

## Internet of Things in Agriculture for Smart Farming

**Takudzwa Fadziso**

Institute of Lifelong Learning and Development Studies, Chinhoyi University of Technology, **ZIMBABWE**

\*Email for Correspondence: [fadziso1986@gmail.com](mailto:fadziso1986@gmail.com)

### ABSTRACT

'Internet of Things in Agricultural Farming' deals with the use IoTs in providing farmers the means to do multiple parallel things with wifi connected and increase their productivity in turn increasing their yearly revenue and profits. This will not only help the farmer but the raw materials which come out will be more than what would have yielded if the farmer had done all by themselves. The IoT network comprises systems and a network of web-connected intelligent devices that employ encoded networks like sensors, processors, and interactive hardware to receive, send and store data. The use of IoT in Agricultural Farming is no doubt going to greatly enhance the farming and improve yields.

**Key words:** IoT, Smart Farm, Agriculture, Machine Learning, Artificial Intelligence, Automation

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### INTRODUCTION

The growth and development of new technologies have greatly affected the ways human operations are carried out. Internet of Things (IoT) is part of the innovations of modern age technological advancement. There is a constant increase in the number of things connected to the internet of things and the volume of data produced by these devices.

The use of IoT sensor devices has enabled farmers to produce high yields efficiently through farm data tracking and analysis of weather conditions, soil moisture, temperature, and so on. This is known as smart farming or Agriculture. In short, the use of IoT in agriculture would enable agricultural enterprises to have better supervision over the internal workings of the business.

### THE INTERNET OF THINGS

The IoT network comprises systems and a network of web-connected intelligent devices that employ encoded networks like sensors, processors, and interactive hardware to receive, send and store data. The network in the IoT uses the stored data. To use the stored data, the IoT device sends out the collected sensor information through a connection with a gateway on the IoT or through other means such as using devices with edge tools where data is either sent for analysis on the local network or in the cloud. Connected devices on the IoT network interact with each other and use the shared data they acquire to solve problems (Ganapathy, 2016b). The interactions within the network are done without human supervision or interference, and most of the job is carried out by the devices. Even though humans may communicate with the devices to set them up, writing scripts for protocols and commands provides access to information.

The Different applications used by IoT decide the protocol and system of connection, communication, and network which the things or devices are to use. Artificial Intelligence (AI) and machine learning in IoT improve data collection and processing by the connected devices in a network system (Neogy & Paruchuri, 2014). Machine learning makes it dynamic. The Internet of Things connects the various things on the Internet, making it easier to live and allow jobs to be done more smartly. It also gives total control to the users.

Also, for business enterprises, IoT gives real-time analysis of their systems' performance and provides examinations into everything regarding the functions of the devices in the supply network and logistics. This makes IoT important for enterprises.



Figure 1: IoT (Source: enterpriseproject.com)

IoT through artificial intelligence and machine learning reduces labor costs by automating jobs and processes for companies (Vadlamudi, 2015). In addition, it reduces waste and makes service delivery more efficient. In the long run, client transactions become more transparent, and the cost of production and delivery reduces remarkably.

The IoT currently plays a very crucial role in our everyday life and remains a vital technology. It would keep developing into a more advanced level as more business enterprises, and people use it. More people would get to understand the need for a connected network of the device. Some of the benefits are mainly for particular industries, while others apply to several types of industries. We would look into the following IoT advantages to business enterprises.

- IoT monitors the process of the business.
- It makes the customer experience (CX) more efficient.
- IoT through automated processes helps save time and reduce cost.
- IoT through the connected network of data helps improve employees' output.
- It also connects various business models
- Through data sharing allows businesses to make better decisions.
- In saving time and cost helps improve revenue.

The connected network system of the IoT allows companies to select a proper technique to use for their business as it gives them the information and tools for better choice (Ganapathy, 2017). IoT uses sensors and other devices to manufacture, transport data. Through machine learning, IoT manages infrastructure within the organization making these industries more digitalized and transformed.

