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Review Article

Artificial Intelligence, Internet of Things (Iot) and Smart Agriculture for Sustainable Farming: A Review

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Abstract

Internet of Things (IoT) is being used in various parts of human life (domestic and commercial) to provide ease in living, safety, increase productivity, monitoring, and resource optimization in various industries. Agriculture is one of them, where IoT and robots are being used before and after the cultivation process, from preparing land for cultivation to supplying them to the consumer market. These domains include crop monitoring, smart irrigation, pest monitoring, and smart pest control, harvesting, and safely supplying them in the consumer market by maintaining the quality and integrity of the final product. Thus, new automated methods were introduced. These new methods satisfied the food requirements and also provided employment opportunities to billions of people. Artificial Intelligence in agriculture has brought an agriculture revolution. This technology has protected the crop yield from various factors like the climate changes, population growth, employment issues and the food security problems. This main concern of this paper is to audit the various applications of Artificial intelligence in agriculture such as for irrigation, weeding, spraying with the help of sensors and other means embedded in robots and drones. These technologies saves the excess use of water, pesticides, herbicides, maintains the fertility of the soil, also helps in the efficient use of man power and elevate the productivity and improve the quality. This paper surveys the work of many researchers to get a brief overview about the current implementation of automation in agriculture, the weeding systems through the robots and drones. The various soil water sensing methods are discussed along with two automated weeding techniques. The implementation of drones is discussed, the various methods used by drones for spraying and crop-monitoring is also discussed in this paper. Therefore, a Remote Sensing Assisted Control System (RSCS) has been proposed for improving greenhouse agriculture requirements. This proposed method utilizes artificial intelligence and machine learning technology for the green development potential industry's ability to manage economic resources and increase innovative agriculture product development patterns. Thus, the key preconditions for increasing healthy food choices and

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promoting local and global organic farmers' potential development are straightforward suggestions for developing an effective marketing strategy.

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Introduction

Food demand and production World population is expected to grow by over a third, or 2.3 billion people, between 2009 and 2050. This is a much slower rate of growth than the one seen in the past four decades during which it grew by 3.3 billion people, or more than 90 percent. Nearly all of this growth is forecast to take place in the developing countries. Among the latter group, sub-Saharan Africa's population would grow the fastest (+114 percent) and East and Southeast Asia's the slowest (+13 percent). Urbanization is foreseen to continue at an accelerating pace with urban areas to account for 70 percent of world population in 2050 (up from 49 percent at present) and rural population, after peaking sometime in the next decade, actually declining. At the same time, per capita incomes in 2050 are projected to be a multiple of today's levels. The production of Food grains in the country is estimated at a record as per 2nd Advance Estimates for 2021-22, total Food grains production in the country is estimated at record 316.06 million tones which is higher by 5.32 million tones than the production of food grain during 2020-21. Further, the production during 2021-22 is higher by 25.35 million tones than the previous five years' (2016-17 to 2020-21) average production of food grains. Record production is estimated for rice, maize, pulses, oilseeds, gram, rapeseed, mustard, and sugarcane. There is a consensus among analysts that recent trends whereby the economies of developing countries have been growing significantly faster that the developed ones is likely to continue in the future. On the other hand, not all the land on earth is arable because of some factors like soil quality, climate, topography, and high variability factors within the homogeneous land. Furthermore, the rate of arable land declining surpasses the rate of recovery because of pollution, soil erosion, and land degradation. All these issues are inclined toward the adoption and advancement of agriculture.

Internet of things (IoT) based systems provide some major capabilities such as data acquisition and communication infrastructure (used to connect smart objects to end-user applications through the Internet), cloud-based intelligent data analysis, decision-making, end-user interface, and operation automation. These capabilities are opening new dimensions in the field of agriculture. This paper is a brief overview of the application of the Internet of Things in smart agriculture for sustainable food security. The overview consists of some practical case studies, white papers, and articles about how IoT could provide sustainable food production with minimal resources and what are challenges to begin with and what could be the possible approach to implementing the IoT-based ecosystem.

Smart farming is a management concept focused on providing the agricultural industry with the infrastructure to leverage advanced technology – including big data, the cloud and the internet of things (IoT) – for tracking, monitoring, automating and analyzing operations. Also known as precision agriculture, smart farming is software-managed and sensor-monitored. Smart farming is growing in importance due to the combination of the expanding global population, the increasing demand for higher crop yield, the need to use natural resources efficiently, the rising use and sophistication of information and communication technology and the increasing need for climate-smart agriculture.

Agricultural production is a system that involves the detection, measurement of crops (Nasir, *et al.*, 2021). It is a technology for recognizing greens, and messages are transferred to the server at this moment, and action is needed from the farmer given the information he obtains (Sekaran, *et al.*, 2020). The innovation that interfaces any except every limitation using advanced methods that present inventions can handle the IoT (Hsu, *et al.*, 2018; Gao, *et al.*, 2020). The integrated sensors innovations support the agricultural production industry for monitoring and comprise both the owner and the servant to improve green production. In the servant, various sensors are employed for temperature for monitoring the ammonium and moisture sensing. Farmers can monitor the food processes remotely over the mobile communication device. Moreover, intelligent agricultural production systems there use several sensors for crop growth monitoring. This means that greenhouse factors such as CO2, soil moisture, temperature, light can be monitored (Gupta, *et al.*, 2020). The unstable environment in greenhouse crops can affect plant development and reduce yield towards the end of culture (Zeb, *et al.*, 2020). This challenge can be addressed by applying IoT innovations in artificial intelligence applications for certain greenhouse factors controlling temperature range, water flow, light radiation (Abdel-Basset, *et al.*, 2020; Vadlamudi 2021). This agricultural instability can gradually increase with the emergence and this method has been involved in the continuous development of artificial intelligence (Arshad, *et al.*, 2020). Remote sensing data with high resolutions and real-time agricultural production crop yield sampling are appropriate machine-learning technology in commercial crop prediction (Saddik, *et al.*, 2021). In the agricultural sector, machine learning is utilized to increase crop output and quality. Seed dealers use this agriculture technology to churn data to develop better crops. Pest control firms use them to identify different bacteria, pests, and vermin's. Organisations/ cooperatives responsible for the production and distribution of vegetable, fruit, cereals, pulses or animal based products make up an agriculture supply chain system. Agricultural products are employed as raw materials in various supply networks to create higher value consumer products. The main contribution of RSCM is described below: . It improves greenhouse farming requirements by using RSCM . It uses artificial intelligence for industry potential green development to control economic resources and increase the growth pattern of innovative agricultural products. The results provide clear suggestions for developing an effective marketing strategy for green farm products and encouraging the potential growth of organic farmers locally and globally.

IoT Ecosystem's Equipment and Technology

IoT ecosystem is a combination of several technologies and equipment that are embodied by integrated systems that work seamlessly in their operations (Figure 1), representing the IoT system architecture. Data acquisition is done from the sensors and the data is transferred to the cloud architecture where decisions are taken to perform operations in the field based to provide insight for the end-user application. All components of the system work independently without having any human-to-human or human-to-machine interaction. Here are some common components that make this whole process seamless and integrated.

IOT Sensor Components/Technology

Smart agriculture cannot be possible without the sensor's technology. Sensors are used to gather and measure different factors and variables of environments that could affect crop yield. The success of precision agriculture is based on accurate sensor data acquisition for crop- and soil-specific management (Benoit, A. 2012). Almost all the equipment and vehicles (i.e., tractor, harvester, unmanned aerial vehicle, and sensor device) are equipped with remote sensing facilities like Geographic Information System (GIS) and Global Positioning System (GPS) for precise and autonomous site-specific operations. A wide range of IoT sensors available for monitoring applications can be classified into two categories. The first one is intelligent multipurpose imagery sensors, which could be embedded on unmanned aerial vehicle (UAV), rails, and fixed position components and could involve remote sensing (Jacob, B, 2014).

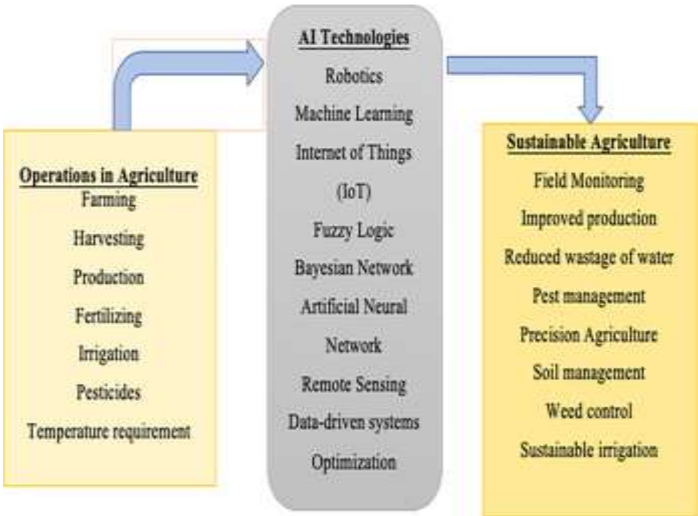


Fig 1: Artificial Intelligence Technology

Combined with deep learning, these sensors can reach their full potential and are capable of soil and vegetation/crops mapping, crop phenology, crop height, estimation of yields, fertilizers' effect and biomass, plants water stress detection and drought conditions, pest detection and management, weed detection, and greenhouse monitoring (Grell, M. *et al.*, 2020). The second type of sensor is more commonly used and specific to their use case and can be deployed at various locations on the field. The most common sensors are airflow, soil moisture, electrochemical, capacitive humidity, and position, mechanical, optical, and temperature sensors. Table 1 represents sensor working and their use cases. Furthermore, there are some worth mentioning factors that make IoT sensors suitable for smart agriculture: (1) computational efficiency, (2) cost, (3) coverage, (4) durability, (5) memory, (6) portability, (7) power efficiency, and (8) reliability.

Unmanned Aerial Vehicles (UAVs)

Apart from the IoT ecosystem, UAVs is itself an emerging and self-existing technology that is a combination of various other technology stocks such as robotics, on-board computing, artificial intelligence (AI), information and communication technology (ICT), IoT, and battery. The reason behind the popularity of UAVs is that it is filling the gap of limitation of remote sensing imaging through satellite because of weather and cloud penetration and on-ground limitation of robots because of uneven plains, obstacles, and speed. UAVs provide imaging with high resolution using hyperspectral, multispectral, and Red Green Blue (RGB) cameras. It entails more accurate details of the field at a much cheaper cost.

UAVs are workable in monitoring as well as in the action phase of the application. Common usage of UAVs in two major phases of precision agriculture is as follows. First one is monitoring, where applications are soil and crop mapping and sampling (De Oca, A. M. *et al.*, 208), yield forecasting (Al-Ali, A.R. *et al.*, 2015), weed detection (Natu, A.S. *et al.*, 2016), pest and disease detection (Abdel-Basset, M. *et al.*, 2020), and soil and crop stress assessment (Abdullahi, H.S. *et al.*, 2015). The second one is an action phase where applications are sowing seed (Anderson, C. *et al.*, 2014), spraying herbicides (Arshad, J. *et al.*, 2020), pesticides (Astrand, B. *et al.*, 2002), and fertilizer (Hanson, B. *et al.*, 2000).

UAVs have two main types shown in Figure 2: fixed-wing UAVs and rotary-wing UAVs. Fixed-wing UAVs are more similar to airplanes and more or less follow similar phenomena for flying; fixed-wing UAVs are more favorable to work on large areas because of the capability of long range, high speed and altitude, and crash tolerance. Rotary-wing UAVs have further classification such as helicopter and multirotary type; commonly, multirotary UAVs are named after their number of rotaries, i.e., four-rotary UAVs as quadcopter (Faiçal, B.S. *et al*., 2014; Faiçal, B.S. *et al*., 2014), six-rotary UAVs as hexcopter (Faiçal, B.S. *et al*., 2014c), and eight-rotary UAVs as octocopter (Faiçal, B.S. *et al*., 2014). Fly in a hovering manner similar to a helicopter. Rotary-wing UAVs have more advantages than fixed-wing UAVs such as being easy to set up and operate, low altitude flight, precise location operation ability, no wind planning required, and being fully autonomous for daily agriculture operations.

With all the ease, UAVs have some limitations as well. The technical limitations of UAVs are low battery time and efficiency, payload, communication distance, and low flight time. Fixed-wing UAVs can communicate up to 100 kilometers, and the average flight time is about 5 h Bhagyalaxmi, K. *et al*., 2016). Battery efficiency researchers are working to develop a more efficient hybrid battery and battery management and optimization techniques (Chang, C.L. *et al*., 2018; Hsu, T.C. *et al*., 2018).

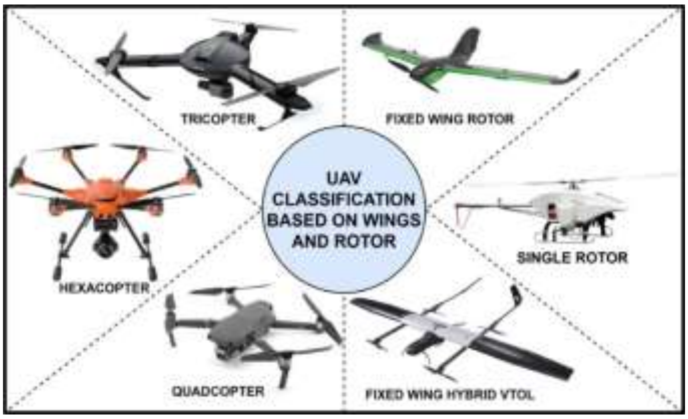


Fig 2: UAV Classified on the Basis of Wings and Rotor

Fig 3: Unmanned Aerial Vehicles with its Parts

Communication Technologies

Smart agriculture is impossible without the inclusion of ICT. Data has no purpose if it cannot be sent to some database or cloud for further computing and analysis; it is considered the backbone of smart agriculture. There are several classifications in communication technologies based on their communication range, data rate bandwidth, power consumption, licensed or unlicensed spectrum, frequency band, and subscription prices. Every communication technology works better than others in different application scenarios which depend on what aspect is most important in that particular application. For each application scenario, some work best or some work worst. For example, Zigbee communication technology is more suitable for greenhouse agriculture monitoring, and Narrowband Internet of Technology (NB-IoT) and long range (LoRa) are more suitable for field precision agriculture (Cioffi, R. *et al*., 2020).

Choosing communication technology for smart agriculture depends on multiple factors. Some factors are more prominent than the other; e.g., unlicensed spectrum technologies could have better bandwidth but come with some pitfalls such as radio frequency interference, insecure communication, infrastructure setup cost, and low range connectivity. Radio frequency identification (RFID), Bluetooth, Wi-Fi, and Zigbee are examples of unlicensed spectrum technologies. On the other hand, licensed spectrum technologies are reliable, provide accessibility for large areas, are secure, and have less infrastructure cost but have a subscription for data transmission and low data rate bandwidth as compared to the unlicensed ones. A survey suggests that ZigBee, Wi-Fi, and cellular technologies are more popular among researchers for agriculture applications. About 45% of Zigbee, 25% of Wi-Fi, and 20% of cellular or multihopping technologies are utilized by the researcher for their agriculture-related experiments (Cillis, D. *et al*., 2018). Furthermore, NB-IoT and Long-Term Evolution Machine (LTE-M) are relatively new Low-Power Wide-Area (LPWA) technologies and could capture more attention as the 3rd Generation Partnership Project (3GPP), the standard group specifying the 5th generation mobile network (5G) and other wireless networking standards, has affirmed that these technologies are going to be a part of 5G and will be the only LPWA-supported 5G technology (Murugan, D. *et al*., 2017). Table 2 shows some widely used communication technologies in smart agriculture.

Smart Agriculture Methods and Techniques

Humans have been trying to improve food production for centuries to meet food requirements. To achieve this task, they are adopting and applying different advanced agriculture techniques. After the emergence of IoT, advanced agriculture techniques like vertical farming, hydroponics, and phenotyping significantly improve their performance by utilizing IoT and becoming an essential part of them. It is cost-effective and can help us in the efficient management of resources ranging from input resources, labor resources, and operational resources and also provide a high yield. Applications of technology are geospatial and temporal sampling and mapping, disease and pest monitoring, smart irrigation, and fertilization. Commonly used technologies and equipment are sensors, UAVs, IoT-based machinery and communication, etc.

Precision Agriculture

Precision agriculture existed long ago but it was not viable for small and medium farmers and even not viable for large farmers in developing countries like Pakistan, the challenges ahead like climate change, a gap in demand and supply of food, urbanization, and declining arable land are unavoidable. In this situation, the emergence of IoT is enabling a new dimension in precision agriculture, consisting of several already existing technologies such as WSN, RFID Gateways; cloud computing, communication protocols, middleware components and end-user inferface (Giles, D.K. *et al*., 2017). Communication protocol, middleware components, and end-user interface (Giles, D.K. *et al*., 2017).

Precision agriculture is focused on the utilization of natural resources efficiently and protecting the natural environment. There are four steps to implement precision agriculture: characterizing the extent and scale of variability in soil and crop attributes, interpreting the significance and causes of variability, managing variability on a spatial and temporal basis, and monitoring the outcomes resulting from the variability management practices (Deshpande, A . *et al*., 2021) that could only be done efficiently using the IoT. To wind up the discussion, Figure 3 illustrates the common hurdle in the adoption and implementation of technology in precision agriculture; on the other hand, Figure 4 indicates the key advantages of IoT in precision agriculture (PA). The precision agriculture adoption starting point could be yield monitoring by gathering data to develop spatial and temporal feature databases for management of land for interpretation and yield mapping.

