International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 11 | Nov - 2021 ISSN: 2582-3930

Artificial Intelligence in Agriculture

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Abstract - Agriculture plays a significant role in the economic sector. The automation in agriculture is the main concern and the emerging subject across the world. The population is increasing tremendously and with this increase the demand of food and employment is also increasing. The traditional methods which were used by the farmers, were not sufficient enough to fulfill these requirements. 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.

***Key Words*:** Artificial intelligence, Herbicide, Pesticide Automation, Irrigation

1. INTRODUCTION

The world's population is assumed to be nearly 10 billion by 2050, boosting agricultural order-in a situation of humble financial development by somewhere in the range of 50% contrasted with 2013 (FAO, 2017). At present, about 37.7% of total land surface is used for crop production. From employment generation to contribution to National Income, agriculture is important. It is contributing a significant portion in the economic prosperity of the developed nations and is playing an active part in the economy of the developing countries as well. The augmentation of agriculture has resulted in a significant increase in the per-capita income of the rural community. Thus, placing a greater emphasis on agricultural sector will be rational and opposite. For countries, like India, the agricultural sector accounts for 18% of GDP and provides employment to 50% of the country's workforce.
With the advent of technology, there has been observed a dramatic transformation in many of the industries across the globe. Surprisingly, agriculture, though being the least digitized,
has seen momentum for the development and commercialization of agricultural technologies. Artificial A system for harvest planning based on the coupling of crop assignment with vehicle routing is provided. Artificial intelligence (AI) has begun to play a big part in our daily lives, expanding our senses and abilities to influence the environment around us. With the advent of developing technology, workers who were formerly limited to only a few industrial areas are now able to contribute to a wide range of industries. Biology, linguistics, computer science, mathematics, psychology, and engineering are just a few of the fields that AI is founded on. a quick review of the present state of agricultural implementation automation. In addition, the study discusses a potential method for the main notion of AI is to build a technology that operates like a human brain (Patel et al., 2020; The basic concept of AI is to develop a technology that functions like a human brain). This technology is based on research into how the human brain thinks, learns, makes judgments, and works when attempting to solve a problem. . Artificial Intelligence (AI) systems and technologies It presented a quick overview of the many uses of neural networks and machine learning in the agricultural area for precision farming. In the realm of agriculture, artificial intelligence (AI) is a new technology. Agriculture has been elevated to a new level thanks to AI-based equipment and tools. Crop production has improved as a result of this technology, as has real-time monitoring, harvesting, processing, and marketing (Yan het al., 2007). In the agro-based industry, the latest technologies of automated systems employing agricultural robots and drones have made a significant contribution. Various high-tech computer-based systems have been developed to identify a variety of critical factors such as weed identification, yield detection, crop quality, and a variety of other ways. This paper discusses the technologies that are used to automate irrigation, weeding, and spraying in order to increase output and minimise farmer workload. GPS modules were used to pinpoint the location of these robotst Google Maps was used to track the location. The robots' data was retrieved via the Zig bee wireless protocol. The data was presented on a 16 2 LCD display that was built inside the LPC2148 microprocessor. The newest automated weeding techniques are addressed, as well as the use of drones for field spraying, as well as the several types of sprayers that may be used on UAVs. In addition to drones, yield mapping and monitoring are presented, starting with an overview of the yield mapping process, followed by software programming and a briefing on the calculation and calibration procedure. Finally, the yield maps' processing is explained.

2. Impact of AI on agriculture

AI-based technologies aid in the improvement of efficiency in all sectors and the management of difficulties encountered by numerous businesses, including crop yield, irrigation, soil content sensing, crop monitoring, weeding, and crop establishment in the agricultural sector (Kim et al., 2008). Agricultural robots are being developed in order to provide high-value AI applications in the aforementioned industry. The agriculture sector is experiencing a challenge as the world population grows. AI, on the other hand, has the ability to provide a much-needed remedy. Farmers have been able to generate more output with less input and increase the quality of their product, as well as ensure speedier go-to-market for their harvested crops, thanks to AI-based technology solutions. Farmers will use 75 million linked devices by 2020. Every day, the average farm is predicted to create 4.1 million data points by 2050. The following are some of the ways that AI has helped the agriculture sector:

2.1. Image recognition and perception

According to Lee et al. (2017), autonomous UAVs and their applications such as recognition and surveillance, human body detection and geolocalization, search and rescue, and forest fire detection have seen an increase in interest in recent years (Bhaskaranand and Gibson, 2011; Doherty and Rudol, 2007; Tomic et al., 2012; Merino et al., 2006). Drones or UAVs are becoming increasingly popular to reach great heights and distances and carry out a variety of applications due to their versatility as well as amazing imaging technology that covers everything from delivery to photography, the ability to be piloted with a remote controller, and the devices being dexterous in the air, which allows us to do a lot with these devices.

