

Improving USDA/NRCS Services with Internet of Things (IoT) and other Emerging Technologies

The USDA/NRCS is mandated by US Congress to help American farmers, ranchers and foresters to put conservation on the ground for improving natural resources (soils, water, air, etc.) and their agricultural operations. It is a voluntary program and is delivered through a network of USDA/NRCS field offices in each state involving the following process:

1. Producer visits the local NRCS field office and discusses her/his goals with the staff in identifying the resource concerns and works with them in developing a conservation plan to take care of the identified concerns,
2. The applicant (the producer) completes the application for the financial assistance program that goes through a rigorous eligibility and ranking process according to local resource concerns,
3. Once approved, NRCS provides financial and technical assistance in implementing conservation practices identified through the plan.

All these steps are very data intensive needing an in-depth and objective analysis. In-addition, the process encompasses considerable amount of proprietary and personal information that needs to be guarded and preserved. Thus, NRCS has been continuously improving the process by adapting latest technologies that help improve the overall delivery process. The examples of the latest national efforts in this direction include: 1) Conservation Delivery Streamlining Initiative (CDSI); and 2) Conservation Assessment Ranking Tool (CART).

The CDSI is a web-based system that enables producers to enter their operational details from the convenient of their home and allows the NRCS field staff to access these data for developing a conservation plan. It is intended to be a more effective, efficient, and sustainable business model for delivering conservation assistance across the nation. On the other hand, CART is being designed to facilitate the process for planners to assess clients' resource concerns, planned practices, and site vulnerability as part of the conservation planning process and will rank client applications for NRCS program funding. These tools will significantly

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enhance conservation delivery process. However, integration and adoption of emerging technologies such as Internet of Things (IoT), Artificial Intelligence (AI), etc. can further boost these efforts in putting more conservation into ground and improving farm operational effectiveness and efficiency.

The IoT is the network of interconnected things/devices which are embedded with sensors, software (intelligent), network connectivity and necessary electronics that enables them to collect and exchange data making them responsive to suggest and/or trigger an action plan. Combining the power of IoT with other technologies such as AI (Artificial Intelligence), analytic, machine learning, etc. provides a unique opportunity for increasing the farm productivity through enhanced human efficiency without further degrading and/or reversing the process of the environment degradation. The four key components of an IoT system are:

1. sensors for measuring one or more parameters such as soil moisture;
2. a communication device and/or mechanism for transmitting the measured data to a data storage system such as clouds;
3. a data analytic system for analyzing the stored data in combination with data from other sources, if so needed; and
4. transmitting back the processed information for an actuation system (automated and/or human controlled) for initiating an action based on the analytic.

Agriculturalists have been using one or more of these IoT components for quite sometimes. For examples, sensors for measuring soil moisture at different depths are very common and are even supported through the NRCS programs. However, currently available enhanced data storage systems (cloud computing), internet capabilities to transmit data (WiFi), and advanced analytics with AI and deep learning open new horizons for agricultural operations.

There are already several examples around the world where farmers are using and benefiting from these technologies. Some of these include:

- Irrigation scheduling in an avocado farm reducing the water cost by 75% (<https://www.youtube.com/watch?v=1D0O4LGkKiY>)
- digital farming for dairy cows for improving farm operational efficiency (<https://www.youtube.com/watch?v=xZaJAIWVRGo>)

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- hydroponic agriculture for optimizing farming decisions and increasing farm productivity (<https://www.telit.com/industries-solutions/agriculture/>).

The USDA/NRCS has also been supporting such efforts through the CIG grant funding, for example:

- the [Next Generation Technology for Monitoring Edge-of-Field Water Quality in Organic Agriculture](#) at the Colorado State University;
- the [Internet of Agriculture \(IoAg\) Network and Services Platform](#) at the White River Irrigation District, AR; and
- [Utilizing Deep-rooted Cover Crops to Enhance Water Quality, Soil Health, and Farm Profits While Reducing Soil Compaction in Coastal Plain Region](#) at Clemson University, SC.

