Mysore J. Agric. Sci., 56 (2) : 14-25 (2022)

A Review on Artificial Intelligence and Robots in Agriculture

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Abstract

Agriculture contributes significantly to the economy. Agriculture automation is a major source of concern and a hot topic around the world. The world's population is rapidly growing, and with it comes increased demand for food and work. Farmers' traditional practices were not sufficient to meet these objectives. As a result, new automated procedures were developed. Agriculture has undergone a transformation as a result of artificial intelligence. This technology has been designed to protect crop yields against a variety of factors such as climate change, population increase, labour issues and food security concerns. Using sensors and other tools incorporated in robots and drones, artificial intelligence can be used in agriculture for irrigation, weeding, spraying, etc. These technologies will reduce irrigation water, pesticides consumption, precise application of herbicides, maintain soil fertility and aid in the efficient use of manpower, thereby increasing productivity and improving quality.

Keywords : Artificial intelligence, Food Security, Robots, Drones, Sensors

The challenge for global agriculture is to meet the demands of a rapidly rising population, which is expected to reach around 10 billion by 2050, while also to boost agricultural production order in a setting of modest financial development by almost 50 per cent compared to 2013. Crop production currently accounts for around 37.7 per cent of total land surface (FAO, 2017). Agriculture is significant in terms of job creation and contribution to national income. It makes a substantial contribution to the economic prosperity of industrialised countries and also plays an important role in the economies of emerging countries. Agriculture expansion has resulted in a large boost in the rural community's per-capita income. Hence, putting a greater emphasis on the agricultural sector is both sensible and practical. In countries like India, the agricultural industry contributes for 18 percent of GDP and employs half of the country's workers (FAO, 2017). Rural growth will be boosted by agricultural development, which will then lead to rural transformation and finally, structural transformation (Mogili & Deepak, 2018 and Shah *et al.,* 2019). Many sectors around the world have seen significant changes as a result of technological advancements (Kakkad *et al.,* 2019). Surprisingly, agriculture, while being the least computerised, has seen a surge in agricultural technology development and commercialization.

Artificial Intelligence (AI) has begun to play a significant part in our daily lives, expanding our perceptions and allowing us to alter our surroundings (Kundalia *et al.,* 2020; Gandhi *et al.,* 2020 and Ahir *et al.,* 2020). Plessen (2019) presented a system for planning harvest based on combining crop assignment and vehicle routing. With the advancement of technology, workers who were formerly limited to a single industrial sector 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. Jha *et al.* (2019) has provided a quick summary of current agricultural automation application. The report also discusses a potential Internet of things (IoT)-based system for flower and leaf identification and irrigation in a botanical farm (Patel *et al.,* 2020a and Albaji *et al.,* 2010). The main idea behind AI is to create a system that works similarly to a human brain (Parekh *et al.,* 2020 and Jani *et al.,* 2019). This technology is perpetrated by researching how the human brain thinks, learns, makes judgments, and collaborates when addressing a problem, then developing intelligent software and systems on this foundation. These intelligent gadgets, like the human brain, are supplied with training data and then provide us with the desired result for every valid input. AI encompasses a wide range of fields, including Machine Learning and Deep Learning (Patel *et al.,* 2020a, 2020b; Pandya *et al.,* 2019 and Sukhadia *et al.,* 2020). While AI is the study of creating intelligent computers and programmes, machine learning (ML) is the ability to learn anything without being explicitly programmed, and deep neural network learning (DL) is the learning of deep neural networks (Kodali & Sahu, 2016 and Kulkarni & Deshmukh, 2013). The primary goal of AI is to make problem solving easier, which may include the usage of artificial neural networks (ANNs) (Shah *et al.,* 2020a, 2020b).

Agriculture industry can experience rapid growth by adopting advanced technologies to bolster the yield of the crops. Accessibility to a large number of equipment and state-of-the-art technologies like Artificial Intelligence (AI) can totally revolutionize this sector in the near future. Since, work from human resource has time limitation; machines with artificial intelligence can be better utilized to overcome this lacuna. Further, farmer needs expert advice to produce good crop but they may not be available at all the time and decision-making ability changes from person to person which may lead to inadequate and indecorous decisions, this can be overcome by adopting Expert Systems (ES) in crop production. These technologies (AI/ES) can aid in providing information and support the decision-making for instance, crop condition, weather signalling challenges, nutrient and water management, crop protection and harvesting. As a result, they may positively contribute towards increasing yields or minimizing losses.

