INTERNET OF THINGS IN AGRICULTURE

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Abstract
There are many ways to refer to modern agriculture. For example, AgriTech refers to the application of technology in agriculture in general. Smart agriculture, on the other hand, is mostly used to denote the application of IoT solutions in agriculture. The same applies to the smart farming definition. Although smart agriculture Internet of Things, as well as industrial Internet of Things in general, aren't as popular as consumer connected devices; yet the market is still very dynamic. The adoption of Internet of Things solutions for agriculture is constantly growing. Namely, BI Intelligence predicts that the number of agriculture Internet of Things device installations will hit 75 million by 2020, growing 20% annually. At the same time, the global smart agriculture market size is expected to triple by 2025, reaching $15.3 billion (compared to being slightly over $5 billion back in 2016). Because the market is still developing, there is still ample opportunity for businesses willing to join in. Building Internet of Things products for agriculture within the coming years can set us apart as an early adopter, and as such, help farmers pave the way to success because technologies and Internet of Things have the potential to transform agriculture in many aspects like lower production risks and increased business efficiency through process automation.

Keywords: agriculture, smart agriculture, Internet of Things, market development, increased business efficiency.

Introduction

The main objective of the research it is represented by the need of to feed a growing population. Food is one of the biggest challenges the world faces, so technological innovation in agriculture is a vital part. According to the UN Food and Agriculture Organization (FAO), the global population is expected to surpass 9 billion people by 2050. To produce enough food for the given population, agriculture production volumes have to increase by 50%. As the resources for agricultural operations are limited (most of the lands suitable for farming are already in use), the only way to increase volume is to improve production efficiency. There is no doubt as to the extent with which smart farming can help tackle this challenge; in fact, it seems that it is not possible without it.

Internet of Things (IoT) can play big role in increasing productivity, obtaining huge global market, idea about recent trends of crops. IoT is a network of interconnected devices which can transfer data efficiently without human involvement. Today many agricultural industries turned to adopt IoT technology for smart farming to enhance efficiency, productivity, global market and other features such as minimum human intervention, time and cost etc. The advancement in the technology ensures that the sensors are getting smaller, sophisticated and more economic. The networks are also easily accessible globally so that smart farming can be achieved with full pledge. Focusing on encouraging innovation in agriculture, smart farming is the answer to the problems that this industry is currently facing. All this can be done using smart phones and IoT devices. Farmer can get any required data or information as well can monitor his agricultural sector.

Smart farming depends on IoT advancement making the farmers and growers to eliminate waste and increase productivity that range from the fertilizer quantity utilized to the number of trips made by the farmer's vehicles.

In smart farming based on IoT, a device is made for screening the agricultural field with the help of sensors, automating the agricultural system. The farmers can screen the condition of agricultural field in all the places. IoT-powered smart agriculture is efficient especially in comparison to the traditional approach.

The use of IoT-based smart agriculture not only focuses on traditional, huge farming activities but also increases other common trends and growing possibilities in farming, such as organic farming, as well as improving highly transparent farming.

When it is comes to environment problems, the agricultural trends based on IoT can give huge benefits like efficient use of water, optimizing the required inputs and treatment, and so on. Now, it is all about the huge applications of smart agriculture based on IoT, which has become a revolutionized agriculture.

This paper is structured in 5 parts. After the introduction, the second section presents the literature rewiev with the role of Internet of Things in Agriculture. It is followed by the benefits of smart farming with the IoT shaping structure. In the fourth part are presented the IoT use cases in agriculture with examples from Romania and conclusions in the final part.

1. Literature review

Internet of Things (IOT) The Internet of things (IoT) is the most efficient and important techniques for development of solutions to the problems. IoT evolve from different building blocks which includes lots of sensors, software's, network components and other electronic devices. Also, it makes data more effective. IoT allows to exchange the data over the network without human involvement. In Internet of Things, we can represent things with natural way just like normal human being, like sensor, like car driver etc. This thing is assigned an IP ddress so that it can transfer data over a network.

