

Review Article

Technology Application in Smart Farming Agriculture: A Survey

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Abstract: In the current state of increasing technology, many new technologies are being introduced and developed by users in various branches of the field including in the cultivation and agriculture sectors, the increase demand for harvested products leading to the need to increase production to meet demand by farmers has prompted the use of technologies in land preparation before the start of planting, crop care, monitoring of crops, and preparation before harvesting. Technology is combined with agriculture to ensure increased yields while reducing dependence on labour. Internet of Things (IoT) is widely used in agriculture because it has the effect of reducing manpower which will reduce mistakes by human error. Farmers nowadays are moving towards autonomous farming as well as smart farming. IoT technology combined with agriculture can provide beneficial effects on crop processes as well as crop yields. This paper describes and discusses the technologies that are suitable to be used in agriculture. This paper also studies the use of IoT technology in farming.

Keywords: Agriculture; land preparation; IoT; precision farming

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1. Introduction

Agriculture can be defined in a variety of terms such as planting vegetables and fruits as well as animal farming. Agriculture can also be described as a form of science and art in terms of technique used when planting crops. This brings us to the needs and importance of including various technologies in this field. The expansion in the worldwide population, combined with progressively unstable raw material costs, has brought about the need to work on the sustainability of food creation to guarantee balanced food security universally (Wenjing *et al.*, 2020).

Agriculture is very important because it plays a role in improving the economic condition of a country. The agriculture sector not only ensures the continuity of foods in a country but also helps in creating and increasing job opportunities for most of the country's population. As for the Malaysian economy, as much as 16 percent of employment opportunities are in the field of agriculture and it is one of the most important contributors to the Malaysian gross domestic product (GDP) (Mumuh *et al.*, 2021).

Agriculture is getting advanced along with the improvement of technology nowadays. Among the technologies used these days included the use of the internet of things (IoT). IoT are among the technologies that are often being used along with agriculture improvement. The worldwide intelligent agriculture market which relied upon technology reached \$15.3 billion before the finishing year 2025 in comparison with \$5 billion that was achieved in the year 2016. The technology of smart farming will turn into a significant IoT application in a region that practices agriculture as the country's production (Ferrag *et al.*, 2020).

IoT are a technology that uses a system to connect a variety of physical sensor to a wireless network and gives the access to a long range connection. It consists in metering, monitoring, and controlling the sensor wirelessly. The purpose of the technology is to transfer and receive data between the sensor and wireless network. Other than that, this technology is to connect, sends and receive precise data to ensure precise results. The IoT is an emerging innovation that plans to get everyone who uses the technology to stay connected with networking. By utilising IoT-related technology, the proficiency and wellbeing of products from the agriculture sector shall be increased in terms of quality and quantity (Minbo *et al.*, 2013).

The objectives of this paper are to study the recent smart farming technology that is been used in agriculture and also discuss the use of IoT in agriculture. Figure 1 shows the main idea on how modern technology can help in the farming industry. This system has a broad future because there is still a lot that can be upgraded in terms of the progress and speed of network access as well as the capacity to perform a task, operate automatically, and ensure a secure data transmission. It needs to keep pace with advances in technology in the agriculture sector. Accuracy in farming technology that works by utilising advanced hardware can decrease the input of agriculture by using a certain application, as it has better objectives in contributing to a certain and temporary requirement of the sector, resulting in a lower industrial gas release (Athanasios *et al.*, 2017).

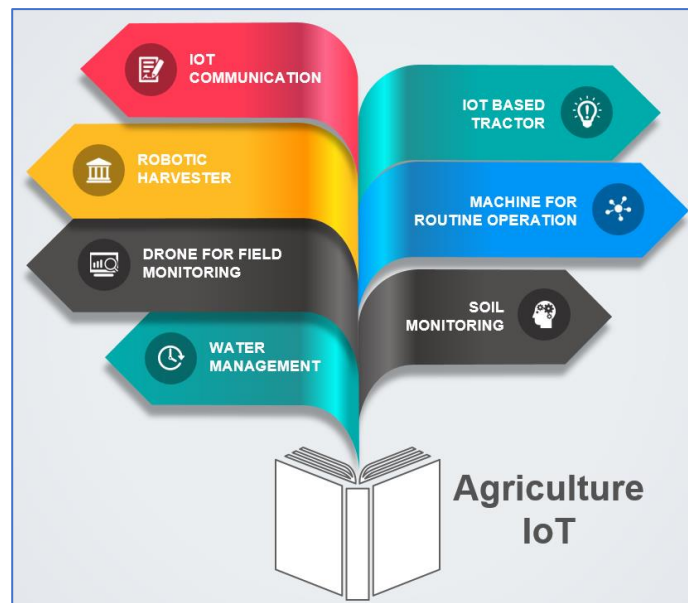


Figure 1. Modern IoT technology in agriculture.