2.2. Skills and workforce

Farming will be discovered to be a combination of technology and biological talents in the near future as a result of artificial intelligence, which will not only provide a better outcome in terms of quality for all farmers, but will also reduce their losses and workloads. According to the United Nations, by 2050, two-thirds of the world's population would be living in cities, necessitating the need to reduce the load on farmers. In agriculture, AI may be used to automate numerous procedures, eliminate risks, and give farmers with a very simple and efficient process.

2.3. Maximize the output

Variety selection and seed quality, according to Ferguson et al. (1991), determine the maximum performance level for all plants. The emergence of Technology has aided in the optimum crop choices and even has increased the number of hybrid seed options available that are best suited for farmer's requirements It has been implemented by comprehending how seeds wor adapt to a variety of climatic conditions and soil types By accumulating Plant diseases are less likely as a result of this information. We are now in a position to are able to keep up with market developments, annual results, and consumer demands As a result, farmers are able to optimise crop returns in a cost-effective manner.

2.4. Chatbots for farmers

Conversational virtual assistants, often known as chatbots, automate interactions with end users. We can now interpret natural language and communicate with people in a more tailored way thanks to artificial intelligence-powered chatbots and machine learning algorithms. They are mostly geared for shopping, travel, and media, but agriculture has taken use of this capacity by supporting farmers in receiving answers to their unanswered queries, as well as providing guidance and other recommendations.

3. Robots in agriculture

In vast areas of the economy with poor productivity, such as agriculture, robotics and autonomous systems (RAS) are being implemented. Food. According to UK-RAS White Papers (2018), the UK Agri-Food Chain generates approximately £108 billion per year, employing 3.7 million people in a genuinely worldwide economy that generated £20 billion in exports in 2016. In agricultural production and administration, robotics has played a significant role. Because traditional farming machinery was inefficient, researchers have begun focusing on technology to build autonomous agricultural implements (Dursun and Ozden, 2011). Manivannan and Priyadharshini (2016) state that the major goal of developing this technology is to replace human labour and create effective benefits on both small and big scale industries. Robotic technology have greatly increased production in this industry (Pedersen et al., 2008). The robots are autonomously executing different agricultural tasks such as weeding, watering, protecting the fields for effective reporting, ensuring that unfavourable environmental conditions do not impair productivity, increasing precision, and so on. and manage individual plants in various unfamiliar ways. The invention of a machine known as EliWhitney's cotton gin sparked the notion for such a technology. Eli Whitney (1765–1825), a native of the United States, created it in 1794. Cotton manufacturing was revolutionised when the process was greatly accelerated. the process of separating seed from cotton fibres It resulted in the production of 50 pounds of cotton. On a single day As a result, autonomous agricultural robots were born. To establish the real position, a rudimentary automated model was devised. of seedlings (Griepentrog et al., 2005). Placement with extreme accuracy It was also confirmed that there existed a supply of seed. Mechanisms that guarantee that the seeds are not contaminated The ground velocity of planted is zero (Griepentrog et al., 2005). This is critical. because it prevents the seed from bouncing from its original place after the soil effect The state of a plant's development was examined. Automated machines took notes. Several biosensors have been developed.

3.1. Irrigation

Agriculture utilises 85 percent of all available freshwater resources on the planet. And this percentage is continuously growing. as a result of population growth and rising food demand This This necessitates the development of more efficient technology. in order to guarantee that water resources are used properly in irrigation Themanual Irrigation based on soilwater measurements was phased out. Using irrigation scheduling strategies that are automated. The evapotranspiration of the plant which was influenced by a variety of environmental factors including as Humidity, wind speed, sun radiation, and even agricultural variables are all elements to consider. such as the stage of development, plant density, soil conditions, and insect infestation When adopting autonomous irrigation, this was taken into account. Smart irrigation technology is being developed to boost productivity without the use of a large number of people by measuring water levels, soil temperature, nutrient content, and weather predictions. The irrigator pump is turned ON/OFF according to the microcontroller's instructions. Machine to Machine (M2M) technology was created to make things easier.

