EARTH SCIENCE APPLIED SCIENCES

2020 ANNUAL SUMMARY

AGRICULTURE

NASA Earth Science
Applied Sciences Program

2020 Annual Summary for the Applied Sciences Agriculture Application Area

Table of Contents

ACRONYM LIST

AMA	Agricultural Monitoring in the Americas
AMIS	Agricultural Market Information System
CEOS	Committee On Earth Observation Satellites
CHIRPS	Climate Hazards Group Infrared Precipitation With Stations
CIMMYT	International Maize and Wheat Improvement Center
COVID	Corona Virus Disease
EO	Earth Observation
EO-FARM	Earth Observations For Field Level Agricultural Resource Mapping
EOS	Earth Observing System
ESA	European Space Agency
FAO	Food And Agriculture Organization
FEWS NET	Famine Early Warning Systems Network
GEFS	Global Ensemble Forecast System
GEO	Group On Earth Observations
GEOCIF	Global Earth Observations For Crop Inventory Forecasting
GEOGLAM	Group On Earth Observations Global Agricultural Monitoring Initiative
GLAD	Global Land Analysis and Discovery
GLAM	Global Agricultural Monitoring
HLT	Harvest Leadership Team
ISRO	Indian Space Research Organization
JAXA	Japan Aerospace Exploration Agency
LANCE	Land Atmosphere Near real-time Capability for Earth Observing System (EOS)
LDAS	Land Data Assimilation Systems
MODIS	Moderate Resolution Imaging Spectroradiometer
MOU	Memorandum Of Understanding
NASA	National Aeronautics and Space Administration
NISAR	NASA- Indian Space Research Organization (ISRO) Synthetic Aperture Radar
PPP	Public-Private Partnerships
RAPS	Rapid Action for Policy Support
RCMRD	Regional Centre for Mapping of Resources for Development
SAP	Systems Applications and Products
SAR	Synthetic Aperture Radar
SARA	Sustainable And Regenerative Agriculture
TAC	Technical Advisory Committee

UMD	University of Maryland
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
VIIRS	Visible Infrared Imaging Radiometer Suite
WFP	World Food Programme

I. INTRODUCTION

The Earth Science Division's Applied Sciences Program promotes efforts to discover and demonstrate innovative and practical uses of Earth observations. The program funds applied-science research and applications projects to enable near-term uses of Earth observations, formulate new applications, integrate Earth observations and related products in practitioners' decision-making, and transfer the applications to stakeholders. The projects are carried out in partnership with public- and private-sector organizations to achieve sustained use and sustained benefits from Earth observations.

The Applied Sciences Program's applications themes are currently focused on five of the eight Societal Benefit Areas (SBAs) of the interagency Group on Earth Observations (GEO): Agriculture Disasters, Ecological Forecasting, Health (including Air Quality), and Water Resources.[1] The program assesses climate-related influences and impacts within each of these themes and includes cross-cutting elements such as Capacity Building.

This annual summary highlights the accomplishments and management of the Agriculture application area throughout 2020.

Agriculture

National Aeronautics and Space Administration (NASA) activities related to agriculture are wide and diverse. NASA has been using satellite information to contribute to the field of agriculture for decades. NASA sustained its longstanding relationships with the U.S. Department of Agriculture (USDA) and many international organizations throughout 2020. To monitor agricultural systems, NASA utilizes satellite observations to assess a wide variety of geophysical and biophysical parameters including precipitation, temperature, evapotranspiration, soil moisture, and vegetation health.

In 2017, the Applied Sciences Program established NASA Harvest, a consortium between NASA and the University of Maryland that focuses on the use and application of Earth observations to support informed decision-making processes in the fields of agriculture and food security.

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[1] The eight USGEO SBAs are Agriculture, Disasters, Ecosystems, Energy, Health, Infrastructure and Transportation, Urban Sustainability, and Water.