2. Technology Used Today

This section discusses the use of technology that can be implemented by farmers to practice smart farming by measuring the soil content using soil sampling and mapping techniques. For irrigation, many technologies can be combined in order to have the right amount of water irrigate the crops. Fertiliser amounts also need to be measured correctly for us to prevent an overused and underused of resources. Crop Disease and Pest Management technique is also described in this section. Other than that, the yield monitoring forecasting technique is discussed in this section for better understanding of the suitable technology to be implemented in the field.

Precision agriculture is a term that refers to the production of efficient output for agriculture. It also covers techniques in the management, collection, processing and analysis of received data. Accuracy in agricultural technology is characterized by the International Society of Precision Agriculture (ISPA) as a methodology that manages temporary and spatial varying to support further development of agriculture product (ISPA 2018) (Justine *et al.*, 2021).

The received data is compared with the existing data to produce a more efficient output. This technology is also used to increase agricultural yield and ensure environmental friendly. Apart from that, the use of the latest technology helps to increase profits while reducing the use of labour and conventional techniques in cultivation. Accuracy in agriculture, as indicated in the agriculture 4.0 phase, has ensured to transform agriculture practices by using monitoring and intervening technologies to expand output production while minimising the effect on ecology (Yuzhen & Sierra, 2020).

Precision farming has a positive impact on the environment by using targeted inputs to reduce unnecessary overused apparatus and planting material, nutrient loss and also damages resulting from insect infection. Accuracy in the agricultural sector is a quickly expanding area at the joining of agriculture and technology industries and is viewed as progressive and has potential chances to provide food for more individuals, tackle ecological problems, and open new business sectors (Emily *et al.*, 2021).

As indicated by the Food and Agriculture Organisation of the United Nations (FAO) and also the International Telecommunication Union (ITU), the earth's total populace needs to think of a new idea to increment food creation by 70% by 2050 (Panagiotis *et al.*, 2020). In recent years, overall people who have interests in the agriculture area have expanded by 80%. The objective of this funding is to accomplish the useful development of agriculture technology to meet the expanded necessities of the number of inhabitants around the globe considering that under development agriculture will reduce (Dimosthenis *et al.*, 2019).

2.1. Soil Sampling and Mapping

Soil sampling is the method that involved taking a little example of soil, which is then tested on the lab to decide the supplement content. The test of the soil is done to have a better understanding of the input in soil. Much research has indicated that microplastic occurrence in agriculture and hardly caused by humans affect the soil condition in farming (Weber *et al.*, 2020). The essential goal of soil inspecting is to give a precise test of the fertility inside the field. In view of the varying content across the field, the quantity of area of land per test will be different. Soil testing is an instrument that gives a sign for the soil tested in terms of soil content and pH value. By relating soil test content values with plant nutrition and well-being, it can figure out how to appropriately lime soils and add plant nutrition to accomplish and keep up with ideal plant development.

Soil testing and study can give helpful data about the substance and state of the soil in a particular area. The leftover soil slope has different qualities. Due to climate condition, the soil content of leftover soil changes with depth depending on the area (Nistor, 2019). This data can be utilised for advancing plant development and also giving solutions to soil-related issues. The objective of soil testing is to give a precise evaluation of soil fertility to make compost suggestions. With the expanding attention to fertilisers impacts on the natural quality of soil, soil tests as well can be utilised to figure out which certain composts or fertiliser must not be applied to soil.

Soil maps can be described in terms of geographical data that shows a variety of soil types and also property inside the soil such as pH values, soil texture, and organic substance. Soil maps are generally utilised for land analysis, spatial land preparation, agricultural land extension, and also environment conservation.