Remote sensing assisted control system (RSCS) This paper provides an innovative approach for automated implementation and sensing in agriculture products. The report examined the integration of IoT technology in control networks and communication systems based on the actual condition of agricultural productivity. The sensing and actuating system for agricultural and greenhouse production environments is applying loT technology in agriculture. This proposed method uses to manage the economic resources of a green development potential industry and enhance innovative patterns of development of agricultural products. In an agricultural manufacturing industry sent over remote notices through the supporting platform, important temperature, moisture and ground signals are collected in real-time. To understand information to lead the production, it is essential to acquire real time agricultural products' data through the short message service, mobile, wireless system pattern. The system includes remote sensing monitoring equipment, data receiver remote acquisition applications, and mobile web applications. The data processing area monitoring system comprises an intelligent network, a connection device for the network, an information collection module and a system configuration control unit. The recipient of the remote sensor consists of a user interaction module, a network communication module and an access control module that can communicate with the remote sensing development tools of the 286 Y. ZHOU, *et al.*, and mobile app monitoring system through the network communication protocols. Computer vision, robotics, and machine learning can all be used by farmers to combat weeds with artificial intelligence (AI). Thanks to artificial intelligence (AI), farmers can spray pesticides only where weeds are found, thanks to artificial intelligence (AI), which collects data on growing weeds. Because of this, a much smaller amount of chemicals was needed to treat the entire field. The use of artificial intelligence (AI) by farmers can help them detect regions of their fields that require irrigation, fertiliser, or pesticide treatment in real-time. Additionally, cutting-edge farming techniques like vertical agriculture may enhance food output while using fewer resources. As a result of precision agriculture, farmers can use less water, fertiliser, and seed to increase yields. Using sensors and mapping fields, farmers may learn more about their crops at a micro-scale, conserve resources, and less impact the environment. The concentration provides the farmer from remote locations with ground measurements that are remotely controlled greenhouse farming variables, such as CO2, soil moisture, temperature and light, and controls for the on/off greenhouse can be made given the estimation of soil moisture. The use of the IoT technology for agriculture industry green development can improve the entire performance of each company and the manufacturing process. It can effectively encourage the communication of knowledge and transfer information between mobile applications. Figure 1 expresses the green agricultural development. Crop production is a major source of food for people that is the world's food consumed. The grains, sugar crops, fruit and plant vegetables and oil crops comprise plant-based food. The massive amount of waste leaked in the soil and lost in the environment through the evaporation of ammonia and oxidising nitrogen fixation has led to an unstable vicious cycle. It has impaired the development of increased environmental protection. To overcome the challenges of maintaining food security and environmental protection by establishing green crop production. A green crop production system is a requirement for green input and green management in agricultural land, as seen in Figure 1. This includes creating new crop plants, food crops and green pesticides to an integrated soilculture control unit and developing rotating and intercropping crop systems to achieve a sustainable increase in high efficiency, high resource utilisation and environmental sustainability in agricultural production. The fundamental transformation of agricultural production from a traditional resource-based model with high ecological cost into increased productivity, high efficient resource use, and poor environmental impact is a significant change in the development of agriculture from purely intensive food production to sustainable production. The production of green crops includes green goods input management and output. The design of the agricultural system can improve adequate means soil quality and agricultural productivity, both essential if high-quality food is to be delivered significantly. Livestock production is an essential component of animal food production, such as meat, eggs and milk that contains nutrients that are easier to digest than many crops. It can supply key raw materials for industry, such as feathers and leathers in the textile and clothing industries needed for human existence. The contributions of animal crop production in agricultural emission to the overall emission of NH3 and chemical oxygen consumption. The data processing system generates a certain set of outputs for each stage of inputs and vice versa. Data, facts, information, and so on are interpreted from the inputs and outputs. The phrase information system is frequently used as a synonym for data processing or storage (codes) management systems. As a result, I've realised that agriculture must meet specific needs to produce food and keep providing it (yes, fibre too, and other nonfood products, but mainly we are concerned with food production). Keep the soil healthy by following these guidelines: Keep the land fertile, and make proper water use. Rural agricultural systems and livestock sectors are essential to residents' livelihood and well-being. These are all essential contributions to climate change development, and there is no appropriate technology to manage livestock excess and crop production from the country's most significant barriers to green agriculture. Green livestock systems such as the crop system can need green management throughout the production phase, including green housing. It offers essential resources for people's daily lives and contributes to most rural people's revenues. Furthermore, these systems are viewed as essential to the stability and sustainable development of the producers of raw materials for the industry. The designs can be integrated so that practically all the materials used to feed the livestock can be supplied to agriculture. The excrement should be collected and used in the nutrient supply to crops. The risks of pollution from emission of animal contaminants from livestock systems, which can be used as essential nutrients for crop production, would be increased by non-connected and interconnected animal mass cultivation. To transform the integrated systems of animal crop production from a single system to a diverse quality in the agriculture ACTA AGRICULTURAE SCANDINAVICA, SECTION B — SOIL & PLANT SCIENCE 287 market should be optimised. Agricultural and livestock farming can be combined to increase the efficiency of nutrient usage all through the food industry considered in such systems.

Fig 4: Challenges in technology adoption

Greenhouse Farm

Greenhouse farming is more or less similar to precision farming with some subtle differences and purposes. The major difference is that greenhouse farming is done in a closed or isolated environment or space where environmental parameters are controlled and managed by smart systems. Although greenhouse farming is not new, the information technology and IoT found applications that are aligned with greenhouse techniques like temperature, humidity control, and monitoring in the shed. The precise and continuous monitoring and controlling cannot be achieved without IoT and smart systems. Greenhouse space is comparatively smaller than open-field agriculture but yields more productivity than traditional methods. The Netherlands is one of the small countries and the second largest exporter of agricultural goods utilizing greenhouse farming and hydroponics variety of crops (Hunt, E.R. *et al.*, 2005). Through greenhouse farming, we can even utilize desert space for sustainable farming (Costa, F.G. *et al.*, 2012).

Fig 5: Key advantages of IoT in agriculture

Urban Farming

Urban farming is another revolutionary idea and a relatively new concept, with the fusion of different methods such as rooftop farming, indoor farming, vertical farming, hydroponics, aquaponics, and aeroponics; as already mentioned in the article, more population is shifting toward urban areas, and urban areas are the large consumer of food products. On the other hand, climate change and water scarcity affect agriculture harshly and are serious challenges for sustainable food security. Also, some other challenges are long distance between food producers and food consumers so there is a transportation and chain supply expense that impacts food quality, causing extra pollution by transport vehicles. Urban farming is a solution where people can grow food in their proximity to have fresh and cheap food. Urban farming is completely dependent on the precise control environment and system to grow day and night and a whole year without any season and weather impact. We can grow food in a closed box without any sunlight the whole year. By realizing the potential of urban farming, Paris is taking a shift with its largest rooftop farm with an expectation to have 30 different types of plants, furthermore aiming to have more than 100 hectares of rooftops farms. Similarly, the 100 ft below the ground abandoned space is well utilized for vertical farming in London.

Smart Agriculture – Data System

Smart agriculture aims to help farmers to make decisions to maximize crop yield and quality, optimize water and other inputs, and maintain soil health. This is particularly important for livelihood of marginal farmers, cattle rearers and other allied occupations, especially in the context of climate change uncertainty. In addition to close understanding of the local agro-ecological zone, geomorphology, subsurface conditions, the local socio-economic conditions, it involves regular data monitoring of weather, water, soil, crop growth, and using this in an integrated manner for decision making. The central government of India plays an active role in developing the agri-tech sector. They always come up with new bills to empower Indian farmers. The Indian government supports smart farming because they want to reduce their effort and enhance their productivity. At present, they are working to double the farmers' income by 2022. They want to increase farmers' income with minimum efforts by smart farming ideas. For this, the NITI Aayog collaborates with the companies that include IBM for technology-driven solutions. For these farmers get real time advice and are financed to increase crop productivity.

Along with this, the government of India plans to digitize the PACS (Primary Agricultural Credit Society) with a grant up to INR 2000 crore. Other supports that initiated by the government for smart farming are MANAGE (Management of Agricultural Extension in Hyderabad), mentoring the agri-tech start-ups, PMKSY (Pradhan Mantri Krishi Sinchayee Yojana), and One Nation One Market.

Are Agri-Tech Products Affordable for the Farmers?

Hi-tech and technologically advanced products indeed provide comfortable work with high productivity. If smart farming is not affordable for the farmers, even if they want to adopt smart farming, they won't. Most of the Indian farmers have limited income that prevents farmers from using the digital revolution in farming. Therefore, start-up agri-tech must prepare their products and services based on the farmer's budget to get the full benefits.

Innovative Technologies to Enhance Smart Farming

Indian people are slightly an orthodox type. They believe that those methods or ancient practices used from ancient times are the best for agriculture. But with the growing population and advanced times that methods should change too. For that, Indian farmers have to adopt innovative technologies to enhance smart farming. Following we are showing some technologies which should be enhanced.

Product Innovations

There is a requirement for innovation in products. Those products which are growing from olden times that need to be updated. For that, new technologies introduced in the market which are designing fully new kinds of foods. Those products which are impossible to grow are tested in lab-grown.

Digital Marketplaces

The government of India started an eNAM facility for the farmers of India. The eNAM (National Agriculture Market) is an electronic trading portal which creates networks between the existing APMC mandis for the farmers all over India. Its main aim is to promote equality in the agriculture market. From this plan smoothness between the buyers and sellers created and it promotes real time price too. And digital marketplace permits farmers to lease equipment, connect to local customers, or pool together for superior insurance

Operations Software

It will help farmers to make better and operation decisions, save money, track resources or productivity.

Skills-Building Tools

In Indian farming, there is a need for skill building. Farmers produce which they learnt from their parents or ancestors. They don't know how to use these newly introduced technologies. For that skill building tools should be introduced in the market for the farmers And Introduce them With latest farming techniques.

It includes hotline voice services, videos, mobile apps and others. These tools help farmers to share experiences and learn new and innovative things. In France, AgriFind is a social networking place to ask questions and advice for the farmers.

Resources

There is a need to utilize resources fully. New irrigation systems in India provide highly targeted fertilizer and water. It is best for urban and vertical farms. In these methods, there used less use of water and soil. That reduces pesticides too.

Smart Farming Ideas

Smart farming connected with innovation. Indian agriculture is facing huge challenges these days. There is an urgent need to accelerate agriculture by smart farming ideas. Around the last 10 years, huge growth noticed in agriculture technology investment. In the last 5 years, investment was $6.7 billion, and in the last year alone, it was $1.9 billion. These investments take place to enhance farming methods in India. We are presenting some smart farming ideas that will guide you 'How to become a smart farmer'. Have a look.

Indoor Vertical Farming

Indoor vertical farming is the procedure of growing plants in closed and controlled environments. With this method, plants mounted vertically, and it takes less land space to grow compared to traditional farming. Vertical farms don't require soil for plants to grow, and in this method, the labour force reduced too. It is the best and the first smart farming technique in India.

Farm Automation

Farm automation is the up gradation in farming machines and equipment. To accomplish this, companies are working on this. They are working on autonomous tractors, automatic watering, develop drones, robotics innovation, and seeding robots. The companies not only provide quality innovative machinery but make these machines affordable for the farmers.

Livestock Farming Technology

Livestock provides much needed products, and in our country, livestock is the most ignorant part of farming. New innovations over the 8 to 10 years created huge changes and improvements to the industry. It helps in managing and tracking livestock easily and comfortably. These technologies come in genetics, nutritional technologies, digital technology, and more.

Modern Greenhouses

Indian agriculture witnessed an increase in the greenhouse in large scale. It is urban centred and capital infused. As the market demand increases dramatically, the trend of the greenhouse is increasing in recent years. A modern greenhouse is now becoming automated control systems, tech-heavy and using LED lights for growing environment.

Precision Agriculture

Precision agriculture (PA) is the science of improving crop yields and assisting management decisions using high technology sensor and analysis tools. PA is a new concept adopted throughout the world to increase production, reduce labor time, and ensure the effective management of fertilizers and irrigation processes. It uses a large amount of data and information to improve the use of agricultural resources, yields, and the quality of crops (Mulla, 2013). PA is an advanced innovation and optimized field level management strategy used in agriculture that aims to improve the productivity of resources on agriculture fields. Thus PA is a new advanced method in which farmers provide optimized inputs such as water and fertilizer to enhance productivity, quality, and yield (Gebbers and Adamchuk, 2010). It requires a huge amount of information about the crop condition or crop health in the growing season at high spatial resolution. Independently of the data source, the most crucial objective of PA is to provide support to farmers in managing their business. Such support comes in diverse ways, but the end result is typically a decrease of the necessary resources (Fig 8–1).

Information System VRT Variable Rate Technology

Modern agricultural production relies on monitoring crop status by observing and measuring variables such as soil condition, plant health, fertilizer and pesticide effect, irrigation, and crop yield. Managing all of these factors is a considerable challenge for crop producers. The rapid enhancement of precise monitoring of agricultural growth and its health assessment is important for sensible use of farming resources and as well as in managing crop yields (Nigam, *et al.,* 2019). Such challenges can be addressed by implementing remote sensing (RS) systems such as hyper spectral imaging to produce precise biophysical indicator maps across the various cycles of crop development.

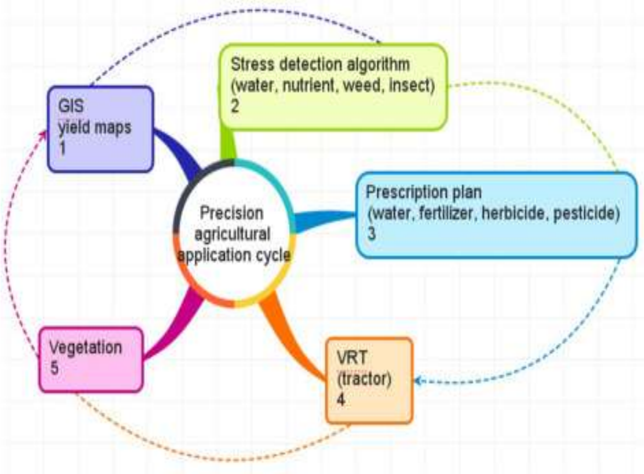


Fig 5: Cycle of precision Agriculture G/S Geographic

RS is a rapidly expanding technology implemented in various agricultural applications. In particular, imaging spectroscopy in large continuous narrow bands provides significant information for understanding the biophysical and biochemical properties of agricultural plants. It is also useful to identify the changes in various physical processes, which can be better identified using multispectral RS (Sahoo, *et al.,* 2015). Advanced techniques of RS have been used for large scale crop inventory and yield predictions (Mulla, 2013). RS applications are used in agriculture studies that are based on the interaction between electromagnetic radiation and soil or plant material on the Earth's surface (Atzberger, 2013). RS combined with geographic information systems (GISs) and/or global positioning systems (GPSs) are often used in PA. This allows farmers and other agriculture producers to reduce inputs and maximize cost benefits using modern technologies rather than traditional field approaches. Nowadays, variable rate technology (VRT) is introduced to increase precision farming practices. VRT is a vital component for PA and is becoming more prevalent for large land holders. In VRT, collections of field variable information and other input data are helpful in defining suitable quantities of chemical inputs required for the fields. Hence the demand of precision agricultural techniques, valuable products, fine RS information as well as VRT has grown tremendously (Brisco, *et al.,* 1998).

This chapter describes the latest developments in Earth Observation (EO) techniques and platforms for PA with particular emphasis on the use of hyper spectral sensors for this purpose. As part of this, it provides useful information regarding the identification of research challenges, limitations, and advantages of different platforms and sensors for PA with specific emphasis placed on hyper spectral sensors.

Precision agriculture (PA) is a farming management concept based on observing, measuring and responding to inter and intra-field variability in crops. First conceptual work on PA and practical applications go back in the late 1980s. (nasa.gov. 2011) The goal of precision agriculture research is to define a decision support system (DSS) for whole farm management with the goal of optimizing returns on inputs while preserving resources.(Haneklaus, S, 2016)(The Economist, 2005) Among these many approaches is a phytogeomorphological approach which ties multi-year crop growth stability/characteristics to topological terrain attributes. The interest in the phytogeomorphological approach stems from the fact that the geomorphology component typically dictates the hydrology of the farm field (www.libelium.com.).

The practice of precision agriculture has been enabled by the advent of GPS and GNSS. The farmer's and/or researcher's ability to locate their precise position in a field allows for the creation of maps of the spatial variability of as many variables as can be measured (e.g. crop yield, terrain features/topography, organic matter content, moisture levels, nitrogen levels, pH, EC, Mg, K, and others).[7] Similar data is collected by sensor arrays mounted on GPS-equipped combine harvesters. These arrays consist of real-time sensors that measure everything from chlorophyll levels to plant water status, along with multispectral imagery.[8] This data is used in conjunction with satellite imagery by variable rate technology (VRT) including seeders, sprayers, etc. to optimally distribute resources. However, recent technological advances have enabled the use of real-time sensors directly in soil, which can wirelessly transmit data without the need of human presence.(Blackmore, S, 2016)

Precision agriculture has also been enabled by unmanned aerial vehicles that are relatively inexpensive and can be operated by novice pilots. These agricultural drones can be equipped with multispectral or RGB cameras to capture many images of a field that can be stitched together using photogrammetric methods to create orthophotos. These multispectral images contain multiple values per pixel in addition to the traditional red, green blue values such as near infrared and red-edge spectrum values used to process and analyze vegetative indexes such as NDVI maps. (Kukutai, A, 2016) These drones are capable of capturing imagery and providing additional geographical references such as elevation, which allows software to perform map algebra functions to build precise topography maps. These topographic maps can be used to correlate crop health with topography, the results of which can be used to optimize crop inputs such as water, fertilizer or chemicals such as herbicides and growth regulators through variable rate applications.