The IoT technology is more efficient due to following reasons:

1. Global Connectivity through any devices.
2. Minimum human efforts
3. Faster Access
4. Time Efficiency
5. Efficient Communication

The most important barrier that arises in traditional farming is climatic change. The number of effects of climatic change includes heavy rainfall, most intense storm and heat waves, less rainfall etc. Due to these the productivity decreases to major extent. Climatic change also raises the environmental consequences such as seasonal changes in life cycle of plants. Today, the Internet of Things (IoT) is transforming towards agriculture industry and enabling farmers to compete with the enormous challenges they face. Farmers can get huge information and knowledge about recent trends and technology using IoT.

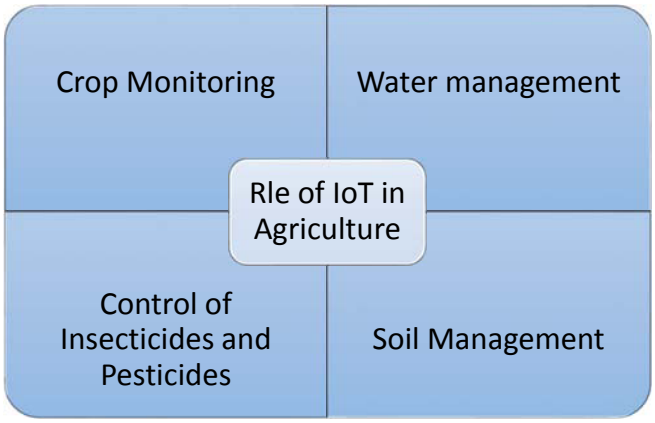

Figure 1. Role of IoT in Agriculture

The smart agriculture market is expected to reach $18.45 Billion in 2022, at a CAGR of 13.8%. BI estimates that 75 million IoT devices will be shipped for agricultural uses in 2020, at a CAGR of 20%.

IoT devices can be of great help in enhancing the production and yield in the agriculture sector since these devices can be used to monitor soil acidity level, temperature, and other variables. Moreover, smart agriculture will help in monitoring livestock productivity and health as well. IoT sensors are capable of providing farmers with information about crop yields, rainfall, pest infestation, and soil nutrition are invaluable to production and offer precise data which can be used to improve farming techniques over time. Internet of Things, with its real-time, accurate and shared characteristics, will bring great changes to the agricultural supply chain and will provide a critical technology for establishing a smooth flow of agricultural logistics.

The key advantages of using IoT in enhancing farming are as follows:

1. Water management can be efficiently done using IoT with no wastage of water using sensors.
2. IoT helps to continuous monitor the land so that precautions can be taken at early stage.
3. It increases productivity, reduce manual work, reduce time and makes farming more efficient.
4. Crop monitoring can be easily done to observe the growth of crop.
5. Soil management such as PH level, Moisture content etc can be identified easily so that farmer can sown seeds according to soil level.
6. Sensors and chips aids to recognize the diseases occurred in plants and crops. The farmer or scientist can access this information from a remote place and take necessary actions, automatically crops can be protected from coming diseases[2].
7. Crop sales will be increased in global market. Farmer can easily connect to the global market without restriction of any geographical area.

2. Benefits of Smart Farming

Technologies and IoT have the potential to transform agriculture in many aspects. Below are presented the most important benefits:

Reducing Waste: With limited resources available for growing crops or raising livestock, farmers are constantly looking for ways to reduce waste.

Better Pest Control: With the public pushing for more natural food and less pesticide use, farmers are increasingly looking to reduce or even eliminate pesticide used.[8]

Livestock Management: The cost of raising livestock continues to rise every year. At the same time, the public is also pushing for the more humane treatment of animals as animals reared in a humane fasion produce higher quality meat that is more nutritious[17]. Increasing Productivity: In order to maximize yields and profits, farmers must increase productivity. Internet of Things (IoT) technology is allowing farmers to become more productive in a variety of ways such as monitoring farm equipment[17].