Soil observation gives guidance to planner and farmer on certain choices in deciding for the land usage. Soil reviews also can act as a forecast to crop yields for various soils and it determine what the harvests product, grasses, and trees are the most appropriate to each soil. It also determines the suitability of the soils and water needed to produce a sustained crop yield.

In order to make soil status predictions, a unique global soil database compares the results with Lab-in-a-Box data. The development is done by Agrocres which involves many teams in making analysis. With this technology, farmers can have direct access to soil sampling results quickly. Agrocres give farmers information about the soil by giving access to the Global Soil Database and farmers are fed with knowledge of scientists to make soil sampling. In the future, it is expected to give information about the measured nutrient and leaf material. For now, the Lab-in-a-Box contributes by giving information about soil fertility.

Augmented reality (AR) can be identified as an upgraded form of our real physical world where it is obtained by utilising the advanced visual components, sound and other stimuli sensors that is achieved by the usage of technology. Many companies in mobile computing are slowly involved in this technology as it becomes a trend in business application. The objective behind AR in this practice is to help farmer to do soil tests. Also, the task of the application must be helping the user and they must not be expected to work the product software. Input from real-world data should be given as automatically as possible (Huuskonen & Oksanen, 2018).

The difference between virtual reality and AR is that virtual reality relies only on virtual and need devices like headset to operate while AR manages to interact with real-world data and can be accessed by using a smartphone only.

AR can play an important role in agriculture, as it can help in checking field conditions and also it can help detect pests and insects. It also manages to identify the suitable soil and crops to be planted in an area. It also manages to identify pest and crop situations by accessing advanced technologies applications.

Soil moisture and ocean salinity are related to the earth's water cycle, where it provides many data required to make a design of model for weather and climate. It also increases the skill involving numerical weather and climate forecasting.

Farming drought occurrence usually happen when water deficiencies lead to decreases in yield production, and are most frequently connected with expansions in transpiration of plant combined with decreases in soil humidity (Champagne *et al.*, 2019). Farmers in the dry season find it difficult to forecast the availability of water for their plants. Usually, during the dry season, there will be a water shortage. This is because some farmers

rely on the water beneath the earth. This type of water is harder to be estimate and forecast compared to rain, snow, and reservoirs in plain sight.

Agribot is the type of robot which invented purposely for agriculture. This robot executes a straightforward task in farming for example separating the soil in the field, distributing the seed and covering the seed back in soil. This type of robot execute task automatically and it gives the user to choose which task to execute first. The continuous improvement in farming robotic technology is expected to improve the difficulties forced by populace development, sped up urbanisation, high intensity of great product, nature conservation and an absence of qualified workers (Oliveira *et al.*, 2021).

When operating autonomously, this robot can help improve efficiency and reduce the dependency on manual workers. By evaluating data obtained and analysis from the robot, information from the usage can be used to improve yield products. The agricultural robot executes simple and repetitive tasks that are usually done by farmers. This allowed the farmers to think and focus more on improving yield products. Some common robots used in agriculture include harvesting, picking and weed controlling.

2.2. Irrigation

Irrigation can be acknowledged as an artificial water flow that is used with a tube, pump, and spraying system. Under ordinary water system framework, watered land which is either under watered or over watered will have impacts on crop development and misuse of water. Hence, it is better to have an automatic system (Kagalkar, 2017). In addition, the automated system can be used in an area that has less rainfall and dry season. The main purpose of irrigation is to assist in agriculture crop maintenance, landscaping and also give support to plants during dry season where rainfall cannot be predicted. The automated watering plant technique, which utilise both rain and groundwater, provides a solid and strong yield product while increasing agriculture yield harvesting (Rosa *et al.*, 2020). This system also allows farmers to control the right amount of water needed by crops to grow and develop, resulting in higher yield with optimum input.

The Crop Water Stress Index (CWSI) is used in measuring the relation of plant transpiration to the time taken during measurement. The calculation is done by comparing the plant canopy temperature with dryness of air which occurs when the vapours amount is less. Irrigation with a high value CWSI shows in lower season irrigation and lower season transpiration of plants (Ahi *et al.*, 2006). This calculation can estimate the water stress for the crops based on the temperature of the canopy surface. The temperature of the canopy related to the plant is usually measured by an infrared thermometer which then is evaluated to estimate the water status to forecast the transpiration rate and heat transfer from the plant.