History

Precision agriculture is a key component of the third wave of modern agricultural revolutions. The first agricultural revolution was the increase of mechanized agriculture, from 1900 to 1930. Each farmer produced enough food to feed about 26 people during this time. (Benoit, A, 2012) The 1960s prompted the Green Revolution with new methods of genetic modification, which led to each farmer feeding about 156 people. (Benoit, A, 2012) It is expected that by 2050, the global population will reach about 9.6 billion, and food production must effectively double from current levels in order to feed every mouth. With new technological advancements in the agricultural revolution of precision farming, each farmer will be able to feed 265 people on the same acreage.(Benoit, A, 2012)

Overview

The first wave of the precision agricultural revolution came in the forms of satellite and aerial imagery, weather prediction, variable rate fertilizer application, and crop health indicators.(Jacob, B, 2015) The second wave aggregates the machine data for even more precise planting, topographical mapping, and soil data.(Grell, M. *et al.*, 2020)

Precision agriculture aims to optimize field-level management with regard to:

Crop Science: by matching farming practices more closely to crop needs (e.g. fertilizer inputs);

Environmental Protection: by reducing environmental risks and footprint of farming (e.g. limiting leaching of nitrogen);

Economics: by boosting competitiveness through more efficient practices (e.g. improved management of fertilizer usage and other inputs).

Precision agriculture also provides farmers with a wealth of information to:

Build up a record of their farm
Improve decision-making
Foster greater traceability
Enhance marketing of farm products
Improve lease arrangements and relationship with landlords
Enhance the inherent quality of farm products (e.g. protein level in bread-flour wheat)

Prescriptive Planting

Prescriptive planting is a type of farming system that delivers data-driven planting advice that can determine variable planting rates to accommodate varying conditions across a single field, in order to maximize yield. It has been described as "Big Data on the farm." Monsanto, DuPont and others are launching this technology in the US.(Bunge, Jacob , 25 February 2014).

Principles

Precision agriculture uses many tools but here are some of the basics: tractors, combines, sprayers, planters, diggers, which are all considered auto-guidance systems. The small devices on the equipment that uses GIS (geographic information system) are what makes precision ag what it is. You can think of the GIS system as the "brain." To be able to use precision agriculture the equipment needs to be wired with the right technology and data systems. More tools include Variable rate technology (VRT), Global positioning system and Geographical information system, Grid sampling, and remote sensors.

Geolocating

Geolocating a field enables the farmer to overlay information gathered from analysis of soils and residual nitrogen, and information on previous crops and soil resistivity. Geolocation is done in two ways:

The field is delineated using an in-vehicle GPS receiver as the farmer drives a tractor around the field.

The field is delineated on a basemap derived from aerial or satellite imagery. The base images must have the right level of resolution and geometric quality to ensure that geolocation is sufficiently accurate.

Variables

Intra and inter-field variability may result from a number of factors. These include climatic conditions (hail, drought, rain, etc.), soils (texture, depth, nitrogen levels), cropping practices (no-till farming), weeds and disease. Permanent indicators—chiefly soil indicators—provide farmers with information about the main environmental constants. Point indicators allow them to track a crop's status, i.e., to see whether diseases are developing, if the crop is suffering from water stress, nitrogen stress, or lodging, whether it has been damaged by ice and so on. This information may come from weather stations and other sensors (soil electrical resistivity, detection with the naked eye, satellite imagery, etc.). Soil resistivity measurements combined with soil analysis make it possible to measure moisture content. Soil resistivity is also a relatively simple and cheap measurement. (Anne-Katrin, M, 2016)

Strategies

NDVI image taken with small aerial system Stardust II in one flight (299 images mosaic)

Using Soil Maps, Farmers Can Pursue Two Strategies to Adjust Field Inputs

Predictive approach: based on analysis of static indicators (soil, resistivity, field history, etc.) during the crop cycle.

Control approach: information from static indicators is regularly updated during the crop cycle by:

Sampling: weighing biomass, measuring leaf chlorophyll content, weighing fruit, etc.

Remote Sensing: measuring parameters like temperature (air/soil), humidity (air/soil/leaf), wind or stem diameter is possible thanks to Wireless Sensor Networks and Internet of things (IoT)

Proxy-Detection: in-vehicle sensors measure leaf status; this requires the farmer to drive around the entire field.

Aerial or Satellite Remote Sensing: multispectral imagery is acquired and processed to derive maps of crop biophysical parameters, including indicators of disease. Airborne instruments are able to measure the amount of plant cover and to distinguish between crops and weeds.

Decisions may be based on decision-support models (crop simulation models and recommendation models) based on big data, but in the final analysis it is up to the farmer to decide in terms of business value and impacts on the environment- a role being takenover by artificial intelligence (AI) systems based on machine learning and artificial neural networks.

It is important to realize why PA technology is or is not adopted, "for PA technology adoption to occur the farmer has to perceive the technology as useful and easy to use. It might be insufficient to have positive outside data on the economic benefits of PA technology as perceptions of farmers have to reflect these economic considerations."

Implementing Practices
New information and communication technologies make field level crop management more operational and easier to achieve for farmers. Application of crop management decisions calls for agricultural equipment that supports variable-rate technology (VRT), for example varying seed density along with variable-rate application (VRA) of nitrogen and phytosanitary products.(De Oca, A. M. *et al*., 2018)

Precision agriculture uses technology on agricultural equipment (e.g. tractors, sprayers, harvesters, etc.):
Positioning system (e.g. GPS receivers that use satellite signals to precisely determine a position on the globe);
Geographic information systems (GIS), i.e., software that makes sense of all the available data;
Variable-rate farming equipment (seeder, spreader).

Block Chain
Block chain used to resolve important issues, including food traceability, supply chain in-efficiency, safety recalls, and food fraud in the food system. It creates a market for premium products with verification and transparency. This verifies transactions that are securely shared with every seller or not. It helps in creating transparency in the marketplace and food supply.

Artificial Intelligence
Artificial intelligence (AI) broadly refers to any human-like behavior displayed by a machine or system. In AI's most basic form, computers are programmed to "mimic" human behavior using extensive data from past examples of similar behavior. This can range from recognizing differences between a cat and a bird to performing complex activities in a manufacturing facility.

Learn More about Artificial Intelligence
Whether you are talking about deep learning, strategic thinking, or another species of AI, the foundation of its use is in situations that require lightning-fast responses. With AI, machines can work efficiently and analyze vast amounts of data in the blink of an eye, solving problems through supervised, unsupervised, or reinforced learning.

Early Days of AI
While its early forms enabled computers to play games like checkers against humans, AI is now part of our daily lives. We have AI solutions for quality control, video analytics, speech-to-text (natural language processing), and autonomous driving, as well as solutions in healthcare, manufacturing financial services, and entertainment.

Powerful Tool for Businesses and Organizations
Artificial intelligence can be a very powerful tool for both large corporations generating significant data and small organizations that need to process their calls with customers more effectively. AI can streamline business processes, complete tasks faster, eliminate human error, and much more.

AI at the Edge
HPE is pioneering a new frontier of AI by harnessing data and gaining insights at the edge. We empower success with real-time

analytical AI for automation, prediction, and control to help you realize the value of your data faster and leverage limitless opportunity for innovation, growth, and success.

A Brief History of Artificial Intelligence

Before 1949, computers could execute commands, but they could not remember what they did as they were not able to store these commands. In 1950, Alan Turing discussed how to build intelligent machines and test this intelligence in his paper "Computing Machinery and Intelligence." Five years later, the first AI program was presented at the Dartmouth Summer Research Project on Artificial Intelligence (DSPRAI). This event catalyzed AI research for the next few decades.

Computers became faster, cheaper, and more accessible between 1957 and 1974. Machine learning algorithms improved and, in 1970, one of the hosts of DSPRAI told Life Magazine that there would be a machine with the general intelligence of an average human being in three to eight years. Despite their success, computers' inability to efficiently store or quickly process information created obstacles in the pursuit of artificial intelligence for the next ten years.

AI was revived in the 1980's with the expansion of the algorithmic toolkit and more dedicated funds. John Hopefield and David Rumelhart introduced "deep learning" techniques that allowed computers to learn through experience. Edward Feigenbaum introduced "expert systems" that mimicked human decision-making. Despite a lack of government funding and public hype, AI thrived and many landmark goals were achieved in the next two decades. In 1997, reigning chess World Champion and Grandmaster Gary Kasparov was defeated by IBM's Deep Blue, a chess-playing computer program. The same year, speech recognition software developed by Dragon Systems was implemented on Windows. Cynthia Breazeal also developed Kismet, a robot who could recognize and display emotions.

Types of Artificial Intelligence

Artificial intelligence is classified into two main categories: AI that's based on functionality and AI that's based on capabilities.

Based on Functionality

Reactive Machine – This AI has no memory power and does not have the ability to learn from past actions. IBM's Deep Blue is in this category.

Limited Theory – With the addition of memory, this AI uses past information to make better decisions. Common applications like GPS location apps fall into this category.

Theory of Mind – This AI is still being developed, with the goal of its having a very deep understanding of human minds.

Self-Aware AI – This AI, which could understand and evoke human emotions as well as have its own, is still only hypothetical.

Based on Capabilities

Artificial Narrow Intelligence (ANI) – A system that performs narrowly defined programmed tasks. This AI has a combination of reactive and limited memory. Most of today's AI applications are in this category.

Artificial General Intelligence (AGI) – This AI is capable of training, learning, understanding, and performing like a human.

Artificial Super Intelligence (ASI) – This AI performs tasks better than humans due to its superior data processing, memory, and decision-making abilities. No real-world examples exist today.

The Relationship between Artificial Intelligence, Machine Learning, and Deep Learning

Artificial intelligence is a branch of computer science that seeks to simulate human intelligence in a machine. AI systems are powered by algorithms, using techniques such as machine learning and deep learning to demonstrate "intelligent" behavior.

Machine Learning

A computer "learns" when its software is able to successfully predict and react to unfolding scenarios based on previous outcomes. Machine learning refers to the process by which computers develop pattern recognition, or the ability to continuously learn from and make predictions based on data, and can make adjustments without being specifically programmed to do so. A form of artificial intelligence, machine learning effectively automates the process of analytical model-building and allows machines to adapt to new scenarios independently.

The Four Steps for Building a Machine Learning Model are

1. Select and prepare a training data set necessary to solving the problem. This data can be labeled or unlabeled.

2. Choose an algorithm to run on the training data.
If the data is labeled, the algorithm could be regression, decision trees, or instance-based.
If the data is unlabeled, the algorithm could be a clustering algorithm, an association algorithm, or a neural network.

3. Train the algorithm to create the model.

4. Use and improve the model.

There are three methods of machine learning: "Supervised" learning works with labeled data and requires less training. "Unsupervised" learning is used to classify unlabeled data by identifying patterns and relationships. "Semi-supervised" learning uses a small labeled data set to guide classification of a larger unlabeled data set.

Deep Learning

Deep learning is a subset of machine learning that has demonstrated significantly superior performance to some traditional machine learning approaches. Deep learning utilizes a combination of multi-layer artificial neural networks and data- and compute-intensive training, inspired by our latest understanding of human brain behavior. This approach has become so effective it's even begun to surpass human abilities in many areas, such as image and speech recognition and natural language processing.

Deep learning models process large amounts of data and are typically unsupervised or semi-supervised.

Turning Data into Efficiency and Competitive edge with Modern AI applications

After centuries of theorizing, decades of research, and years of advertising, artificial intelligence has finally begun to make inroads into the enterprise, where it's set to become a pervasive feature. In a recent industry survey, 50% of respondents said they have deployed an AI initiative, have one in a proof-of-concept stage, or plan to within the next year.

Why the Pace of Enterprise AI is Quickening

Recent advances in algorithms, the proliferation of digital data sets, and improvements in computing—including increases in processing power and decreases in price—have come together to initiate a new breed of AI technology that is enterprise-ready. Nearly all organizations have an ever-growing mountain of data assets, and AI provides the means to analyze this resource at scale.

AI is also set to become an enterprise staple as a cornerstone in the digital transformation process. AI is an Omni-use technology that can optimize efficiency and insight in almost any business process—from customer service operations and physical and cybersecurity systems to R&D functions and business analytics processes.

Modern Applications for AI

AI has the unique ability to extract meaning from data when you can define what the answer looks like but not how to get there. AI can amplify human capabilities and turn exponentially growing data into insight, action, and value.

Today, AI is used in a variety of applications across industries, including healthcare, manufacturing, and government. Here are a few specific use cases:

Prescriptive maintenance and quality control improves production, manufacturing, and retail through an open framework for IT/OT. Integrated solutions prescribe best maintenance decisions, automate actions, and enhance quality control processes by implementing enterprise AI-based computer vision techniques.

Speech and language processing transforms unstructured audio data into insight and intelligence. It automates the understanding of spoken and written language with machines using natural language processing, speech-to-text analytics, biometric search, or live call monitoring.

Video analytics and surveillance automatically analyzes video to detect events, uncover identity, environment, and people, and obtain operational insights. It uses edge-to-core video analytics systems for a wide variety of workload and operating conditions.

Highly autonomous driving is built on a scale-out data ingestion platform to enable developers to build the optimum highly-autonomous driving solution tuned for open source services, machine learning, and deep learning neural networks.

The Value of Finding the Right AI Partner

One crucial part of mapping out the enterprise AI journey is finding a partner that understands the organization's current stage in the AI journey—and can help chart a path forward to meet near- and longer-term objectives.

Working with the right partner can help an enterprise unlock the value of data across the enterprise to empower business transformation and growth. Look for a partner that can offer:

End-to-end solutions to reduce complexity and support integration with existing infrastructure
Advisory and professional services
On-prem, cloud, and hybrid options that take into account team location, access needs, security, and cost constraints
Systems that scale for current and future needs
A knowledgeable partner ecosystem with industry-specific solutions

HPE AI Delivers Insights on Demand, at any Scale

Transforming businesses requires real-time analytical AI for proactive controls, predictive maintenance, autonomous processes and game-changing insight. AI at the Intelligent Edge enables businesses to realize value from data faster and gain limitless opportunities for innovation and growth.

HPE partners with organizations to capture the full power of data in the new frontier of AI, harnessing insights at the edge when, where, and how they are needed.

Why HPE for AI?

With HPE as your AI partner, customers can leverage:

AI Technology Leadership and Innovation

HPE's outcome-based solutions are purpose-built for AI and expertly designed for the intelligent edge.

Wide range of HPE hardware and software
HPE Ezmeral software portfolio for container orchestration, data management, and data fabric
Aruba edge services platform

AI Expertise

Service and deployment models built on deep expertise and proven experience includes:
HPE Pointnext advisory and operational services
HPE financial services options
HPE GreenLake deployment and consumption models
HPE IoT transformation workshop to get you stated on your AI at the edge journey

AI Competitive Advantage

HPE's strengths work to our customers' business advantage, delivering:

Life on the edge with real-time analytic power for automation, prediction, and control

Edge in action to create new value, business opportunities, models, and customer experiences

IT and operational technology (OT) partnership that accelerates time-to-insight with greater efficiency

HPE AI Spans Multiple Industries

HPE AI helps enterprises in every industry unleash edge insights with purpose-built technologies. Organizations are enabling AI at the edge for connectivity, autonomy, high volume data management, and time-sensitive events. From clinics to labs and warehouses to enterprises, use cases include natural language processing (NLP), video analytics, quality assurance (QA), surveillance, and security as well as customer sentiment.

Organizations in healthcare and life sciences use HPE AI to unlock medical insight and deliver new levels of care at the edge. Use cases range from wearable health monitoring and personalized healthcare to health medicine and connected health. AI at the edge is also used in swarm learning for distributed discovery and in other applications for driving medical research and scientific breakthroughs.

In manufacturing, HPE AI helps heighten productivity and overall equipment effectiveness (OEE) at the edge. Use cases include intelligent operations, predictive analytics on assets and processes within the supply chain, and simulations with AI.

Benefits of Smart Farming in India

These techniques of smart farming come with enormous benefits and can help to improve farming productivity. Check out below for benefits of smart farming in India.

Increase in Efficiency

By smart farming, farmers can increase their efficiency. With advanced technologies farmers, now farmers can produce more products in a limited time period. They get inspected fast, forecast matters before they happen and make important decisions on keeping them away.

Expansion

With the use of smart farming technologies, expansion in farming takes place. All the agriculture activities take place on time and are of good quality. The short food chain completes on time for these technologies, and everyone in the country gets proper food at an affordable price.

Proper Use of Resources

By smart farming technologies resources used fully and properly. Resources that include energy, water, and land. By the IoT farming data collected from the sensors which help to allocate an optimum amount of resources to the plants.

Cleaner Process

It is a cleaner process that can save energy, water and make framing greener. These technologies evaluate the use of fertilizer and pesticides. These processes provide organic and cleaner products in comparison to traditional farming methods.