Today, many farmers are already using digital technologies such as smart phones, tablets, sensors on land, drones and satellites. These technologies offer a series agricultural solution such as remote measurement soil condition, better water management and a livestock and crop monitoring. Analyzing the data collected, farmers can take a picture of it future crop patterns or health and animal welfare, which allows them to do so more efficient planning and be more effective. The possible benefits of using digital technologies may include improving crop yield and animal performance, optimizing factors production and reduction of labor, all increasing profitability. Also, digitization can improve working conditions for farmers and can reduce the negative impact of agriculture on the environment. Another benefit relates to agricultural data flows. Improving information flows upstream and downstream of agro-food chains could generate a wide range of benefits for those involved, including farmers and stakeholder's distribution and retail.

Measurement of different working parameters through sensors and transducers, analysis of information received through computer systems and specific software and sending orders to modify other parameters on tractors and agricultural machines have created the Intelligent Agriculture, system based on the use of logical schemes and programs very well-defined process, which aims to increase the quality indices of the works performed simultaneously with the reduction of the human factor-induced errors. Most of them are driven by GPS systems, and for each operation they can be mapped using the GIS method.

Some of the benefits of Intelligent Agriculture development are:

- coordinating the aggregates or self-propelled machinery by GPS;
- automatic holding of a predetermined grip force;
- modification of working depth in real time to soil work depending on the amount of vegetal debris present at the surface;
- changing the working depth in real time to sowing and placing the seeds in the area with optimum humidity;
- detection of plants and weeds and their distinction;
- automatic speeding of the speed of movement as required (material flow, degree of baking, plant density, etc.);
- monitoring and control of each nozzle in plant protection treatments;
- optimization of fillings and management of plant waste solutions;
- ntelligent agriculture uses high-tech food growth and plant cultivation, clean and sustainable for the population. Intelligent agriculture based on IoT technology will allow

farmers to reduce waste and increase productivity, optimizing the amount of fertilizer used up to the number of trips made by agricultural vehicles.

In intelligent agriculture, a culture monitoring system is built with sensors (light, humidity, temperature, soil humidity, etc.) and automation of the irrigation system. Farmers can monitor ground conditions from anywhere. This IOT-based approach is very effective compared to the conventional approach. This type of farming can be successfully used by both large farmers, organic farms or family associations that own small land.[20]

With regard to environmental issues, smart IOT-based agriculture can provide great benefits, including more efficient use of water or optimization of fertilization and treatments. The main applications of IOT-based intelligent agriculture that revolutionize this area are related to: agricultural management, agricultural drones, real-time monitoring of animals and greenhouses. Such IoT farm applications help farmers to collect significant data. Large landowners and small farmers need to understand the potential of the IoT market for agriculture by installing smart technologies to enhance the competitiveness and sustainability of their productions.

3. IoT- use cases in Agriculture

IoT-based smart farming can provide great benefits including more efficient water usage, or optimization of inputs and treatments. We will discuss here the major applications of IoT-based smart farming which are revolutionizing agriculture. Precision Farming can be thought of as anything that makes the farming practice more controlled and accurate when it comes to raising livestock and growing of crops. In this approach of farm management, a key component is the use of IT and various items like sensors, control systems, robotics, autonomous vehicles, automated hardware, variable rate technology, and a lot of IoT components, here we find some examples of Precision Farming and Smart Farming combined with IoT:[17]

Driver Connect Connection Guide "Electronic Drawbar"

It is a system in which a tractor in the field automatically follows another leading tractor that moves in front. The two vehicles communicate via radio and are coordinated by a high-precision GPS driving system. The driver on the tractor tractor monitors both vehicles and has full access to the control and operation of the next tractor. Moving two tractors at the same time greatly increases productivity.

Non-Stop Combination for round and inflated balls with ISOBUS control

Modern baler machines achieve great productivity but the process is interrupted for bundling and emptying the bale. The development of a non-stop press allows for continuous displacement of the baler that binds and unloads the bale without the need to stop the tractor. Intelligent Pre-Press Room Control allows automatic operation. The tractor's travel speed is adjusted by the ISOBUS system at the flow rate of material entering the press. By using automation, the mechanic's effort is greatly reduced and the human error diminishes.

Smart smart key-Smart Key

This new universal key can be used on fleets of tractors or machines, this will allow mechanicians to work only with machines that are unlocked for them. That is how you can track exactly where and how each machine is working.

