Data Science in Agriculture

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The world population is expected to reach 9.3 billion by the year 2050 from the current 7.3 billion. The Food and Agriculture Organization (FAO) predicts the growth of agriculture to be increased by 70% to serve the projected demand (“The Future of Agriculture”, 2016). There is a great need to increase the production of crops with limited available resources such as land, water, and fertilizers to cater to the needs of this increasing population. Agriculture, as classified by Lance Donny, has evolved from small scale labour intensive stage (until the 1920s) to industrial stage (from 1920 till 2010) with the improvement in heavy machinery and seed sciences, and it is paving its way towards the third stage or “Ag 3.0”, which involves making data-driven decisions using the data obtained from external sources (Lohr, 2015). Donny claims that data-driven decisions in agriculture provides higher productivity, practices sustainability and even helps to provide transparency to consumers wanting to know more about their food.

Data science is changing the way farmers and agricultural professionals have been making decisions (Matthews, 2019). Modern technology has made it possible to collect data of soil, water, and minerals from farms, and store them in a centralized system, popularly known as the Internet of Things (IoT). IoT refers to the idea of connecting interrelated devices to the Internet so that they can share and exchange data independently (Clark, 2016). Such data can be combined with data from external sources such as satellites, weather stations and even data from neighbouring farms to form a bigger volume. Data analytics can be used in the accumulated bulk to obtain information which can be used by farmers to optimize their farming. Farmers can thus make smart farming decisions using that information throughout the production cycle; from planning, plantation, harvesting, all the way to its marketability (Maru, 2018).

This paper discusses the increasing scope of data science in modern agriculture. It firstly gives an account on the need for data science in agriculture, followed by a discussion of opportunities, the issues that can arise in its implementation. After that, the impacts of data-driven agriculture are highlighted followed by impacts assessment and conclusion.

Factors Driving Innovation in the Field of Agriculture

Agriculture has prevailed since the dawn of human civilization as a society. It had always been a labour-intensive task rear crops and animals. Farming has undergone a lot of changes with regards to methods, tools, and machinery. A lot of research and development has been done to bring agriculture to the present stage, and it is still in the phase of continuous improvement.

One of the factors driving innovation is the dependence of farmers in their intuition only to make agricultural decisions ("The Future of Agriculture", 2016). There is a risk because if the farmer makes a mistake, there may be no production at all in that season. Thus, there is a need for the farmer to alleviate such a burden of risk and make sure that cost-effective decisions are undertaken.

Moreover, emerging field of nanotechnology and implementation of various kinds of sensors can be done to gather data of high volume, quantity, and accuracy from the farms. There is also a huge amount of digital data available on the internet. All these data can be utilized effectively to make improvements in agriculture (Es & Woodard, 2017).

It also has been noticed that behaviour of consumers has changed in recent years. They are more into eating good food, and consequently want to know where and how their food has been produced, packaged, modified and distributed (Brown, 2017).

The most important factor for driving innovation in the field of agriculture is to make food available to the entire human population itself. Hence, there is a prodigious need to innovate new ways to increase agricultural production using fewer resources ("The Future of Agriculture", 2016).

Opportunities for Data-Based Solutions

Farmers constantly juggle between a set of variables and make agricultural decisions. To raise a variety of crop, they need to plan what they are going to cultivate, where and when. Then they should decide on irrigation, fertilizers, and pesticides to be used. This is followed by deciding the time to reap, harvest and send the products to the market (Maru, 2018). This method of farming is an arbitrary science, and it is necessary to get all the variables right to for maximum gain.

Fortunately, in this era, farmers can use data to assist them in making those complex decisions. Farmers can gather data from different sources and use them with data analytics to gain insights on their farm and crops. The data obtained by using sensors inside the farm such as that of soil nutrients, water content, air permeability etc. (also termed as localized data) can be used separately, or with data from external sources like temperature and rainfall to gain different types of information. All these data can be coalesced to continually assess the and make changes whenever necessary (Maru, 2018).

Additionally, the data available from new technologies like spectroscopes can be used in farms to identify the quality of soil and the readiness and quality of fruits that are produced in the farm. The principle of spectroscopy is passing different wavelengths of light through an object so that different properties such as temperature, mass, luminosity and composition can be obtained (Cuffari, 2018). So, the spectroscopy data can be used to automate some processes in the farm as well; such as the opening and closing of irrigation sprinklers according to the moisture content recorded in the soil. Moreover, the data can be used in prediction models to forecast production (Es & Woodard, 2017).