Agility

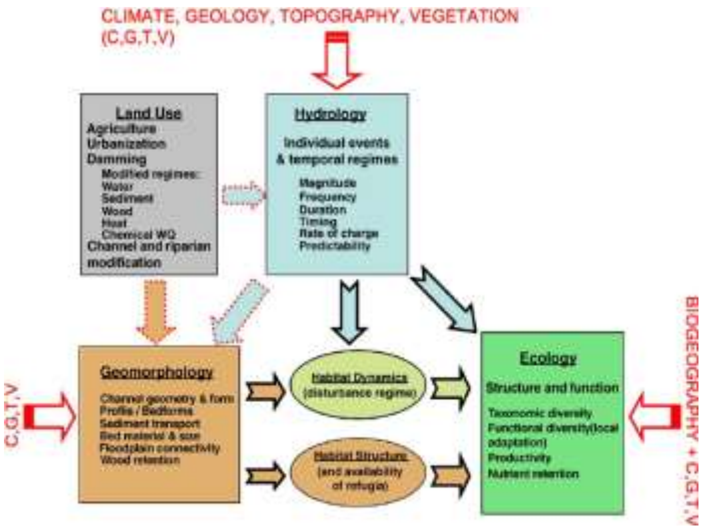
Uncertain weather changes, air quality, humidity, soil in the fields, and health of crops monitored by the smart farming technologies. That provides real time monitoring that can predict the condition of the crop. This provides professional advice in extreme weather changes that can save the crops.

Improved Product Quality

These help to improve product quality by using crop sensors, farm mapping, and aerial drones. Smart farming technologies create the best conditions to boost the value of nutritional products. These are all about smart farming in India. I hope you get all the detailed information regarding innovation in farming and advanced technologies that make your farms more productive. For further details, stay tuned with TractorJunction.

The Following Picture Depicts Smart Agriculture System

Smart agriculture aims at increasing crop yield and quality, with efficient use of inputs through data based decision at farm level. The data collection will include:



One Time or Infrequently Varying Data
Topography, aquifer, hydrogeology, geomorphology
Water sources in the vicinity, in village, in taluka,
Soil type.

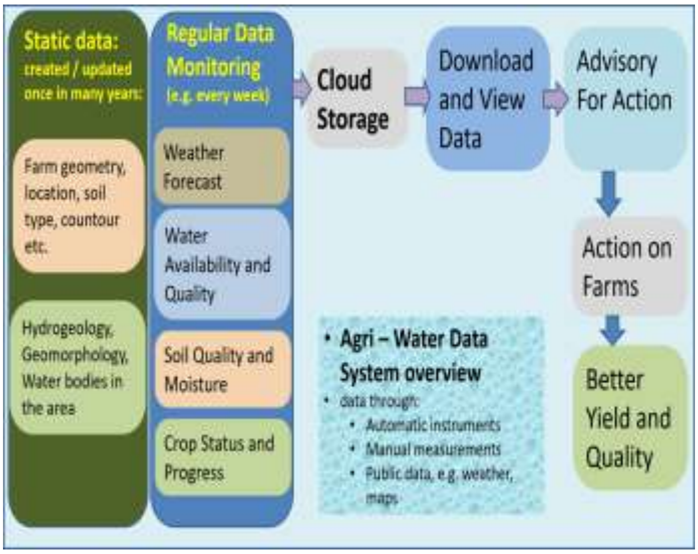


Fig 6: Agri-Water Data System Overview

Regularly and Frequent Collected Data Collected Throughout the Cropping Season, from Pre-Sowing to Harvest, for
Local weather conditions and forecast,
Soil quality and moisture,
Water availability from all sources, and
Crop growth status

The data may include that collected through automatic or manual measurements as well as publicly sourced data. The data is uploaded to an integrated system and stored, for viewing and analysis by experts as well as farmers or local agriculture extension workers or others. This enables expert advisory to farmers, at farm level as well as village level, and helps them make decisions at all stages of the crop cycle, make optimum use of inputs including water and nutrients and maintain soil health. The system also involves providing training to farmers and local village based trained persons for using technology and incorporating data guided decisions with their traditional agriculture practices.

The system will accumulate data, from large number of farms, over a long period of time, to develop a data repository which will help to improve decisions over time. Data collection at localized scale will help to get a clear picture of field conditions; and such collection done at multitude of field points will enable to gather the regional scenario. And so the system will need data collection points at various scales, covering clusters of farms and spreading to villages, clusters of villages, talukas, districts and so on. This vast data, over time, will also help develop AI/ML (Artificial Intelligence / Machine Learning) based improvements to decision making.

The system will also enable long term decisions like cropping pattern changes for various cropping seasons, irrigation pattern, village water budgeting, and developing village water security strategy.

Smart Agriculture – Input-Process-Output Framework

The following framework provides another view of a smart agriculture project and guides its various components.

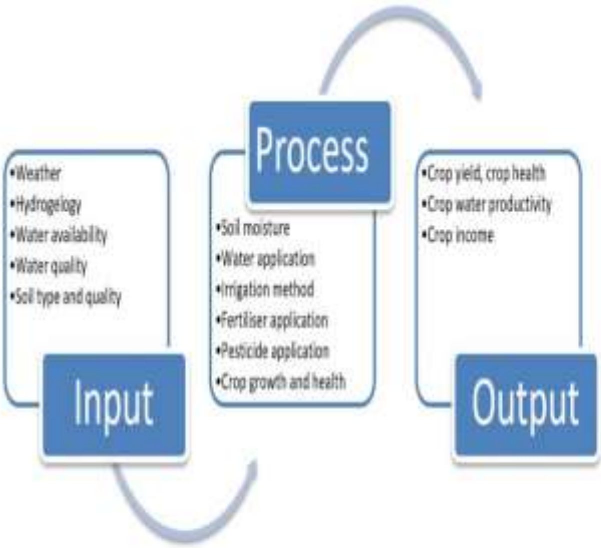


Fig 7: Smart Agriculture – Input-Process-Output Framework

As illustrated above, this consists of input and process parameters which in turn affect the output parameters, as well as maintenance of health of basic input parameters, like water sources and soil health. The parameters include those from atmosphere – surface – subsurface areas, as illustrated in a diagram below:

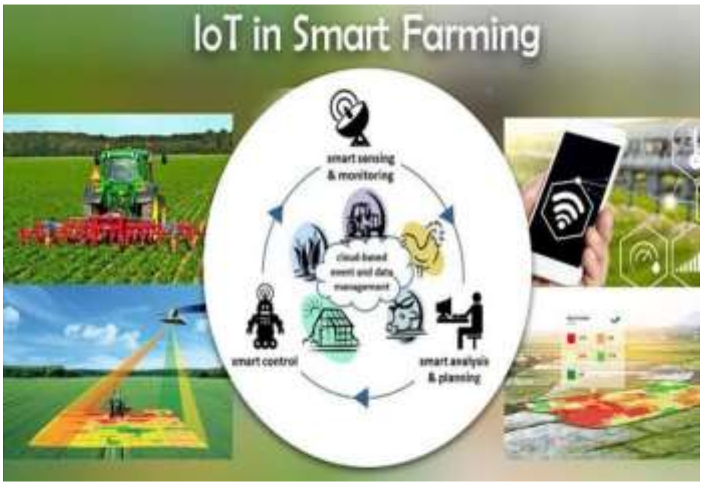


Fig 8: Internet of Things in Agriculture

Such a monitoring system as seen in the diagram will include measuring different parameters for water, soil, atmosphere and crop growth, either digitally or manually. Some of these monitored parameters Include:

Smart Farming Technologies

The Intelligent Farm includes the use of Technology such as:

Sensors for soil scanning and water, light, humidity and temperature management.

Telecommunications technologies such as advanced networking and GPS.

Hardware and software for specialized applications and for enabling IoT-based solutions, robotics and automation.

Data analytics tools for decision making and prediction. Data collection is a significant part of smart farming as the quantity of data available from crop yields, soil-mapping, climate change, fertilizer applications, weather data, machinery and animal health continues to escalate.

Satellites and drones for gathering data around the clock for an entire field. This information is forwarded to IT systems for tracking and analysis to give an "eye in the field" or "eye in the barn" that makes remote monitoring possible.

The combination of these technologies facilitates machine-to-machine (M2M) derived data. This data feeds into a decision support system so that farmers can see what is happening at a more granular level than in the past. For example, by precisely measuring variations within a field and adapting the strategy accordingly, farmers can greatly increase the effectiveness of pesticides and fertilizers and use them more judiciously. Similarly, smart farming techniques, help farmers better monitor the needs of individual animals and adjust their nutrition to prevent disease and enhance herd health.

Benefits of Smart Farming

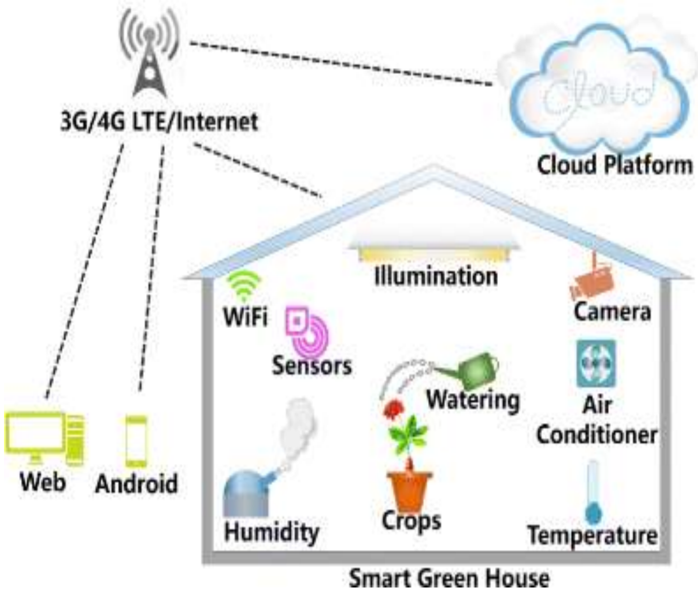
By making farming more connected and intelligent, precision agriculture helps reduce overall costs and improve the quality and quantity of products, the sustainability of agriculture and the experience for the consumer. Increasing control over production leads to better cost management and waste reduction. The ability to trace anomalies in crop growth or livestock health, for instance, helps eliminate the risk of losing yields. Additionally, automation boosts efficiency. With smart devices, multiple processes can be activated at the same time, and automated services enhance product quality and volume by better controlling production processes.

Smart farming systems also enable careful management of the demand forecast and delivery of goods to market just in time to reduce waste. Precision agriculture is focused on managing the supply of land and, based on its condition, concentrating on the right growing parameters – for example, moisture, fertilizer or material content – to provide production for the right crop that is in demand. The types of precision farming systems implemented depend on the use of software for the management of the business. Control systems manage sensor input, delivering remote information for supply and decision support, in addition to the automation of machines and equipment for responding to emerging issues and production support.

Fig 9: Smart Farming Systems and its Management

Is Smart Farming the Future of Agriculture?
Smart farming and IoT-driven agriculture are laying the groundwork for a "third green revolution," which refers to the combined application of information and communications technologies. This includes devices such as precision equipment, IoT sensors and actuators, geo-positioning systems, unmanned aerial vehicles (UAVs) and robots. IoT technology helps better control agricultural processes to reduce production risks and enhances the ability to foresee production results, which helps farmers better plan and distribute product. Data about exact batches of crops and the quantity of crops to harvest can help farmers cut down on labor and waste, for example.

Additionally, in a number of sectors, including agriculture, service providers and mobile operators are modernizing their network infrastructure, bringing network resources to the edge and integrating far distances through technologies such as small cells and massive MIMO to get ready for the 5G roll-out.



Weather
From locally installed automatic weather stations (AWS), monitoring weather parameters such as rainfall, humidity, temperature, UV index unit, wind direction and wind speed.

Through public weather data from agencies like IMD, Skymet, for the region/taluka etc

Water Availability
Surface water:

water levels in village water bodies, availability of canal / river water, if any

Groundwater level:
Through automatic electronic water level sensors

Though Manual Measurements
Water Use

Flow Meter: (if available) to estimate of volume of water used for irrigation.

Water Quality: Through on field water quality testing kit to test parameters like Arsenic, Fluoride, Nitrate, Total Iron, Sulphate, Chloride, pH, EC and TDS can be used.

Monitored Parameters

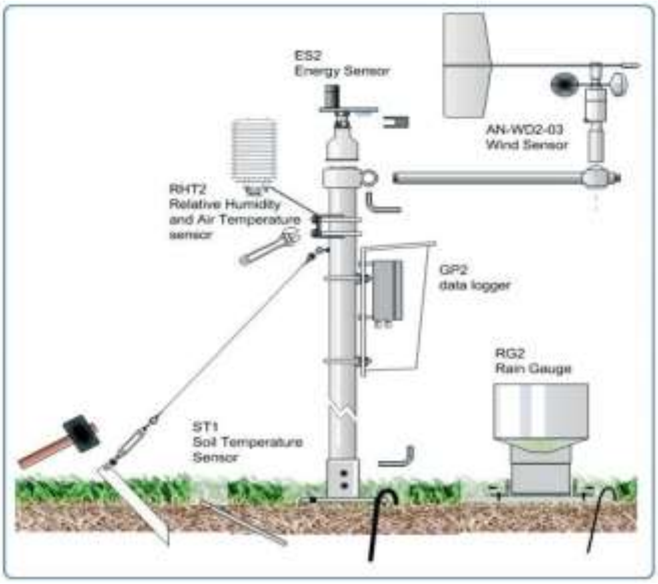


Fig 10: Automatic Weather Station

Fig 11: Soil and Water Quality Testing Kit

Soil
Quality: through the field testing kits for soil test parameters like Organic Carbon, Nitrogen, Phosphorous, Potassium and pH is used.

Soil moisture: through the soil moisture meters (portable or fixed) for monitoring moisture levels at various points within the field.

Applications of IoT in Agriculture
In the smart era of agriculture, almost all the agriculture processes are data-driven that are acquired by continuous monitoring of on-site IoT devices. Applications of smart agriculture that can only be done by utilizing IoT are

geospatial and temporal mapping and sampling (Kormann, G. *et al*., 1988), smart drip and sprinkler irrigation, pest and pathogen monitoring and controlling, yield assessment, precision fertilization, and environment maintenance. All these applications are briefly discussed below:

Fig 12: Iot Sensors are creating a More Efficient Precision Agriculture Industry

Geospatial and Temporal Mapping and Sampling

The simple and crucial application of precision agriculture can be used for crop field assessment and mapping. Applications that depend on the geospatial and temporal sampling are weed management systems, water stress assessments, and vegetation indexes. Also, it can be used for spatial variability assessment using GIS (Kumar, K, 2014).

Geospatial can be done using remote sensing, aerial surveys using planes, and remote imagery using UAV. Initially, it was expensive and not as efficient as today. Because of satellite remote sensing and cloud distortion, UAV is cost-effective and way more efficient and could be adopted as the first step for precision farming, even by farmers in developing countries like Pakistan.

Smart Irrigation

As the world has been facing the challenge of water scarcity, Pakistan is becoming water scarce from a water-stressed country (Shah, G, 2019). By using IoT and smart systems, weather adaptive smart irrigation systems can be implemented and reduce the usage of precious resource water (Gao, G. *et al*., 2020). Smart irrigation is designed to irrigate only if necessary, depending on the crop and soil stress level. UAV is a great tool to deal with the variability factor of water stress; sprinkler irrigation can be done using UAV for precise irrigation on the spot (Gao, G. *et al*., 2020). In the United States, outdoor water use alone averages more than 9 billion gallons of water each day, mainly for landscape irrigation. As much as 50% of this water is wasted due to overwatering caused by inefficiencies in traditional irrigation methods and systems. Smart irrigation technology is the answer. Smart irrigation systems tailor watering schedules and run times automatically to meet specific landscape needs. These controllers significantly improve outdoor water use efficiencies. Unlike traditional irrigation controllers that operate on a preset programmed schedule and timers, smart irrigation controllers monitor weather, soil conditions, evaporation and plant water use to automatically adjust the watering schedule to actual conditions of the site. For example, as outdoor temperatures increase or rainfall decreases, smart irrigation controllers consider on site-specific variables, such as soil type, sprinklers' application rate, etc. to adjust the watering run times or schedules. There are several options for smart irrigation controllers.

The Difference Between Weather-Based and Soil Moisture Sensors

Essentially there are two types of smart irrigation controllers: weather-based (ET) and on-site soil moisture sensors. The right solution depends on your geographic location and landscape environment.

Weather-Based Smart Irrigation Controllers

Weather-based controllers, also referred to as evapotranspiration (ET) controllers, use local weather data to adjust irrigation schedules. Evapotranspiration is the combination of evaporation from the soil surface and transpiration by plant materials. These controllers gather local weather information and make irrigation run-time adjustments so the landscape receives the appropriate amount of water.

ET weather data uses four weather parameters: temperature, wind, solar radiation and humidity. It's the most accurate way to calculate landscape water needs.

There are three basic forms of these weather-based ET controllers:

Signal-based controllers use meteorological data from a publicly available source and the ET value is calculated for a grass surface at the site. The ET data is then sent to the controller by a wireless connection.

Historic ET controllers use a pre-programmed water use curve, based on historic water use in different regions. The curve can be adjusted for temperature and solar radiation.

On-Site Weather Measurement Controllers use weather data collected on-site to calculate continuous ET measurements and water accordingly.

Soil Moisture Sensors used with Smart Irrigation Controllers

Soil moisture sensor-based smart irrigation controllers use one of several well-established technologies to measure soil moisture content. When buried in the root zone of turf, trees or shrubs, the sensors accurately determine the moisture level in the soil and transmit this reading to the controller.

There are two different soil moisture sensor-based systems available:

Suspended Cycle Irrigation Systems, which are set like traditional timer controllers, with watering schedules, start times and duration. The difference is that the system will stop the next scheduled irrigation when there is enough moisture in the soil.