For instance, IoT can help improve farming and make it easier to farm in the agricultural industry. Information and data about the weather can be collected by sensors connected to the Internet of Things which detect rainfall, temperature, and the content of the soil, along with other pieces of information that may help improve the industry. IoT through automated machines would help improve farming methods.

Also, the need to manage the operations of machines, pieces of equipment, and infrastructure can be so solved using IoT. For instance, structures and buildings could be monitored by sensors that can detect changes in events and malfunctioning of infrastructures and equipment within the industries. These management techniques are cost-effective, save time, and increases the quality of workflow.

Also, IoT can be used to automate electrical systems by manipulating and monitoring systems in a home. Also, people can be monitored by IoT in an intelligent City to limit unnecessary cost and energy use. The business, Health, financial, and manufacturing industries can all be influenced by IoT.

#### **Advantages and disadvantages of IoT**

The connected network of IoT allows for access to data. Information may be accessed from anywhere irrespective of time and using any web-enabled device.

IoT improves interaction amongst electronic devices.

IoT saves time and resources as data packets are moved through a connected network system.

Automated machine function helps develop the quality of service delivery and reduces the importance of human interference.

### Some of the downsides of IoT

- The risk of data and information theft by hackers. The growth of IoT means an increase in the connection of devices and the growth of data sharing between connected devices. The impact and likely hood of a hack would also be huge.
- The volume of data used would also increase. This would make it a more complicated task to manage the large inflow of data in IoT by persons and content management systems.
- Through the shared network, whenever a bug affects a system, there is the tendency that it may also affect all the devices connected and corrupt them.
- IoT lacks an international standard for the compatibility of the device. In addition, issues may come up due to the difference of the manufacturing devices to communicate with each other.

## SMART AGRICULTURE

There are several ways by which smart and modern agriculture can be termed. For instance, it can be term AgricTech, which is generally used in agricultural practices and farming. On the other hand, smart Agriculture is primarily used to refer to the application and use of Internet of things connected devices and solutions in agriculture. Through the use of the Internet of things network devices like sensors to gather particular machine and environmental data, farmers can take informed actions to relatively enhance approximately every area of their work, from crop to livestock farming.

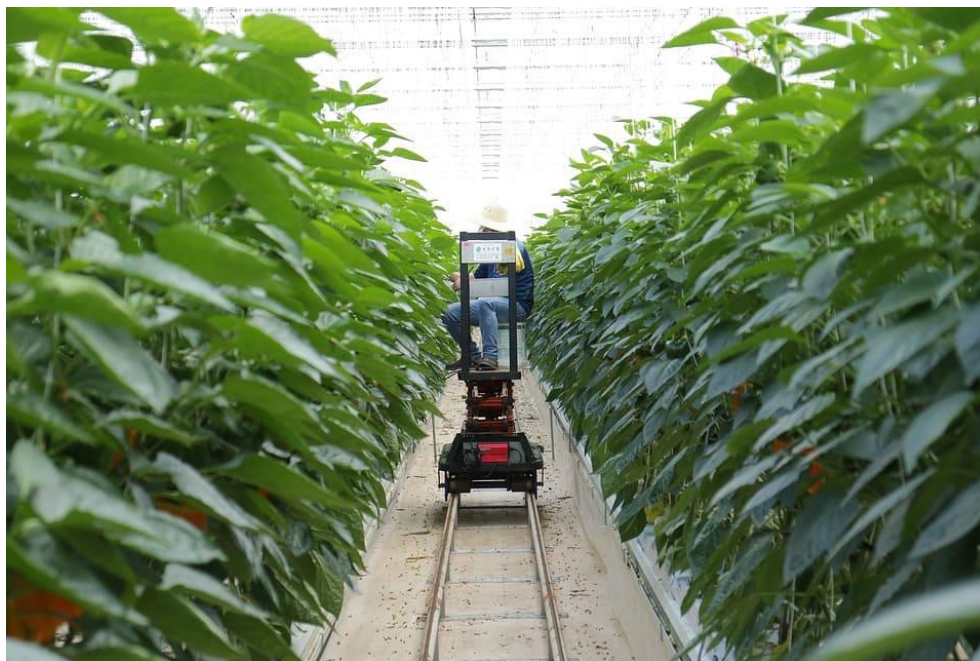


Figure 2: Smart Agriculture (Source: easternpeak.com)