NASA Harvest

NASA Harvest aims to enhance the adoption of Earth observations by decision-makers and policymakers in the realms of food security and agriculture by advancing the state of the science of agricultural monitoring and transitioning novel methods into operational use. It is a dynamic and agile program supported by over forty leaders in the fields of agriculture and Earth science from public, private, nongovernmental, intergovernmental, and humanitarian sectors. The priorities, needs, and challenges of end users from multiple fields drive the program to invest in Earth Observation (EO) data access and utilization technologies geared toward improving the derivation of agricultural information and its provision to end users. By empowering end user organizations to derive and/or access the timely, synoptic, objective, and repeatable EO-based information that they critically need to act or react to a dynamic food system, the program aims to strengthen food security and human resiliency while decreasing market volatility and human vulnerability to food system shocks. The NASA Harvest Program objectives include the following:

- Enable and advance use of Earth observations by domestic and international organizations (public and private) to benefit food security and agriculture
- Encourage coordination among agriculture programs and projects via a consortium of partners
- Integrate and promote NASA's agriculture and food security activities
- Improve and promote application-ready research methods and tools both domestically and abroad
- Transition research to operational use
- Build a "community of practice" for Earth observations in agriculture

II.   OVERVIEW AND ASSESSMENT

Overview

Despite the challenges caused by the global pandemic, 2020 was an active year for the Agriculture application area. NASA Harvest provided leadership to enable the Corona Virus Disease-19 (COVID-19) Trilateral (NASA, European Space Agency [ESA], and Japan Aerospace Exploration Agency [JAXA]) Dashboard for agriculture. NASA Harvest provided both site-specific data products such as a rapid-response cropping information for Togo and GEO Global Agricultural Monitoring (GEOGLAM) products. This success led to the development of a specific NASA Harvest COVID-19 Dashboard. NASA signed a Memorandum of

Understanding (MOU) with the USDA to encourage, facilitate, and support collaborations and synergistic initiatives. NASA and USDA have maintained a steady and active partnership since the 1970s. This recent MOU recognized the growing need for Earth observations to address agriculture and food security challenges. In 2020 USDA senior leaders initiated discussions with NASA on an approach to establish active engagements with NASA across USDA mission areas.

Another key challenge the Agriculture application area faces is balancing a vigorous domestic strategy while maintaining a leadership role in global agriculture monitoring. NASA Harvest's Sustainable and Regenerative Agriculture (SARA) Initiative was designed to encourage industry to invest in the development of common yardsticks for sustainable and regenerative agriculture. The SARA initiative includes a public-private partnership component focused on U.S. agriculture.

The Agriculture application area has an established foundation and tremendous capabilities within NASA and the Earth observation industry. 2020 was certainly a challenge but it clearly demonstrated the need for better and more information on global agriculture and the global flow of agriculture commodities. The Agriculture application area is well-positioned to address these current and future challenges.

2020 Program Assessment

The impacts of COVID-19 were devastating to humanity and affected science advancements and research. Many team members experienced work delays, shifting responsibilities at work and at home, and even the illness of themselves, family, and colleagues. In the absence of on-the-ground data collection, the Agriculture application area was able to step up and use remote sensing to fill the gaps caused by COVID-19. NASA Harvest worked with country governments to provide remotely sensed information on crops.

- Dry conditions in 2020 and export restrictions early on in the COVID-19 pandemic increased uncertainty regarding wheat crop yield. NASA Harvest quickly produced early and accurate estimates of Russia's wheat crop yields in the key growing region. Russia is the largest wheat exporter and critical to market stability.

- Given constraints in field access due to COVID-19 restrictions, the United States Agency for International Development (USAID) Famine Early Warning Systems Network (FEWS NET) conducted a 'virtual crop tour.' As part of this effort, NASA Harvest supported an assessment of planted area change due to the pandemic in selected pilot areas in Ethiopia and Sudan.

- NASA Harvest provided data for the NASA Harvest COVID-19 Dashboard and the COVID-19 Trilateral EO Dashboard. The dashboards included Harvest's quick-response, national-scale, 10-m map of Togolese croplands that helped the

Agriculture Ministry implement a COVID-19 response loan program for farmers. The dashboard also integrated global crop conditions as an agricultural indicator using data from the GEOGLAM Crop Monitor website.

- The Agriculture application area produced a portal to monitor the impacts of COVID-19 on agricultural supply chains and markets. The portal provides access to machine-learning applications for analyzing commodity crops in the U.S. and Russia in the wake of COVID-19 restrictions on movement.

Despite the challenges of 2020, the Agriculture application area made several gains. 2020 was a year for growing collaborations and partnerships. NASA and USDA signed a Memorandum of Understanding, NASA began a partnership with Mercy Corps' AgriFin Program on climate-smart agriculture, and NASA Harvest established the SARA initiative connecting NASA capabilities with the U.S. domestic private agriculture sector.

