DIGITAL AGRICULTURE IN NEW YORK STATE

Report and Recommendations

Abbreviated Version

This document is an abbreviated version of a report titled "Digital Agriculture in New York", which contains more exhaustive analyses and recommendations.

The full report is available at: bit.ly/NYSDigitalAgReport

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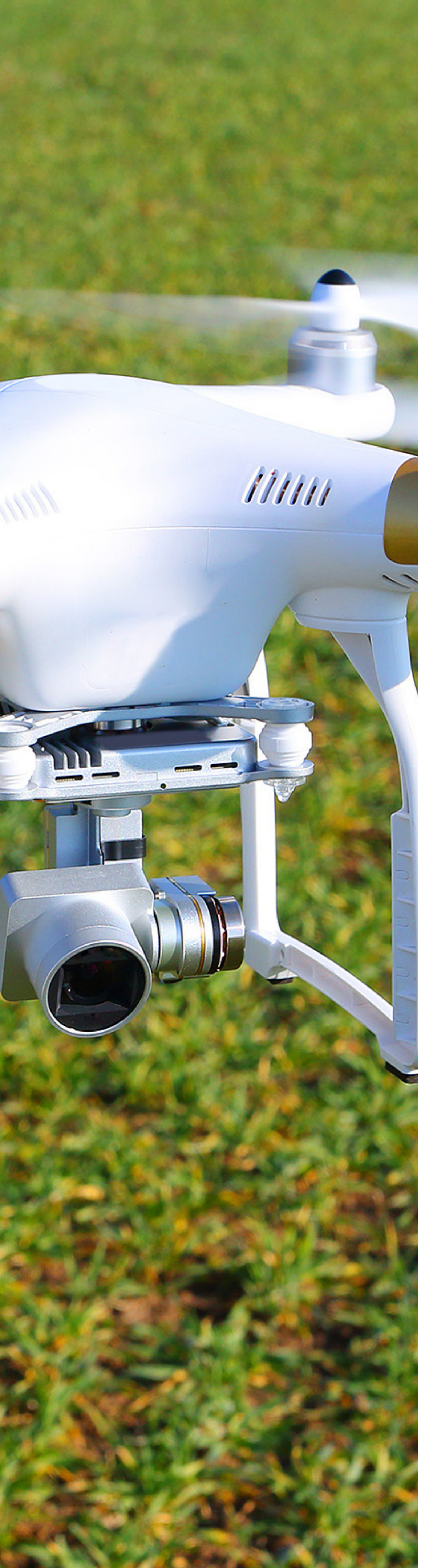
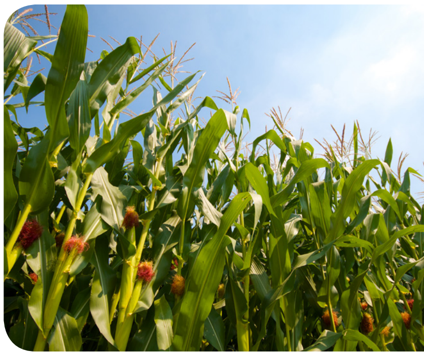
November 2016



A New Era for Agriculture

Like other economic sectors, agriculture is increasingly affected by the digital revolution. Digital Agriculture refers to the employment of computational and information technologies to improve the profitability and sustainability of agriculture. It is a new direction for Precision Agriculture, a more established concept that is broadly defined as "the use of advanced technologies to precisely match agricultural inputs with needs", and which has historically been aimed at crop production. Digital Agriculture (DA) offers new opportunities through the ubiquitous availability of highly interconnected and data-intensive computational technologies, as part of the so-called Fourth Industrial Revolution.



Digital Agriculture applies to all crop and livestock systems, and reflects a shift from generalized management of farm resources towards highly optimized, individualized, real-time, hyper-connected and data-driven management. The desired outcomes of leveraging Digital Agriculture are more profitable and sustainable production systems.

Mandate

In 2015, the New York State Legislature directed the Commissioner of Agriculture and Markets to "issue a report assessing the use and development of precision agriculture in the state with recommendations pertaining to rural broadband accessibility, use and support for the farmer, as well as cost savings and higher crop yield." This is an abbreviated version of a document that details the technologies, opportunities, barriers and recommendations around Digital Agriculture. As part of the mandate, agricultural professionals were engaged to assess adoption of new agricultural technologies and to help identify challenges and recommendations to advance Digital Agriculture in New York.