Variable Rate Irrigation (VRI) in planting includes the rate of water available to supply to crops throughout the planting season. In general, the VRI system gives chances in

supplying water to the separate area by various moving rates and various cycles of solenoid valve (Shi *et al.*, 2019). Irrigation rate can be obtained by analysing the water supply for a hectare of irrigated water to crop in a single execution. The (VRI) innovation can assist with applying the perfect proportion of water in the ideal places of the field at an ideal time resulting in water reserving (Neupane & Guo, 2019). VRI can help farmers estimate the optimum rate of water to be used in an area. This technology is usually used by fitting the water supply to centre pivot and linear irrigation which help farmer locate an optimum amount of water in different part of the field.

2.3. Fertigation

Technology of fertigation uses the injected fertiliser inside the irrigation system to water plants through the field. Malaysian farmers that plant rice usually use fertilisers by one measurement to be used in the overall crop field (Abu Bakar *et al.*, 2021). It is important to apply scientific study in farming such as the quality of the seed and water, and the protection of the plant such as the agriculture house (Sharma *et al.*, 2021). Fertigation is usually done with injectors and pressure-controlled valves. The demand of food and the deficient of water resources must be solved by inventing new technology for more efficient use of resources. Drip irrigation can save up to 50 percent of water by designing and executing the system properly (Cetin & Akalp, 2019). The advantage of using fertigation is that it can help the soil in maintaining the amount of nutrient concentration. The advancement of a plant irrigation model combined with a fertigation framework is important to guarantee sustainable plant production with the precise injection of fertilisers (Concepcion II *et al.*, 2021). It can also ensure optimum amount of nutrients is concentrated inside the soil based on nutrients required by the crops. Fertigation is used by farmers widely because it can save time, resources, and energy. This is obtained by executing two tasks at the same time. When fertigation concentration is used together with irrigation, both nutrient and water can be precisely managed to maximise yield production.

Normalised Difference Vegetation Index (NDVI) is a standard way in measuring healthy vegetation. The value of the NDVI represents the health of the vegetation. If the value is high it means that the plant is healthy. In simple words, the NDVI helps in evaluating the planting area with other land and analyse it. NDVI give clear information about the community of the plant, the plant form and structure, plant density and plant reflection (Pettorelli *et al.*, 2011). This technology also interprets and pictures the growing process of plant and detects abnormality and changes in the planting area. The NDVI evaluation is done by determining the green patched on targeted plantation area. The observer need to identify the different colour output affected from the reflected sunlight on the plant. From this technology, the density of green area is easily estimated and it helps in differentiating common soil with grass and forest, detecting plant under stress and makes a comparison between crop and stages of crops.

Variable Rate Application Technology (VRT) is a system that varies the amount of fertilisers used for farm based on the amount of concentrated nutrient in the soil and crop. The economic and ecological benefits of VRT in limited spaces farming system must be recognised so that the decrease of negative impact on climate can be achieved (Späti *et al.*, 2021). In precision farming, VRT can act to manage nutrients and estimate the usage of fertiliser on a certain soil type, fertility and water content. VRT also manage the fertilisers and water irrigation to be supplied to different area of the field at different rates based on the concentration of nutrient in the area. By using VRT, crop yield can be increased with a standard optimum resource usage (Rahim *et al.*, 2022).

2.4. Crop Disease and Pest Management

Plant disease and pests such as weeds and insects usually cause harm to the plantation especially in big-scale crop planting has resulted in an increase of disease and also insects. As a result, much research discussing the effects of plant diversification and also insect population related to beneficial insects in agriculture have been reported (He *et al.*, 2019). Farmers often use pesticides and biological pest control methods. In order to provide a better food to population in the world, there must be action taken in decreasing the use of pesticides while maintaining crop bugs and disease of plant under control (Ratnadass *et al.*, 2012). The high demand for food has led to various studies of strategic methods being carried out in handling crop pests and disease. However, relying on synthetic products is not recommended as it affects human health and nature (Lengai *et al.*, 2019). Crop disease also can come from infection in damaged areas caused by agriculture tools, insects fleas and also vary weather conditions such as heavy rain, dust and wind. Insects are also causing damage to crop by causing injury to the plant by feeding the on leaves, and burrow in plant stems and fruits. This plant disease can be detected with an image processing technique. By using image processing techniques, the detecting plant diseases can be enhanced rather than using manual observation from farmers in the crop field (Husin *et al.*, 2022).