Data can enable consumers to break down the constituents of their food right to its molecular composition. The data from sensors and spectroscopes that detect chemical composition in the air, soil, and crops can be made available in the web which can be looked up by the consumers using their smart devices (Brown, 2017). This will help to build trust among concerned customers and increase customer adherence.

Availability of localized and external data can help to practice precision agriculture. The idea of precision agriculture revolves around sustainability and using resources just at the right amount, without wasting them. Via precision agriculture, plants can be assessed, and their needs of minerals, fertilizers and water can be addressed individually. Only those plants that have not got sufficient resources can be supplied with what they need. So, a lot of resources can be saved by this method and ultimately the cost of production will be decreased (Creutzberg, 2014). In horticulture as well, precision can be obtained by attaching Radio Frequency Identification (RFID) chips to all the animals. These chips can be used to identify and track farm animals. Once a sick animal is identified, the farmer can proceed for its treatment (Kshetri, 2016). It is believed that digital agriculture practices by both smallholding and large-scale farmers can relieve the world of hunger in the upcoming years.

Issues in Implementation of Data Based Solutions

One of the major issues faced in the implementation of data science is that the agriculture industry is not readily welcoming change. Farmers are very skeptical about changing their farming methods because it is very costly to them if things go wrong. Shifting to digital methods of farming also requires a large investment, which only large-scale farmers can afford. Big companies can get return relatively quicker, as compared to smallholder farmers ("The Future of Agriculture", 2016). Uneducated and small-scale farmers may not be able to implement digital farming, and also, they may be incapable of discerning from data that has been provided to them. So, another concern for the implementation of data-driven solutions is that it may only benefit educated large scale farmers (Kshetri, 2016).

The second issue comes with any type of data-based solutions; its collection, cleaning, storing and its distribution via secure channels. Agricultural data is no different. A farmer should incur the cost of installing sensors storing it in a centralized server for localized data. The problem with the agriculture data is that it comes in various forms and time intervals. For example, the data given by a sensor that provides the content of water and pH value of soil can be taken at any instance of time, but those such as checking fruits for ripeness, which need to be collected manually cannot be obtained so readily. So, it is necessary to convert such data as point in time or aggregate them so that they can compared with standard data of similar nature and kind. The data must be evaluated according to its interoperability, reusability, usefulness, applicability, appropriateness and effectiveness so that it can be used in analytics. A standard must be formulated and that must be used for a particular area and type of plant as a baseline for comparison. Farmers should also share their local data with other farmers so that a big volume of data is there to perform analytics. This data should be shared with trusted people only as it may be misused, monetized by another party or it may introduce unfair competition (Maru, 2016).

Impacts of Data Science in Agriculture and Conclusion

Digital transformation in agriculture has brought about a variety of innovations in the present world. One of such initiatives is MyCrop, an intelligent and self-learning real-time system which takes into account each farmer's location, weather, and crop data. It uses big data, machine learning, and smartphone technology to deliver information, expertise, and resources to smallholder farmers (Trendov, Varas, & Zeng, 2019).

Large scale farmers and those in the industrial countries are using modern technology for automation in their farms. They have turned their farms into a factory; and have automated every process possible with a heavy amount of computing. Such type of farming is called smart farming ("The Future of Agriculture", 2016).

At TH Milk facility, Vietnam, data science is being used to regulate the quality of milk production in cows where every cow is tagged with an RFID chip. The milking process is automated with sensors in the suckers that can detect inflammation in the cow's mammary glands. If inflammation is detected, the machine will stop the milking process and the cow will be marked and checked. In AfiMilk, a similar chip is attached to each goat's legs that tracks its movement. If the goat does not move for a long period, or if it is showing ambiguous sleeping patterns then it will be checked for illness. (Kshetri, 2016).

With the movement of the world towards digital agriculture, a lot of investment has been poured into it. Numerous research and development are going on to maximize the efficiency of farms. Incorporating new technology will escalate the yields of both small- and large-scale farms. New trends in farming by including data science and analytics will revolutionize the agriculture industry; producing higher-quality foods in a larger quantity sustainably so that the global target of increasing food production by 70% will be met by 2050.

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