Water on Demand Irrigation requires no programming of irrigation duration (only start times and days of the week to water). It has a user-set lower and upper threshold, which initiates irrigation when the soil moisture level fails to meet those levels.

Smart Irrigation Controllers save Water and Money

The experts agree that smart irrigation systems and controllers versus traditional irrigation controllers conserve water across a variety of scenarios. Several controlled research studies indicate substantial water savings anywhere from 30 to 50 percent.

Tests by the Irrigation Association (IA) and the International Center for Water Technology at California State University in Fresno have shown smart irrigation controllers to save up to 20 percent more water than traditional irrigation controllers.

Another study tested a prototype controller/receiver system consisting of a traditional irrigation controller modified to receive a signal broadcasted via satellite. Outdoor water savings were calculated based on 2-years of pre-installation usage and were adjusted for weather conditions. The reported average outdoor savings is 16 percent and it is also reported this represents 85 percent of potential savings based on reference ET.

A water efficient irrigation study of the Saving Water Partnership, a coalition of 24 water purveyors, was conducted in Washington State's Puget Sound. Water savings were calculated based on historical consumption and adjustments were made for weather conditions. The reported water savings were 20,735 gallons per year per site for sites with rain sensors controllers and 10,071 gallons per year per site for sites using traditional controllers.

Pest and Weed Management System

Pest, weeds, and pathogens can affect the crop harshly and may reduce productivity by up to 30% only by weeds (Amarendra. *et al*., 2018). On the other hand, pesticides and herbicides also reduce the profit and degrade the product quality as well which is a big concern for the consumer. IoT and smart systems can assess the disease, pest, and weed in the crop in the early stages and can inform the farmer, also capable of eradicating the pest and pathogens by precise targeting with pesticides and herbicides; smart vehicles (Gupta, D. *et al*., 2020) can also be used for this purpose.

Yield Assessment

Yield assessment is the most essential part of smart agriculture. For any type of assessment, data acquisition is the first step. Precise and continuous monitoring for the biotic and abiotic factors is only possible by IoT, WSNs, and UAV imagery. All these devices generate enormous amounts of unstructured data. The acquired data can be utilized for the early prediction of disease (Sun, H. *et al*., 2010), crop prediction (Yang, H. *et al*., 2007), and harvest planning (Zheng, H. *et al*., 2016). Through these applications, farmers can reduce their labor cost and operation cost, can do the error-free assessment for diseases and pests, estimate the revenue and profit, and schedule and plan a more suitable harvesting period that results in less input cost and more profitability in the long run.

Precision Fertilization

Another most important application of IoT for agriculture is that it can save money and the environment at the same time. Imbalance fertilization can cause multi-impact damage; i.e., sometimes plants require fewer nutrients; thus, excessive fertilizer may drain away or cause salinity in the soil which may rotten the plant, decrease productivity, cost you extra, and also cause climate change by evaporation. On the other side, if the plant required more nutrients, but was provided less, that also caused a decline in productivity and growth. Furthermore, fertilizer proportions of different elements such as nitrogen (N), potassium (K), and phosphorus (P) and water also matter because proportion depends on plant type, soil type, and weather; otherwise, crops cannot be productive. One more aspect is the variability which can only be handled through precision monitoring and mapping of land and crop. Smart IoT-based agriculture systems provide an optimal estimation of nutrient requirement (Zhu, H. *et al*., 2010) and reduce the labor cost and input costs.

Fig 12: Application of Fertilizer through Iot for Agriculture

Impact of AI on Agriculture

The technologies which are AI-based help to improve efficiency in all the fields and also manage the challenges faced by various industries including the various fields in the agricultural sector like the crop yield, irrigation, soil content sensing, crop- monitoring, weeding, crop establishment (Kim, *et al.*, 2008). Agricultural robots are built in order to deliver high valued application of AI in the mentioned sector. With the global population soaring, the agricultural sector is facing a crisis, but AI has the potential to deliver much-needed solution. AI- based technological solutions has enabled the farmers to produce more output with less input and even improved the quality of output, also ensuring faster go-to- market for the yielded crops. By 2020, farmers will be using 75 million connected devices. By 2050, the average farm is expected to generate an average of 4.1 million data points every day. The various ways in which AI has contributed in the agricultural sector are as follows:

Image Recognition and Perception

Lee, *et al.*, (2017) said that in recent years, an increasing interest has been seen in autonomous UAVs and their applications including recognition and surveillance, human body detection and geolocalization, search and rescue, forest fire detection (Bhaskaranand and Gibson, 2011; Doherty and Rudol, 2007; Tomic, *et al.*, 2012; Merino, *et al.*, 2006). Because of their versatility as well as amazing imaging technology which covers from delivery to photography, the ability to be piloted with a remote controller and the devices being dexterous in air which enables us to do a lot with these devices, drones or UAVs are becoming increasingly popular to reach great heights and distances and carrying out several applications.

Skills and Workforce

Panpatte (2018) said that artificial intelligence makes it possible for farmers to assemble large amount of data from government as well as public websites, analyze all of it and provide farmers with solutions to many ambiguous issues as well as it provides us with a smarter way of irrigation which results in higher yield to the farmers. Due to artificial intelligence, farming will be found to be a mix of technological as well as biological skills in the near future which will not only serve as a better outcome in the matter of quality for all the farmers but also minimize their losses and workloads. UN states that, by 2050, 2/3rd of world's population will be living in urban areas which arises a need to lessen the burden on the farmers. AI in agriculture can be applied which would automate several processes, reduce risks and provide farmers with a comparatively easy and efficient farming.

Maximize the Output

Ferguson, *et al.*, (1991) said in his wok that Variety selection and seed quality set the maximum performance level for all plants. The emerging technologies have helped the best selection of the crops and even have improved the selection of hybrid seed choices which are best suited for farmer's needs. It has implemented by understanding how the seeds react to various weather conditions, different soil types. By collecting this information, the chances of plant diseases are reduced. Now we are able to meet the market trends, yearly outcomes, consumer needs, thus farmers are efficiently able to maximize the return on crops.

Chat bots for Farmers

Chatbots are nothing but the conversational virtual assistants who automate interactions with end users. Artificial intelligence powered chatbots, along with machine learning techniques has enabled us to understand natural language and interact with users in away more personalized way. They are mainly equipped for retail, travel, media, and agriculture has used this facility by assisting the farmers to receive answers to their unanswered questions, for giving advice to them and providing various recommendations also.

Sustainable Farming

Sustainable farming is a broad, umbrella term for growing food using methods that will also nurture society, the environment, and the economy. It is an alternative to mainstream, industrial agriculture practices. Sustainable farmers seek to support community health and well-being and to work with nature, while still being profitable businesses—though farms can also be run as non-profits or recreational projects.

Importance of Sustainable Farming

Sustainable farming is important because it offers a solution to the problems caused by the way most of our food is grown today. Today's industrial farming methods, many stemming from the Green Revolution of the 1950s and 1960s, are depleting our natural resources through monocultures and the overuse of pesticides and fertilizers, among other practices, while leaving people with unequal access to food and nutrition around the world.

Environment. Soil is considered a **non-renewable resource**, and sustainable farming promises to protect and preserve soil health.

Public Health. Putting food production in the hands of disenfranchised communities, as sustainable farming advocates often do, is one way to **correct food system injustices** that result in continued health disparities among people of color.

Animal Welfare. Most animals raised for human consumption are grown and processed in conditions that are bad for their health. Sustainable farmers think about how to reform those industrial practices, such as reducing the use of antibiotics.

Local Economies and Workers. Farmers and **farmworkers** are often exploited for their labor in industrial agriculture. The sustainable farming movement is creating the space for a food system that respects the dignity of **farmers** and **workers**.

Most Efficient Use of Non-Renewable Resources. Coal, nuclear, oil, and natural gas are non-renewable energy **resources that we use** to drive cars and trucks, to cook, to heat our homes, and to **run power plants** that light our tablets and screens. The use of non-renewable energy resources is the leading cause of climate change, and food production is a primary sector contributing to greenhouse gas emissions. Sustainable farmers seek to be careful in their use of such resources, in alignment with their goal of protecting the environment.

Like the biodiversity of a forest, sustainable farmers are also diverse and creative as they attune their practices to their local communities and environments.

Practices and Methods Sustainable Farming

The term "sustainable farming" describes a general approach, and there is not an exact recipe for how to operate a sustainable farm. Growers apply methods that make sense to them and that reflect their values. The following are some popular terms you may hear as you learn more about sustainable agriculture.

Adopting Agroforestry Practices. Forests have multiple **layers**, have a diversity of species, and **store carbon**. Agro forestry is when farmers plant crops using patterns observed in natural forests. See Soul Fire Farm's **video** for some of their agro forestry practices, including alley cropping and terracing.

Applying Integrated Pest Management (IPM). Farmers can use **biological and mechanical ways** of keeping away unwanted animals and insects from their crops. **Chives, sage, and mint plants** are examples of natural insecticides.

Aquaponics and Hydroponics. Aquaponics is when people grow fish and vegetables in a mutually beneficial system of sharing water and nutrients. **Hydroponic** farmers grow plants without using soil and instead use materials like **clay balls, coconut hair and fabric**. See Charles Collins' outdoor aquaponics and hydroponics systems in this **video**. These practices can also be used indoors with electric light.

Avoid Soil Erosion. To prevent **soil erosion**, sustainable farmers can plant cover crops, use **stones** or **logs** to build terraces, and limit how much soil they dig up where there is already plant cover. Farmers can also avoid overgrazing and deforestation.

Better Water Management. Farmers can take care of the ecosystem by minimizing their use of fertilizers and pesticides, so that runoff from their farms does not contribute to water pollution. Instead of using sprinklers, for example, farmers seeking to conserve water can install drip lines to irrigate their plants, as **Matt Romero Farms** did.

Food Forests. To create a **food forest** one grows food in vertical layers that mimic the layers of a forest. The goals of an established **food forest** are to be low maintenance and to **feed people** with edible plants.

Growing Heirloom and Older Varieties. Beyond different-tasting vegetables and genetic diversity, heirloom seeds offer a connection to ancestors who thought to save their seeds. The **Cultural Conservancy** maintains a "living **seed library**" in relationship with a diasporic Native community. Chief Program Officer Sara Moncada explains in this KCET **video**, "I think about what it meant for our ancestors who were being relocated, who were facing an unknown future. They didn't just take what they could grab. They took the seeds. They tucked them in their pockets and wove seeds in their hair, knowing that that seed could be the revitalization of a people. A seed is immense and it's an immense system of knowledge. Within that system of knowledge is our capacity to connect, to learn, to flourish, to grow, to shift, to adapt, and to feed ourselves."

Integrating Livestock and Crops. Farmers can plant cover crops to help them **to manage manure and to feed domesticated animals** like cows, goats, and sheep.

Managed Grazing. Farmers who raise livestock such as cows can seek to reduce the animals' **harm to the land on which they graze** by limiting their access to the land. Read more about the trend of **regenerative grazing**, and its critics.

Managing Whole Systems and Landscapes: Holistic approaches to farming are an Indigenous practice. The **Cultural Conservancy** bought land that was intended for **return to Native people** and turned it into a **farm** and cultural center. They transformed the land using ancestral farming practices that focus on the relationship between people and the ecosystem. The land stewards grow native edible and medicinal plants, support wildlife habitats, and honor the "sacredness of life."

Permaculture: Permaculture is a set of ecological design principles and methods that scientists took from Indigenous communities and codified. It is now a worldwide movement. One of the 12 principles of permaculture is to observe and interact. Indigenous community members of the Cultural Conservancy dedicated a year to **listen to the land and to each other** prior to naming their farm, as a way to re-engage with ancestral traditions of land stewardship while unlearning internalized oppression.

Planting Cover Crops: Cover crops such as rye, clover, oats, buckwheat, and mustard grass protect soil from erosion and **stop earthworms** from dying of frost in the winter. Cover crops can also help with pest management and soil fertility.

Polyculture Farming: Farmers can plant more than one crop in the same area at the same time. The Three Sisters growing technique is an indigenous method of farming where plants demonstrate "**interconnection and interreliance**," says Maya Harjo, Native Foodways Director of **The Cultural Conservancy**. Read more about polyculture farming **here**.

Reducing or Eliminating Tillage: Farmers can allow the soil to stay intact and allow crop residue to protect it through **no-till farming**. Learn about the harms of tillage introduced by settler colonialism in the United States and how to build a no-till bed **here**.

Removal of Weeds Manually: Farmers can use their hands and hand tools, and even plows and tillage, to remove unwanted plants.

Rotating Crops and Embracing Diversity: Crop rotation, or changing the type of crop you grow in the same location, helps growers manage pests, weeds, and soil health. In this Soul Fire Farm **video**, Amara Ullauri of Rock Steady Farm explains, "There is no single way to create a crop plan." They give examples of Indigenous farming practices and demonstrate how an Excel spreadsheet or a journal can help plan for a variety of crops.

Save Transportation Costs: Farmers can find ways to reduce their use of tractors, and the cost of fueling them. At The Cultural Conservancy, for example, Three Sisters **crops are not grown in rows**, requiring harvesting by hand. Adherents to the eat local or local food movement care about reducing the greenhouse gas emissions caused by transporting food from farm to table.

Urban Agriculture: Urban farmers are reviving the notion of **farming within city limits** in places like Shanghai, Havana, and other cities around the world. In the United States, some of the best examples of **urban farming** are **community** gardens.

Using Renewable Energy Resources: Permaculture practitioners value the re-use of materials and avoid single-use products.

Organic Farming Sustainable
Because **organic farming** rejects the use of harsh pesticides and herbicides, and because of its focus on environmental health, it is generally considered a type of sustainable farming.

You have taken a leap and seen a menu of trendy terms in sustainable farming. The options of how to support agriculture that embraces nature and uplifts ordinary people are limitless.

If you're looking for ideas on how to make farming more sustainable, check out this **article** based on interviews with three leaders in the food justice movement. Soul Fire Farm, a leading sustainable farming organization, has also developed a set of resources for its supporters **here**.

To learn more about Indigenous farming practices promoted by the Cultural Conservancy, watch this **video**.

And if you're looking to try your hand at sustainable farming, consider checking out your local library for how-to manuals, or YouTube for tips on getting started in urban farming.

Towards a More Sustainable Futur
Whether high-tech or low-tech, larger- or smaller-scale, and regardless of where the growing happens or their underlying philosophies, sustainable farmers rely on methods that go beyond industrial agriculture, to grow food in ways that are both more just, and more tenable over the long term.

Robots in Agriculture
Robotics and Autonomous Systems (RAS) are introduced in large sectors of the economy with relatively low productivity such as Agri-Food. According to UK-RAS White papers (2018) the UK Agri-Food chain, from primary farming through to retail, generates over £108bn p.a., and with 3.7 m employees in a truly international industry yielding £20bn of exports in 2016. Robotics has played a substantial role in the agricultural production and management. The researchers have now started emphasizing on technologies to design autonomous agricultural tools as the conventional farming machineries lacked in efficiency (Dursun and Ozden, 2011). The main purpose of coming up with this technology is to replace human labor and produce effective benefits on small as well as large scale productions (Manivannan and Priyadharshini, 2016). In this sector, the room for robotic technologies has amplified productivity immensely (Pedersen, *et al.,* 2008). The robots are performing various agricultural operations autonomously such as weeding, irrigation, guarding the farms for delivering effective reports, ensuring that the adverse environmental conditions do not affect the production, increase precision, and manage individual plants in various unfamiliar ways.

The idea of coming up with such a technology came with the introduction of a machine called Eli Whitney's cotton gin. It was invented in 1794 by U.S. - born inventor Eli Whitney (1765–1825), a device which revolutionized cotton production by significantly accelerating the process of extracting seed from cotton fiber.It created 50 pounds of cotton in one day. Thus this gave birth to the autonomous agricultural robots. A basic automated model was introduced to determine the actual position of seeds (Griepentrog, *et al.,* 2005). Ultra high precision placement of seed was also established. Mechanisms that ensure that the seeds planted has zero ground velocity (Griepentrog, *et al.,* 2005). This is important as it ensures that the seed does not bounce from its actual position after the soil impact. The status or the development of plant was recorded by automated machines. Various biosensors were established to monitor the plant growth and also to detect plant diseases (Tothill, 2001).The process of manual weeding was replaced by the laser weeding technology, where a mobile focused infra-red light disrupts the cells of the weeds, this beam was controlled by computers (Griepentrog, *et al.,* 2006). For the effective use of water, automated irrigation systems were also established.

Technology of Smart Irrigation

The technology of smart irrigation is developed to increase the production without the involvement of large number of man power by detecting the level of water, temperature of the soil, nutrient content and weather forecasting. The actuation is performed according to the microcontroller by turning ON/OF the irrigator pump. The M2M that is, Machine to Machine technology is been developed to ease the communication and data sharing among each other and to the server or the cloud through the main network between all the nodes of the agricultural field (Shekhar, *et al.,* 2017). They (2017) developed an automated robotic model for the detection of the moisture content and temperature of the Arduino and Raspberry pi3. The data is sensed at regular intervals and is sent to the microcontroller of Arduino (which has an edge level hardware connected to it), it further converts the input analog to digital. The signal is sent to the Raspberry pi3 (embedded with KNN algorithm) and it sends the signal to Arduino to start the water source for irrigation. The water will be supplied by the resource according to the requirement and it will also update and store the sensor values. Jha, *et al.,* (2019) also developed an automated irrigation system with the technology of Arduino for reducing the man power and time consumption in the process of irrigation. Savitha and Uma Maheshwari, (2018) also developed the idea of efficient and automated irrigation system by developing remote sensors using the technology of Arduino which can increase the production up to 40%.