For instance, smart agriculture sensors can be used for monitoring the condition of crops. This can enable farmers to accurately access the exact amounts of fertilizers and pesticides to maximize efficiency. This is also what smart farming entails also.

However, consumer-connected devices are more popular than smart industrial and agricultural IoT devices, even though the smart agriculture IoT devices market remains very flexible. The application of IoT frameworks and systems in agriculture grows constantly. The impact of coronavirus on the application of IoT in the agriculture market has been positive. Disturbances in the chain of supply and the inadequacy of qualified workers have boosted its compound annual growth rate to 9.9%. According to reported research, the smart farming market stocks could get to about \$8 billion by 2022, and by 2025, the world smart agriculture market size will go up by 300% to about \$16 billion.

The market is still in its developmental stages, businesses and investors still have the opportunity to go in (Ganapathy, 2016a). Therefore, there is still a huge chance for early adopters to develop agricultural-based IoT products in the coming years. However, what is the advantages we could derive from the use of IoT in agriculture?

## BENEFITS OF IOT FARMING

IoT is no doubt transforming farming and agriculture. The following are five (5) ways through which IoT beneficially shapes and improves the use of technologies in agriculture.

- **Data Gathering:** Smart IoT-connected agriculture sensors gather huge amounts of data on crops and animal growth, weather conditions, cattle's health, soil quality, and so on. The state and conditions of the agricultural enterprise, workers' performance and efficient equipment, can be monitored using this data.
- **Advanced management:** The use of IoT in agriculture would enable agricultural enterprises to have better supervision over the internal workings of the business. Advanced management and supervision would reduce the risks involved in production. The collected data can also be used to determine production output, giving farmers the chance to organize for better distribution of products. Getting data of total production output (harvest) gives you the ability to plan for efficient delivery, so your harvest doesn't just lie unsold.
- **Management of Cost and Reduction in Waste:** flowing from product management, which increases production efficiency directly reducing waste. The ability to detect abnormalities in livestock health and crop growth gives you the chance to reduce the possibilities of yield loss.
- **Business Efficiency Increase:** Automation of business processes could improve business efficiency. Through the use of smart IoT devices, multiple processes can be automated across numerous production processes, such as pest control, irrigation, or fertilizing.
- **Improved Quality and Volumes of Products:** With advanced control over the processes involved in the production, you will be able to maintain a greater quality of crops and capacity of growth using automated processes. The combined effects of all the stated factors can ultimately result in greater dividends.

Haven dealt with the benefits of IoT application in the agricultural sector, and it becomes important to consider how they are practically applied.

## HOW IOT CAN BE APPLIED IN AGRICULTURE?

Numerous IoT sensors are available for use in agriculture as well as other IoT devices in general, such as;

- **Climate monitors:** Weather stations presumably the most known and used IoT-connected agriculture devices. They combine several IoT farming sensors. They gather numerous data from different positions in the environment and across the field and send them to the cloud. The analysis provided can be used in mapping the conditions of climate, select reasonable crops and implement the needed strategies to enhance crop capacity. This is referred to as precision farming. Smart Elements Pycno and allMETEO are examples of some agriculture IoT technology.