Early Warning Systems (EWS) technology is developed to improvise and give information and early warning so quick action can be taken to reduce crop damage. From the information obtained, decision making can be made using analysed data from previous events. It is important to know the main elements for early warning such as monitoring technically, warning services and response by community to ensure effective action is taken from the warning system. In agriculture practices, problems occur in protecting plants usually related to pests and diseases resulting in the decreasing factor in yield production (Karaca *et al.*, 2010).

Unmanned Aerial Vehicles (UAV) such as drone is widely used for agriculture and plant disease such as weed control. Drones in UAV have become an important tool in the remote sensing sector as they help in managing better agriculture practices (Kaivosoja *et al.*, 2021). Drones can help farmers by executing main tasks such as seeding, fertilising, and

putting pesticide more efficiently. This will help to protect crop from pests frequently and save time. Drones can also supply high resolution data that can be used to monitor the fertility of crops and improvise in managing accurate application of fertiliser and reduces wastage. Agriculture drones improve farming by gaining data that regulate crop condition such as health, treatment and irrigation. It is also able to analyse crop damage for further action to be taken.

IoT can be used to monitor crop conditions. This technology obtained humidity, temperature, soil moisture information and autonomously execute irrigation systems. In saving water, improvement can be made by limiting the usage of water by applying an irrigation method that covers 70 percent of the full field (Debauche *et al.*, 2020). This system can be monitored from anywhere. IoT give farmer the capability to monitor their crop in real-time data monitoring and have information on crop condition. IoT in farming helps farmers in reducing waste and improving production by precisely executing fertiliser which will helps with efficient usage of source.

2.5. Yield Monitoring Forecasting and Harvesting

Crop forecasting is a very important method in ensuring the sustainability of food supply. Yield monitoring and yield mapping improvised the agriculture sector. By practicing this method, yield production can be increased by managing fertilisers and chemical usage on precise location and time combined with the correct input amount (Putri *et al.*, 2016). Crop and yield forecasting are used by farmers to estimate yield production before any harvesting is done. Improvised in the skill of predicting is very important as it creates a strong and accurate time in informing early warning system (Zhang *et al.*, 2018). Crop yield prediction in agriculture usually uses soil content, environment and parameters of crop. In recent years, technology has improvised image technology and processing which led to the use of automated technique in determining yield condition (Whalley, 2013). In making predictions, a model of forecast is used to evaluate crop condition for a better precise prediction. In reducing the dependency on additional accessory, workers and increase in data collection, yield monitoring on machine is reliable for farming because it has accuracy on data collected and need a minimum specific calibration (Pelletier *et al.*, 2019). Food prediction can have a great effect on farmers by giving information for economy and management decisions. Yield prediction can identify the factors that impact crops. It also helps in evaluating the area that needs more fertilizers and also management of the seeding rate. The study stated that the application of balanced amount of fertilisers can be observed from NDVI reading. This can help in keeping track of and monitoring the nutrient supply (Otieno *et al.*, 2020).

3. Major Equipment Technology

In this section, this paper discusses robotic harvester, large equipment and also machines that usually been used in agriculture. It includes the use of many types of harvesting

robots that match the type of plant to be harvested. Types of tractor used are also described in this section with additional tractor that can be implemented with IoT technology. The final part of this section describes the suitable communication system to be chosen depending on the types of connection needed and the stability of connectivity, range of network and cost to be implemented in a certain farming area.

3.1. Harvesting Robot

Harvesting is an important stage when it comes to production because it is the last process and indicates the yield success. There is different picking time for different crop and sometimes it is done in either once or several times depending on the crop condition. Harvesting the crop needs to be done in a precise time because a late harvest product tends to affect the quality of crops. In the current industrial era, there is an increasing demand for automated technology. A convenient worker who is able to do repeated and continual tasks is slightly decreasing (Arad *et al.*, 2020).

Based on traditional practices, a sickle is used during harvesting. As a modern technology farming, a harvester is used to cut the crops. As for tomato plantation, harvesting a large-scale plantation require big labour, time consuming, and is less efficient (Wang *et al.*, 2017). When a harvester is combined with other machines, that do cleaning to grain, it can be called a combined harvester.