In 2021, NASA Harvest will aim to strengthen ties with NASA centers and other NASA programs to connect relevant EO capabilities with potential users. NASA Harvest will also endeavor to increase domestic use of Earth observations and further connect its private industry counterparts with EO through the new SARA initiative.

III.   PORTFOLIO OF RESEARCH PROJECTS

NASA sponsors a large array of projects that span both basic research and applied research relevant to the fields of agriculture and food security. Projects that qualify as basic research are supported by the NASA Earth Science Division's Research and Analysis Program. This includes programs like the Land Cover Land Use Change Program and projects supported under the Carbon Cycle and Ecosystems Focus Area and the Terrestrial Hydrology Focus Area.

Applied research takes proven capabilities and works to put them in the hands of decision-makers who can utilize the tools and data to inform critical decisions. Many programs within the Applied Sciences Program support the development and access to tools and information relevant to agriculture. The Applied Sciences Capacity Building program area provides remote and local training on data products, data access, and case-studies demonstrating how remote sensing data can be used for decision-making by the agriculture and food security communities. The SERVIR network enables experts at SERVIR regional hubs to partner with local decision-makers and scientists to create new datasets, maps, and decision-support tools that answer critical development questions and provide training on EO for agricultural use.

The advancement of EO data applications for agriculture use is supported by both the Water Resources and the Agriculture application areas within the Applied Sciences Program. The Water Resources application area supports projects utilizing EO for better crop irrigation and management through use of improved evapotranspiration and soil moisture information. However, the vast majority of the agriculture application projects are supported by the Agriculture application area's NASA Harvest Program.

NASA Harvest 2020 Project Portfolio

Throughout 2020 NASA Harvest funded partners to conduct 27 applied research projects. The projects represent a wide breadth of applications selected to advance crop mapping, crop statistics, crop yield, crop conditions, and cropping practices. The program also closed out two projects in 2020 and initiated two new projects through the program's project evaluation and selection process. The two new projects are:

- A project in conjunction with the Swiss Re Foundation, "Earth Observations for Field Level Agricultural Resource Mapping (EO-FARM)," uses Earth observation data to enhance food security and resilience in smallholder-dominated regions. Beginning with two pilot studies in Kenya and Mexico, the goal is to scale fundamental datasets globally and to support enhanced crop insurance programs.

- A project called, "Estimating Cropped Area and Production in the Feed the Future/Mali Zone of Influence," is underway in collaboration with Lutheran World Relief and USAID and is featured on the NASA Applied Sciences website.

Notable Achievements

- NASA Harvest provided a rapid response to the Togolese government regarding a COVID-19-related request. Census data did not capture information pertaining to all small-holder farmers in Togo and access to ground data was inaccessible during the COVID-19 pandemic. The Togolese government requested NASA Harvest's assistance to identify the locations of all fields. NASA Harvest's Planet Inc. partners mobilized quickly to provide Harvest with access to additional mapping data, demonstrating agility of public-private partnerships. As a result, NASA Harvest was able to produce 10m resolution maps of the entire country within 10 days of the request. To address COVID-19 impacts on farmers, the Togolese government used the information provided by NASA Harvest to support a digital loan program providing relief to farmers that needed supplies and equipment.

- On August 10, 2020 a severe Derecho caused widespread damage across Iowa's key agricultural regions, bending and flattening crops over approximately one-third of the state. NASA Harvest used Synthetic Aperture Radar (SAR) data to estimate the damage extent and severity for different crop types across the state, quickly providing critical

information about the storm impacts on crops in the area. This work demonstrates how satellite imagery can enable rapid-response capabilities, which can be extremely valuable for government agencies, insurance companies, and agricultural economists in the wake of an unanticipated natural disaster where we lack in situ data.

- NASA Harvest partners at Stanford used satellite information to generate maps of crop yields and selected management factors in the Midwestern U.S. The satellite-based information helped generate several new insights into climate sensitivity and resilience including: (1) drought sensitivity for maize has increased ~50% since 2000; (2) no-till farming (a technique where soil is not disturbed via tilling) provides yield benefits, especially in dry summers; and (3) wet springs and late sowing continue to play important roles in limiting crop yields. The project team published a [paper in Scientific Data](#) analyzing 20 years of satellite data for maize and soybean crops throughout the Midwestern U.S. In 2021, the team plans to integrate tillage and yield correlation data and tillage base maps into the Harvest Portal, the Harvest Program's repository for agricultural geospatial data.