Figure 3: Climate Monitors (Source: easternpeak.com)

- **Automated Greenhouse:** The traditional means of intervention in greenhouse environment management by farmers is manual. With IoT sensors, accurate real-time data on the conditions of the greenhouse can be obtained. Greenhouse Information such as temperature, humidity, lighting, and soil conditions. Weather stations can modify the conditions automatically to fit the presented parameters in addition to environmental data gathering. A related principle is used by greenhouse automation particularly. Growlink, Farmapp among others, are examples of IoT agriculture devices that offer such features. Another fascinating device that utilizes IoT agriculture sensors is GreenIQ. It is used to manage lighting and irrigation systems remotely by controlling smart sprinklers.





Figure 4: Automated Greenhouse (Source: easternpeak.com)

- **Management of crop:** Crop management products are another type of IoT device in agriculture with an element of precision farming. They are used just like weather stations by positioning them parts of the field to gather data, particularly crop farming. Data ranging from overall crop health to leaf water potential and precipitation. Crop growth can then be monitored, and abnormalities can be detected efficiently to avoid any harm from infections or diseases to your yields. Good examples of how this can be practically applied are Semios and Arable.



Figure 5: Crop Management (Source: easternpeak.com)



Figure 6: Cattle Monitors (Source: easternpeak.com)

- **Cattle management and monitoring:** Like in monitoring and managing crops, several IoT agriculture sensors may be attached to farm livestock to keep track of their health status and record performance. In addition, tracking and monitoring animals on the farm can help data collection on the well-being, health, and physical location of stocks. For instance, sick animals can be identified by these sensors to enable farmers to isolate them from the rest to prevent the spread of the infection. Real-time cattle tracking can be done by using drones. It will also reduce expenses spent on workers (Ganapathy, 2015). Collar tags, which are smart Agriculture sensors, currently use the collar and SCR by Allflex to deliver data in health and temperature activities. They can also be used to provide insights into specific and collective nutrition data.
- **Precision agriculture:** This is also known as precision farming. It is taking accurate and efficient data-based actions. It is also part of the most popularly used and efficient IoT applications in agriculture. Huge amounts of data from every aspect of the area of the ecosystem and microclimate can be gathered by farmers. Data on things such as pest infections, lighting, soil condition, CO<sub>2</sub> levels, and temperature. Farmers can use this data to enhance the measure and quantity of pesticides, fertilizers, and water that their products need to lower cost and increase the level of health of crops. For instance, IoT soil sensors developed by CropX measures temperature, the conductivity of electricity and soil moisture, allowing farmers to tackle each crop based on their unique needs. This technology combines with geospatial data to help generate accurate soil maps for all the fields. Other IoT applications offer comparable services to farmers like improving yields, reducing waste, and increasing farm sustainability.
- **Farm drones:** The use of farm drones is seen by many as part of technologies with the most potential in smart agriculture. Drones are also known as unmanned ariel vehicles (UAVs). They are better suited for farm data collection and gathering than satellites or aeroplanes. Drones can carry out several tasks (I.e. apart from its surveillance features) that human workers will normally do. Tasks such as pests fighting, planting and monitoring crops, farm spraying and so on. DroneSeed produces IoT drones used to plant trees in areas of deforestation. These drones, according to research, are 600% more efficient than human labour. ebee SQ farm drone, built by Sense Fly, estimates crop health using multispectral image analyses, and it is also affordable.



Figure 7: Farm drone (Source: easternpeak.com)

- **Smart agriculture predictive analytics:** Predictive analytics of data and precision farming are two peas in a pod. Smart sensors technology and IoT are promising and beneficial applications for highly critical real-time data. To understand the IoT smart sensor data, farmers utilize data analytics. It also helps them in essential predictions: the potential infections and diseases, yield volume, crop harvesting time, and so on. Agriculture is majorly reliant on climate conditions; utilizing analytic data devices would make farming more predictable and manageable. For instance, farmers are assisted by Crop Performance systems in assessing the amount and quality of farm outputs beforehand. Farmers may also access data on the risk of adverse events like bad weather conditions, like drought and floods. In addition, predictive analytics allows farmers to enhance nutrients and water supply all the crops. For example, SoilScout is applied in farming and provides farmers with solutions to reduce irrigation water use by up to 50%, reducing fertilizer lost due to excess watering.
- **Enhanced farm management systems:** Farm productivity management systems are more complicated methods of IoT product application. This system consists of installations of several farm IoT sensors and devices on the farm environment along with an effective dashboard with analytical features and preinstalled reporting and accounting