In the realm of agriculture, artificial intelligence (AI) is a new technology. Agriculture has been elevated to a new level by AI-based equipment and tools. Crop production has improved as a result of this technology, as has real-time monitoring, harvesting, processing, and marketing. In the agro-based sector, the latest technologies of automated systems using agricultural robots and drones have made a significant contribution. Several high-tech computer-based systems have been developed to identify various critical factors such as weed detection, 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 reduce farmer workload. Various methods of automated soil sensing are discussed.

Artificial intelligence (AI): Every aspect of learning or any other feature of Intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. AI is the intelligence exhibited by machines, rather than human or other animals. They are the intelligent agents which perceives its environment and takes action to maximize the success. Word Artificial intelligence was coined by John McCarthy. Artificial intelligence is not 'Man Vs Machine' but is 'Man and Machine' synergy.

History of Artificial Intelligence (AI)

- 1950 - *Alan Turning*: He published a landmark paper in which he speculated about the possibility of creating machines that think
- 1951 - *Game AI* : Christopher Strachey wrote a checkers program and Dietrich Prinz wrote one for chess
- 1956 - *The birth of AI* : John McCarthy coined the term 'Artificial Intelligence' in 1956 at the Dartmouth conference
- 1959 - *First AI Laboratory* : MIT AI Lab was first set up in 1959
- 1960 - *General Motor's Robot* : First robot was introduced to GM assembly line
- 1961 - *First Chatbot* : The first AI chatbot called ELIZA was introduced in 1961
- 1997 - *IBM Deep Blue* : IBM's Deep Blue beats champion Garry Kasparov in the game of chess
- 2005 - *DARPA Grand Challenge* : Stanforf Racing Team's autonomous robotic car, Stanley wins the 2005 DARPA Grand Challenge
- 2011 - *IBM Watson* : IBM's question answering system, Watson, defeated two greatest jeopardy! Champions, Brad Rutter and Ken Jennings

Types of Artificial Intelligence

Artificial Narrow Intelligence (ANI): Also known as weak AI involves applying AI only to specific tasks. *e.g.,* Alexa, Siri, Sofia, Self-driving cars.

Artificial General Intelligence (AGI): Also known as a strong AI involves machines that possess the ability to perform any intellectual task that a human being can. *e.g.,* Robots in Agriculture.

Artificial Super Intelligence (ASI): It is a term referring to the time when the capability of computers will surpass humans.

Sub areas of artificial intelligence: Expert systems (ES), Internet of things (IoT), Cloud computing, Machine learning, Robotics, Computer vision, Natural language processing, Deep learning, Natural language processing, Automated reasoning, Speech recognition and Knowledge representations.

Expert Systems (ES)

Expert systems are computer programmes that imitate the problem-solving behaviour of a subject matter expert in a certain topic, at a high level of human intellect and expertise. It's also called as knowledge-based system (KBS).

Expert systems in agriculture bring together the knowledge of various areas. Plant pathology, entomology, horticulture, and agricultural meteorology, for example, are all integrated into a framework that best serves farmers' individual, on-site needs, which helps farmers in making the optimal decisions for their crops by combining both experimental and experiential information with specialist reasoning skills.

Robots: Field robots work with respect to environment and medium. They change themselves according to the required condition. Mobile robots are those which possess mobility with respect to a medium. The entire system moves with respect to environment.

The most common applications of Agricultural Robots are in : Harvesting Management, Pruning Management, Field Mapping, Weather Tracking and Forecasting, Dairy Farm Management, Soil Management, Irrigation Management and Inventory Management. Harvesting and picking is one of the most prevalent robotic applications in agriculture. This is because of the precision and speed that robots can achieve to improve yield size and reduce wastage. To counter this problem, mounted sensors and cameras are used to monitor crops on their growth and alert farmers on their smartphones, in case of troubleshooting or to notify about the best time to harvest. Companies like AgriBotix have already commercialized that analyses drone captured infrared images to spot unhealthy vegetation. The farmer is alerted on his device when the troubled area is identified.