- A team supported by NASA Harvest at the University of California, Santa Barbara is continuing to provide climate contributions to GEOGLAM's Crop Monitor for Early Warning and Crop Monitor for Agricultural Market Information System (AMIS) monthly reports. In 2020 the team incorporated forecast products (including Climate Hazards Group Infrared Precipitation With Stations [CHIRPS]-Global Ensemble Forecast System [GEFS] 15-day forecasts and SubX 4-week forecasts) into the regional writeups in the Crop Monitor for Early Warning reports and is currently providing a Global Climate Outlook section for both the AMIS and Early Warning reports. The team is helping develop seasonal forecast alerts for areas where forecast products indicate concern regarding the upcoming crop season. As an example, "Seasonal Forecast Alert over East Africa," published in September 2020, brought attention to the below-average seasonal rain forecast for East Africa in October, November, and December 2020, and the potential for a dry March, April, and May 2021. The team released a drought index dataset for Africa, which was highlighted on the NASA Harvest website and the NASA Harvest Twitter account. The forecast alert and work conducted by the team focusing on acute food insecurity in Sub-Saharn Africa were published on Agrilinks (an online forum for agriculture and food security professionals) and featured in an [American Association for the Advancement of Science article](#) about work on drought monitoring in collaboration with FEWS NET, USAID, and Harvest.

- A team working with Matt Hansen at the Global Land Analysis and Discovery Laboratory at the University of Maryland (UMD) is advancing global crop-type area estimation and mapping for commodity crops including wheat, soybeans, and corn, integrating yield estimation, as feasible. Harvest support enables the extension of their methods to different geographies via prototyping activities. The team is continuing work towards operational capability for crop monitoring and conducted

field work in 2020 to validate South American and U.S. soybean/corn/wheat maps. In addition, the team collected ground data on U.S. soybean fields to be compared to USDA data in 2021.

IV.   PROGRAM MANAGEMENT

In 2020, the NASA Administrator and USDA Secretary of Agriculture signed a joint Memorandum of Understanding (MOU). This agreement provides a foundation and a channel for NASA and USDA to easily collaborate, leverage each other's resources, and align efforts to advance the technology and information accessible for those working in the fields of agriculture and food security. This MOU exemplified the 2020 theme for the Agriculture application area: partnership development. NASA Harvest worked to develop new partnerships domestically and abroad (see more on partnerships in the Community Leadership section).

In 2020, NASA Harvest made efforts to better organize its partners, priorities, project deliverables, and public-facing program structure. The resulting approach includes clearly defined Impact Areas, Product and Method Areas, Focus Areas, Innovation Pathways, and Facilitating Mechanisms. The program's consortium model allows for a management and decision structure that promotes agility and responsiveness. This revamped structure expands upon 2019's strategic shift towards mission-focused and partner-led programmatic activities with the goal of improved buy-in from partners and additional uptake of Earth observations in agricultural applications.

Because the consortium is implemented by a university (UMD), its cross-coordination benefits are enabled by academic institutions and it has the ability to start, alter, or end projects quickly in direct response to stakeholder needs and shifting/emerging consortium priorities. In 2020, the Harvest Leadership Team (HLT) adjusted consortium partnerships, adding two new project partners and discontinuing completed projects.

The program improved tracking of projects involving funded partners and unfunded collaborators, and now documents all pre-defined deliverables, progress reports/project updates, potential synergies, and communications/outreach products. NASA Harvest also hosted a virtual consortium-wide roundtable in place of the in-person annual meeting. The HLT continues to conduct work plan meetings twice per year with each funded partner to review progress updates and deliverable timelines, define synergies, and adjust activities as needed.

The consortium empowers success by:
- leveraging expertise and resources across multiple actors toward the same goal in a noncompetitive environment,
- drawing upon the best information from world experts in the field,
- expanding outreach using a unified and authoritative voice (especially via NASA Harvest and GEOGLAM),
- maintaining flexibility to engage and disengage partners and projects through multiple modalities (funded, unfunded, leveraged, etc.),
- implementing a strategic and agile management structure focused on forging strong partnerships and trusting relationships, and
- employing strong leadership with support from NASA.