system. This enables farmers to remotely monitor and reduce most of the farm tasks drastically. Crop and FarmLogs provide similar services. Aside from farm activity tracking and the other listed IoT farm uses, there are other general applications of these technologies in areas like logistics, storage management, and vehicle tracking, and so on (Paruchuri, 2017).

## THINGS TO CONSIDER IN DESIGNING AN IOT FARM APPLICATION TOOL

The case application of IoT in agricultural farming is quite numerous. Farm yield, output, and revenue can be increased with the help of smart IoT devices in different ways (Paruchuri, 2015). Nonetheless, designing IoT systems can prove to be a difficult task.

Before investing in smart Agricultural farming, you need to be aware of the challenges.

- **Hardware:** In building an IoT application for agricultural farming, there is a need to select device sensors or even design a custom one. The type of data you want to gather, and the general purpose of the application will inform your choice. The success of any product deals relatively with its quality which is how reliable and accurate it gathers data.
- **The Brain:** Every IoT agricultural application must be centered on data analytics. The gathered data will be useless to the farmer if it is inaccurate and makes little or no sense. Therefore, there is a 100% need to have high-end data analytics features and connect them to machine learning and predictive algorithms to get usable knowledge based on gathered data.
- **Maintenance:** Hardware maintenance issues are of significant importance for IoT devices in agricultural farming. Sensors and other IoT tools deployed in the field can get damaged easily. This makes it necessary to design your hardware in a way that it can easily be maintained for durability. If this is not done, the alternative is the constant replacement of sensors.
- **The mobility:** IoT devices for smart agriculture farming should be designed for field use. Users (farm admins or owners) must be able to access data and information remotely using mobile phones or computers. It should also be accessible on-site. Also, each IoT device must be independent and possess a sufficient network range to interact with other devices as well as transfer the data to the main server.



Figure 8: Mobility (Source: easternpeak.com)

- **Infrastructure:** There is a need for a robust infrastructure to make sure the agricultural farming applications perform at optimal levels. It will also enable it to handle huge loads of data. Security of infrastructure is also an important aspect of the system. Systems have to be secure to prevent hacking, data theft, or even getting control of an autonomous device.
- **Connectivity:** Transmission of data to and from numerous agricultural farming establishments is still a huge issue faced in the application of IoT farming. However, the connections must be strong enough to resist harsh weather restrictions and make operations are not disrupted. There are different connection protocols used by IoT devices presently. However, plans are currently underway to provide a unified network in this area. The development of technologies like 5G and space-based internet perhaps may be a solution.



- **Frequency of data collection:** Due to the numerous variations of data in the farming sector, making sure data collection frequency is at an optimal level can be very complicated. There are lots of regulations and restrictions currently placed on information and data gathered from apps, machinery, environmental sensors, equipment, field-based, and even processed analytical data (Vadlamudi, 2017). Sharing and delivering data on time and safely is part of the issues faced by smart farming applications.

## FACTORS AFFECTING THE MASS APPLICATION OF IOT IN SMART FARMING

The Internet of Things plays a critical role in smart agricultural farming and other areas presently. In the future, as the Mobile network connectivity system develops and farmers can access more loans, IoT applications would also grow. Currently, it is correct to say that IoT application in farming is still at its take-off stage. However, the following challenges have slowed down the mass application of IoT devices in agriculture and farming.