Types of Robots used in Agriculture : Demeter (used for harvesting), Robot for weed control, Robot Gantry, Tree Robot, Forester robot and Fruit picking robot.

Artificial intelligence and Robots in Agriculture
Sowing advisory app

In India, agriculture in general is a gamble with the monsoon. Any delay in the onset of the rainy season can adversely affect the harvests, yields and subsequent profits. The cooperation of Microsoft India (R&D) Pvt. Ltd. with International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and a local community in south- eastern Indian state of Andhra Pradesh under the project Andhra Pradesh (AP) Primary Sector Mission (Rythu Kosam Project) aims at addressing this problem by making use of advanced analytics and cloud-based machine learning to build a customized advisory dashboard for 4000 farmers in 106 villages and a sowing app for 175 farmers equipped with simple SMS enabled phones. Farmers can access advices through mobile app for the region (Anonymous, 2017).

Selection of Suitable Varieties / Hybrids

Selection of suitable variety is very important in order to achieve good yields because, the same variety / hybrid may not be suitable for all the agroclimatic zones due to variation in climate, soil type, season / time of sowing, the situation in which the crop is sown (irrigated / rainfed) etc.

Fig. 1: Types of Robots used in Agriculture

Ravisankar *et al.* (2018) developed an online ES for selection of suitable tobacco varieties at ICAR-Central Tobacco Research Institute, Rajahmundry (AP). In India, they looked at 93 tobacco varieties that had been released, as well as three cultivars that had been recognised for commercial production in 10 different types of tobacco grown in distinct agro-climatic areas. To make this information available to researchers, farmers, and students, an online expert system on tobacco varieties was created with the AGRI Daksh tool, which is aimed to create a knowledge base of all crops on a single platform for worldwide access. The knowledge model was built using information on tobacco varieties provided by domain specialists in the tobacco crop. The created system holds a knowledge base of tobacco types with various parameters that may be updated as needed by specialists. Users can access this through user-friendly menus and an ontology-based inference engine *via* the internet from any location and at any time.

Marwaha (2014) in New Delhi developed an online expert system by using AGRI daksh tool for selection of suitable maize varieties for a particular location, where the user need respond to the questions asked by the Expert Systems in order to select a suitable variety of maize varieties along with the grain type, grain colour and average yield.

Kumar *et al.* (2018) in Varanasi, Uttar Pradesh studied on 'Design and implementation of web-based expert tool for selection of climate resilient rapeseed-mustard varieties'. They have named that tool as a Rapeseed-Mustered select (RM select). For development of knowledge base, they have classified percentage of varieties mainly by considering three parameters.

NADAMS (National Agricultural Drought Assessment and Monitoring System)

During the *kharif* season (June-October), it provides near real-time assessment of agricultural drought at the district and sub-district level in terms of prevalence, severity, and persistence, as well as monthly drought reports to the Ministry of Agriculture and State Departments of Agriculture and Relief of various states. Drought data is used efficiently for disaster preparedness and the drought declaration procedure. It was developed by Indian Space Research Organization (ISRO) and from the year 2012, the NADAMS project is being implemented by the MNCFC (Mahala Nobis National Crop Forecast Centre). It envisaged use of remote sensing, moisture availability index (MAI) and meteorological data. Monthly Drought Reports (June to October) are sent to concerned state departments and national level government agencies and are also available in public domain (www.ncfc.gov.in). Many States regularly use

MNCFC's Drought reports for drought declaration in the state.

A group of researchers in the year 2019 at ISRO studied on assessment of drought through NADAMS and shown in Fig. 2. Firstly, the drought assessment is to be done only based on rainfall data, in some cases the socio-economic indicators (community ponds) can also be taken in to consideration. If the drought is not there then it is declared as no drought (drought trigger 1). If drought is there, as the second step three among the four parameters. *viz*., RS data like NDVI and NDWI, soil moisture data, hydrological data and crop sown data are considered and the drought condition is categorized as normal, moderate or severe. If the drought is there then ground truth verification is done. If the RS data compared with ground truthing is more than 90 per cent accurate, then NADAMS can be employed for drought assessment (drought trigger 2).

