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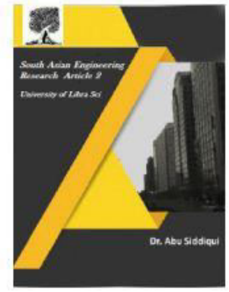

Importance of Big Data Analytics in Agriculture and Smart Farming

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Abstract

Farming is undergoing a digital revolution. Our existing review of current Big Data applications in the agri-food sector has revealed several collection and analytics tools that may have implications for relationships of power between players in the food system (e.g. between farmers and large corporations). The potential for Big Data application in the agricultural sector is examined. The role of analytics and the variety and velocity characteristics of Big Data as they can apply to the sector are stressed. Integration of data and analysis across business and government entities will be needed for successful implementation. The eventual impact of Big Data within the agricultural sector likely will require both organizational and technological innovation.

Keywords
digital revolution in agriculture, farmers, agribusiness, power, material implications of big data

Introduction

Over the past three decades, the application of information and communication technologies (ICT) and Internet of things (IOT) has had marked impact across society and the economy. Changes fueled by ICT & IOT adoption are apparent to us today and the processes by which those changes occurred are a tacit part of our experience base. Today, ICT-based advances continue to offer opportunities and challenges. One of the most talked about, for business, government, and society, is called "***Big Data***". (A term often followed by either the phrase –"whatever that is" or by a measure expressed as "****bytes", which then is explained as equivalent to some multiple of the information stored in the Library of Congress.)As smart machines and sensors crop up on farms and farm data grow in quantity and scope, farming processes will become increasingly data driven and data-enabled. Rapid developments in the Internet of Things and Cloud Computing are propelling the phenomenon of what is called

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Smart Farming (Sundmaeker et al., 2016).While Precision Agriculture is just taking in-field variability into account, Smart Farming goes beyond that by basing management tasks not only on location but also on data, enhanced by context- and situation awareness, triggered by real-time events (Wolfert et al., 2014). Real-time assisting reconfiguration features are required to carry out agile actions, especially in cases of suddenly changed operational conditions or other circumstances (e.g. weather or disease alert). These features typically include intelligent assistance in implementation, maintenance and use of the technology. Fig. 1 summarizes the concept of Smart Farming along the management cycle as a cyber-physical system, which means that smart devices – connected to the Internet - are controlling the farm system. Smart devices extend conventional tools (e.g. rain gauge, tractor, notebook) by adding autonomous context-awareness by all kind of sensors, built-in intelligence, capable to execute autonomous actions or doing this remotely.

In this picture it is already suggested that robots can play an important role in control, but it can be expected that the role of humans in analysis and planning is increasingly assisted by machines so that the cyber physical cycle becomes almost autonomous. Humans will always be involved in the whole process but increasingly at a much higher intelligence level, leaving most operational activities to machines.

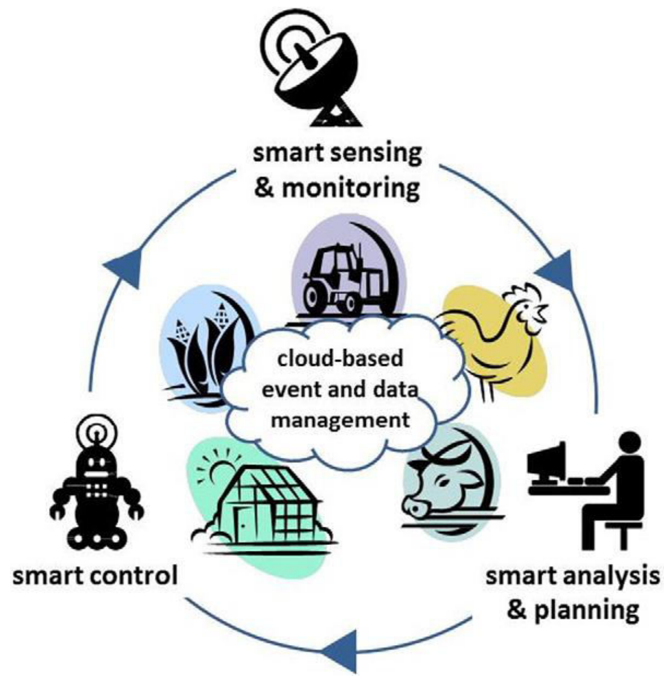

Fig. 1. The cyber-physical management cycle of Smart Farming enhanced by cloud-based event and data management (Wolfert et al., 2014).