Understanding Digital Agriculture

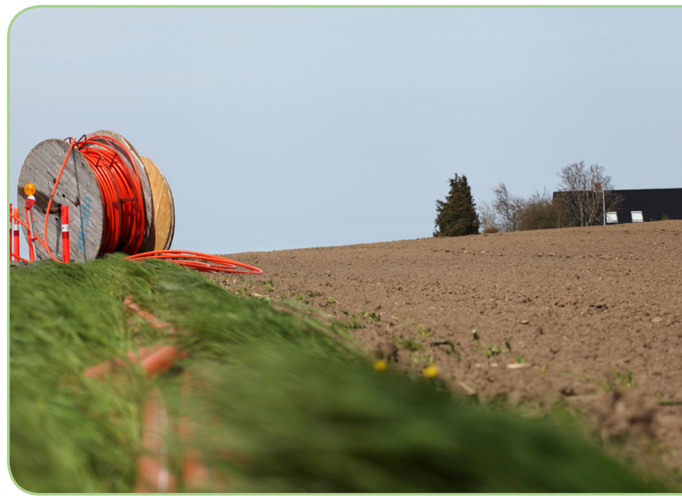
Digital Agriculture leverages the smart use of data and is enabled by high-performance computing power, hyper-connectivity through mobile technologies and the Cloud, and advanced analytics. New York farmers are adopting advanced technologies, but their complexity makes it difficult to discern the benefits, especially for non-traditional sectors like specialty crops. It is also becoming increasingly difficult for farmers to manage, interpret, or make use of their data due their volume and complexity, as well as privacy concerns. Farm data and access needed to make new discoveries and management guidelines are increasingly controlled by corporate entities with less opportunity for public-sector research or extension for communal benefits. There is a compelling need to support Digital Agriculture adoption through investments in infrastructure, knowledge, e-communication, education, and business development.

Enabling Technologies for Digital Agriculture

Type of Technology
Cross-Cutting
- Computational Decision Tools and Data
- The Cloud
- Sensors
- Digital Communication Tools
Field
- Geo-locationing (GPS, DGPS, RTK)
- Communications (Cellular, Broadband, LPWAN)
- Geographic Information Systems (GIS)
- Yield Monitors
- Precision Soil Sampling
- Sensing (Proximal and Remote)
- UAVs/UASs
- Auto-steering and Guidance
- Variable Rate Technology
- On-board Computers
Livestock-specific
- Radio Frequency Identification (RFID)
- Automated Milking and Feeding Systems
- Livestock Software Models

Digital Agriculture Technologies

The technologies that enable Digital Agriculture are multiple and varied, and are inclusive of current precision agriculture tools, as well as computational and sensing tools that are yet to be developed. The main enabling DA tools that exist today include cross cutting technologies such as computational decision tools, the Cloud, sensors, and digital communication tools. Field-based activities are also enabled by technologies such as geo-locationing, communication, geographical information systems, yield monitors, precision soil sampling, proximal and remote sensing, unmanned aerial vehicles, auto-steer and guidance, and variable rate technologies. Livestock-specific technologies include radio frequency identification, automated (robotic) milking systems and electronic feeding systems, among others. Controlled-environment agriculture (greenhouses, etc.) are also increasingly enabled by digital technologies like sensors, controllers and robots.



Expanding broadband to rural areas is critical.

Production efficiencies can be gained from the integration of data associated with multiple technologies (which currently are mostly considered independently), and from the real-time transfer of data between field equipment, barn, office, and the Cloud. Inadequate data analytics and telematics (the long-distance transfer of digital information) are currently constraining the potential benefits from these technologies.

For a farm enterprise, three different types of technology investments can be identified:

(i) Capital investments that promote efficiencies, like computer hardware/software; robotic systems; auto-steering; variable rate equipment; sensors; high precision GPS, etc. Education and support are needed for their effective implementation.

(ii) Service investments that provide actionable information for improved management (remote sensing images; cloud-based models; etc.). The utility of these tools need to be proven and explained.

(iii) Farm knowledge investments that involve the development of actionable knowledge for a specific farm, herd, or field location and require the collection of data that are then analyzed to generate specific recommendations. This requires advanced analytics and a commitment to on-farm research.

Each requires different types of support from dealers, consultants, educators, and researchers. Much of the research on profitability has focused on straightforward equipment investments, like auto-steer, yield monitors, variable rate technology, and automated milking or feeding systems. Agriculture will follow other industry sectors in that the benefits from digital technologies will materialize and become a source of increased production efficiencies once ubiquitously available data are effectively employed. In a global economic environment, New York agriculture's competiveness is strongly tied to its ability to innovate in these key aspects of the production system. Therefore, the question is not whether NY farmers will adopt digital technologies (they will) but how this adoption process can be supported by an environment that allows them to fully capitalize on the potential production gains.