On-line anti-slip adjustment system for rollers

Large diameter rollers can gather high ground in front of them, which worsens the work process and prevents rotation. The rotational speed of the rotor on the sowing machine is compared to the rotation speed of the roller. By integrating the ASR of the roller into a TIM system (application of tractor control equipment), sliding measurement can be used to adjust the tractor's hydraulic lifter. The weight is moved from the roller to the rear wheels of the tractor until the slip is eliminated.

Wind fertilizer fertilizer machine

Wind Control was developed to compensate for the influence of wind on the distribution of solid chemical fertilizers by centrifugation. The goal is to fertilize uniformly, even in windy conditions. The fertilizer machine is equipped with a weather station that measures the parameters of the dominant wind and its direction in the area of the distribution disk. A control mechanism, combined with a control software, changes the rotation speed and spreading angle to the distribution discs. Account shall also be taken of the physico-mechanical properties of the materials distributed and of their flooding speed. These data are stored in the process computer, so it is possible to use these properties to develop a suitable computing model. The data taken by the weather station mounted on the car is used to calculate the necessary corrections in the process computer and the distribution unit and the imparting process is adjusted accordingly. The result is a cross-sectional pattern that remains stable even under the influence of wind. This optimizes the fertilization process and helps prevent pollution. The possible implementation period is also extended.

Monitoring of sensor nozzle operation

The flow rate of each nozzle is recorded by sensors mounted on each nozzle body. This type of sensory monitoring has distinct advantages compared to conventional monitoring by visual checks. Any damaged or clogged nozzle can be quickly identified. The faults are displayed automatically and without any delay on the screen.

Synchronization of transport machines with harvesters

When harvesting cereal with combines, unloading in means of transport is a problem in view of the fact that the driver on the transport system does not know the position of the combines, their direction of movement and the degree of filling of bunkers. The logistics optimization system consists of a transmission system between the combine and the tractors. The driver of the tractor sees the position through the GPS, the direction of travel and the filling level of the bunker combines it on a monitor, and the combination of the largest one is taken first.

Analyzing the above presented we can notice the increasing trend of computerized automation of processes and technologies in agriculture. In Romania and also in the others countries too are used a lot of applications of IoT in agriculture, below are presented some of these applications and one of the more efficient in Romania.

- *FarmFacts Greenseeker*[19]

Optimization of nitrogen fertilization = low cost and protectionthe environment, determination of differentiated fertilization strategy and you can control your data and ratings, it can already be used in the early stages of culture, calculation of nutrient requirements in rape through mapping plants before modifying the stage of vegetation, significant price advantage compared to other active systems, interfaces for all fertilizer, herbicide or other machines technologies used for application, system tested with thousands

of active sensors, expandable sensors depending on application, active system with its own lighting source (benefit and daytime) and easy to use by connecting it to your ISOBUS system.

- *Enten Systems*[21]

The ENTEN system of forecasting, warning and agricultural advice helps farmers to know how to adapt to climate and disease and pest attacks, so they can protect their crops and make the production more efficient. Explained a bit more practical, this concept involves a network of equipment that continuously monitors microclimate, giving farmers key dates about crop condition and the potential risks to which they are exposed. It operates with the parameters of detection of existing soil nutrients, remote sensing, multispectral analysis and other specific processes. Farmers are informed in real time about the actions which they have to take and the optimum conditions for intervention to have a healthy culture.

- *Beia Consult*[22]

One of the Romanian companies specializing in high technology is Beia Consult International. The company is one of the main telecommunication equipment providers in Romania, having more than 25 years experience in more than 10,000 projects for telephone exchanges, telephone exchange networks, advanced communications solutions. The company's representative, Andrei Vasilescu, first degree researcher, with many years of scientific activity behind, says that the supply to the agricultural sector is one that fits into the global trend. It has to be said that Beia is mainly an IT & C firm, but at the moment it also deals with agricultural telemetry. In short, agricultural telemetry means totally autonomous weather stations that feed on solar energy and measure weather parameters that are important for culture and transmit these parameters to a central-server computer. This server is at the disposal of the farmer with everything he needs to know about his culture. Among the measurements, the farmer can also find out if the plants have traces of mana.