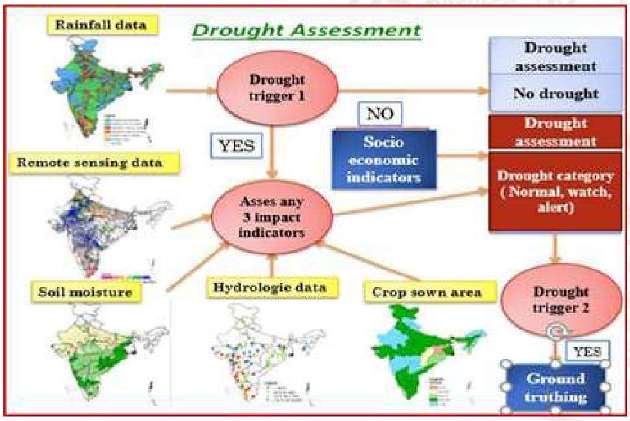


Fig. 2: Drought assessment through NADAMS

Automatic Seed Sowing Robot

Kumar and Ashok (2020) developed an Automatic Seed Sowing Robot, which consists of a single robotic arm that sows seeds from a seed container. Using a cleverly built mechanical mechanism, this technology totally automates the seed sowing procedure. This robot saves time and money by reducing the effort and overall cost of sowing seeds. In comparison to other seeds of other crops, it was found that sesame seed sowing took the most time. This was due to the shape and size of the sesame seed which made it tough to grasp.

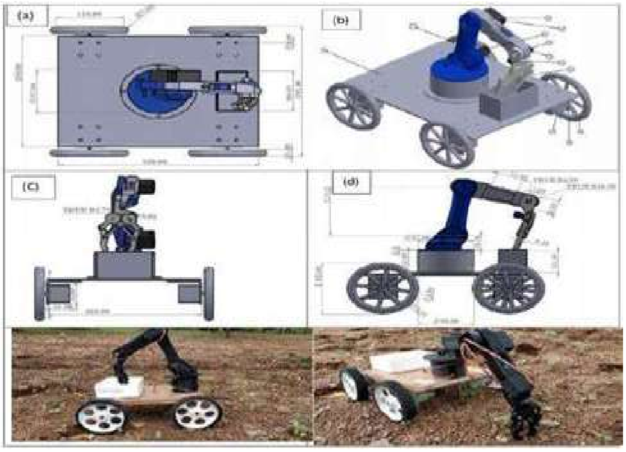


Fig. 3 : Three-dimensional CAD model of the different components of Smart seed sowing robot and actual 3D printed robot (a) Top view of the smart robot, b) Isometric view of the smart robot, (c) Front view of the smart robot, (d) Side view of the smart robot, (e) and (f) Testing of the fabricated robot in the field

Irrigation

Water usage is indispensable for carrying out agricultural activities. However, with the application of advanced technologies like IoT (Internet of Things) or DSS (Decision Support System) based irrigation water management, the indiscriminate use of this stressed resource can be avoided. It is therefore, no surprise that precision farming has set an undeviating focus on scientific water management to increase crop yield.

Agriculture absorbs 85 per cent of the world's available freshwater resources. And this fraction is progressively rising in tandem with population expansion and rising food demand. As a result, we need to develop more efficient methods to ensure higher irrigation efficiency. Automatic irrigation scheduling systems have replaced manual irrigation based on soil water monitoring. While implementing autonomous irrigation equipment, the plant evapotranspiration was taken into account, which is based on many climatic characteristics such as humidity, wind speed, solar radiation, and even crop aspects such as stage of growth, plant density, soil attributes and pest.