Both Big Data and Smart Farming are relatively newconcepts, so it is expected that knowledge about their applications and their implications for research and development is not widely spread. Some authors refer to the advent of Big Data and related technology as another technology hype that may fail tomaterialize, others consider Big Data applications may have passed the ‘peak of inflated expectations’ in Gartner's Hype Cycle (Fenn and LeHong, 2011; Needle, 2015). This review aims to provide insight

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into the state-of-the-art of Big Data applications in relation to Smart Farming and to identify the most important research and development challenges to be addressed in the future. In reviewing the literature, attention is paid to both technical and socio-economic aspects. However, technology is changing rapidly in this area and a state-of-the-art of that will probably be outdated soon after this paper is published. Therefore the analysis primarily focuses on the socio-economic impact Big Data will have on farm management and the whole
network around it because it is expected that this will have a longer lasting effect. From that perspective the research questions to be addressed in this review are:

1. What role does Big Data play in Smart Farming?
2. What stakeholders are involved and how are they organized?
3. What are the expected changes that are caused by Big Data developments?
4. What challenges need to be addressed in relation to the previous questions?

The latter question can be considered as a research agenda for the future.

To answer these questions and to structure the review process, a conceptual framework for analysis has been developed, which is expected to be useful also for future analyses of developments in Big Data and Smart Farming.

A recent *Wall Street Journal* article outlined on-going efforts to transform Unmanned Aircraft Systems (UAS) capabilities originally focused on military purposes to applications supporting production agriculture. "As the spring growing season unfolds, universities already are working with agricultural groups to experiment with different types of unmanned aircraft outfitted with sensors and other technologies to measure and protect crop health". Applications include:

- Monitoring of potato production (Oregon State University),
- Targeting pesticide spraying on hillside vineyards (University of California-Davis),
- Mapping areas of nitrogen deficiency (Kansas State University), and
- Detecting airborne microbes (Virginia Polytechnic Institute and State University).

Those specific examples are only a sample of the numerous experiments and demonstrations being conducted to identify cost effective means to employ the UAS technology to enhance agricultural systems. UAS capabilities offer flexibility and potentially lower cost relative to the use of even small manned aircraft, especially for monitoring and measurement.

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Messages sent by cell phone users also can provide important data -- that when aggregated can provide important and timely insights. Figure 1 illustrates this point (Mock et al. 2013). A key factor indicating social well-being in developing countries is the food price index. While extensive efforts are made to track food prices, official reporting processes take time to collect data and therefore may unduly lag actual conditions affecting low income consumers and social stability. However, individuals “talk” about changes in food prices continually. The two graphs in Figure 2 both track movements in food prices in Indonesia during 2010 and 2011. The bottom graph provides the official monthly inflation rate for food prices. The top graph tracks the volume of tweets per month in Indonesia, where the topic was the price of rice. The similarity in direction and turning points of the two graphs provides support for the belief that important information can be acquired from social media sites.

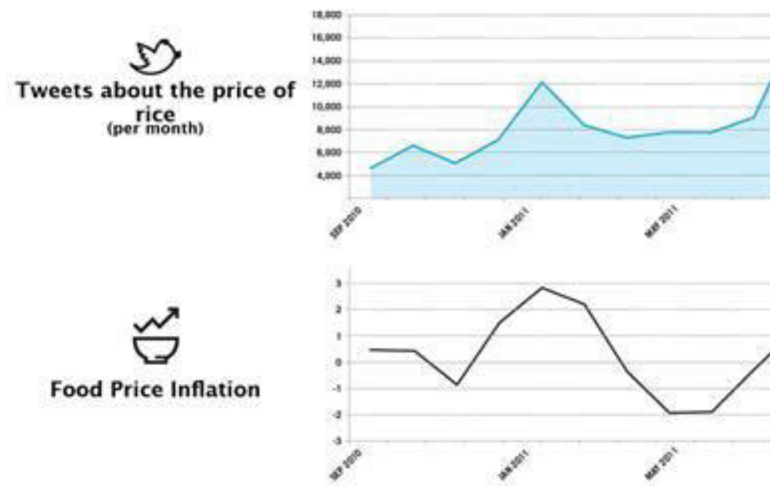

Figure 2. Comparison of estimates of food price inflation and tweets about the price of rice in Indonesia.