Digital Agriculture Adoption

Ag Community Engagement

To understand the status of digital and precision agriculture in New York, several activities were performed:

(i) a workshop with farmers and agribusinesses

(ii) a statewide farmer survey

(iii) a literature analysis

(iv) a study on current and evolving trends in Digital Agriculture.

The statewide survey targeted farmers throughout the state across all farming sectors and was conducted in collaboration with several NY farmer organizations, with 388 responses received. The survey assessed farmers' current and expected use and adoption of precision agriculture technologies, as well as barriers, opportunities, and perceptions of benefits. Adoption rates in New York State remain well below those in leading agricultural states.

The results of the survey analysis suggest several interventions for improving digital agriculture adoption. A recurring theme was the large analytics and data management gap relative to the capabilities of modern-day equipment. 34% of respondents indicated insufficient technical support, while 51% reported that they are uncertain on how to implement new technologies in a profitable manner.

Producers reported their priorities to be extension and education (24%), research and development (20%), infrastructure (20%), and business development (18%). Access (or lack thereof) to high speed internet was found to be a significant factor affecting benefits of DA technology. These results suggest that government programs that invest in public R&D, education, and data communication infrastructure are paramount to capturing the full benefits for New York farmers.

In terms of whether producers were favorable toward future developments in DA, only about 7% indicated disagreement, whereas 54% indicated a belief that digital/precision agriculture has a bright future in NY State. Most producers concurred that DA has good business and employment opportunities, and almost 74% agreed that the use of DA technologies bring environmental benefits and efficiencies. However, only 22% agreed that new college graduates have a good understanding of DA technologies.

Digital Agricultural for Different Sectors

The new opportunities offered by Digital Agriculture in New York are dependent on reducing several barriers to adoption, notably

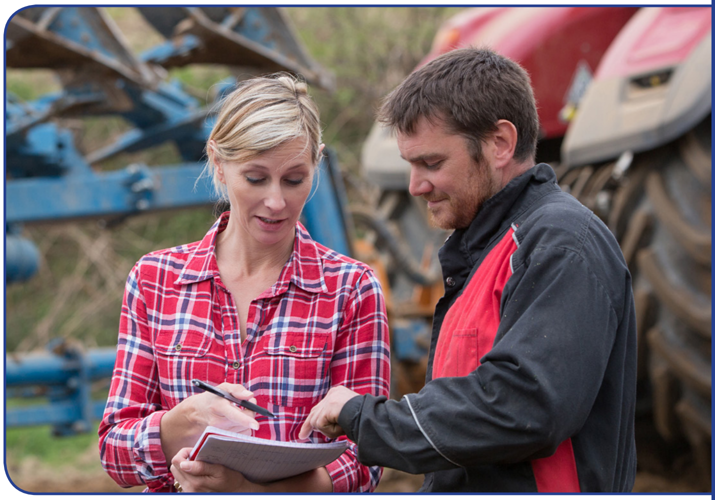
(i) better adaptation of technologies and knowledge to NY conditions (forage crops, variable fields, high-value specialty crops, dairy, etc.),

(ii) improved educational programs to support agribusiness service companies,

(iii) improved research, and

(iv) improved communication infrastructure.