Another system for automated irrigation was given by Varatharajalu and Ramprabu, (2018). In this approach different sensors were built for different purposes like the soil moisture sensor to detect the moisture content in the soil, the temperature sensor to detect the temperature, the pressure regulator sensor to maintain pressure and the molecular sensor for better crop growth. The installation of digital cameras. The output of all these devices is converted to digital signal and it is sent to the multiplexer through wireless network such as Zigbee and hotspot.

The first technique was the subsurface drip irrigation process, which minimized the amount of water loss due to evaporation and runoff as it is directly buried beneath the crop. Later researchers came with different sensors which were used to detect the need of water supply to the fields as soil moisture sensor and rain drop sensor, which were instructed through wireless broadband network and powered by solar panels. The rain drop sensor and soil moisture sensor informs the farmer about the moisture content in the soil through SMS in their cell phone using GSM module. Accordingly the farmer can give commands using SMS to ON and OFF the water supply. Thus we can consider that this system will detect part or area in the fields which required more water and could hold off the farmer from watering when it's raining.

Soil moisture sensors use one of the several technologies used to measure the soil moisture content. It is buried near the root zones of the crops (Dukes, *et al.,* 2009). The sensors help in accurately determining the moisture level and transmit this reading to the controller for irrigation. Soil moisture sensors also help in significantly conserving water (Quails, *et al.*, 2001). One technique of moisture sensors is the water on demand irrigation in which we set the threshold according to the soil's field capacity and these sensors permits your controller to water only when required. When the scheduled time arrives, the sensor reads the moisture content or level for that particular zone, and watering will be allowed in that zone only if the moisture content is below the threshold. The other was the suspended cycle irrigation which requires irrigation duration unlike the water on demand irrigation. It requires the start time and the duration for each zone (Yong, *et al.*, 2018).

Dielectric Method

The moisture in the soil is calculated by the sensors which basically evaluate the moisture content in the soil based on the dielectric constant (soil mass permittivity) of the soil. The amount of irrigation needed can also be determined on the basis of the dielectric constant (Gebregiorgis and Savage, 2006). Kuyper and Balendonck (2001) proposes an automated system that uses dielectric soil moisture sensors for real time irrigation control. The measurement method based on the dielectric properties is considered to be the most potential one (Zhen, *et al.*, 2010). Hanson, *et al.*, (2000) gave the information regarding how soil types affect the accuracy to dielectric moisture sensors. The dielectric steady is only the capacity of soil to transfer power or electricity. The soil is comprised of various parts like minerals, air and water, subsequently the estimation of its dielectric consistent is determined by the general commitment of every one of these segments. Since the estimation of the dielectric value of water (Kaw = 81) is a lot bigger than the estimation of this consistent for the other soil parts, the estimated value of permittivity is primarily represented by the nearness of moisture in the soil. One method to calculate the relationship between the dielectric constant (Ka_b) and volumetric soil moisture (VWC) is the equation of Topp.

VWC=−5.3×10−2+2.29×10−2Kab−5.5×10−4 Kab2+4.3×10−6Kab3

The other method used for determining the dielectric constant is the by the Time Domain Reflectometry (TDR). It is determined on the basis of the time taken by an electromagnetic wave to propagate along a transmission line that is surrounded by the soil. As we probably are aware, the propagation velocity (V) is an element of the dielectric constant (Kab), therefore it is legitimately corresponding to the square of the transmission time (t in a flash) down and back along the transmission line:(2) Kab=c/v2=ct/2L2where c is the speed of electromagnetic waves in a vacuum (3·108 m/s or 186,282 mile/s) and L is the length of the TL in the soil (in m or ft).

Neutron Moderation

This is another technique for deciding the moisture content in the soil. In this strategy fast neutrons are launched out from a decomposing radio dynamic source like 241Am/9Be (Long and French, 1967) and when these neutrons slam into particles having a similar mass as theirs(protons, H+), they drastically slow down, making a “cloud” of “thermalized” neutrons. As we already know that water is the primary wellspring of hydrogen in soil, the thickness of thermalized neutrons around the test is about corresponding to the division of water present in the soil. The arrangement of the test is as a long and limited chamber, comprising of a source and a finder. The estimations are taken in this test by bringing the test into an entrance tube, which is as of now presented in the soil. One can decide soil amount of moisture in the soil at various profundities by balancing the test in the cylinder at various profundities. The moisture substance is gotten with the assistance of this gadget dependent on a direct alignment between the check pace of thermalized neutrons read from the test, and the soil moisture substance got from adjacent field tests. The installation of sensors plays an important role in the efficient implementation of irrigation robotics. One can use a single sensor to control the irrigation of multiple zones in the fields. And one can also set multiple sensors to irrigate individual zones. In the first case where one sensor is utilized for irrigating multiple zones, the sensor is places in the zone which is the driest of all or we can say the zone which requires maximum irrigation in order to ensure adequate irrigation in the whole field. The placement of the sensors should be in the root zone of the crops (ensuring that there are no air gaps around the sensor) from where the crops extract water. This will ensure the adequate supply of water to the crops. Later, we need to connect the SMS controller with the sensor. The controller will control the working after the sensor responds. After making this connection the soil water threshold needs to be selected. Then water is applied to the area where the sensor is buried and it is left as it is for a day. The water content now is the threshold for the sensor for scheduled irrigation as described earlier.

After fetching the data through the sensors the microcontrollers come into work. It is the major component of the entire automated irrigation process. The whole circuit is supplied with power up to 5 V with the help of transformer, a bridge rectifier circuit (which is a part of electronic power supplies which rectifies AC input to DC output) and voltage regulator. Then the microcontroller is programmed. The microcontroller receives the signals from the sensors. The OP-AMP acts as an interface between the sensors and the microcontroller for transferring the sensed soil conditions. The irrigator pumps thus operates on the information of the soil properties at run time (Fig 1).The irrigation process can therefore be automated with the help of moisture sensors and microcontrollers (Rajpal*, et al.*, 2011). (See Table 1.)

Weeding

Zimdahl (2010) in his report on "A History of Weed Science in the United States" stated about Thomas K. Pavlychenko, a pioneer weed experimentalist, who did a study on the competition among plants. After his detailed research on the same, he came concluded that the competition among the plants for water begins when their roots in the soil overlap to absorb water and nutrients and weeds were the strongest competitors for water. The water requirement for the aerial parts of the plant is the number of pounds of water used to produce a pound of dry matter. The wild mustardplant (*Brassica kaber* var. *pinnatifi da*) requires four times as much water as a well-developed oat plant, and the common ragweed plant (Ambrosia artemisiifol ia) requires three times as much water as a corn plant to reach maturity.

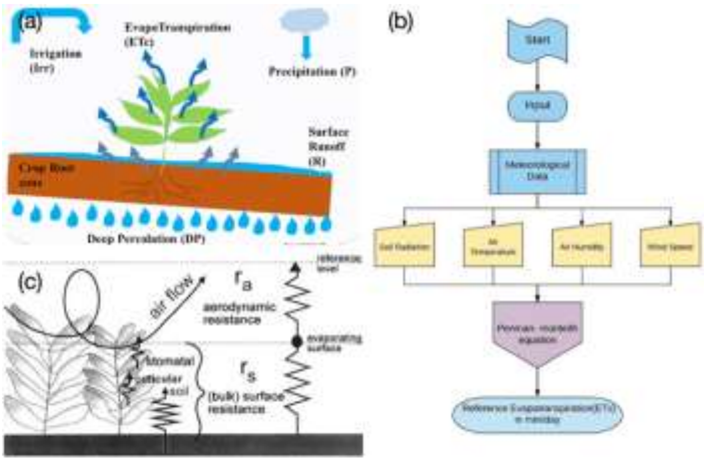


Fig 13: (A) Soil Water Balance Components for Evapotranspiration Model Source: University of Minnesota (B) Flowchart for Evapotranspiration Reference (Jha*, et al.*, 2019) (C) FAO Penman-Monteith Method

Table 1: Summary of Irrigation Automation Using Various Artificial Intelligence Technologies

S.N.	Algorithms	Method of evapotranspiration / desired calculation	Other Technologies	Advantages/Results	References
1.	PLSR and other regression Algorithms	Evapotranspiration model	Sensors for data collection, IOT Hardware Implementation	Increased efficiency and economic feasibility	Choudhary, *et al.,* (2019)
2.	Artificial Neural Network based control system	Evapotranspiration model	Sensors for measurement of soil,temperature,wind speed, etc.	Automation	Umair and Usman (2010)
3.	Fuzzy Logic	FAO Penman-Monteith method	–	Optimization	Kia, *et al.,* (2009)
4.	ANN (multi-layer neural model), Levenberg Marquardt, Back-propagation	Penman–Monteith method	–	Evaporation decreased due to schedule and savings observed in water and electrical energy	Karasekreter, *et al.,* (2013)
5.	Fuzzy Logic	–	WSN, Zigbee	Experimental results verification. Can be applied to home gardens and grass	Al-Ali, *et al.,* (2015)
6.	ANN Feed Forward, Backpropogation	–	–	Optimization of water resources in a smart farm.	Dela Cruz, *et al.,* (2017)
7.	Fuzzy Logic Controller	Penman–Monteith method	Wireless sensors	Drip irrigation prevents wastage of water and evaporation	Anand, *et al.,* (2015)
8.	Machine Learning algorithm	–	Sensors, Zigbee, Arduino microcontroller	Prediction and tackles drought situations	Arvind, *et al.,* (2017)

One can calculate the water requirement per acre is determined by multiplying the production of the plant in pounds of dry matter per acre times the plant's water requirement. Light is also an essential component for the growth of the plants. Weeds which grow tall, generally blocks the way of light to the plants. Sometimes weeds like green foxtail and redroot pigweed are intolerant of shade but may times weeds like field bindweed, common milkweed spotted spuroe, and Arkansas rose are shade tolerant. According to a study by researchers of the Indian Council for Agricultural Research, the country India, loses agricultural produce worth over $11 billion — more than the Centre's budgetary allocation for agriculture for 2017–18 annually due to weeds. So to remove these weeds from the fields is of great importance otherwise it will not only occupy the land space but will also adversely affect the growth of other plants (Bak and Jakobsen, 2003).

Lie Tang, *et al.,* (2000) brought up a vision based weed detection technology in natural lighting. It was created utilizing hereditary calculation distinguishing a locale in Hue-Saturation-Intensity (HSI) shading space (GAHSI) for open air field weed detecting. It utilizes outrageous conditions like radiant and shady and these lightning conditions were mosaicked to discover the likelihood of utilizing GAHSI to find the locale or zones in the field in shading space when these two boundaries are displayed at the same time. They came about given by the GAHSI gave proof to the presence and severability of such a locale. The GAHSI execution was estimated by contrasting the GAHSI-portioned picture and a comparing hand sectioned reference picture. In this, the GAHSI achieved equivalent performance.

Before developing a weed control automated system we need to differentiate between the crop seedlings and the weeds (Bhagyalaxmi, *et al.,* 2016; Chang and Lin, 2018). A method was applied for recognition of carrot seedlings from those of ryegrass. Aitkenhead*, et al.,* (2003) implemented this method by the simple morphological characteristic measurement of leaf shape. This method has varying effectiveness mostly between 52 and 75% for discriminating between the plants and weeds, by determining the variation in size of the leaf. Another method for weeding was implemented using digital imaging. This idea involved a self-organizing neural network. But this method did not give appropriate results which were expected for commercial purposes, it was found that a NN based technology already existed which allows one to find the differences between species with an accuracy exceeding 75%.

In the contemporary world many automated systems are developed (See Table 2.) but earlier various physical methods were used which relied on the physical interaction with the weeds. Nørremark and Griepentrog, (2004) proposed that weeding depends on the position and the number of weeds. Classical spring or duck foot tines were used to perform intra row weeding by breaking the soil and the interface of roots by tillage and thus promote the witling of the weeds. But this is not advisable method as tillage can destruct the interface between the crop and the soil. Thus, further no contact methods like the laser treatments (Heisel*, et al.,* 2001) and micro spraying, which do not affect the contact between the roots and the soil was developed. Nakai and Yamada, (2014) explained the method of the use of agricultural robots for the suppression of weeds and developing methods of controlling the postures of robots in case of uneven fields in the rice cultivation. It used the method of Laser Range Fielder (LRF) for suppressing the weeds and controlling robot's posture. Åstrand and Baerveldt, (2002) presented a robotic weed control system.

The robot was embedded with different vision systems. One was the gray- level vision which was used in developing a row structure in order to guide the robot along the rows and the other vision was color-based which was most important and used to differentiate a single among the weeds. The row recognition system was developed with a novel algorithm with an accuracy of ±2 cm. The first trial of this system was implemented in a greenhouse for weed control within a row of crops. The same technology was mentioned in the research done by Fennimore*, et al.,* (2016). The vision based technologies which were used to guide the robots along the row structure to remove weeds and to differentiate the single crop among the weed plants. The various weeding systems are:

Table 2: Summary of Applications of AI in Weeding Operations

S.N.	Application	Crop	Algorithms for Weed Detection	Weed Removal Methods	Accuracy	Reference
1.	Precision Weed Management	Pepper plants, artificial plants	Machine Vision, Artificial Intelligence	A smart sprayer	–	Partel*, et al.,* (2019)

2.	Autonomous Weeding Robot.	Sugar beet	Machine vision algorithm	High power lasers for intra-row weeding proposed.	–	Bakker, *et al.,* (2006)
4.	Weeds Detection in Agricultural Fields	–	Data augmentation for image preprocessing; Convolutional neural networks for weed detection	Herbicide Spray	70.5%	Ngo, *et al.,* (2019)
5.	Robot for weed control	Sugar Beets	Machine Vision	Rotatory hoe/ Mechanical removal	92%(detection)	Åstrand and Baerveldt, (2002)
6.	Weeding Robot	Rice	–	Motion of robot prevents weed growth	–	Nakamura, *et al.,* (2016)
7.	Weed Prevention Robot	Rice	–	Motion of robot	–	Maruyama and Naruse, (2014)
8.	Weed Detection	Sugarcane	Color Based and Texture Based algorithms; Greenness Identification; Fuzzy Real Time Classifier	Robotic arms for mechanical removal	92.9%	Sujaritha, *et al.,* (2017)
9.	Weed Control System	Lettuce	Machine Vision	Electrical Discharge	84%(detection)	Blasco, *et al.,* (2002)
10.	Robotic Weed Control	Cotton	Machine Vision algorithm based on Mathematical morphology	Chemical spraying	88.8% sprayed	Lamm, *et al.,* (2002)

Chemical Based

In this technology, the system consisted of 8 nozzles at the back which were used for spraying herbicides. The whole system divided the images captured in 8 × 18 small rectangles or we can say blocks, each of these blocks covered an area of 8128 sq. mm. Later, each row which consisted of these blocks corresponding to number of nozzles was examined and processed one after the other. After examining the blocks, each box containing weeds are sprayed. On can also divide the images into 16 × 40 blocks, in this case each blocks covers an area of approximately 8768 sq. mm. Thus, in this case we need 16 nozzles instead of 8. The further processing, that is, the task of spraying was done on the basis of the conditions mentioned. The conditions are: If the block examined consisting of weed pixels exceeding 10% of the total area of the block, then it is categorized into a weed block.

All the Blocks Examined are Sprayed with Herbicides.

Then after these two conditions, the weeds whose area equal to or more than 30% is sprayed are supposed to be destroyed. The herbicide which is sprayed in this method is a selective herbicide, which destroys only the weeds and not the other plants. The first two conditions mentioned above defines the where the herbicides are to be sprayed, that is, defines the areas which requires spraying. The first condition mentioned reduces the areas which contains very small amount of weeds and which does not require spraying. This is an important part of weeding. To destroy weeds, all the parts of the weeds does not require spraying, but only spraying enough areas is important as when spraying is done on one part of weeds it is absorbed by different parts of the weeds ultimately destroying the weeds. But one needs to take care that enough areas in a weed are sprayed because if the sprayed areas are too small then, in that case the weeds may not destroy. Thus we define a minimum spraying area in the condition 3.The defined condition 4 is there to calculate the reduction in the amount of herbicides used as compared with the spraying in the overall area. The evaluation of this weeding method requires the calculation of the destroyed weed rate, the correct spray rate, the false spray rate and the herbicide reduction rate.

The Following Data is to be calculated as Follows:

Destroyed weed rate=NK/NW×100

Correct spray rate=NCSR/NSNWB×100

False spray rate=NFSB/NSB×100

Herbicide reduction rate=1−NSB/NB×100

Here N_K is the number of weeds killed, N_W is the total number of weeds in the block, N_{CSB} is the number of sprayed weed blocks, N_{FSB} is the number of sprayed non-weed blocks, NSB is the total number of sprayed blocks and N_B is the total number of blocks examined.