3.2. Weeding

In his article "A History of Weed Science in the United States," Zimdahl (2010) mentioned Thomas K. Pavlychenko, a pioneer weed experimentalist who studied plant competition. He arrived to the conclusion that the struggle among plants for water begins when their roots in the soil overlap to absorb water and nutrients, and that weeds were the strongest competitors for water after conducting extensive study on the subject. The amount of pounds of water used to create one pound of dry matter is the water demand for the aerial portions of the plant. To attain maturity, the wild mustard plant (Brassica kaber var. pinnatifida) needs four times the water of a well-developed oat plant, and the common ragweed plant (Ambrosia artemisiifol ia) needs three times the water of a corn plant.

The water need per acre may be calculated by multiplying the plant's production in pounds of dry matter per acre by the plant's water requirement. Light is also necessary for the growth of plants. Weeds that grow tall impede the route for light to reach the plants. Some weeds, such as green foxtail and redroot pigweed, are shade tolerant, whereas others, such as field bindweed, common milkweed spotted spuroe, and Arkansas rose, are not. According to a study by experts at the Indian Council for Agricultural Research, India loses agricultural output worth more than $11 billion yearly owing to weeds, which is more than the Centre's financial allocation for agriculture for 2017–18.

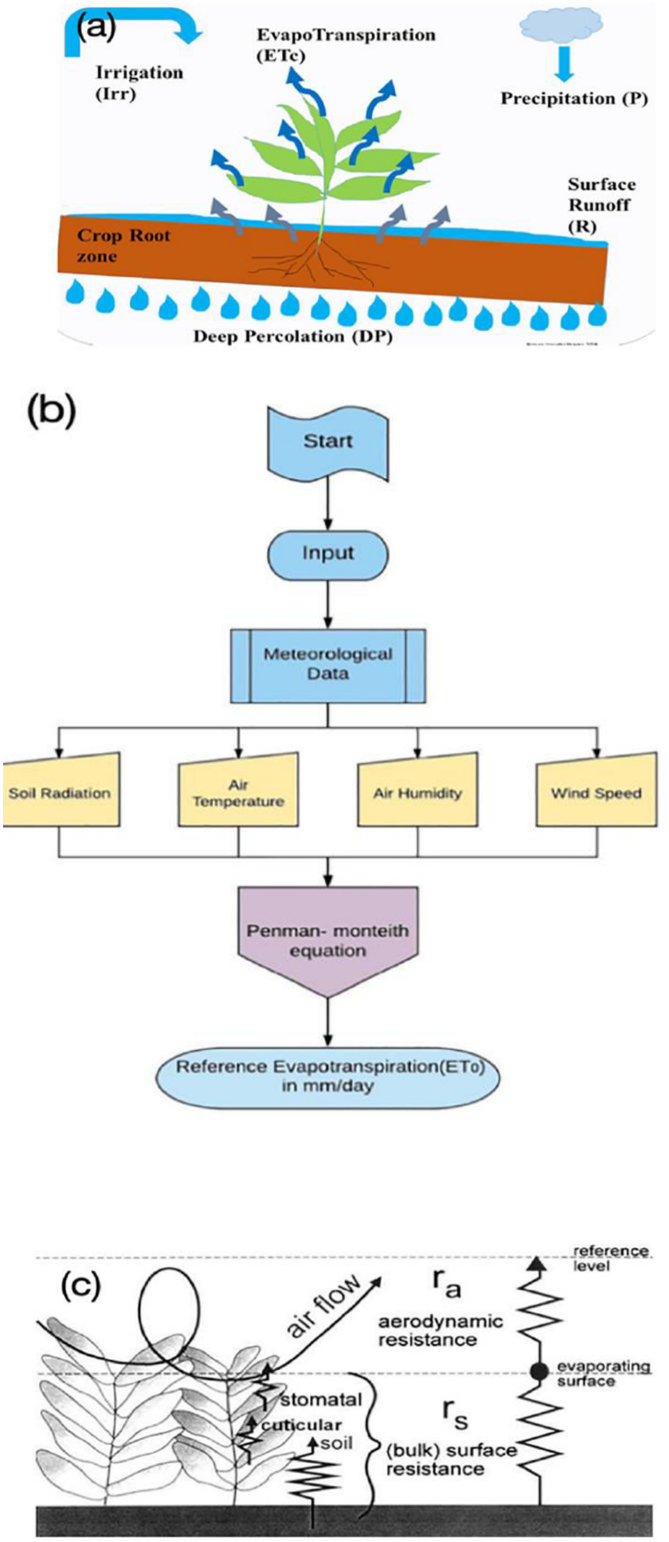


Fig. 1. (a) SoilWater Balance Components for EvapotranspirationModel Source: University ofMinnesota (b) Flowchart for Evapotranspiration Reference (Jha et al., 2019) (c) FAOPenman-Monteith method.

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

No.	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 (multilayer neural model), Levenberg Marquardt, Backpropagation	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)

The crop and the soil are in a symbiotic relationship. As a result, no-contact approaches such as laser treatments (Heisel et al., 2001) and micro spraying, which do not alter root-soil contact, have been developed. Nakai and Yamada (2014) described how to employ agricultural robots to eradicate weeds and create strategies for regulating robot postures in uneven rice fields. It employed the Laser Range Fielder (LRF) technology to manage the robot's position and suppress the weeds. A robotic weed management system was described by strand and Baerveldt (2002). Various visual systems were incorporated in the robot. One was gray-level vision, which was used to construct a row structure in order to guide the robot through the rows, and the other was color-based vision, which was the most significant and was used to distinguish a single weed from the others.

4. Drones in agriculture