NASA Harvest Coordination with Other NASA Programs and Centers

NASA Harvest engages with NASA centers to share capabilities and regularly communicates with various researchers working on Land Data Assimilation System (LDAS) and the Landsat Science team. NASA Harvest collaborates with the Land Cover Land Use Change Science Team and works with external partners on fine-resolution data evaluations. The program engages with various science teams and working groups focused on missions and sensors including the upcoming NASA- Indian Space Research Organization (ISRO) Synthetic Aperture Radar (NISAR) mission, Moderate Resolution Imaging Spectroradiometer (MODIS) – Visible Infrared Imaging Radiometer Suite (VIIRS) capabilities, and NASA's Land Atmosphere Near real-time Capability for Earth Observing System (EOS) (LANCE). In addition, the NASA Harvest team is working closely with the Landsat communications team to prepare for the Landsat 9 launch and highlight NASA Harvest work that utilizes Landsat.

The program also connects with the Applied Sciences SERVIR Program by supporting local trainings and engaging with the SERVIR teams on topics relevant to agriculture. In 2020, NASA Harvest worked with the teams developing the NASA COVID-19 Dashboard and the NASA/ESA/JAXA Trilateral COVID-19 Dashboard to integrate maps developed by NASA Harvest into those platforms.

Communications

NASA Harvest excels at connecting with the community. The program runs a robust Twitter account (@HarvestProgram), in addition to maintaining a regularly updated website and issuing periodic newsletters. During 2020, the NASA Harvest communications team made a concerted effort to coordinate and align its efforts with NASA's communications. NASA Harvest participated in weekly meetings with the communications team of NASA Earth Science Division to brief leadership and coordinate activities as needed. A broader audience was reached when NASA communications channels shared news and stories of agriculture applications. In 2020, two NASA Harvest agriculture stories were showcased on the NASA.gov website and four were featured on the NASA Applied Sciences site. These stories

and the successes of the Agriculture application area were also promoted through NASA's social media accounts including Facebook, Twitter, and Instagram.

The NASA Harvest website underwent some improvements in 2020 including a reorganization to enable more intuitive navigation. A new "NASA Agriculture Activities" page highlights the four areas of NASA agriculture activity, the partner page was revamped, and the site provides a stronger emphasis on focus areas. The NASA Harvest website, hosted and managed by the University of Maryland, had over 60,000 visits in 2020 with the most visitors hailing from the U.S., China, India, Argentina, and the United Kingdom.

The NASA Harvest team also redesigned the [Harvest Newsletter](#) and began monthly publication, highlighting recent stories about partner accomplishments and upcoming events. The newsletter reaches over 900 active subscribers through voluntary sign-up on the website, with the number of subscribers consistently increasing each month.

The program uses the Harvest Twitter account to promote partner accomplishments, Harvest website stories, and agriculture/remote sensing/EO work accomplished by the larger remote-sensing community. At the end of 2020, the account had almost 4,000 followers and the average number of impressions (the number of people who viewed Harvest tweets) reached nearly 150,000 individuals per month!

V.   COMMUNITY LEADERSHIP

NASA's Agriculture application area is able to contribute data, applications, knowledge, and experience to the field of agriculture and has established itself as a trusted source for information and guidance.

Agriculture application area team members were invited to give numerous presentations in 2020. For example, one team member gave a presentation to the Colombian Senate in the context of "Food Security for Colombia," which covered NASA Harvest, GEOGLAM, and Agricultural Monitoring in the Americas (AMA). In addition, a NASA Harvest team member was invited by Project Geospatial to speak about program activities in Africa and the impact the work has had in Eastern Africa. Project Geospatial is a podcast and movement dedicated to increasing education and awareness of geospatial technology, industry best practices, and community resources.

2020 Emerging Technologies Workshop

The 2020 NASA Harvest Emerging Technologies Workshop was held on February 25-27 at the National Agricultural Library in Beltsville, Maryland. The meeting was co-sponsored by NASA Harvest, the USDA, and Agriculture and Agri-Food Canada and was held in coordination with the GEOGLAM Program. The focus of the workshop was to share up-to-date results and advances pertaining to operational agricultural monitoring via Earth Observations (EO) from the research community and to define gaps and challenges for the operational user community. Recognizing that significant advances in EO missions and data use are being made in the private sector, the workshop organizers invited NASA Harvest private sector partners to share their recent developments. The workshop presentations and discussion were aimed at:

- identifying priority areas for operational research and development activities;
- enhancing the "community research agenda;"
- identifying applications that are approaching readiness levels suitable for transition to operational application;
- identifying promising new satellite missions, technologies, data initiatives, and applications that would meet operational information needs; and
- discussing ideas for future national and international collaboration to strengthen agricultural monitoring.