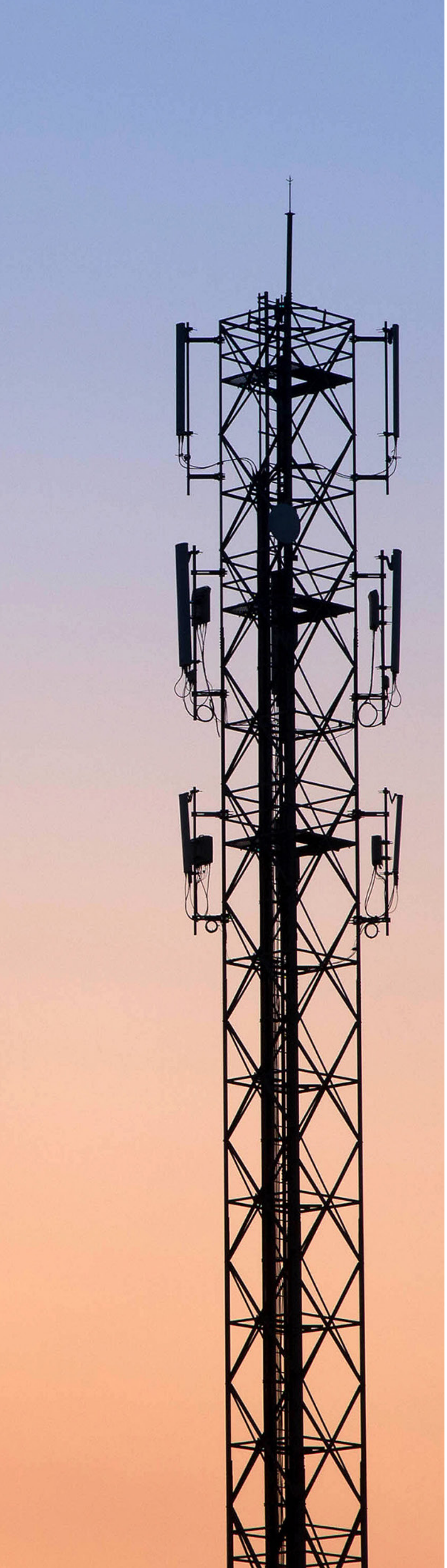
Many of the DA tools used for field crops are also relevant to horticultural crops. Technologies like auto-steer, precision planting, and VRT can be effectively employed to high value crops like vegetables, fruits, and landscaping. Since their crop input costs are generally high, DA technologies can potentially have a large impact in these sectors. Dairy farms have been early DA adopters, and swine and poultry farms are also increasingly employing these technologies. Controlled environment agriculture (greenhouses, etc.) is also rapidly adopting electronic and computational controls to optimize growing environments and improve products.



A statewide survey with 388 responses was performed.

Organic farms in New York stand to benefit from many of the same DA technologies as conventional crop farms. Some DA technologies that could be especially relevant to organic farmers include (i) precision planting technologies and tractor guidance systems that assure more uniform crop stands and make straighter, more uniform rows that enable much better weed control, and (ii) DA software that can track much of the production information needed for organic certification on a site specific basis. Organic products currently have considerable price premiums, but organic inputs are more expensive than conventional inputs and DA technologies therefore have high potential impacts.

Larger farms can more readily justify and implement DA technologies that are capital intensive than smaller farms, and a "digital divide" is emerging that may create inequitable adoption and benefits. On the other hand, some DA technologies are more scale neutral, like site-specific weather and pest prediction models that are often freely available or on a per-acre cost basis. Some farm management software is scaled for small operations to help organize and utilize the data that are collected.



Connectivity and Data Management

For its potential to be realized, Digital Agriculture requires multi-faceted hyper-connectivity and high-precision GPS. Connectivity limits the effective employment of DA technologies in many rural areas of the state, and needs exist around (i) expanding broadband access to 100 Mbps for the most remote unserved areas, (ii) improving cellular coverage and data transmission speeds for proper uploading and downloading of data and effective use of high-precision GPS, (iii) establishing low-power wide area networks that offer opportunities for the use of sensor technology and equipment communications through the so-called "Internet of Things", and (iv) universal access to RTK-GPS technology.

Improvements in this realm are currently underway, through the New NY Broadband program initiative. Currently about 25% of all crop acres in the state fall in Census Blocks deemed to be underserved or unserved, but under Phase II of the NYS Broadband Program, virtually 100% of households will be covered with speeds up to 100 Mbps by 2018.

As farmers adopt precision agriculture technologies, they accumulate large amounts of data in the form of yield files, as-applied maps, aerial imagery, nutrient applications, milking and animal health records, etc. Agricultural data are no longer confined to on-farm computers or equipment, rather, much of the processing and storage of farm data resides in the Cloud. Increasingly, data are being accumulated by integrated agricultural companies which are investing heavily in digital technologies. Farmers are concerned about data privacy and ownership issues, and are hesitant to give unlimited access of their data to corporate or government entities. Several initiatives have been proposed to establish industry standards on the use and protection of farmer data. For example, the Ag Data Transparency initiative is backed by a broad coalition of agricultural groups, and establishes some standards for data privacy and retention.

A remaining concern, however, is that while corporate entities are amassing large databases on farmer production details, there is no avenue for the vast majority of these farm data to be available for public-sector or university analytics, and therefore the development of next-generation agricultural management strategies. In addition, universities in New York have limited capacities or funding support to address these Big Data needs. There are also issues with the use of DA technologies in the context of farm regulations, where benefits of new technologies cannot be realized due to outdated guidelines. Conversely, automated digital record keeping offers opportunities for better regulatory compliance.