In a mechanical context, unmanned aeronautical vehicles (UAVs) or unmanned ethereal frameworks (UAS), often known as automatons, are unmanned aeroplanes that may be operated remotely (Mogli and Deepak, 2018). They function in tandem with the GPS and other sensors that are attached to them. In agriculture, drones are being used to monitor crop health, irrigation equipment, weed detection, livestock and animal monitoring, and disaster management (Veroustraete, 2015; Ahirwar et al., 2019; Natu and Kulkarni, 2016). Agriculture is benefiting greatly from remote sensing, which includes the use of unmanned aerial vehicles (UAVs) for picture capture, processing, and analysis. (Abdullahi and colleagues, 2015). The agriculture industry appears to have embraced technological innovation with zeal, employing these propelled devices to alter present farming practises (Pederi and Cheporniuk, 2015). According to a current PwC investigation, the total addressable estimation of automation-fueled arrangements in every significant area is important – more than USD 127 billion. They can be compared to a standard camera for clear pictures, but while a standard camera can provide some data about plant development, inclusion, and other things, a multispectral sensor expands the utility of the procedure and allows farmers to see things that aren't visible in the visible range, such as moisture content in the soil and plant health monitoring. These might aid in the removal of various barriers to agricultural output. Wireless Sensor Networks are used in the development of the UAS (WSN). The information gathered by the WSN allows the UAS to improve its use, such as limiting its spraying of synthetic substances to certain areas. Because ecological conditions are always changing, the control circle must almost surely respond as quickly as is reasonably possible.

4.1. Crop spraying

The UAVS, also known as drones, are primarily based on sensor and microcontroller advancements, which were developed specifically to compensate for the absence of a pilot and so enable the flight of unmanned vehicles and their autonomous operation (Spoorthi et al., 2017). Farmers have been using drones as substance sprayers for some years, and they are believed to be useful and important in foggy climates, as well as in solving the problem of inaccessibility to a field of tall crops, such as maize (Sugiura et al., 2005; Simelli and Tsagaris, 2015). They are also acknowledged to have a

In contrast to satellite aerial sensors with excellent picture resolution (Jannoura et al., 2015; Simelli and Tsagaris, 2015), the firm advantageous position (Jannoura et al., 2015; Simelli and Tsagaris, 2015) An air-carrier plantation sprayer was retrofitted with a microcomputer-based sprayer control framework by Giles et al., 1987. A PC was interfaced to a foliage volume estimation framework based on ultrasonic range transducers, which controlled the 3-nozzle manifolds on each side of the sprayer using control calculations based on the quantity of spray deposited. Drones were used by Kale et al. (2015) to spray synthetic compounds on the yield, with the drones connected to form a control circle for horticultural applications. These drones were equipped with sensors called remote sensor networks (WSN) that were placed on the crops in the field and controlled the application of synthetic substances.

