruption to global chains of supply and demand for food. This threatens to impact global food security in the near future, with impacts felt most strongly in the developing world.

In their latest research, Dr Humber's team is working towards expanding the scope of the NASA Harvest project to study these effects in detail, even without access to reliable ground-based measurements.

The team's results are now filling in potentially dangerous gaps in this data, enabling farmers, governments, and agricultural stakeholders to continue to accurately monitor the health of their crops. Their observations can also be combined with other data, including estimates of market prices, freight costs, and numbers of daily new COVID-19 cases and vaccinations, enabling more detailed assessments of the impacts of the pandemic. As the economic effects of COVID-19 are likely to be felt for years to come, the project could become a crucial tool ensuring sustainable global recovery.

Preparing for New Challenges

The ultimate goal of Dr Humber's team is to build a 'dashboard' of data – bringing information about supply chains, ground-based crop assessments, and satellite observations, together in one place. Combined with the COVID-19 data gathered by John Hopkins University, their interactive tool will enable all players involved in agriculture, food production, and supply chains to easily access the information they need to coordinate their efforts, and make the best possible decisions.

With these measures in place, the dashboard could one day enable these groups to prepare for potential future incidents, including pandemics, human conflicts, natural disasters, or any other event with the potential to cause major disruption to the global economy. Even as the effects of the pandemic subside in the coming years, climate change threatens to place an ever-increasing strain on food security. NASA Harvest's investment in documenting supply chains will enable analysts to learn from the past in order to begin to understand how future shocks might affect the flow of agricultural goods and food availability in the future.

To avoid a reversal in the previous trend of declining world hunger, intelligent decisions will be more important than ever. As a result, the team's work could play a vital role in continuing the United Nations' goal to eradicate world hunger, even in the face of mounting challenges.

Meet the researcher

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Dr Michael Humber completed his PhD in Geographical Sciences at the University of Maryland in 2019. Since 2015, he has been the NASA Harvest Data Lead at the University of Maryland's Department of Geographical Sciences. This important role involves collaboration with groups within agriculture, government, and the private sector to create customised software, capable of meeting the unique monitoring needs of individual organisations. Elsewhere, Dr Humber's research interests include the use of high-performance computing for image analysis; assessments of the quality and accuracy of maps based on satellite observations; and methods for mapping crops and agricultural practices at national scales.

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FURTHER READING

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