NASA HARVEST(ING) EARTH OBSERVATIONS FOR INFORMED AGRICULTURAL DECISIONS

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ABSTRACT

Agriculture, while critically important to humanity in terms of jobs and sustenance, is also one of the largest contributors to climate change, the largest user of freshwater, and one of the primary drivers of land cover and land use change. Accordingly, the need for timely, accurate, and actionable information to understand these impacts and dynamics is growing. NASA Harvest – NASA's multisectoral food security and agriculture program – contends that Earth observations play a critical role in both the attainment of and the monitoring of progress toward the United Nations 2030 Agenda for Sustainable Development. In order to really deliver on what will be in 2030 six decades of investment in Earth observations with respect to agricultural productivity, sustainability, and land use, we posit herein several critical areas of necessary investigation, collaboration, partnership, and action for 2020-2030 and beyond.

Index Terms **—** remote sensing, agriculture, NASA, food security, GEOGLAM

1. WORKING TOWARD SUSTAINABLE & PRODUCTIVE AGRICULTURE IN 2030

Agriculture, while critically important to humanity in terms of jobs and sustenance, is also one of the largest contributors to climate change, the largest user of freshwater, and one of the primary drivers of land cover and land use change [1]. At the same time, the number of undernourished people is increasing, reaching an estimated 821 million in 2017 [2]. Global population is continuing to increase while becoming increasingly affluent and more consumptive. The need for sustainable solutions to hunger, production, consumption, and associated land use are of critical importance.

As such, the needs for information to understand agricultural land use, productivity, and sustainability are growing. NASA Harvest contends that Earth observations play a critical role in both the attainment of and the monitoring of progress toward the United Nations 2030 Agenda for Sustainable Development [3, 4]. Agriculture is a major component of human well-being and development, and intersects with multiple Sustainable Development Goals (SDGs), including 1 (No Poverty), 2 (Zero Hunger), 3 (Good Health & Wellbeing), 6 (Clean Water and Sanitation), 12 (Responsible Consumption and Production), 13 (Climate Action), 15 (Life on Land), and 17 (Partnerships for the Goals).

Since 2014, the number of Earth-observing satellites launched all-time has doubled [5], and as commercial satellite companies continue to launch more and more "small sats," the volume of observations will grow exponentially. At the same time, revolutions in information and computing technology (ICT) including cloud computation, artificial intelligence, and machine learning mean we are poised as a community to turn massive, multidimensional arrays of pixels into meaningful and actionable information.

2. NASA HARVEST BACKGROUND & OBJECTIVES

In order to really deliver on what will be in 2030 six decades of investment in Earth observations, we posit several critical areas of necessary investigation and action. Agricultural decision makers need access to timely, objective, accurate, and actionable information to strengthen food security, market stability, and human livelihoods. NASA Harvest – NASA's multisectoral food security and agriculture program led and implemented by the University of Maryland – is driven from this decision maker or "end user" perspective. NASA Harvest's Programmatic Mission is to enable and advance adoption of satellite Earth observations by public & private organizations to benefit food security and agriculture in the US and worldwide. NASA Harvest is composed of over 60 partners who are leaders in their fields and who are advancing both the state of the science as well as the adoption of satellite-based Earth observations in support of informed decisions for food security and agriculture.

NASA Harvest was established under the NASA Applied Sciences Program in 2017. It is the first of its kind wherein NASA competed and subsequently established a program outside of a NASA headquarters or a NASA center. The objective in doing so was to empower the program to be agile in its organization and management and responsive to the highly dynamic nature of global agriculture, particularly with

respect to initiating and discontinuing partnerships in the public and private sectors alike. In the just over two years since its creation, the program has coalesced on core priorities, added (and discontinued) multiple partners, and developed renown in the international community. More information can be found at www.nasaharvest.org.

3. NASA HARVEST FOCUS AREAS

NASA Harvest works at global. regional, national, and field levels in agricultural systems that range from subsistence to large-scale commodity production. The program has three impact areas: agricultural land use, sustainability, and productivity. It aims to improve these three areas by advancing the quality of Earth observations (EO) based products and methods in crop and crop type mapping, crop condition monitoring, crop statistics generation, crop yield forecasting and estimation, and cropping practices characterization. To accomplish this, we work to advance the state of the science and the state of use through innovation in field data collection and sharing, public-private partnerships, open, transdisciplinary data platforms, data integration, and artificial intelligence and machine learning (Figure 1).

Figure 1: NASA Harvest impact areas, product and method areas, and facilitating innovation pathways.

