Big Data for Agriculture: Six Steps to overcoming barriers to innovation

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Abstract

With the population reaching 9 billion by 2050, there is a need to increase agricultural productivity. By 2030, the Food and Agriculture Organization of the U.N. estimates there will be a 35% increase in global food demand [16]. Along with this increasing demand, climate change and a decreasing amount of arable land will affect the food supply. Leveraging information gained from big data analysis and implementing it in agriculture could help meet these growing demands on the food supply. Innovative solutions from big data insights will be the key to feeding the next generation. Three main challenges in agricultural applications include: data infrastructure, data integration and deriving value from the data. Six steps to overcoming these challenges are explored.

Introduction

The good news is that emerging technologies continue to make it easier to collect and use large amounts of data cheaply. Big data can make a farmer more productive. This potential will drive agricultural innovation to minimize the effects of climate change, natural disasters and limited resources for society [10]. It is essential to break down barriers so farmers can produce more with fewer resources and so the world has enough to eat. The stakes have never been higher for overcoming these challenges .

Three main challenges in agricultural applications include: data infrastructure, data integration and deriving value from the data.

These steps will help overcome these challenges:

1. Set up an appropriate infrastructure.
2. Establish partnerships to integrate data.
3. Communicate across silos.
4. Ask the right questions.
5. Find the data's value.
6. Data experts need to collaborate with domain experts.

For purposes of this research, big data means data that is generated by private entities such as corporations and non-government organizations. This paper explains the three challenges along with the six steps to overcome them .

Problem Definition

The first challenge when implementing big data is creating an effective data infrastructure. The data infrastructure includes the data itself, how it is managed, analytics, storage and security [3]. All of these aspects are important from an organizational and social context because without one of them, big data implementation will fail .

The second challenge is how heterogeneous data are integrated. IBM Analytics defines data integration as 'the combination of technical and business processes used to combine data from disparate sources into meaningful and

valuable information' [4]. Agricultural data includes weather data, sensor data from GPS transceivers, smart meters and cell phone data. In order to optimize production, the data need to be linked [8].

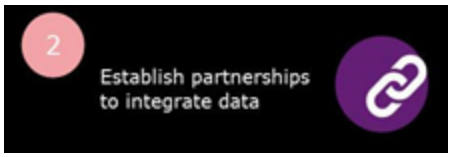
The third challenge is how to derive value from big data. Using big data means organizations have a lot of data that may not be needed for agricultural innovations. In two days, society now creates as much data as all of civilization created prior to 2003 [14]. Sorting through this amount of data and finding value has been compared to finding a needle in a haystack. Innovative solutions require stakeholders to ask what data is necessary and what value it will create.

High-Level Solutions

There are several high-level solutions for overcoming each of these challenges. Creating a *successful Infrastructure* may mean the organization has more cloud-based solutions with adequate storage, scalability and security that big data requires. In this research, an organization could be a farmer's association or agribusiness. One example is when an organization used Eucalyptus cloud software to give crop data access to remote areas of the country [6]. Next, in order to solve the *Integration challenge*, commercial applications such as TeraStream batch all of the data, link it and convert it to quickly process it. This type of solution allows the data from a field sensor to communicate with the data from a farmer's mobile phone. Finally, to solve the third challenge of *Deriving Value,* the success of big data for agricultural innovation depends on the participation, support from and collaboration between public and private entities.

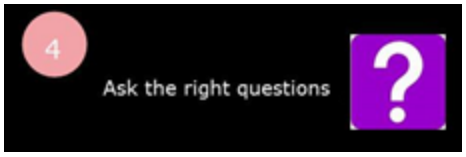
Six Steps to Overcome Big Data Challenges

Step 1 - As data volume continues to grow, organizations need to make investments in infrastructure to 'capture, store, aggregate, manage, govern and analyze data' [1]. One of the key aspects to a great data infrastructure is setting up a cloud which is a centralized knowledge repository [8]. When all the data is in one place, anyone with access can have the data at any time. One example is farmers in Sudan that use a cloud-based system with mobile phones to disseminate data about crop status, planting schedules, harvesting times and market prices using their mobile phones [15].