In practice, the modern design of harvesting robots can automatically pick fruit in any environmental condition. This robot usually uses machine vision to operate although the technology is still in early studies. Combining it with artificial intelligence helps in data processing and improves in targeting the fruit before plucking it from the stem. An important technology for robotic agriculture includes machine vision which enables the machine to discover and concentrate on targeted fruits (Xiong *et al.*, 2019).

As for strawberry harvesting, a robot called Rubion is used in picking fruit. The robot moves forward and backward to find the suitable way to the crops. In order to have a successful and functional harvesting robot, the robot need to recognise and track down crop to perform its task (Jun *et al.*, 2021). It can pick fruits like a human without damaging the quality of the fruits. With a quality monitor, this robot can sort the fruits based on quality. This robot can pick fruit with a smooth robotic arm movement and separate every fruit based on its weight.

A SWEEPER is a sweet pepper harvester that uses robotic technology to simplify harvest. This robotic skill is improvised by using a crop model to determine the position and exact location of the peppers. The use of crop models will help in accelerating fruit detection during the harvesting process. The importance of autonomous harvesting includes the ability to target fruit locations. The challenges that might occur involve the task of recognising the light intensity, overlap fruit, and the fruit placement between leave and stem (Yu *et al.*, 2020).

FFRobot is usually used for a tree-based fruit such as apple. This robot includes a precise robotic control, is simple and fast, and also accurate in processing image for a better fruit target. Combined with its smart algorithm, a fruit with disease and damages can be discriminated. The harvester can be modified to the suitability of the tree based on its type, making it able to be used multiple times during harvest.

3.2. IoT-Based Tractor

As the crop industry grew bigger, many conventional methods of farming started to become stressful due to the load of work needed in maintaining crops. This phenomenon has resulted in an increase of tractors and heavy machinery used in this farming sector. In order to fulfil the demand for tractors, many manufacturers like New Holland, Case IH, John Deere, and Hello Tractors have been providing a solution to meet farmer needs. With the help of modern technology, all of these manufacturers can offer a tractor with automatic control that has mechanical and electronic parts and has a cloud to store and process data. In the paddy industry, a bad conventional land levelling usually causes problems related to irrigation and this can affect crop yield (Abu Bakar *et al.*, 2020). In modern farming, IoT can be implemented into mechatronic systems to make autonomous systems such as sugarcane harvesters. A chopper is usually used to harvest the sugarcane. The sugarcane harvester is a mechanical and electronic system combined into a tractor (Rijanto *et al.*, 2020).

Automatic tractors are not a new technology, as a tractor with self-drives has been in the market before the modern autonomous car. There is advantages in self-drives tractor as they can avoid going in the same area twice, resulting in the reduction of overlapping phenomenon in farming. Other than that, it can do a turn precisely without the presence of drivers. This technology can help in reducing error when applying crop needs. In measuring farm machinery used in the working area, it is important to precisely perform the measurement as it indicates the machine operation, a better distribution of supply, and estimate the machine result on certain yield. By using manual measurement, the result tends to be affected by human error and is a time-consuming process (Waleed *et al.*, 2020).

Modern farming has encouraged farmers to use modern technology. For example, is the Case IH Magnum series tractor. This tractor has a modern technology attached to it as it has cameras and also a sensor called LiDAR to detect object and avoid collision. The use of sensors helps in providing smart services to provide smart yield production. Intelligent technology applications are also being developed and applied in the agriculture and farming industries (Kaňovská & Tomášková, 2018).

As modern technology uses many data, all collected data need to be stored and processed. The John Deere tractor pushes this data to the cloud so data processing can be done. In this tractor system, data analysis is done based on the tractor's input as it is more precise. The data analysis can be modified in real-time as it depends on the condition of the

field. This improves the tractor as the machine is connected to internet. IoT is a good technology that gives systematic and reliable solution to problem occurred in agriculture. Solutions based on IoT are being created to autonomously sustain and observe agricultural farms with the least use of labour (Farooq *et al.*, 2019).

Modern technology machines despite its intelligence in farming, have high prices that are usually unaffordable to normal farmers. As for the tractor owner, the operation of the machine is below optimum. Based on this problem, Hello Tractor has provided a solution for the issue. This company has developed an affordable monitoring device that can be used in any tractor. This system also can connect farmers to tractor owners as a farming service while it monitors a tractor's condition. Monitoring used in agriculture includes the yield measurement system attached to a harvester tractor to obtain field data. Taking data on the same field allows a better study of the area. Many properties can be recorded such as grain moisture which can be used for further evaluation (Oksanen *et al.*, 2016).