The workshop hosted 78 participants, including a number of international NASA Harvest partners. Sessions focused on a wide range of topics including agency updates and priorities, improved methods to estimate crop status and yield, fine-resolution EO data and its use, data fusion and applications, EO missions, high-performance cloud computing, recent developments in soil moisture monitoring, private sector technical innovations, and new contexts for agricultural monitoring. Breakout discussion groups focused on cloud computing, public-private partnerships, soil moisture and evapotranspiration, and crop type and yield estimation; these groups sparked interactive discussion and encouraged collaboration between partners with overlapping activities.

Data and Knowledge Sharing

NASA Harvest provided several successful open platforms for agriculture data, completing three releases in 2020:

- The Harvest Portal, which will serve as the data clearinghouse for the Harvest supported projects, Global Agricultural Monitoring (GLAM) system, and Crop Monitor reports.

- GLAM system updates, with two versions available for global use and a customized GLAM Brasil interface, which is currently receiving widespread media attention in

Argentina and is used regularly by partners of the Buenos Aires Grain Exchange to develop their weekly outlook on crops.

- A Crop Monitor Exploration Tool, which was developed by the NASA Harvest Hub team now ingests automated condition plots. The tool was developed to monitor various Earth observation (EO) variables that convey crop condition. The data was then used to develop the Global Earth Observations for Crop Inventory Forecasting (GEOCIF) system for yield forecasting.

Public-Private Partnerships

Public-Private Partnerships (PPP) are high-priority innovation mechanisms for reaching Harvest's goals. Harvest has three PPP objectives:
1. Establish successful partnerships with diverse actors and engagement modalities
2. Convene key actors to facilitate collaboration via forthcoming collaborative forum for agricultural industry partners
3. Document outcomes, successful business models, and best-practices as a community good

NASA Harvest is launching the SARA initiative as an innovative forum for researchers and private industry. SARA will enable these parties to come together to advance EO-based integrative methods and knowledge about the adoption and impacts of sustainable and regenerative agriculture techniques including cover crop utilization and reduced/conservation tillage. SARA was developed to address a changing climate, growing food insecurity, and soil degradation. SARA's objective is to empower transparent, scalable science and solutions for sustainable and regenerative agriculture adoption and evaluation through multisource data and model integration. Initially, SARA will work with agricultural stakeholders to identify key knowledge priorities, convene top scientists to answer critical questions about agricultural land use, and develop map products of agricultural land use practices and outcomes.

NASA Harvest is also involved in ongoing partnerships through which it has collaborated to launch new application projects. NASA Harvest has bilateral partnerships with consumer-packaged goods (CPGs) manufacturers, space data providers, analytics services and input companies. Harvest has also started a data-sharing agreement with Planet Inc. to enable crop mapping activities and initiated a field-level agricultural resource mapping project with the Swiss Re Foundation. Examples of Harvest PPP projects include the following:

- SIMA, a digital agriculture company based in Argentina, wanted to forecast crop yields for the farmers supported by the company's digital application. NASA Harvest and SIMA entered into a public-private partnership to use Harvest technology to accurately determine crop yields at field scale. This tool was operationalized starting in

Fall 2020 and is helping farmers improve their profits through better predictability of crop yields on their farms.

- The Earth Observations for Field Level Agricultural Resource Mapping (EO-FARM) project co-funded by Swiss Re Foundation officially began in 2020. Beta testing is to be implemented in Kenya through collaboration with the Ministry of Agriculture Livestock Fisheries (MoALF), followed by a pilot study in Mexico to generalize methodology in partnership with the International Maize and Wheat Improvement Center (CIMMYT).

- NASA Harvest has partnered with CropX, a global leader in soil analytics for agriculture, to provide farmers and industry experts with the data and information they need to improve farming sustainability by conserving resources and improving crop yields. Over a 12-month time period, the pilot program will establish parameters for water usage estimates, yield prediction, and soil quality and land usage assessments based on multiple crop-growing cycles.

Enabling Early Career Scientists

Most importantly, the NASA Harvest team is enabling young scientists to utilize NASA data and Earth observations. The program hired seven graduate and undergraduate students in 2020 as part of a Harvest education expansion effort toprovide opportunities and mentorship for young scientists.