Opportunities and Challenges for Digital Agriculture

In order to advance Digital Agriculture in New York, educational issues need to be addressed at multiple levels related to

(i) farmer knowledge on the use and economics of DA technologies, data management, and emerging technology applications,

(ii) training of professional service providers and educators, and

(iii) undergraduate and graduate training of the next generation of professionals at universities and colleges.

For research, concerns that need addressed center around:

(i) limited farm data availability for analytics,

(ii) the small researcher community and limited funding at universities in promising areas of DA,

(iii) limited capacity for highly innovative research initiatives and new management recommendations, and

(iv) limited partnerships between the present research-extension community and private sector agriculture and technology companies.

Recommendations for Digital Agriculture

By seizing opportunities and overcoming barriers, New York's technology companies and public institutions can help lead its agricultural industry into the digital age. Conversely, foregoing these opportunities will negatively impact the industry's national and global competitiveness. Given that agriculture forms the backbone of the Upstate economy and employment profile, the state should leverage Digital Agriculture technologies through significant investments, specifically in the following:

Connectivity

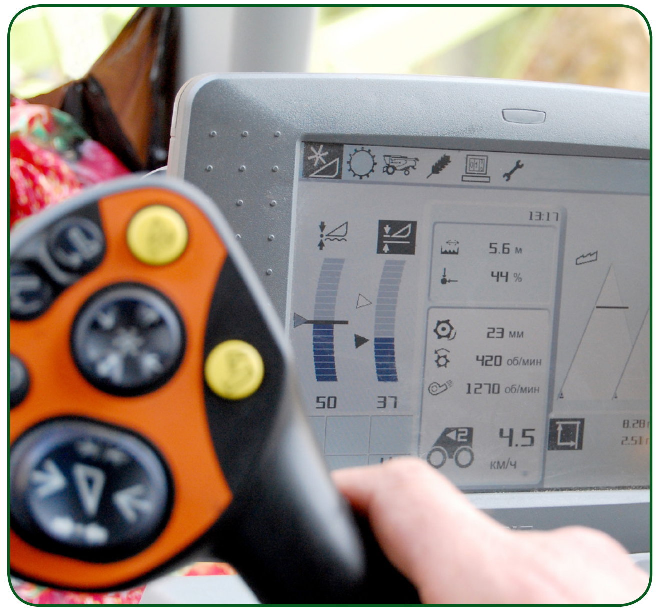
- Expand broadband access to all rural areas in the state; this is already underway with the successful implementation of the NYS Broadband Initiative.
- Promote the expansion of next generation cellular technology in rural areas to connect mobile farm equipment with the Internet, and enable high levels of data acquisition and transfer.
- Explore opportunities offered by low-cost LPWAN networks to facilitate the Internet of Things (multiple farm tools and sensors having Internet connectivity).

Ear tag with RFID technology.

Data, Education and Research

- Establish an Institute for Digital Agriculture (IDA) at Cornell University focused on research, education, data management, and business development. Such an institute would enhance the recently developed DA initiative at the University, serve as a focal point for DA activities, attract talented researchers and educators, facilitate robust and innovative research efforts, and foster collaborations with New York-based agricultural and technology enterprises and institutions.

- Establish within IDA a data center infrastructure that allows for the collection, curation, and analysis of data from New York farms, with appropriate consent, privacy and security considerations. The data would be stored for farmer use and benefit, and also be available for university researchers in aggregate and anonymized form to enable development of a new generation of technologies and recommendations to benefit NYS farmers.
- Within IDA, allocate funding to support highly-innovative research efforts in Digital Agriculture, while also enhancing on-farm research through existing programs (NYFVI, IPM, etc.).
- Develop an educational program within IDA working with agribusinesses, consultants, Extension, and SUNY institutions to advance Digital Agriculture adoption in the state.
- Initiate a coordinated faculty hiring effort at Cornell University and SUNY agricultural and technology institutions to increase research, education and extension capacities in DA. This would build a cadre of specialists with high skill levels in data analytics and precision technologies in different agricultural disciplines who could effectively engage with other technology disciplines, notably engineering and computer science.
- Consider guidelines that pro-actively address privacy, availability, regulatory, and equity issues around agricultural data.
- Link research and education with entrepreneurship and venture development programs at the university and state level. IDA should also support and engage with initiatives that address concerns about data privacy, security, and ownership for agricultural data.



Using real-time, in-field monitoring.

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Correct Citation:

van Es, H.M., J.D. Woodard, M. Glos, L.V. Chiu, T. Dutta, and A. Ristow. 2016. Digital Agriculture in New York State: Report and Recommendations. Abbreviated Version Cornell University, Ithaca, NY.