4. 2020 PRIORITIES

The core priorities for NASA Harvest in 2020 are:

1. Public private partnerships for sustainability: Many PPPs in EO for agriculture have focused on a unidirectional transition of methodologies from public research to private sector, limiting the knowledge sharing between sectors and arguably slowing progress toward the revolution in agriculture and food systems needed to achieve the 2030 Agenda for Sustainable Development and other critical milestones. NASA Harvest emphasizes that we all have a role to play in revolutionizing the food system and addressing critical global challenges, and actively seeks to engage actors who share this vision. In late 2019, we initiated a facilitation mechanism to accelerate PPPs, with a particular emphasis in supporting supply chain and consumer goods companies to measure and meet their sustainability commitments [6].
2. Field data collection initiative: While we have entered the "Big Data Era," we are still data poor in terms of field data, particularly in smallholder systems. This is a major bottleneck to the development and application of robust crop monitoring methodologies. We launched a major field data collection initiative with Swiss Re in Ukraine in 2018, resulting in the largest set of open field data on yield and type, and plan to expand this to smallholder regions in 2020 and beyond.
3. Essential Agricultural Variables for GEOGLAM: NASA Harvest is NASA's contribution to the G20 Group on Earth Observations Global Agricultural Monitoring (GEOGLAM) program, which shares similar aims with NASA Harvest in promoting food security and reducing food price volatility through improved, timely, and actionable EO-based information. There is a lot of distance covered between satellite data acquisition and decision making for policy, and GEOGLAM and NASA Harvest aim to bridge that gap. Among many roles, NASA Harvest co-leads (with VITO-Belgium) a working group geared toward defining high-value EO-based products with direct policy relevance known as "Essential Agricultural Variables for GEOGLAM" (EAVs for GEOGLAM). See www.geoglam.org for more information.
4. Standard crop products: Related to the EAVs for GEOGLAM as well as to Harvest's product and method areas (Figure 1), NASA Harvest aims to generate standard subnational, national, and global crop products and/or the underlying methodology as a public good. 2020 marks a continuation of a multi-year effort toward this objective, in support of the EAVs for GEOGLAM and general agricultural assessment by diverse stakeholders (Figure 2).

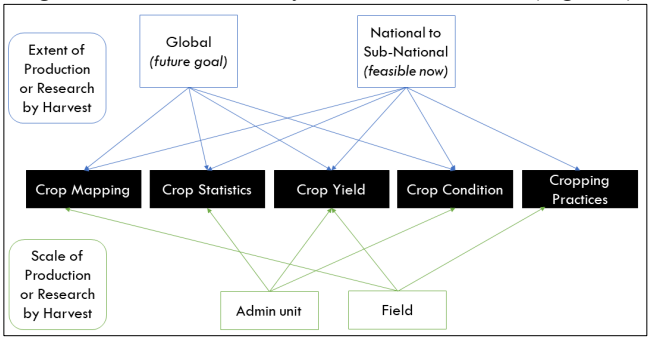

Figure 2: Extent (top) and scales (bottom) of production of or underpinning methodologies for standard products for agricultural assessment (center).

5. Focus on end users in high-priority geographic regions: Since NASA Harvest's inception we have established strong foci on strengthening connections with end users and stakeholders working in agriculture, food security, and EO in Eastern Africa & in the United States. We additionally have regional foci in the Americas (through affiliation with the GEOGLAM regional network, Agricultural Monitoring in the Americas [7]) and South & Southeast Asia. We will continue to invest in operational research, development, and transition of methodologies with applicability and ownership in these geographic areas.

5. NASA HARVEST PARTNERS & AFFILIATES

We recognize that we can only reach such ambitious goals through strong partnerships across public and private sectors as well as across multiple disciplines ranging from remote sensing to economics to reinsurance to statistics to sociology and beyond.

NASA Harvest's primary sponsor is NASA, under cooperative agreement #80NSSC18M0039, and NASA Harvest utilizes these funds to in turn sponsor its core operations – at the Harvest Hub at the University of Maryland – as well as operational research and implementation partners at a variety of research institutes, universities, and private sector companies. NASA Harvest also has partners and collaborators whose resources, missions, and/or projects are leveraged and who do not receive direct funding from NASA Harvest. In total, as of early 2020, NASA Harvest has over 60 partners from public and private sectors alike (Figure 3), and will continue to add (and discontinue) partners strategically to ensure we meet our ambitious but critically necessary goals.

Figure 3: Logos of NASA Harvest Partners, as of January 2020

6. CONCLUSION

NASA Harvest is a diverse, multidisciplinary consortium of over 60 international partners anchored by a strong Hub at the University of Maryland. It is driven by the challenge that sustainably feeding a growing and dynamic population presents, recognizing that all human beings deserve a secure existence as envisioned by the UN 2030 Agenda for Sustainable Development. We see EO as a critical element to this success, but much work remains to be done in terms of methodological development, data integration and sharing, and methods transition to operational usership. Outreach, communication, and integration of our work with that from other sectors and disciplines is critical to forward movement, and informs our key priorities for 2020 and beyond.

7. REFERENCES

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