Pulse High Voltage Discharge Method

There is an increase in the desire to implement non-chemical weeding methods as the pressure to reduce chemical costs on the environment and farming increases. The interest in organic farming has also led to the rise in interest of non-chemical weed management (Bond and Grundy, 2001). Non-chemical weed control methods were studied (Parish, 1990) and include mechanical, electrical, and biological methods. The pulse high voltage discharge method is one such non- chemical weed control method that was implemented mainly to destroy small weeds. These small weeds (of an approximate size of about 5 cm tall and stem diameter of about 2 mm) can be destroyed with just one spark with energy of 153 mJ and a 15 kV. Whereas the large weeds (which vary in size from about 80 cm to 120 cm tall and a stem diameter of about 10–15 mm) can be destroyed with a charge of 20 Hz. Because of these spark charges, the stem and the roots of the weeds gets adversely affected, thus leading to a disruption in the transportation of waiter to the various parts of the weeds. Thus, the weeds wilt within a few days after the spark. In this weeding method, spark discharging devices are set up on the system in place of the nozzles in the previous chemical based method. Here the system is designed to apply spark only on the areas where weeds are detected. Once the sites having weeds are detected, the selection of weed points is done by the system for spark discharge, these weed points represent the weed areas. Like the above discussed chemical method, in this method also some conditions are defined. The conditions are as follows:

The average of all the coordinates of the pixels in the images is calculated and it is defined as the center of that region.

The spark discharge applied for weeding is applied at this center.

If a weed receives the spark discharge, then that particular weed is considered as destroyed.

The first two conditions are established in order to select the spar discharging points in the fields and the third condition is for setting the potential of weed destruction. In this method some more factors are evaluated along with the three factors calculated in the previous method, the correct spark rate and the false spark rate.

Correct spark rate=NCSK/NSK×100

False spark rate=NFSK/NSK×100

Here N_{CSK} is the number of sparked weed pixels, N_{FSK} is the number of sparked non-weed pixels and N_{SK} is the total number of sparked points.

Drones in Agriculture

Unmanned aeronautical vehicles (UAVs) or unmanned ethereal frameworks (UAS), otherwise called automatons, in a mechanical setting are unmanned aircrafts that can be remotely controlled (Mogli and Deepak, 2018). They work in confluence with the GPS and others sensors mounted on them. Drones are being implemented in agriculture for crop health monitoring, irrigation equipment monitoring, weed identification, herd and wildlife monitoring, and disaster management (Veroustraete, 2015; Ahirwar, *et al.,* 2019; Natu and Kulkarni, 2016). Remote Sensing with the use of UAVs for image capturing, processing, and analysis is making a huge impact on agriculture. (Abdullahi*, et al.,* 2015). The rural business appears to have grasped ramble innovation with great enthusiasm, utilizing these propelled instruments to change current agricultural methods (Pederi and Cheporniuk, 2015).

The complete addressable estimation of automation fueled arrangements in every single relevant industry is critical – more than USD 127 billion, as indicated by an ongoing PwC analysis. They can be contrasted with a normal simple to use camera for unmistakable pictures, yet while a standard camera can give some data about plant development, inclusion and different things, a multispectral sensor extends the utility of the procedure and enables farmers to see things that can't be found in the noticeable range, for example, moisture content in the soil, plant health monitoring. These could help defeat the different restrictions that obstruct agrarian production. The development of the UAS is incorporated with Wireless Sensor Networks (WSN). The data recovered by the WSN enables the UAS to advance their utilization for instance to restrict its spraying of synthetic compounds to carefully assigned regions. Since there are abrupt and continuous changes in ecological conditions the control circle must almost certainly respond as fast as could reasonably be expected.

The reconciliation with WSN can help toward that path (Costa*, et al.,* 2012). In precision agriculture, UAVs are mainly applicable for agriculture operations such as soil and field analysis (Primicerio*, et al.,* 2012), crop monitoring (Bendig*, et al.,* 2012), crop height estimations (Anthony*, et al.,* 2014), pesticide Spraying (Faiçal*, et al.,* 2017; Faiçal*, et al.,* 2014a, Faiçal*, et al.,* 2014b, Faiçal*, et al.,* 2014c; Huang*, et al.,* 2009). (See Table 4.) However, their hardware implementations (Maurya, 2015) are purely adherent on critical aspects like weight, range of flight, payload, configuration and their costs. A research involving technologies, methods, systems and limitations of UAVs are examined (Huang*, et al.,* 2013). About more than 250 models are analyzed as well as summarized in order to choose an appropriate UAV in agriculture (S.R. Kurkute*, et al.,* 2018) (See Table 3.). The agricultural drone market is expected to grow over 38% in coming years. It is believed that the need for efficient agriculture is only going to become more important due to increasing population levels and changing climate patterns (Puri*, et al.,* 2017).

Table 4: Summary of Various Applications of Drones in Agriculture

S.N.	Application	Technologies/algorithms used	Results	Reference
1.	Pesticide Spraying	Wireless Sensor Networks, Gyroscope and Accelerometer sensors	N/A	Garre and Harish, (2018)
2.	Crop Monitoring, Mapping, and Spraying	DJI Phantom 3 Advanced UAV and other softwares	UAVs could be used in order to detect abnormalities and identify potential problems.	Psirofonia, *et al.,* (2017)

3.	Crop Monitoring	Multispectral sensor	Linear regressions between NDVI and plant nitrogen, aerial biomass, etc. were significant. This has the potential to provide insight to good management practices and techniques.	Vega, *et al.*, (2015)
4.	Pesticide Spraying	Spray motor	Worked satisfactorily when tested on groundnuts and paddy crops	Yallappa, *et al.*, (2017)
5.	Remote Sensing	Multispectral camera	The UAV remote sensing system was tested on a turf grass field and was capable of monitoring the temporal changes in the field.	Xiang and Tian, (2011)
6.	Remote Sensing	Spectral Spatial classification, Bayesian information criterion (BIC)	Manual Tomato detection is difficult so using this technology, the areas could be classified into tomato and non tomato regions. Detection was carried out successfully on two representative images.	Senthilnath, *et al.*, (2016)
7.	Crop Monitoring	Hyperspectral Frame Camera	Camera flight campaign successfully delivered the hyperspectral data. This enables the monitoring of the leaf nitrogen concentration in rice.	Zheng, *et al.*, (2016)
8.	Crop Monitoring	Camera and Softwares	Accurate way to monitor various aspects of the farm like creating digital map of field, detecting problems with crop health, etc.	Reinecke and Prinsloo, 2017a, Reinecke and Prinsloo, 2017b
9.	Precision Agriculture Monitoring	–	Provides an approach for the segregation of sparse and dense areas within a sugarcane field. It makes use of satellite data. Accuracy was 87% for testing.	Murugan, *et al.*, (2017)
10.	Spraying Fertilizers and Pesticides	Accelerometer and Gyroscope Sensors, Arduino	It has the ability to reduce time and human effort.	Pharne, *et al.*, (2018)

Table 3: Classification of Drones for Agricultural Application

UAV	ROTARY WINGS	FIXED WINGS
Flight duration	Fly upto 20 min	Fly up to an hour
Wind pressure	Can be flown from in winds gusting from 20 to 50 mph	Fly in and out of the wind for satisfactory images
Flexibility in changing direction	Allow new direction during flight for re-direction	Allow new direction upload during flight for re-direction
Price range	\$500 to \$100,000	\$500 to \$100,000
Deployable option	Highly deployable	Highly deployable

Crop Spraying

The UAVs, otherwise called drones, are chiefly established on the innovations of sensors and microcontrollers which are grown especially with an expectation to make up for the nonattendance of the pilot and accordingly empower the trip of unmanned vehicles and their independent conduct (Spoorthi, *et al.*, 2017). These drones have been utilized as substance sprayers by farmers since numerous years now and they are considered as effective and of great importance in the situations of cloudy climate and has also solved the problem of inaccessibility to a field of tall crops, for example, maize (Sugiura, *et al.*, 2005; Simelli and Tsagaris, 2015). Additionally, they are likewise accepted to have a solid favorable position contrasted with satellite airborne sensors of high picture resolution (Jannoura, *et al.*, 2015; Simelli and Tsagaris, 2015). Giles, *et al.*, 1987 retrofitted an air-carrier plantation sprayer with a microcomputer based sprayer control framework. A foliage volume estimation framework, in view of ultrasonic range transducers was interfaced to a PC which controlled the 3-nozzle manifolds on each side of the sprayer by the utilization of control calculations dependent on the amount of spray deposited. Kale, *et al.*, (2015) utilized drones for spraying synthetic substances on the yield where the drones are joined to actualize a control circle for horticulture applications. These drones were implemented with sensors conveyed on the crops in the field known as remote sensor networks (WSN) which controlled the way toward applying the synthetic compounds. The data recovered by these remote sensors limited drones to spray the synthetic substances only into the assigned regions. Huang and Reddy, (2015) built up a low volume sprayer for an unmanned helicopter. The helicopter utilized in this investigation has a principle rotor distance across of 3 m and a most extreme payload of 22.7 kg. For like 45 min one gallon of gas was involved. This technique and the systematic outcomes from this methodology gives a precursor that could be utilized in creating UAV flying application frameworks for higher yields which has a higher target rate and bigger VMD droplet size.

Xue, *et al.*, (2016) built up an unmanned airborne vehicle based programmed flying praying framework. The framework utilized a profoundly coordinated and ultra-low power MSP430 single-chip miniaturized scale PC with a free practical module. This permitted course was programmed to coordinate the UAV for spraying at the required or the desired areas on the fields. The spray consistency for these UAV tests was better than the Standard Requirement for ultra-low volume spraying variety coefficient. Zhu, *et al.*, (2010) developed a PWM Precision Spraying Controller for Unmanned Aerial Vehicles. This paper shows another Pulse Width Modulation (PWM) controller for Unmanned Aerial Vehicle (UAV) accuracy sprayer for farming utilizing a TL494 fixed-recurrence beat width modulator together with an information obtaining board and created programming. A UAV can be remotely controlled or automated by pre-modified flight plans. Therefore to this examination, PWM controller develops as a high exactness system for the spraying applications. Zhang, *et al.*, (2015) assessed powerful swath width and bead circulation of aeronautical showering frameworks on M-18B and Thrush 510G planes. In this examination they assessed the powerful swath width and consistency of the droplet dispersion of two agrarian planes, M-18B and Thrush 510G, which flew at 5 m and 4 m tallness, individually. The consequence of this examination expresses that the flight stature prompts the distinction in swath width for both the farming planes.

The sprayer is the one which crumbles the sprayed liquid which is possibly a suspension, an emulsion or an answer into tiny drops and launch it with negligible power for circulating it appropriately (Nørremark, *et al.,* 2008). It is additionally in charge of the guideline of the measure of pesticide in order to maintain a strategic distance from extreme application. Intemperate use of pesticides may demonstrate inefficient or harmful to the dirt too the yield. Likewise, the residue definitions of pesticides are disseminated with the assistance of dusters. Based on vitality required to atomize and to toss out the shower liquid, sprayers are arranged into four categories namely: The hydraulic energy sprayer, the gaseous energy sprayer, the centrifugal energy sprayer and the kinetic energy sprayer (Fig 2).

Hydraulic Energy Sprayer

In Hydraulic Energy Sprayer, the material to be sprayed is pressurized up to 40–1000 psi in any of the two potential ways. Either straightforwardly by utilizing a positive uprooting siphon or by utilizing a vacuum apparatus which will make the gaseous tension over the shower material noticeable all around tight holder. This pressurized material is shot out through the splash spout. Here, the siphon supplies the vitality which conveys the material to the plant foliage. Water driven Sprayers produce a splash with most beads in the 200–400 μm width extend.

As the beads framed are very little the structure a fog or haze which results in uniform inclusion and better contact with the bug or illness. In spite of the fact that, if the beads are little, they will in general vanish immediately when the mugginess is low and probably won't arrive at the objective. A water driven sprayer contains the accompanying parts: tank, siphon with instigator, weight measure, controlling valve, help valve, control valves, funneling and spouts, control source and bolster outline.

Fig14: Types of agricultural drones

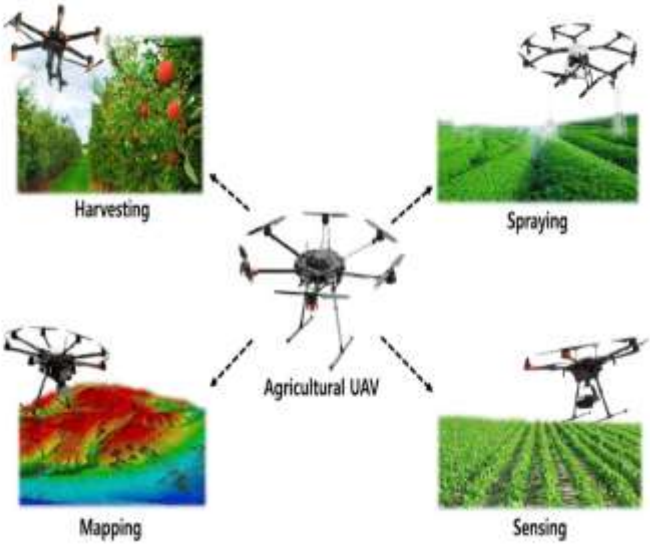


Fig 15: Types of agricultural UAV

Gaseous Energy Sprayer

In Gaseous Energy Sprayer a blower produces a high speed air stream. This air stream is coordinated through the pipe toward the finish of which spray liquid will be available which will be permitted to be streamed by the activity of gravity through a diffuser plate. A fluid or residue is sustained into air stream to be conveyed to the objective.

Centrifugal Energy Sprayer

The Centrifugal Energy Sprayer consists of a fast turning devise, for example, level, a concave or a convex plate, a wire mesh cage or a bucket, a puncture strainer or chamber or a brush. At the focal point of this gadget, the shower liquid is nourished under low weight which is additionally atomized by diffusive power as it leaves the outskirts of the atomizer. The droplets are conveyed by the air stream created by the blower of the sprayer or by the common breeze, if the sprayer isn't furnished with a fan.

Kinetic Energy Sprayer

In Kinetic Energy Sprayer the spray liquid streams by gravity to a vibrating or swaying spout which delivers a coarse fan like spray design. This is explicitly utilized for the spraying of herbicides. **The spray effectiveness of any of the above utilized showers can be determined by utilizing the equation given underneath:**

Spray proficiency % =Minimum spray volume required×100%

The plant foliage which is tainted by a pest or weed or any other reason has to be sprayed. The region which is required to be sprayed differs with separation between the lines of plants, separation between the plants in a similar line just as the development of the harvest. In addition, it is important to complete sprayer alignment practice before embraced real spraying work to guarantee uniform use of pesticides on the yields. We can process the spraying volume by utilizing the formula:

Application Rate in Liter per Acre or Hecter = (Constantfig 495 or 600 British Matric Nozzle Discharge Rate in Liter every Minute) / (Effective Swath Width in Feet or Meters Spraying speed in Mile or Kilometer every hour)

Pesticides are for the most part connected on the objective of the sprayed droplets which comprises of both, fine and coarse drops. They are characterized in term of their distance across and thickness on the objective. In fact, now and again the objective leaf area which is required to be secured might be a lot more prominent than the ground region. The Leaf Area Index (LAI) is the proportion of Leaf Area to Ground Area. LAI tents to shift with various yields and only from time to time surpasses around 6–7. Henceforth this is the reason behind per section of land requirement of water in a sprayer changing from harvest to yield contingent on the complete leaf territory to be secured. However numerous advances are being made in the sprayers which are to be utilized alongside the UAVs which give high inclusion also is effective spraying.

Crop Monitoring

The advanced sensors and imaging capabilities have provided the farmers with many new ways to increase yields and reduce crop damage (See Table 5.). Unmanned airplanes which are used for practical purposes in recent years have taken a bizarre flight. New sensors mounted on UAV, with high-tech cameras being the eyes of the client on the ground and optimal procedures for survey, data acquisition and analysis are continuously developed and tested. As a matter of fact, the use of aerial surveys is not new to the agricultural world. Satellites have been used for a decade to inspect large croplands and forestry but a new level of precision and flexibility has been obtained with the use of UAVs. To carry out UAV flights, one does not need to depend on the position of the satellite or having the correct weather conditions and as UAV pictures are taken 400–500 ft. from the ground level, they result in better quality and provide precision.