3.3. Communication Used

Communication is very important in smart agriculture. This is because information is being transferred from time to time resulting in a set of data. This information can only be achieved by having a strong, firm and reliable connection. In achieving the reliability of communication, telecommunication provider needs to play an important role. In developing IoT in agriculture, many important aspects need to be taken care of such as coverage, cost, energy usage and reliability. Low-energy technology can help in maintaining data transfer with minimum power usage. However, this technology can only send a small amount of data at a time. In an IoT system, data transfer from hardware is transmitted wirelessly. **Table 1** shows the comparison of wireless networks. The wireless connections that are usually used include Wi-Fi, Lora WAN, Bluetooth and mobile communication (Ardiansah *et al.*, 2020).

Table 1. Comparison of different wireless network range.

Parameters	Frequency Band	Data Rate	Transmission Range	Energy Consumption	Cost
Wi-Fi	5 GHz - 60GHz	1 Mb/s –7 Gb/s	20 m–100 m	High	High
Lora WAN	868/900 MHz	0.3–50 Kb/s	< 30 km	Very Low	High
Mobile Communication	865 MHz, 2.4 GHz	3G: 200 Kb/s, 4G: 0.1–1 Gb/s	Entire Achievable Line Area	Medium	Medium
Bluetooth	24 GHz	1–24 Mb/s	8 m–10 m	Very Low	Low

Wireless technology is very important tool in agriculture. Wi-Fi is one of example of wireless technology that can be used to connect to smartphones and computers with the presence of the internet. The signal sent from the router can be detected by devices nearby.

The signal is then converted into data that the user can see and use. This technology provides users with a secure network as a password can be set to ensure safety. Modern farming technology is improving when data collected is transferred using Wi-Fi. Combining different technologies can help in reducing system costs and also ensure reliability and security (Liu *et al.*, 2019).

Long-range technology in communication is also important in agriculture. This is because it uses a low-power transmission system. By using a low power concept, it can have a connection between the sensor and server for a longer period. This LoRa technology combined with a sensor can be used in small devices for continuous monitoring. This technology can send signals in buildings through thick walls and can cover a large area. This is good as IoT aims to maximise the connection so that a data can be transferred and processed optimally. The monitoring and controlling can be done remotely using a computer or smartphone and this technology can be applied in various fields (Astutiningtyas *et al.*, 2021).

Bluetooth technology is usually used for a short-distance connectivity. In smart farming technology, Bluetooth is used because it is easy and operates with low-power energy. Many IoT technology uses Bluetooth Low Energy (BLE). Even it transfers data in low power, the data is also small to conserve energy. Other than Bluetooth, cellular technology is also suitable for farming. It ranges from 2G to 4G. However, the main problem occurs when using cellular phones in a rural area. The choices of end nodes for this technology are important and it depends on the farm's needs, for example, low data transfer over a long period of time. Wireless sensor network is an IoT technology that plays important role in agriculture, healthcare and environment application (Elattar *et al.*, 2017).

4. Conclusion

This work represents some of the latest technologies that are often used in the field of agriculture. Among the technologies that have been used include IoT technology. Along with the development of the internet, IoT technology is becoming more sophisticated and used in many fields. This includes smart farming and precision farming. Soil sampling data collection is also becoming easier as technology helps in the identification of soil content and pH. value. Prediction of suitable soil for agriculture is also easier to determine through AR techniques and soil moisture and salinity techniques. The use of workers can also be optimised with agricultural robots that can perform tasks autonomously. In the water system, the stress index in plants can be identified through the crop water stress index. Water control is also more accurate through variable rate irrigation. Plant growth can be measured by normalised difference vegetation index. Proper steel sowing can be achieved with variable rate technology. In disease monitoring, EWS technology can be used to warn of pests. Bugs can often be eradicated with rapid and frequent spraying of fertiliser via UAV drones. Harvesting tasks can become easier with the help of a harvesting robot. In managing large agriculture fields, IoT-based tractor can improvise and ease the management. Combining

all the technology that has been discussed can add information to the monitoring of agricultural yields through yield forecasting and harvesting.

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