- *Agriso*[22]

Agriso is an integrated application that keeps an optimal record of costs to increase productivity, rotation of crops, sole measurements, and the introduction of new ones, as well as measurements of day-to-day field operations. In addition, the application, which can be run both on the computer and on the mobile phone, effectively monitors every meter the machines are doing on the ground, but also the speed or number of hours the operator with the engine started.'

- *Dekalb* Romania[23]

In Romania, the maximum production gap between the density recommended by Dekalb through the Smart Digital Platform and appropriate to each farm plot, according to land data - soil type and culture medium - compared to the production that farmers in the testing centers achieved, on the same plot, with the same hybrid, but in farm density, was on average 1.3 tonnes. The Smart Digital Platform helps farmers with a range of innovative solutions to increase the production of corn on the same surface. With the help of this new IT product, farmers benefit from recommendations for choosing hybrid maize depending on soil type and culture medium at optimum density to achieve maximum profitability. The productivity of the culture can grow by up to 30%, according to Dekalb technology centers. Also now are a lot of farmers from Romania who use theproducts and the Dakalb application and they declared that their productivity was maximum. The Dekalb Smart version is already available and the mobile app is about to be available shortly. Romania is among the first European countries in which the new technology is launched. Among the first in Europe, Romanian

farmers will be able to monitor all corn parcels, even on their own smartphone, and will be able to keep up with what's on the ground no matter where they are.

The Dekalb Smart concept, developed at the pilot project level in 2017 across Europe with excellent results, is a smart program that generates customized solutions for corn crop optimization, seed selection, variable rate sow, appropriate treatments, differential tracking and management per soil types, to optimize the culture of each farmer using smart applications and technologies. By 2019, this concept will be available in major European markets, with Romania being among the first to access it, alongside France, Spain, Hungary and Italy. In Romania, Dekalb provides farmers with state-of-the-art products and technologies, as well as specialized consultancy services, assuming their role in education and avant-garde, as a premium partner of Romanian farmers. Dekalb is a registered trademark of Monsanto Technology LLC.

Conclusions

The Internet of Things. Economic organizations will have to begin to implement IoT technology if want to survive in the long run, however will also have to implement strategies to meet the many risks associated with IoT. Internet of Things will produce significant challenges in all sectors and for all industries. Although will solves problems that have affected business time for decades, even centuries and will create completely new procedural and ethical dilemmas. Concerns about privacy personal data, cyber security, as well as property and responsibility on products will grow with development of new specific applications.

The Internet of Things (IoT) will allow entering a new economic era for the whole world. The perspectives offered by IoT are not only refers to simple improvements of processes and economic models, but rather to transforming the domain of their application. The IoT economy will revolutionize the way in which economic organizations carry out activities of production, operation and development. And the change will happen more quickly than in previous industrial revolution.

As we can see, the use cases for IoT in agriculture are endless. There are many ways smart devices can help you increase your farm’s performance and revenue. However, agriculture IoT apps development is no easy task. There are certain challenges farmers need to be aware of if they are considering investing into smart farming, below are presented some of the most importants: The hardware-To build an IoT solution for agriculture, farmers need to choose the sensors for their device (or create a custom one). The brain- Data analytics should be at the core of every smart agriculture solution. The collected data itself will be of little help if farmers cannot make sense of it. This brings many benefits, but the staff who must serve these systems must be well trained and qualified. The maintenance-Maintenance of the hardware is a challenge that is of primary importance for IoT products in agriculture, as the sensors are typically used in the field and can be easily damaged. The mobility-Smart farming applications should be tailored for use in the field. The infrastructure- To ensure that the smart farming application performs well (and to make sure it can handle the data load), you need a solid internal infrastructure. Furthermore, farmer’s internal systems have to be secure.[18]

Farming will play vital role in next few years in country. Thus, there is need of smart farming. Internet of Things will help to enhance smart farming. IoT works in different domains of farming to improve time efficiency, water management, crop monitoring, soil management,

control of insecticides and pesticides etc. It also minimizes human efforts, simplifies techniques of farming and helps to gain smart farming.