Table 5: Summary of the literature of the weeding, soil moisture detection, spraying and crop yield monitoring

S.N.	Function	Method	Description	Challenges and future scope	References
1.	Weeding	Bradley Method	The Bradleys used their approach to successfully remove weeds in Ashton Park, part of Sydney Harbor National Park, NSW, from a 16-hectare (40-acre) reserve.	The word 'bush regeneration 'currently includes practices other than weed removal, such as replanting and adding species to an environment where soil, water, or fire regimes have transferred the correct type of plant to the region.	Buchanan, (1989).
2.	Weeding	Computer vision assisted system	The mechanically weeding actuator consists of an integrated servo motor coupled with the computer vision aided system to detect plant sites and direct the weeding actuator to perform mechanical weeding operations without harming crops.	The accuracy of the system is found to be 93.6% using haar cascade classifier using OpenCV open source framework. Hence, it can be continued using in future.	Nanda and Reddy, (2018)
3	Soil moisture detection	Moisture Analyzers and METTLER TOLEDO	Precise temperature control with halogen heating technology and outstanding weighing technology	Robust construction, built-in performance tests and a comprehensive service offering	(Hanson, *et al.*, 2007)

4	Spraying	Telerobotic navigation and target selection	Targeted selection focuses on the development of a user interface suitable for targeted spraying, while simultaneously telerobotic navigation acknowledges the robot along the rows, so the farmer will be at a safe place away from hazardous materials during the spraying process.	Operator has to guide the robot in any given environment; it may be harsh, mild, etc. Aims to develop further for making it applicable in Agri-Robot Project.	George Adamides, *et al.,* User Interface Design Principles for Robotics in Agriculture: The Case of Telerobotic Navigation and Target Selection for Spraying
5	Spraying	Filter-paper ratio assured methods for spraying droplets	In this method, the spraying droplet is measured through filter paper ratio-assumed titration,and works out the corresponding function relationship between the diameter of coloured spots and diameter of liquid drops with regression analysis	Provides simpler way for gathering data, sampling, measuring spraying droplet and research on new type of plant protection machine.	Chen Zhenyu, *et al.,* (1996)Shang, *et al.,* (2004)
6	Crop Yield Monitoring Systems	Grain flow sensors for crop yield monitoring	It includes mass flow and volume flow methods which are located below the pivoted auger under the grain tank and in the middle of the elevator respectively. Mass flow methods use weighing type, impact-type, and radiometric-type units while Volume flow methods include paddle wheel type and optical type units.	Design and fabrication of any particular crop might be affected by the sensing approach which is employed. Signal processing as well correction approaches should be implemented for accurate monitoring	Sun-Ok-Chung, *et al.,* (2016) Kormann, *et al.,* (1998)

ER Hunt, *et al.,* (2005) evaluated Digital Photography from Model Aircraft for Remote Sensing of Crop Biomass and Nitrogen Status. In their examination, they advanced an aerobatic model airplane for capturing images utilizing a buyer arranged computerized camera and the hued canvases were utilized to adjust the images. They watched huge contrasts in computerized number (DN) for a similar reflectance and that was a result of contrasts in the introduction settings chosen by the advanced camera. Further they utilized Normalized Green–Red Difference Index (NGRDI) and directly related it to the standardized contrast of the green and red reflectances, individually. The aftereffects of this investigation mirrored that for soybeans, horse feed and corn, dry biomass from zero to 120 g m^{-2} was straightly corresponded to NGRDI, however for biomass more noteworthy than 150 g m^{-2} in corn and soybean, NGRDI did not increment further. Sun, *et al.*, (2010) demonstrated the achievability of utilizing a continuous kinematic (RTK) worldwide situating framework (GPS) to consequently delineate area of transplanted column crops. They utilized a positive-situation vegetable harvest transplanted retrofitted with a RTK GPS recipient, plant, tendency, and odometry sensors, and an on-board ongoing information lumberjack for transplant mapping in the field during planting. Field test outcomes demonstrated that the mean blunder between the plant map areas anticipated by the planting information and the over viewed areas in the wake of planting was 2 cm, with 95% of the anticipated plant areas being inside 5.1 cm of their real areas. Sonaa, *et al.*, (2016) showed UAV multi spectral overview to guide soil and harvest for exactness cultivating applications. Multi spectral and multi temporal orthomosaics were delivered over a test field, which was a 100 m × 200 m plot inside a maize field, to delineate and soil files, just as yield statures, with reasonable ground goals.

A low cost multispectral imaging system was designed and developed for application to crop monitoring (De Oca, *et al.*, 2018). It consists of a microcontroller along with two cameras embedded into the drone. One camera is sensitive to Infrared radiation while the other is a common RGB camera. This system provides images and information which are used by a software to compute the NDVI and subsequently the health status of a crop.

Reinecke and Prinsloo, 2017a, Reinecke and Prinsloo, 2017b studied the benefits of drones in agriculture, and their limitations, illustrating from examples how drones operate on farms. They discussed different features of deones and specifically how they assist farmers in maximizing their harvest by detecting problems early, and managing the crops by using specific cameras to detect pests and water shortages. (S. Nema, *et al.*, 2018) performed a detailed study on Spatial Crop Mapping and Accuracy Assessment Using Remote Sensing and GIS in Tawa Command. They did special crop mapping using satellite Landsat * data for Hoshangabad district of Madhya Pradesh and also carried out a Satellite data classification accuracy which resulted in overall accuracy as 87.60%.

Yield Mapping and Monitoring

One of the key segments of the unprecedenting progressions in exactness cultivating frameworks, yield mapping, enables the farmer to see spatial variety over the field perceiving zone for future activities and outcome of the past sessions, management. It alludes for the most part to the way toward gathering geo-referenced information on harvest yield and qualities, for example, showing in-field fluctuation, and the soil moisture content of the yield giving a benchmarking apparatus, when the yield is being harvested. In combination with soil examining data, yield maps empowers the arrangement of variable compost maps which considers soil supplement levels just as the supplement which was expelled in the collected harvest. Last result of yield mapping is typically a tonal or shaded guide showing scopes of yield inside a field. Fundamental segments of grain yield mapping framework incorporate grain fow sensor (determines grain volume gathered), grain moisture content sensor (remunerates for grain moisture variability), GPS antenna (receives satellite sign), Yield screen show with a GPS receiver (geo-reference and records information), header position sensor(distinguishes estimations logged during turns), travel speed sensor (determines the separation the join goes during a specific logging interim) (Fig 3).

Programming of the Software:

For yield mapping, there are basically 5 errands which are to be managed; information procurement, information preparing, LCD displaying < contact screen info and information sparing. The details of each one of them can be alluded from as:

These 5 undertakings inside and out, structures in performing various tasks sometimes bring about clashes. Predominantly these contentions are identified with the time arrangement. To conquer these contentions and to mull over every one of the undertakings we utilize four interfere with wellsprings of P80C592 in the framework, which are the clock intrude on source, the outer intrude on source, the ADC end-of-transformation intrude on source and the UART sequential I/O port intrude on source.

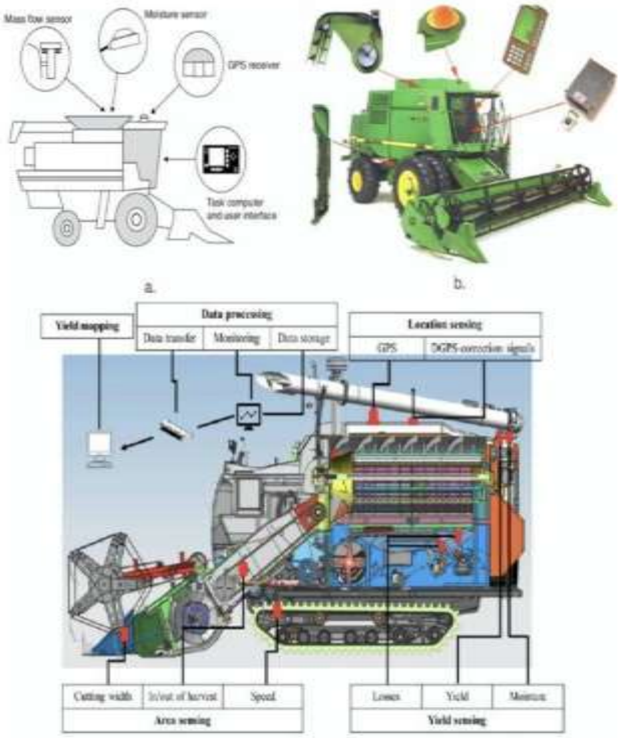


Fig 16: Yield mapping devices equipped to do both tasks (Kormann, *et al.*, 1998)

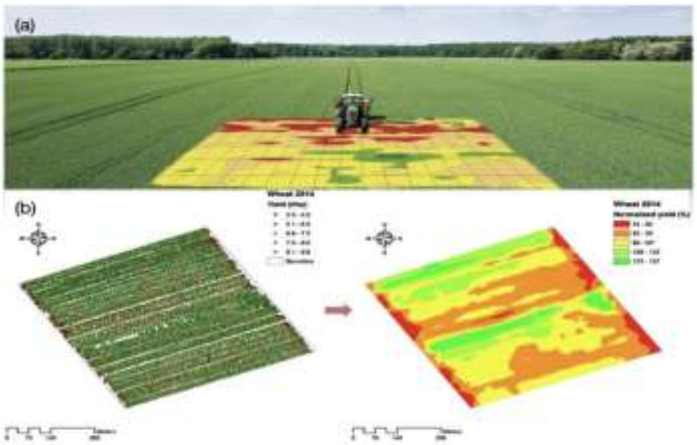


Fig 17: Yield Mapping (a) Sensing for yield (Source: Utah State University) and (b) example of raw yield map versus interpolated yield map using GIS (Source: Cillis, *et al.*, 2018)

Yield Calculation and Calibration

Yield is characterized as harvest weight (lbs for cotton) or volume (bu for grains) reaped per unit region, which is in a roundabout way estimated by the yield sensor stream rate/(speed x swath width). Yield stream rate is commonly determined each 1–2 s during collecting. The begin and end times for each line pass are balanced relying upon the measure of time the harvest takes to travel through sifting, isolating, and cleaning to the area of the yield sensor. The deferrals for beginning of-pass and end-of-pass will rely upon the yield and speed of the consolidate. Scientific interjection systems have been utilized to expel commotion because of blunders and regular spikes in the crude sensor and area information (Searcy, *et al.*, 1989; Birrell, *et al.*, 1996).

Yield is by implication estimated as a mass power or volume estimation by the yield sensors. Presently the yield count needs to join an adjustment factor because of the way that the yield figuring that changes over to weight relies upon the harvest. To acquire exact yield information a legitimate sensor alignment is imperative. Contrasting the scale loads of four with five burdens with the determined yield decides an alignment bend. Yield sensors ought to be recalibrated as factors change, for example, dampness substance or half breed. However, utilizing the Yield Sense screen evacuates the requirement for recalibration after the underlying alignment toward the start of the period (Precision Planting).

Processing Yield Maps

With the utilization of a Geographic Information System (GIS) programming, the yield determined at each field area can be shown. The raw log document, contains focuses which are recorded during turns and as the grain move through a consolidate is a deferred process (unless ongoing amendment is connected), the sensor estimations neglect to compare to the careful gather areas. To dispense with these conspicuous mistakes, the crude information is moved to make up for the joining delay. Increasingly finished, the focuses which compare to the header up position are evacuated. Settings for grain stream postponement are join and some of the time even harvest explicit, yet run of the mill esteems for grain yields extend from around 10 to 12 s.

Typically a couple of focuses toward the start and toward the finish of a pass ought to be expelled too. These focuses are alluded to as begin and end-pass delays. Begin pass postponements happen when the grain stream has not balanced out in light of the fact that the lift is bit by bit topping off yet the consolidate begins gathering the yield. Thus, end-pass deferrals happen when the join moves out of the yield and grain stream progressively decreases to zero when the lift is totally exhausted. Moving of raw information to address for grain stream postponement and exclusion of focuses that speak to header status up and begin and end-pass deferrals is the essential information separating method incorporated with programming provided with yield mapping frameworks.

Challenges and Future Scope

Agriculture has been tackling significant difficulties like absence of irrigation system, change in temperature, density of groundwater, food scarcity and wastage and substantially more. The fate of cultivating depends to a great extent on reception of various cognitive solutions. While large scale research is still in progress and some applications are already available in the market, the industry is still highly underserved (Shobila and Mood, 2014). When it comes to handling realistic challenges faced by farmers and using autonomous decision making and predictive solutions to solve them, farming is still at a nascent stage. In order to explore the enormous scope of AI in agriculture, applications need to be more robust (Slaughter, *et al.*, 2008). Only then will it be able to handle frequent changes in external conditions, facilitate real-time decision making and make use of appropriate framework/platform for collecting contextual data in an efficient manner. Another important aspect is the exorbitant cost of different cognitive solutions available in the market for farming. The solutions need to become more affordable to ensure that the technology reaches the masses. An open source platform would make the solutions more affordable, resulting in rapid adoption and higher penetration among the farmers. The technology will be useful in helping farmers in high yielding and having a better seasonal crop at regular interval. Many countries, including India, the farmers are dependent on monsoon for their cultivation. They mainly depend on the predictions from various departments over the weather conditions, especially for rain-fed cultivation. The AI technology will be useful to predict the weather and other conditions related to agriculture like land quality, groundwater, crop cycle, and pest attack, etc.

The accurate projection or prediction with the help of the AI technology will reduce most of the concerns of the farmers. AI-driven sensors are very useful to extract important data related to agriculture. The data will be useful in enhancing production. In agriculture, there is a huge scope for these sensors. Agriculture scientist can derive data like quality of the soil, weather and groundwater level, etc.; these will be useful to improve the cultivation process. AI empowered sensors can also be installed in the robotic harvesting equipment in order to get the data. It is speculated that AI-based advisories would be useful to increase production by 30%. The biggest challenge to farming is the crop damage due to any kind of disasters including the pest attack. Most of the time due to lack of the proper information farmers lose their crops. In this cyber age, the technology would be useful for the farmers to protect their cultivation from any kind of attacks. AI-enabled image recognition will be useful in this direction. Many companies have implemented drones to monitor the production and to identify any kind of pest attacks. Such activities have been successful many times, which gives the inspiration to have a system to monitor and protect crops. A robotic lens zooms in on the yellow flower of a tomato seedling. Images of the plant flow into an artificial intelligence algorithm that predicts precisely how long it will take for the blossom to become a ripe tomato ready for picking, packing, and the produce section of a grocery store. The technology is being developed and researched at Nature Fresh Farms, a 20-year-old company growing vegetables on 185 acres between Ontario and Ohio. Knowing exactly how many tomatoes will be available to sell in the future makes the job of the sales team easier and directly benefits the bottom line, said Keith Bradley, IT Manager for NatureFresh Farms. It's only one example of AI transforming agriculture, an emerging trend that will help spur an agricultural revolution. From detecting pests to predicting what crops will deliver the best returns, artificial intelligence can help humanity confront one of its biggest challenges: feeding an additional 2 billion people by 2050, even as climate change disrupts growing seasons, turns arable land into deserts, and floods once-fertile deltas with seawater. The United Nations estimates we will need to increase food production 50% by the middle of the century. Agricultural production tripled between 1960 and 2015 as the world's population grew from 3 billion people to 7 billion. While technology played a role in the form of pesticides, fertilizers, and machines, much of the gains can be attributed to simply plowing more land—cutting forests and diverting fresh water to fields, orchards, and rice paddies. We will have to be more resourceful this time around. AI is likely to transform agriculture and the market in the next few years. The technology has been useful for the farmers to understand various types of hybrid cultivations which would yield them more income within the limited time frame. The proper implementation of AI in agriculture will help the cultivation process and to create an ambiance for the market. As per the data with leading institutions, there is a huge wastage of the food across the world and using the right algorithms, this problem can also be addressed which will not only save the time and money but it will lead to sustainable development. There are better prospects for digital transformation in agriculture backed by leveraging technologies like AI. But, it all depends on the huge data which is quite difficult to gather because of the production process which happens once or twice in a year. However, the farmers cope up with changing scenario to bring digital transformation in the agriculture by implementing AI. It's only one example of AI transforming agriculture, an emerging trend that will help spur an agricultural revolution. We will have to be more resourceful this time around.

Summary of Artificial Intelligence and Machine Learning for the Green Development of Agriculture Using IoT Platform: The green revolution has helped prevent and combine high-yielding crops, chemical fertilizers, and water for millions of people in developing countries (Maddikunta*, et al.,* 2021). However, due to the extensive inappropriate use of agrochemicals in particular chemical fertilizers, the green revolution cannot be seen as entirely green. Specific technologies of highly productive crops usually require a lot of fertilizer and water (Seyhan, *et al.*, 2021). The Greenhouse is a flexible plastic structure mainly designed for the production of the products inside. It can adapt crops' growth approach to support plants' requirements and improve crop quality and quantity. Since most traditional greenhouses, particularly in dry locations, numerous environmental factors such as moisture temperature and others have been ignored (Shakeel, *et al.*, 2020). Greenhouses normally require a set number of environmental control devices and require standard precise control and multi-parameter management. Fresh vegetables are one of the main foods in any family's healthy routine (Pérez-Pons, *et al.*, 2021). However, the environment does not ensure food safety and crop plantation (Tran, *et al.*, 2021). In other circumstances, the workforce is not insufficient to monitor the planting process (Nguyen, *et al.*, 2020). Automated technology is used in agriculture to monitor crop development using a quadcopter and achieve massive emerging food manufacturing requirements (Manogaran, *et al.*, 2021). The design of mechanical, organic irrigation systems allows water resources easily accessible to the irrigation system to have been effectively allocated and maintained (Vangala, *et al.*, 2020; Sagheer, *et al.*, 2021). Crop productivity has shown to be an innovative evaluation given that crop field and plant strength are now an essential consideration by profit and food crops each day (Manogaran, *et al.*, 2019). One of the major challenges in current agriculture is the lack of knowledge on agricultural conditions and the reduction of emerging innovations (Manogaran, *et al.*, 2020). The development of remote sensing in the greenhouse environment has been important for less costly innovations for farmers to recover production (Shamshiri, *et al.*, 2020). A greenhouse is a construct with a light source that can maintain temperature control, the required moisture, and light absorption for the healthy development of a production facility (Gao, *et al.*, 2020; Lv, *et al.*, 2020).

Conclusion

The agricultural industry faces various challenges such as lack of effective irrigation systems, weeds, issues with plant monitoring due to crop height and extreme weather conditions. But the performance can be increased with the aid of technology and thus these problems can be solved. It can be improved with different AI driven techniques like remote sensors for soil moisture content detection and automated irrigation with the help of GPS. The problem faced by farmers was that precision weeding techniques overcome the large amount of crops being lost during the weeding process. Not only do these autonomous robots improve efficiency, they also reduce the need for unnecessary pesticides and herbicides. Besides this, farmers can spray pesticides and herbicides effectively in their farms with the aid of drones, and plant monitoring is also no longer a burden. For starters, shortages of resources and jobs can be understood with the aid of man-made brain power in agribusiness issues. In conventional strategies huge amount of labor was required for getting crop characteristics like plant height, soil texture and content, in this manner manual testing occurred which was tedious. With the assistance of various systems examined, quick and non-damaging high throughput phenotyping would occur with the upside of adaptable and advantageous activity, on-request access to information and spatial goals.

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