- **Investment capital:** capital investment is necessary for the implementation and maintenance of IoT devices and systems. The various important devices connected to the network are relatively expensive. However, they are integral to the installation of IoT devices on farms. For instance, to gather field data, numerous sensor devices need to be installed at different points on the field. Also, there are the analytical parts, connectivity structures, and the main application. Therefore, the various parts need significant investment upfront.
- **Weak network:** There are usually poor connectivity issues in remote and rural areas around the world. However, satellite internet and mobile network coverage improved substantially towards the end of the 2010s. Nevertheless, network connectivity issues persist, especially in the growth of the Internet of Things in smart Agriculture, mostly in Asia and Africa. Some areas lack the required internet connection power to transmit a huge volume of data from the fields to the mobile applications held by the farm admin or owner.
- **Security Threats:** Data protection is essential in any enterprise. Several marketers sell data transmission and connectivity from the data-gathering stage through IoT sensors, the data processing stage in which the data is displayed and monitored on the farmer's screen. There are several farm data securities that can be breached (Ganapathy & Neogy, 2017). There are many sensitive and secret data even though the agricultural sector relies substantially on the abundance of shared and open data. Some companies have been established to deal with such vulnerabilities by developing Agritech software. With the increased number of security breaches reported yearly, this issue has become a paramount focus for several investors (Vadlamudi, 2016).

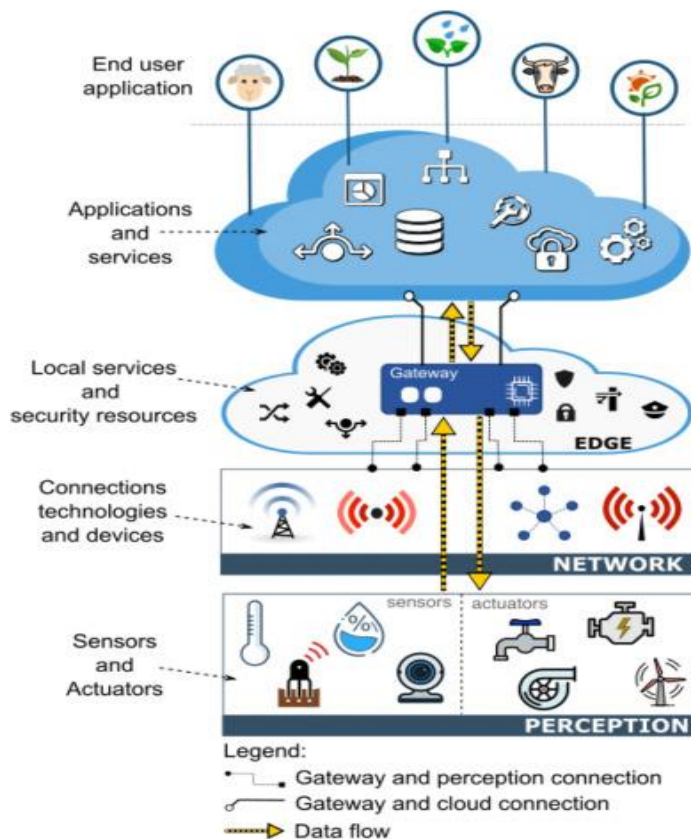


Figure 9: IoT working challenges (Source: ars.els-cdn.com)