Kumar (2014) explored the various irrigation systems with the goal of building a system that uses less resources and is more efficient. Fertility meters and pH meters were set up on the field to detect the proportion of the primary ingredients of the soil, such as potassium, phosphorus, and nitrogen, to measure the fertility of the soil. Wireless technology was used to plant automatic plant irrigators on the field for drip irrigation. This strategy ensured soil fertility as well as the efficient use of water resources. Smart irrigation technology is being developed to boost production without the use of man power 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 has been created to facilitate communication and data sharing among nodes in the agricultural field, as well as to the server or cloud, *via* the main network (Shekhar *et al.,* 2017). They created an automated robotic model for detecting moisture content and temperature in Arduino and Raspberry Pi3 boards. The data are collected at regular intervals and transferred to the Arduino micro controller (which is coupled to edge level hardware), which converts the analogue input to digital. The signal is transferred to the Raspberry Pi3 (which is embedded with the KNN algorithm) which then transmits it to Arduino to activate the irrigation water source. The resource will supply the water based on the demand, and it will also update and store the sensor results. Jha *et al.* (2019) also built an automated irrigation system using Arduino technology to reduce the amount of manpower and time spent on irrigation. Savitha and Umamaheshwari (2018) devised the concept of an efficient and automated irrigation system in maize by building remote sensors utilising Arduino technology, which could boost production by 40 per cent.

Zubaidi *et al.* (2019) evaluated the performance of IoT (Internet of Things) based integrated expert water management (IEWM) system. The results revealed that IEWM system recorded higher accuracy (98.7 %) as compared to traditional water management system (87 %). Since, IEWM system is an artificial intelligence based expert system which is integrated with IoT sensors, because of this it's having a high level of human intelligence and expertise which will overcome various complicate issues with the help of applications within the system and works like human experts but respond very quickly as compared to human experts. This IEWS is used for water management at farmland and water tank level which can also be used to alert various abnormal conditions identified in various applications. Chaitra (2020) reported that growth and yield of maize were drastically affected by moisture stress. Also kernel yield was influenced by different levels of irrigation scheduling. The higher kernel yield observed in sensor-based drip irrigation at 25 per cent DASM was due to adequate availability of moisture throughout the crop growth period which might have helped in better nutrient uptake leading to enhancement in yield attributes. Significantly lower grain yield in surface irrigation was associated with lower number of irrigations which created stress at root zone of the crop.

Crop Nutrition

Various new technologies are available to help farmers and crop advisors to make decisions related to nutrient management ranging from soil sampling to fertilizer application and yield measurements. The advanced technologies enhance the ability to fine tune nutrient management decisions and in turn helps in reducing the adverse effect of chemical fertilizers on soil health. Prakasha and Mudalagiriyappa (2018) reported higher gross returns and net returns (Rs.1,91,650 ha^{-1} and Rs.1,38,100 ha^{-1}, respectively) were noticed in application of NPK fertilizers through STCR method for target yield of 11 t ha-1 but higher B: C ratio (3.60) was registered in nitrogen management through GreenSeeker as compared to recommended dose of nitrogen as per package of practices and absolute control.

Basavaraja *et al.* (2020) from AICRP-STCR, Bengaluru center reported the availability of Krishi Ganaka app, both for desktop and mobile app enable in 8 different languages (Kannada, Hindi, English, Tamil, Telegu, Odia, Malayalam and Marathi). Farmers just need to tap on the app then it will take location automatically (latitude and longitude). Later user has to enter their name, survey number, crop to be grown, variety / hybrid, season, soil type, target yield, situation (irrigated/rainfed) and the place. It will give the soil health status (pH, EC, OC and all the other nutrient elements) and recommend the nutrients to be applied (in PDF format) where the farmers can also take the printout of that soil health card. Further, they revealed that, in drylands soil test values should be updated to KrishiGanaka software at least once in 5 years and alternative years in irrigated situations. At present it is developed for complete Tumakuru district and ongoing project for Chamarajanagar, Hassan, Mysore and Kolar districts. The same authors conducted field demonstration trials in farmers field at Tumakuru district and results revealed that the fertilizer recommendation through online STCR approach using KrishiGanaka mobile app recorded significantly higher grain yield of maize (64.38 q/ha) and ragi (44.78 q/ha). Further, increment in grain yield was to the tune of 2.65, 10.0 and 17.3 per cent in maize and 4.9, 20.3 and 27.7 per cent in ragi as compared to offline STCR approach, Recommended dose of Fertilizers (RDF) and farmers practice, respectively. They conducted 6 field trials in maize and 15 trials in ragi. Here, even though the offline STCR method is at par with the online STCR approach, we have to recommend online STCR method. Because in offline STCR method farmer has to analyze soil for its available major nutrients in order to calculate the amount of nutrients to be applied for particular crop which may not be possible for all the farmers in all the cases and it's time consuming too. Whereas, in online STCR approach farmers just need to enter latitude and longitude, his farm details, crop, variety, season and target yield etc., automatically it will give soil health card with the nutrient prescriptions which is very quick and handy for the farmers. Significantly higher grain yield (68.85 q ha^{-1}) and straw yield (74.19 q ha^{-1}) of aerobic rice was recorded in treatment received fertilizer nutrients based on STCR inorganic approach for the targeted yield of 65 q ha^{-1} based on predicted soil test values which was superior compared to package of practice (POP) and low-medium-high (LMH) / soil test laboratory (STL) approach (Bhavya and Basavaraja, 2021).