Drones were only allowed to spray synthetic compounds in the designated areas based on the data collected by these distant sensors. For an autonomous aircraft, Huang and Reddy (2015) developed a low-volume sprayer. The helicopter used in this study has a main rotor diameter of 3 metres and a maximum payload of 22.7 kg. One gallon of petrol was used for around 45 minutes. This approach and the systematic results provide a precursor that might be used to create UAV flying application frameworks for greater yields with a higher goal rate and larger VMD droplet size.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 11 | Nov - 2021 ISSN: 2582-3930

a) Irrigation Drone

b) Crop Spraying Drone.

c. Soil Analysis Drone

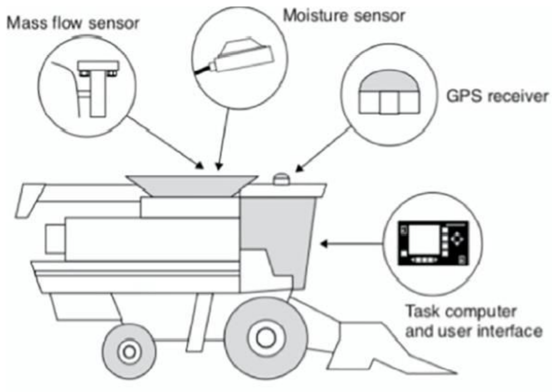
Fig. 2. Types of agricultural drones. Source: modern agriculture drones (Unpaprom et al., 2018

4.2. Crop monitoring

Farmers now have a plethora of new options for increasing yields and reducing crop damage thanks to enhanced sensors and imaging capabilities. In recent years, unmanned aeroplanes that are utilised for practical reasons have assumed an unusual flight. New sensors installed on UAVs, high-tech cameras serving as the client's eyes on the ground, and ideal survey, data collecting, and analysis techniques are all being developed and tested. In truth, aerial surveys are not new to the agricultural industry. Satellites have been used to scan big croplands and forests for a decade, but the advent of unmanned aerial vehicles (UAVs) has provided a new degree of precision and flexibility. UAV flights do not need the position of the satellite or the presence of favourable weather conditions, and because UAV images are captured 400–500 feet above ground level, they are of high qualityresult in better quality and provide precision.

4.2.2. Programming of the software

Information acquisition, information preparation, LCD display of the contact screen information, and information sparing are the five errands that must be managed for yield mapping. These 5 projects, both inside and out, as well as the institutions that support them in completing various duties, might lead to conflicts. The majority of these disagreements are related to the scheduling. We use four P80C592 interfere with wellsprings in the framework, which are the clock intrude on source, the outer encroach on source, the ADC end-of-transformation intrude on source, and the UART sequential I/O port intrude on source, to contend with and consider each of the undertakings.

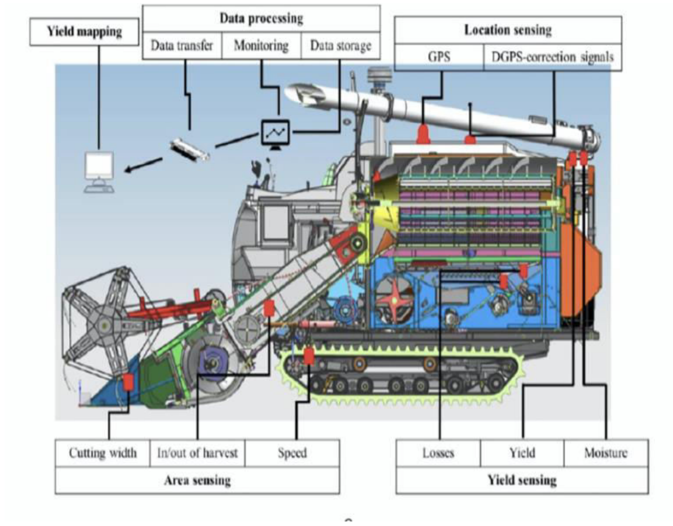


a.