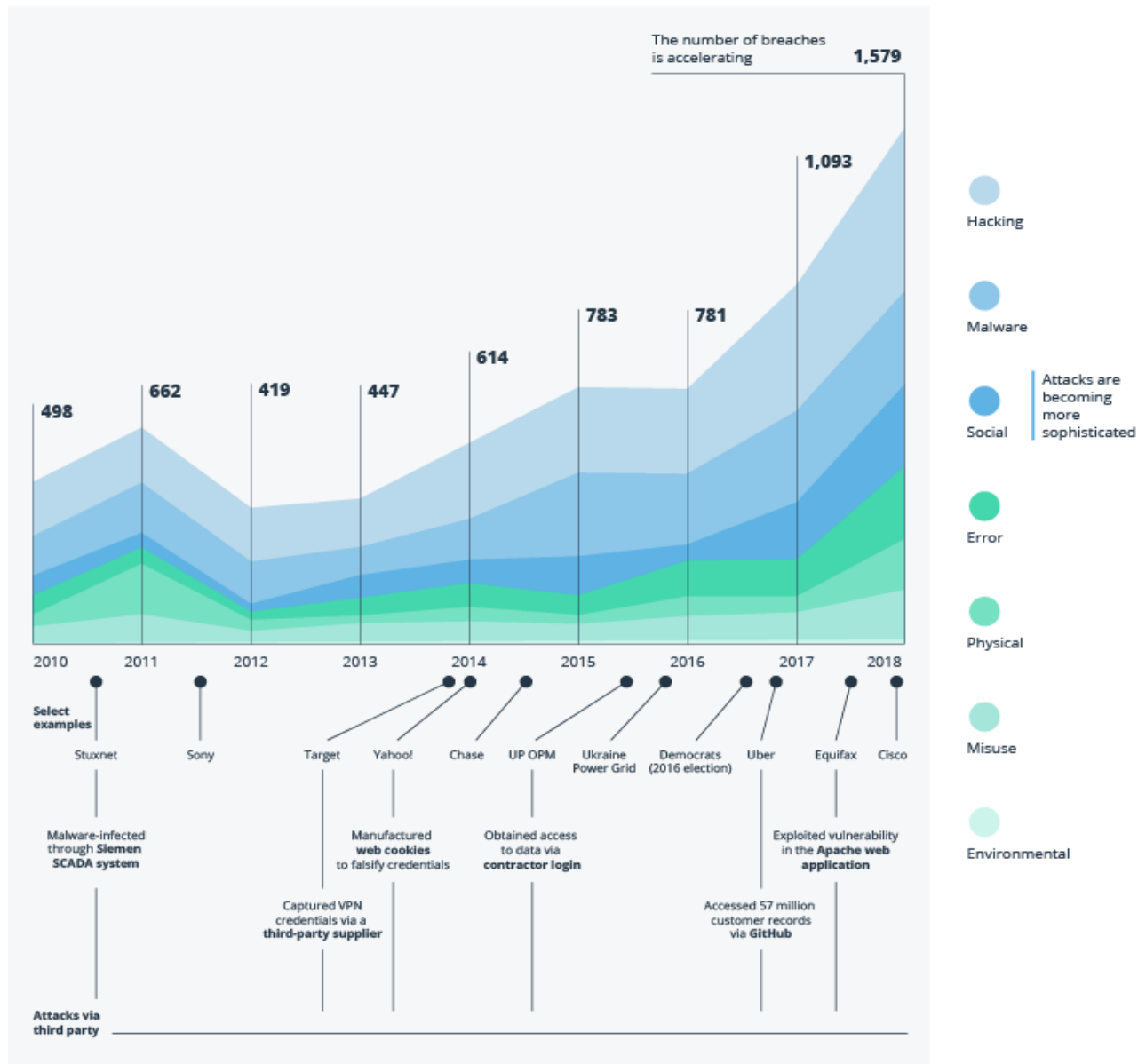


Figure 10: Annual amount of breaches in the US, 2010-2018 (Source: intellias.com)

### CONCLUSION

The Internet of Things is part of the technological advancements that are changing the mode of human operations worldwide. Farmers can use sensors and other IoT devices to gather data and carry out analyses for accurate estimates. With IoT capabilities, farmers can be able to optimize functions and improve yield at a lower rate. These may also result in reduced costs for consumers.

As mentioned earlier, there are numerous challenges that have limited the full adoption of IoT in different industries, including the agricultural sector. From capital to weak network connectivity, these issues have limited the full adoption of IoT in farming. In the future, with advancements and the development of IoT, the limitations would be bypassed, and more farmers will be able to access IoT for smart farming.

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