VI.   INTERNATIONAL ACTIVITIES

Through NASA Harvest, the Agriculture application area has established a strong presence in the international fields of agriculture and food security. NASA Harvest represents NASA's EO capabilities through participation in various international committees, advisory boards, and working groups including the Digital Earth Africa Technical Advisory Committee (TAC). For example, in Central and South America, NASA Harvest worked to grow the Agricultural Monitoring in the Americas (AMA) initiative. The AMA working group expanded in 2020 to include over 25 participants from nine countries and intergovernmental authorities.

Other connections include support of GEOGLAM and the introduction of NASA Harvest to the European Delegation at the World Food Program's Uganda offices to facilitate synergies with an upcoming pro-resilience action project led by World Food Programme (WFP), Food and Agriculture Organization (FAO) and Office of the Prime Minister, Uganda. The Harvest team also

met with the Second Secretary of Diplomatic Career, Embassy of Panama, to discuss potential collaboration and to provide advice on implementing the Government of Panama's plan to invest in digital agriculture. In addition to representing NASA on committees, in meetings, and at various international events, the NASA Harvest team has supported many international application projects throughout 2020. See the NASA Harvest website for a list of the program's international activities and funded projects.

Education and Technology Transfer

In 2020, Harvest team members led various trainings to the community on the use of particular EO-based tools to meet the needs of a community or specific stakeholder. A Harvest team member led four trainings in Mali on Systems Applications and Products (SAP) in Data Processing . In addition, remote training was conducted by for Conab Brasil on the updated GLAM system.

Group on Earth Observations Global Agricultural Monitoring Initiative (GEOGLAM)

NASA Harvest is instrumental in Group on Earth Observations Global Agricultural Monitoring Initiative (GEOGLAM) leadership, and provides critical support for the GEOGLAM activities led by Harvest. Harvest coordinates the monthly GEOGLAM Crop Monitor for AMIS and Crop Monitor for Early Warning reports, staffs the GEOGLAM Secretariat position, and Harvest staff serve as co-leads for the Committee on Earth Observation Satellites (CEOS) Ad Hoc Team for GEOGLAM and on regional networks (e.g., AmeriGEOSS, GEOGLAM Latinoamerica, and AfriGAM). NASA Harvest leaders also led the GEOGLAM Essential Agricultural Variables teleconference.

The GEOGLAM Crop Monitor reports provide the Agricultural Market Information System (AMIS) with an international and transparent multi-source, consensus assessment of crop growing conditions, crop status, and agro-climatic conditions likely to impact global production. This activity covers the four primary crop types (wheat, maize, rice, and soy) within the main agricultural regions of the AMIS countries.

In 2020, GEOGLAM published four Crop Monitor for AMIS reports and four Crop Monitor for Early Warning reports, including new special reports and updates on Lake Chad Basin Conflict and Violence Issues (August) and the Democratic People's Republic of Korea's August Rainfall and Flooding situation (September). The Crop Monitor data and reports were showcased in a special feature in an FAO Crop Prospects and Food Situation Quarterly Report in an article titled, "The GEOGLAM Crop Monitor: Reducing uncertainty in support of agricultural decision making". Many government agencies reference the Crop Monitor when making critical decisions

NASA team members translated crop condition plots from the GEOGLAM Crop Monitor reports into the local language for inclusion in the newly updated Buenos Aries Grain Exchange website and integrated the Crop Monitor time series plots into the site, as well.

VII. LOOKING AHEAD

The Applied Sciences Agriculture application area and NASA Harvest look forward to building upon ongoing successes in 2021. With the goal of increasing attention to public-private partnerships, NASA Harvest intends to build on the SARA initiative to bring industry and the science community together in a pre-competitive forum to develop common yardsticks for sustainable and regenerative agriculture. To increase the program's policy impact, NASA Harvest will initiate a rapid action for policy support (RAPS) initiative.

In 2021, program staff will continue to attend meetings such as the Global Forum for Food and Agriculture scheduled for January 18-22, and the Regional Centre for Mapping of Resources for Development (RCMRD) International Conference in August 2021. The Agriculture application area will continue supporting the use of Earth observations to benefit communities interested in agriculture and food security.

The Agriculture application area intends to strengthen its domestic strategy by utilizing the new USDA- NASA MOU to broaden engagements and will leverage the consortium model to increase and strengthen collaborations.