4.2.3. Yield calculation and calibration

Harvest weight (lbs for cotton) or volume (bu for grains) harvested per unit region is defined as yield, which is determined in a roundabout fashion by the yield sensor stream rate/ (speed x swath width). During collection, the yield stream rate is usually determined every 1–2 seconds. The start and stop periods for each line pass are balanced based on the amount of time it takes for the harvest to move through sifting, isolating, and cleaning to the yield sensor area. The beginning of-pass and end-of-pass deferrals will be determined by the yield and speed of the consolidation. Because of mistakes and regular spikes in the crude sensor and area data, scientific interjection techniques have been used to clear the disturbance (Searcy et al., 1989; Birrell et al., 1996).

The yield sensors imply that yield is measured as aggregate power or volume estimates. Because the yield calculation that converts to weight is dependent on the harvest, the yield count now requires an adjustment factor. A proper sensor alignment is required to provide precise yield information. An alignment bend is found by comparing the scale weights of four and five burdens with the calculated yield. As factors such as moisture material or half breed alter, yield sensors should be recalibrated. Using the Yield Sense screen, on the other hand, eliminates the need for recalibration after the underlying alignment near the beginning of the period (Precision Planting).



b.

Fig. 3. Yield mapping devices - (a) diagram (b) yield mapping harvester equipped to do both tasks

4.2.4. Processing yield maps

The yield determined for each field area may be shown using Geographic Information System (GIS) programming. The raw log document comprises focuses that are captured throughout turns, and because grain movement via a consolidation is a delayed operation (unless continuing amendment is linked), sensor estimations fail to compare to the carefully collected regions. To avoid these obvious errors, the raw data is relocated to compensate for the joining delay. As the project progresses, the foci that correspond to the header up position are gradually removed. Grain stream deferment options are numerous, and some are even harvest specific, however standard grain yield estimates range from 10 to 12 seconds.

Typically, a couple of focuses towards the start and end of a pass should be removed as well. Begin and end-pass delays are terms used to describe these focuses. When the grain stream has not levelled out due to the lift gradually topping off while the consolidate begins gathering the yield, start pass postponements occur. As a result, end-pass deferrals occur when the join moves out of the yield and the grain stream gradually diminishes until the lift is completely depleted. Raw data is moved to an address for the grain stream.

The main information separating procedure included with programming given with yield mapping frameworks is the postponement and exclusion of focuses that speak to header status up and begin and end-pass deferrals.

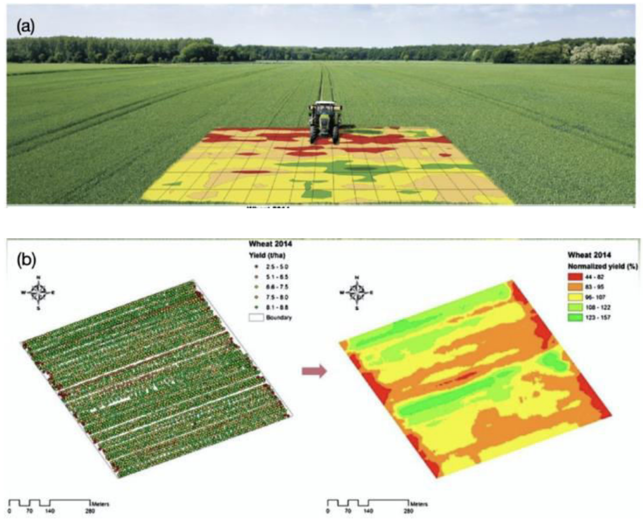


Fig. 4. Yield Mapping (a) Sensing for yield (Source: Utah State University) and (b) example of raw yield map versus interpolated yield map using GIS

5. Challenges and future scope

Agriculture has faced considerable challenges such as a lack of irrigation systems, climate changes, groundwater density, food scarcity and waste, and much more. The reception of distinct cognitive solutions has a significant impact on the fate of cultivating.