Figure 3 cites numerous potential benefits of use of Deep Thunder-based services. These include direct linkage to precision agricultural practices, increased yields, reductions of postharvest loss, and consumer benefits of lower price, improved quality and presumably lesser environmental impacts. A key factor noted is the potential for more effective water use, a critical global concern.

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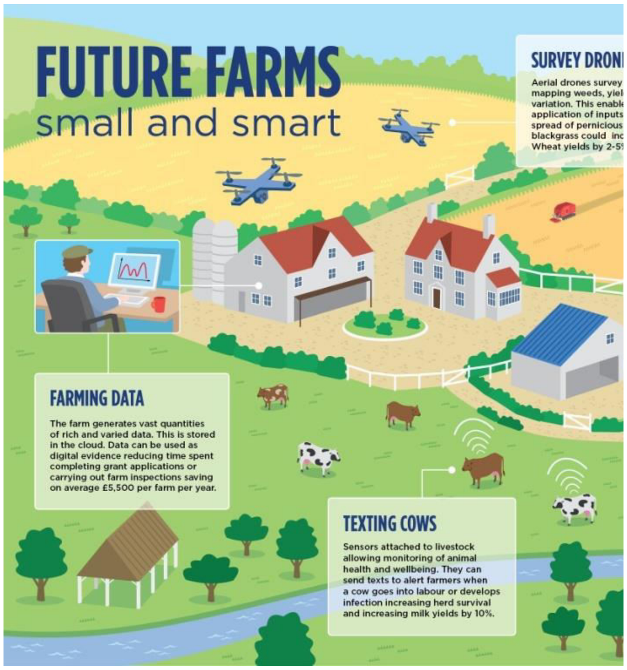

Figure 3. Representation of data integration and analysis for production agriculture

Figure 3, although useful, masks two key factors that will have to be addressed if Big Data applications are to alter the basis of competition in agriculture. One factor relates to the word integration, in particular, the process of integrating across numerous sources of data – where the control of those data doesn't exist within a single entity. The second factor relates to the word analysis. Figure 4 suggests that the needed data can be obtained from field operations, just as counting the turns of a screw can determine if manufacturing processes are within bounds.

Wrapping It Up (Conclusion)

Agriculture, globally and in the United States, has been identified as a target for Big Data application by technology developers, including both startups and multinationals. The established firms include those currently in the ag sector or those in the non-ag technology sector.

While the term Big Data is new, application of ICT- & IOT based innovation has driven economic transformation over the last three decades. In the 1990s, "the knowledge economy" was the hyped term of the decade and understanding the transformative role of ICT was a key research and practical question. Findings from that work focused on the need for implementation of low-cost means to capture numerous information attributes at the time transactions occurred. Although low-cost reparability is necessary, industry transformation occurs only when the information acquired can be aggregated to form new knowledge --which leads to novel operations and offerings. Although the terminology has changed, these findings also apply to the successful application of Big Data technologies today.

The three commonly cited characteristics of Big Data are Volume, Velocity and Variety. A key factor to understanding the potential of Big Data is to realize that it is not **just** about lots of numbers. The variety characteristic emphasizes that data now includes a stunning range of phenomena. Further, it is important to appreciate the power of "analytics", where findings and insights are gained from multiple data sources that differ in structure and original purpose.

Over the last 50 years computation and analysis have enhanced performance in the economy and in agriculture. Ag sector analysts contributed to those enhancements. However with the limited computer power available then, a key to success was to effectively constrain the problem to fit the data and computational power available. No longer is that constraint needed as Big Data approaches come to agribusiness. Successful application will occur in US and global agriculture but that success will be determined as much by organizational and managerial factors as by technology.

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