Along with these features smart farming can help to grow the market for farmer with single touch and minimum efforts. As we can see, now exist and are used smart applications which really help farmers, DEKALB genetics has confirmed its performance in all major agricultural regions in Romania accordding to their results[24]. In many ways, thanks to Internet of Things

References

1. Marin A., Ion, R. A., Chetroiu, R., & Iurchevici, L. (2017). Designing and experimenting models for the development of short chains for fruit production. [Proiectarea şi experimentarea de modele de dezvoltare a lanţurilor scurte de valorificare a producţiei de fructe]. Editura ASE. Bucureşti
2. Jim Chase: The Evolution of the Internet of Things. White Paper, Texas Instruments, September, 2013.
3. Deeksha Jain, P. Venkata Krishna and V. Saritha, "A Study on Internet of Things based Applications", 2012. http://www.businessinsider.com/internet-of-things-smart-agricul ture-2016-10?IR=T
4. Xiaohui Wang and Nannan Liu, "The application of internet of things in agricultural means of production supplychain management", Journal of Chemical and Pharmaceutical Research, 2014, 6(7):2304-2310, *ISSN: 0975-7384,2014*
5. https://www.engineering.com/DesignerEdge/DesignerEdgeArticles/ArticleID/16653/ Smart-FarmingAutomated-and-Connected-Agriculture.aspx
6. FAO (Food and Agricultural Organization). (2008). Climate Change: Implications for food safety. Rome: FAO. FAO (Food and Agricultural Organization) database.
7. https://easternpeak.com/blog/iot-in-agriculture-5-technology-use-cases-for-smart-farming-and-4-challenges-to-consider/
8. https://www.engineering.com/DesignerEdge/DesignerEdgeArticles/ArticleID/16653/ Smart-FarmingAutomated-and-Connected-Agriculture.aspx
9. IBM Watson Internet of Things. 2016. Available online: http://www.ibm.com/internet-of-things/
10. Jeung, H.; Sarni, S.; Paparrizos, I.; Sathe, S.; Aberer, K.; Dawes, N.; Papaioannou, T.G.; Lehning, M. Effective Metadata Management in Federated Sensor Networks. In Proceedings of the 2010 IEEE International Conference on Sensor Networks, Ubiquitous, and Trustworthy Computing (SUTC), Newport Beach, CA, USA, 7-9 Jun 2010; pp. 107-114.
11. Atzori, L., Iera, A. and Morabito, G. (2010) "The Internet of Things: A survey", Computer Networks, Vol. 54, No. 15, pp. 2787-2805. ISSN 13891286. DOI:10.1016/j.comnet.2010.05.010.
12. European Commission (2016) "The Internet of Things. Digital Agenda for Europe", European Commission" [Online] Available: https://ec.europa.eu/digital-agenda/en/ internet-things [Accessed: 01 February 2016].
13. https://ec.europa.eu/digital-single-market/en/policies/internet-things
14. http://www.endeva.org/blog/precision-agriculture-can-small-farmers-benefit-large-farm -technology
15. http://www.cema-agri.org/page/precision-farming-producing-more-less
16. http://www.ajer.org/papers/Vol-7-issue-1/ZI0701277282.pdf

17. https://easternpeak.com/blog/iot-in-agriculture-5-technology-use-cases-for-smart-farming-and-4-challenges-to-consider/
18. https://davra.com/iot-and-agriculture-how-the-internet-of-things-is-changing-agricultural-operations/
19. https://www.farmfacts.de/Media/FarmFacts/Aktuelles/FF_catalog_romanesc.pdf
20. https://easyengineering.ro/agricultura-viitorului/
21. https://enten.ro/despre-noi/
22. https://www.agro-business.ro/agricultura-inteligenta-culturi-monitorizate-cu-telefonul-mobil/2016/12/05/
23. https://www.revistafermierului.ro/romania-agricola/tehnica-agricola/item/3100-revolutie-digitala-in-agricultura-densitatea-recomandata-prin-platforma-digitala-dekalb-smart-a-generat-o-diferenta-maxima-de-productie-la-porumb-de-1-3-tone-la-hectar.html
24. https://www.dekalb.ro/rezultate-porumb-2018