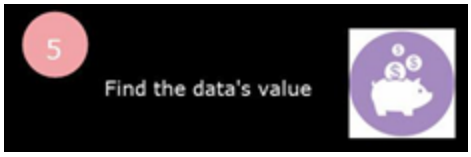


Step 2 - With the use of big data comes more complex and intertwined data. There is a need 'to link, match and transform data across heterogeneous entities and systems' [8]. Various sources of data means that not one single entity has control over the data. It's important for different groups to work together to link and manage their data. Partnerships between farmers and global technology companies benefits both parties and can serve as one way to integrate data.

Step 3 - Silos of information are one of the biggest threats to using big data in agriculture. A silo mentality is harmful because the information is not shared between groups inside of or outside of organizations. Collaboration and communication could help advance knowledge that otherwise might not be advanced if the data was hoarded [9].



Step 4 - It's important to understand what big data can and cannot do to benefit agriculture. Asking the right questions should ideally happen before you get the data. Without research questions that are relevant and within context, researchers are less likely to produce findings with any local impact [14]. It is important for organizations and society to ask the 'right questions' before you can find the right data.



Step 5 - Before analysis begins it's important to determine which data is valuable. What may seem at first to be unimportant data can be valuable when combined with other data sources. By asking the right questions, the most valuable data can be extracted. Adopting big data is also a cultural issue, where organizations and farmers don't implement programs because they don't appreciate how data can enhance their business [5]. Tying valuable data to measurable business outcomes can help overcome implementation challenges (http://openag.io/blog/).

Step 6 - To maximize the benefits of big data, people with data skills need to work with agriculture domain experts to understand the context and meaning of the data to create innovative solutions. Although there is no quantitative data that measures how much more effective a multi-disciplinary data team is, some research suggests great value in having different people focus on their particular skillset to accomplish a goal [13]. The interaction between those with technical data skills and domain expertise will help organizations integrate the information gained from the data into agricultural processes.

Business Benefits and Risks

Typically, business benefits are seen in terms of return on investment. The benefits to implementing big data solutions for agriculture are 1) fewer resources are needed to produce more food and 2) a reduced dependence on foreign aid. Each of these benefits will be discussed in more detail and should convince stakeholders to do the six steps above to overcome the big data challenges.

Each of these case studies describes ways that big data has measurably increased production and profitability for farmers. Although this is not an exhaustive list, it shows how big data innovations can yield more food for the planet. From increasing wheat production in Sudan to saving Columbian rice farmers millions of dollars, big data innovation is an exciting key to solving the global food supply problem.

Table 1. Fewer Resources to Produce More Food

Case Study	**Big Data Solution**	**Return on Investment**
Technical Centre for Agricultural and Rural Cooperation in Sudan [15]	Satellite and crop data sent to farmers' mobile phone using cloud technology	Produced 10 times more wheat
Center for Tropical Agriculture in Columbia [7]	Machine learning models of weather data enabled 170 rice farmers to know when to plant.	Saved about $3.6 million
Accenture Precision Agriculture Service [2]	Tractor sensors and field monitoring by unmanned aerial vehicles provide real-time data to farmers.	Estimated increase in profits by $55 - $110 per acre

In addition to producing more food with fewer resources, big data solutions could reduce dependence on foreign aid. According to the Organisation for Economic Co-operation and Development, in 2014 the U.S. gave about $275 billion dollars in aid to developing countries, or about 0.2% of the total federal budget [17]. The Center for Global Development says the assistance is for national security, political development, humanitarian crisis and long-term development purposes of developing countries [20].

There seems to be no quantitative data on how much of the $275 billion in aid dollars is given to feed people. However, if developing countries were producing more of their own food, it's fair to presume they wouldn't need the same quantity of foreign aid for food[HR1] . If farmers can move beyond subsistence levels, they can add to the county's GDP. There's also the potential to alleviate some of the effects of poverty and disease with big data innovations if people can produce enough healthy food to eat.

Risks to implementing big data in agriculture will be the effort required to starting from scratch and collecting data where no sensors exist. Both of these risks are most prevalent in the developing world where generally there is less technological capability than in the developed world [5].

Summary

Capitalizing on big data solutions will require changes in how data in seen within and across organizations [1]. Three challenges to implementing big data in agriculture for innovation are: infrastructure, integration and deriving value from the data. There are six steps to overcome the challenges: set up an infrastructure, establish partnerships to link data, communicate across silos, ask the right questions, find the data's value, and have data people collaborate with domain experts. Extracting knowledge from big data is and will be part of the solution to increasing global food production.

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