Pest and Disease Management

Among different plant protection aspects, the yield losses due to damage caused by pest and disease stand second and third, respectively next to weeds. Framers are faced with many challenges in controlling pests and diseases because of the routine arrival of new pests and diseases. The advanced technologies like expert systems may help in making decisions on identification and management of pests and diseases observed from time to time. Whereas, the variable rate applicators enable spot application of pesticides.

e-SAP

Electronic Solutions against Agricultural Pests (e-SAP), is an ICT solution in the field of Plant protection. It is a dedicated system that effectively integrates Mobile communications, Tablet-based technologies and Cloud solutions to bring different players of the agricultural ecosystem including farmers, agricultural universities and policy makers to interact on a single

Fig. 4a & 4b : Soil health card as generated by Krishi Ganaka software in Kannada and English, respectively

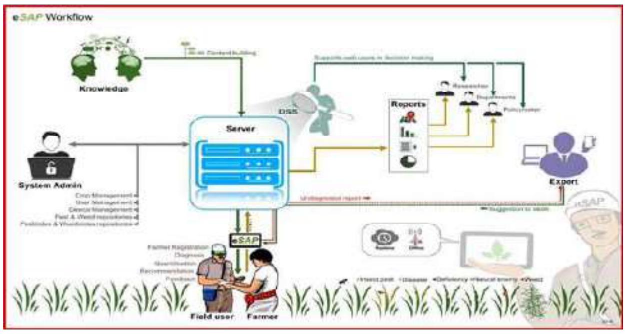


Fig. 5 : Work flow of e-SAP
(Electronic solution against agricultural pests)

Fig. 6 : Steps in work flow of e-SAP
(Electronic solution against agricultural pests)

platform in real time enabling two-way dissemination of real time information strengthening the agricultural sector of a nation (Anonymous, 2019b). The e-SAP uniquely addresses crop health management issue structured with multimedia-based presentation of information in the field devices transcending language and literacy barriers. It is the first solution to enable on-field identification and quantification of pest problem along with instant solutions. It also generates and synthesizes real time data of pest situations of a region (country) and makes it available over its web solution to other players in the agriculture sector. Deployment of e-SAP technology started since January 2013 onwards after pilot scale studies during 2012 under the aegis of University of Agricultural Sciences, Raichur and has spread to all the districts under the Agricultural Universities in Karnataka.

Tewari *et al.* (2020) from West Bengal developed a real-time variable-rate chemical spraying system based on image processing for precision administration of agrochemicals in diseased rice crops based on crop disease severity information. Web cameras for image acquisition, a laptop for image processing, a microcontroller for system control, and solenoid valve aided spraying nozzles were all part of the designed system. The sick zone of paddy plants was detected using a chromatic aberration (CA) based image segmentation algorithm. The system then estimated the disease severity level of paddy plants, based on which the solenoid valves were left open for a certain amount of time, allowing the required amount of agrochemical to be sprayed on the diseased rice plants. The variable-rate application (VRA) and continuous-rate application (CRA) modes of the designed sprayer prototype were tested in the field. When compared to the CRA mode, field testing revealed a minimum 36.65 per cent reduction in applied chemical when operating in the VRA mode. This is due to the fact that the VRA only applied chemicals to disease-infected sections of the plants, whereas the CRA administered chemicals uniformly to all plant parts, resulting in higher chemical consumption in the case of the CRA. As a result, the created approach appears promising and might be utilised to reduce pest management costs as well as environmental contamination caused by such agrochemicals.