Despite the fact that large-scale research is still underway and some applications are now on the market, the industry remains underserved (Shobila and Mood, 2014). Farming is still in its infancy when it comes to dealing with real-world difficulties and solving them with autonomous decision-making and predictive solutions. Applications must be more resilient in order to explore the vast potential of AI in agriculture (Slaughter et al., 2008). Only then would it be capable of handling frequent changes in external conditions, facilitating real-time decision making, and utilising a suitable framework/platform for efficiently collecting contextual data.

Another significant factor is the high expense of many cognitive farming technologies available on the market. To ensure that technology reaches the masses, solutions must become more affordable. The solutions would be more economical if they were built on an open source platform, leading in faster acceptance and higher penetration among farmers. The technique will aid farmers in increasing yields and producing a better seasonal harvest at regular intervals. Farmers in many nations, including India, rely on the monsoon for their crops. They are primarily reliant on weather forecasts from several departments. circumstances, particularly for rain-fed agriculture The AI technology will be useful in predicting weather and other agricultural circumstances such as soil quality, groundwater, crop cycle, and pest assault, among others. Most of the farmers' fears will be alleviated by precise projection or prediction using AI technology. AI-powered sensors are extremely beneficial for extracting critical agricultural data. The information will be helpful in improving output. These sensors have a lot of potential in agriculture. Data such as soil quality, weather, and groundwater level, among other things, can be derived by agriculture scientists and used to optimise the cultivation process. In order to collect data, AI-enabled sensors can be integrated in robotic harvesting equipment.

AI-based advice are thought to be effective in increasing production by 30 percent. The most difficult aspect of farming is crop damage caused by natural disasters, such as pest attacks. The majority of the time, farmers lose their crops owing to a lack of sufficient information. In this cyber age, technology might be beneficial to farmers in protecting their crops from cyber-attacks. In this case, AI-assisted image recognition will be advantageous. Drones have been used by a number of businesses to monitor production and detect pests attacks Farmers have been able to grasp many forms of hybrid cultivations thanks to technology. would bring them more money in a shorter period of time. The AI in agriculture will aid the farming process if it is implemented properly as well as to set the tone for the market According to the data with leading There is a lot of food waste at institutions all throughout the world, and This problem can also be solved with the correct algorithms. Not only will it save time and money, but it will also contribute to long-term development. Agriculture has a higher chance of embracing digital transformation. aided by the use of artificial intelligence (AI). But it all depends on the situation. Because of the production, there is a lot of data that is tough to obtain. Once or twice a year, a process takes place. Nonetheless, the Farmers must adapt to shifting circumstances in order to implement digital transformation. Artificial Intelligence (AI) is being used in agriculture. It's just one example of AI's impact on agriculture, which is a growing trend that will help usher in a new era in agriculture. This time around, we'll have to be more resourceful.

6. CONCLUSION

The agricultural industry has a number of obstacles, including a lack of appropriate irrigation systems, weeds, crop height-related issues with plant monitoring, and extreme weather conditions. However, with the help of technology, performance may be improved, and thus these issues can be resolved. It can be improved with AI-driven techniques such as remote sensors for detecting soil moisture content and GPS-assisted automated irrigation. Farmers' difficulty was that precision weeding techniques were able to offset the high amount of crops lost during the weeding procedure. These self-driving robots not only increase productivity, but they also cut the use of unneeded pesticides and herbicides. Aside from that, farmers may use drones to successfully spray pesticides and herbicides on their farms, and plant monitoring is no longer a hassle. For starters, in agriculture difficulties, man-made brain power can be used to understand resource and job shortages. In traditional tactics, a large amount of labour was necessary to get agricultural parameters such as plant height, soil texture, and content, which necessitated manual testing, which was time-consuming. Quick and non-damaging high throughput phenotyping would be possible with the help of the various systems investigated, with the added benefit of flexible and favourable activity, on-demand access to information, and spatial goals.

ACKNOWLEDGEMENT

It gives me a great pleasure to present my research paper on " Artificial Intelligence in Agriculture ". I would like to express my deepest appreciation to all of the teachers who have supported me in the study and given sufficient guidance.

I'm very thankful to the Director of the Department. If this acknowledgment is unfinished, I would like to mention a sense of appreciation to our respected Principal, who gave me the direction, support and all the facilities available to work on this initiative.

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