All these examples show the power of IoT and other associated technologies and how they can improve farm operational efficiency leading to the increased farm productivity and efficient and effective utilization of natural resources. However, a lot more needs and can be done for American producers to reap the full benefit of these technologies. The USDA/NRCS can play a significant role in these efforts by adopting these technologies in its own service delivery process and to encourage producers to do so through its programs.

Farmers served through the USDA/NRCS programs come from different background & experiences with varying aptitude to change and/or adopt new technologies. This complexity further increases as agriculture deals with biological systems (crops, animals, etc.) under the dynamic natural environment (climate and soils). Thus, intervention of these emerging technologies needs to be carefully planned and executed for achieving the desired results. For the USDA/NRCS I would propose two broad categories: 1) top-down approach, and 2) bottom-up approach for these interventions.

The top down approach deals with the USDA/FPAC/NRCS leadership to accept the approach and commit the necessary resources for such interventions. The bottom-up approach deals with identifying, selecting and testing IoT applications at the field levels that can help improve the operational efficiency of individual farmer and that of NRCS field staff. Some

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of the examples for such applications could include internet connected sensors (soil moisture and other parameters) that provide continuous data with appropriate analytic (edge or in-cloud). This would facilitate decision making, evaluating effectiveness of the installed practice(s) and make the follow up verification process by NRCS field staff easier and more quantitative. Currently, in most cases the follow up verifications are limited to visual observations and information supplied by the farmer.

Several specialists at the field, state and national level perform different functions for achieving NRCS goals and objectives. Each of these individuals need to be educated and trained about the emerging IoT technology and how it could facilitate in delivering NRCS services to producers. There are isolated efforts underway around the nation demonstrating usefulness of AI and IoT applications in agriculture. An in-depth analysis of the whole system to develop a holistic plan of using IoT and other emerging technologies will prepare NRCS for the future and help American farmers further improve farm operational efficiency and minimize environmental degradations. I would suggest a two-fork approach to achieve these goals: 1) enhancing the ITC capabilities with a Digital Technology Advancement (DTA) team, and 2) having specialists with digital technology skills/expertise at each state office and regional technology centers. These specialists could serve as a conduit between the natural resource specialists and the ITC-DTA team. This approach is similar to the one adopted by the US Department of Defense for preparing its armed forces for the future which includes: 1) creation of an [artificial intelligence hub](#) and 2) changing its Marine squad structure by including [a quadcopter drone operator](#) in each squad.

The best place to start for the bottom up approach would be to include the topic of the “**Agricultural Applications of AI & IoT**” as one of the priority topics within the [NRCS Conservation Innovation Grant \(CIG\)](#) process. Although there are already few examples of the grantees working on this approach, however, its inclusion as a special topic in the future CIG requests would encourage many more to work on these emerging technologies for the benefit of American producers.

In addition to CIGs, there is a need to develop and launch a training program to increase awareness about these emerging technologies for the NRCS technical staff at field, state and national levels. There are already few NRCS

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standards and cost sharing programs that employ IoT components such a soil moisture sensor(s) but they need to be extended to include the current status of the technologies (internet connectivity, data storage and data analytic). A successful planning and implementation of such a holistic program should achieve the following goals and prepare USDA/NRCS for the future:

1. Improvement in producers requesting and getting the NRCS assistance easily and comfortably without compromising their confidentiality and privacy,
2. Improved ability of the NRCS field staff to develop conservation plan(s) by accessing producer's information and other site-specific data from the national and corporate databases
3. Ability to monitor the performance of installed conservation practices by accessing and analyzing the data transmitted by internet connected sensors. This should also help in quantitative evaluation of the installed practices.
4. It should lead to considerable increase in operational efficiency in farm operations resulting in timely operations, reduced environmental impact, and increased productivity and farm income because of better access to markets.

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