Weed Management

Pena *et al.* (2013) assessed weed mapping in early-season maize fields using object-based analysis of Unmanned Aerial Vehicle (UAV) images. The spectral characteristics and general appearance of crop and weed plants are highly similar in the early season and are even more pronounced in remote images. Therefore, the effectiveness of weed discrimination might be increased by taking advantage of the relative position of every plant with reference to the crop row structure. This information can be included in the classification procedure using the OBIA methodology, allowing the combination of spectral, contextual and morphological information, among other features, of the objects created using a procedure known as segmentation. The commercial software eCognition Developer 8 (Trimble GeoSpatial, Munich, Germany) was used to analyze the UAV images and develop an OBIA procedure. The rule set algorithm for weed mapping ran automatically and consisted of three consecutive phases: 1) classification of crop rows, 2) discrimination between crop plants and weeds based on their relative positions and 3) generation of a weed infestation map in a grid structure.

Blue River Technology (See and Spray technology) : Deep learning is being used by some big agricultural firms and their high-tech subsidiaries. In September 2020, John Deere Labs, which started in 2017, paid US$305 million for Blue River Technology, a Sunnyvale, California-based firm. See & Spray, a tractor-mounted device invented by Blue River, uses two colour cameras, computer vision, and a deep-learning algorithm to recognise weeds [pig weed (*Amaranthus palmeri*)] and cotton plants in milliseconds and spray pesticide just on the weeds. Blue River Technology supplied its algorithm precisely annotated, high-resolution photos of cotton plants and weeds at various times of day to train it. 'To account for changing field conditions, the algorithm has to be highly resilient', explains Lee Redden, the company's co-founder and chief technology officer. The more photographs the model 'sees', the better it becomes at identifying plants. Simple elements in plant photos, such as edges and corners, are detected by the model's first computational layers. The following layers can join corners and edges to generate features like leaf margins. Each succeeding layer of the model draws on the previous levels' knowledge. The software gets better at identifying the features that the programmers tell it to look for. When the model incorrectly detects a plant, the programmers note the error and make changes to the model.

Their projects revolve around computer vision, machine learning, and robotics which the company refers to as the eyes, brains and hands of a machine. The front cameras use computer vision and machine learning to make on-the-spot judgment calls, while the rear cameras calibrate the systems for adjustments on the fly which helps in weed identification and precise application of herbicide to the specific weeds. This technology is mainly developed to control pig weed (*Amaranthus palmeri*) in the cotton field. See & Spray is currently in the field-testing stage.

Blue River offers an alternative approach : customizing where herbicides are deployed at the plant level so that they can be sprayed only where they are needed, reducing resistance and creating longer-term viability. According to Blue River, the herbicide usage can be reduced by 90 per cent as compared to conventional method there by the farmer's annual herbicide bills, which are a massive recurring cost, could be reduced by up to 80 per cent that could range from hundreds to thousands of dollars per year.

Harvesting

Onishi *et al.* (2019) used a robot manipulator with a harvesting hand to accomplish automatic fruit harvesting utilising a method of fruit position recognition and harvesting that did not harm the fruit or its tree. They demonstrated that the fruit location of 90 per cent or more can be recognised in 2 seconds using the SSD. One fruit may be gathered in about 16 seconds, according to the suggested fruit harvesting algorithm. Even if it is a close species of apple, the fruit harvesting algorithm provided should work. Furthermore, if one learns the target fruit again, picking fruits like pears could be tried.

Forest Fire Alert

Near Real Time Monitoring of Forest Fire Based on MODIS and SNPP-VIIRS (Forest Survey of India)

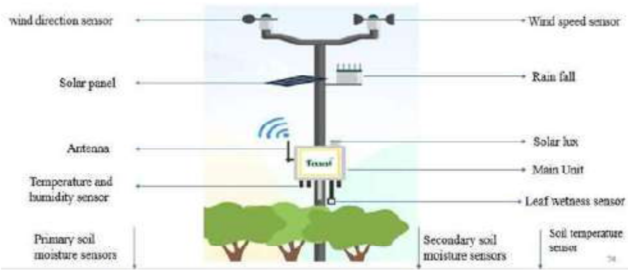
A forest fire, wildfire, wildland fire or rural fire is an uncontrolled fire in an area of combustible vegetation occurring in rural areas. Depending on the type of vegetation present, a wildfire can also be classified more specifically as a brush fire, bushfire (in Australia), desert fire, forest fire, grass fire, hill fire, peat fire and vegetation fire. In the year 2018, 37,059 fires were detected using MODIS (Moderate Resolution Imaging Spectro-radiometer) sensor data. Based on the forest inventory records: 54.40 per cent of forests in India are exposed to occasional fires, 7.49 per cent to moderately frequent fires, 2.40 per cent to high incidence levels and 35.71 per cent of India's forests have not been exposed to fires of any real significance (Forest Survey of India, 2019).

MODIS: The Moderate Resolution Imaging Spectroradiometer (MODIS) is a payload imaging sensor built by Santa Barbara Remote Sensing. It was launched into the Earth's orbit by NASA in 1999 on board the Terra satellite,and in 2002 on board the Aqua satellite. Forest Survey of India has been alerting State Forest Departments about forest fire locations detected by the MODIS sensor on-board Aqua and Terra Satellites of NASA since 2004. As each satellite has two passes over the country daily, fire alerts of 1 km x 1 km resolution pertaining to 10.30 a.m., 1.30 p.m., 10.30 p.m. and 1.30 a.m. are sent to the users.

SNPP-VIIRS : The Visible Infrared Imaging Radiometer Suite (VIIRS) is a sensor designed and manufactured by the Raytheon Company. It was launched into Earth orbit by NASA on October 28, 2011 on board Suomi National Polar-orbiting Partnership (SNPP) and weather satellites. From the year 2017, FSI has incorporated another sensor, SNPP-VIIRS into its second version Forest fire alerting system. SNPP-VIIRS has spatial resolution of 375 m and two equatorial passes at 1.30 a.m. and 1.30 p.m. It has a better night time detection capability as compared to MODIS and can also detect small fire and under canopy fire.

Fasal Software

Fasal : An agri-tech platform, developed by Wolkus Technology Solutions, is an AI-powered platform for the Agriculture ecosystem. Fasal is a horticulture / Plantation specific solution, providing farm level crop - specific and crop - stage specific actionable intelligence in local language. This Product is an IoT device equipped with various parts like sensors, solar panel, chip etc. which works on a specific algorithm to provide the Advisory services to the farmers.



Chatbots for Farmers

Conversational virtual assistants, often known as chatbots, automate interactions with end users. We can now interpret natural language and communicate with users in a more tailored way using artificial intelligence-powered chatbots and machine learning algorithms. They are mostly equipped for retail, 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.

The agricultural industry has a number of obstacles, including lack of efficient irrigation systems, weeds, crop height issues, and extreme weather. However, with the help of technology, performance could 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. Precision weeding techniques were able to overcome the enormous quantity of crops lost during the weeding procedure. These self-driving robots not only increase productivity, but they also curtail indiscriminate use of pesticides and herbicides. AI can be appropriate and efficacious in agriculture sector as it optimizes the resource use and efficiency and also helps to solve the problem of the scarcity of resource and labour up to an extent of 40%. Smart sensor-based irrigation system saves water nearly 41.43 per cent when compared to the flood irrigation and 13.03 per cent when compared to drip irrigation in paddy cultivation. Weed management through automated robots helps in precise weed management and saving of weedicides to a large extent. Pest management through e-SAP helps in quick assessment and quantification of pest, pesticide recommendation and reduces unnecessary usage of pesticides.

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(*Received :* December 2021 *Accepted :* April 2022)