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Research Article

Artificial Intelligence in Water Management

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With the ever-growing population and the challenges that the human-kind is facing currently such as climate change, poverty and hunger, there is a need of tech-based agriculture that would be highly efficient, productive and sustainable. Artificial intelligence in the present times holds the key for a tech-based revolution in agriculture. Artificial intelligence is basically a branch of computer science that imitates through processes, learning abilities and knowledge management. The core of artificial intelligence lies with artificial neural networks that are at the most similar to human brain neurons and are connected to each other by artificial synapses. Water is one of the major inputs required to crop fields. Optimization of their application is the major aim for most of the agronomic practices, but due to the spatial, temporal variability within crop fields and lack of site-specific information in real time there is a great hindrance to such optimized applications. AI based water management helps in assessing farm fields at their micro-climate levels and make efficient decisions keeping in mind the real crop needs and thus resulting in enhanced productivity levels and resource use efficiency, maximized returns and improved soil health. These technologies integrate historical, real time and forecasted data from various resources to make fruitful decisions. Data can be obtained from different sensors located in the crop fields or through unmanned aerial vehicle mounted spectral camera or through remote sensing. Data obtained as such is transferred to GIS based software to create digital maps which are fed to decision support systems to make efficient decisions or provide optimized input application recommendations. These recommendations are in last forwarded to variable rate applicators for site specific application to achieve sustainable enhanced productivity levels along with natural resource conservation.

INTRODUCTION

There is a need of transition from industrial based farming systems to tech-based farming systems due to several reasons such as increasing population, hunger, poverty and climate change (Linaza *et al.,* 2021). A tech-based farming system will involve a blend of digital technologies such as ICT (Information and Communication Technology) and AI (Artificial Intelligence) that maintains farming operations at precise scales and sustainable levels (Sinwar *et al.,* 2020). With such precise field operations, AI technologies are able to produce higher productivity levels along with minimal impact to the environment.

John McCarthy was a computer scientist who gave the term "Artificial Intelligence" in 1955. Artificial Intelligence which involves the abilities to learn and imitate human thought processes as well as knowledge management as its scope is finding a huge practical application in agricultural sector (Sak and Suchodolska, 2021; Sinwar *et al.,* 2020). The future of AI was reflected in the concept of "Google Tulip" developed by scientists of Wageningen University and Google. The basic functioning of Artificial Intelligence relies heavily on its core i.e., Artificial Neural Networks. Artificial Neural Networks are a network of artificial neurons that are connected to each other by artificial synapses in a highly organized manner.

How does AI work?

Artificial intelligence systems are trained to create meaningful outputs from a defined set of data fed to them. These systems are first trained using descripted data i.e., supervised learning to develop ability to learn something. In near future, if similar data is fed to them, Artificial Intelligence using ANNs create meaningful data from it using their own intelligence (Khare and Seth, 2020).

Technology used in AI and ICT based nutrient and water management systems

- Sensors
- Decision Support Systems
- Variable Rate Applicators

Sensors

Sensors are basically the input generating devices in a system. Sensors can be used to asses physical, chemical

and biological properties from a plant or soil system. Generation of data in real time for various parameters such as nutrients, soil reaction can be done by on-the-go assessment of such parameters and such data is then converted into georeferenced maps. Such sensor-based maps make these technologies suitable for precision nutrient monitoring and management (Adamchuk *et al.,* 2004; Kim *et al.,* 2009).

Mostly two types of sensors are used for measuring soil properties

- Electrochemical sensors
- Electrical and electromagnetic sensors

Electrochemical sensors are used for measuring quantitative and qualitative characteristics of soil chemical properties. measurement of soil chemical properties is done using ion selective electrodes or ion-selective membrane sensors (Adamchuk *et al.,* 2004; Schirrmann and Domsch, 2011).

Electrical and electromagnetic sensors

These sensors measure the soil media's ability to conduct electrical charge. Various soil physical and chemical properties affect soil's ability to carry such charge and measurement of magnitude of such charge help us determine the magnitude of various soil properties (Bah *et al.,* 2012; Adamchuk *et al.,* 2004).

Plant sensors

Measurement of plant properties i.e., spectral reflectance is done mostly using unmanned aerial vehicles, satellites or hand-held instruments. Unmanned Aerial Vehicles are highly preferred for such purposes because of their ability to cover large size farms areas in short spans, no hinderance from clouds, freedom from timing and positioning limitations, and the affordability (Olson and Anderson, 2021).

Decision support systems (DSS)

Decision Support Systems are software-based programs that help to perform complex learning, thinking and analytical tasks in a shorter period of time. Decision Support Systems are fed data by sensors and after analysing using ANNs these systems provide prescriptions to variable rate applicators for input application in crop fields (Mirás-Avalos *et al.,* 2019).

Examples of decision support systems are:

Irrigation advisor and IRRINET

Variable rate technology

Variable rate technology is one of the major methodologies being used in site-specific crop management. Variable rate applicators may be connected to a system based on decision support systems that are either AI or computer-based programs. The goal is to apply inputs as per the recommendation generated by a DSS. The goal is to distinguish the required inputs of fertilizer, seed, pesticides etc., in specific areas (Mirzakhaninafchi *et al.,* 2021).

Artificial intelligence in water management

Artificial Intelligence based efficient and accurate decision-making help farmers to perform different tasks in

Table 1. Types of Unmanned Aerial Vehicles

Airframe	Types	Advantages	Disadvantages
Rotocopter	Quadcopter	Ease of operation	Shorter flight time (about 30 minutes)
	Hexacopter	Better Flight stability	Limited coverage per battery
	Octocopter	Able to move in different directions	
		Little space required for landing and Vertical take-off	
		Higher payload capacity	
Fixed wing	Straight wing	More flight time	Unidirectional movement i.e., straight movement
	Swept wing	More coverage per battery	No ability to hover in place
			Landing requiring more space and Horizontal take off
			Requirement of launcher may be there off take-off
			Lower payload capacity

a disciplined manner and thus improve their income and livelihoods (Khare and Seth, 2020). Efficient decision making involves:

1. Improving crop planning by assessing water balance
2. Optimization of irrigation schedules

With the ability to utilize accessible data in a better way and integrate historical events with real time data and the forecasts available, artificial intelligence helps to have better automation in farm operations and better insights of farm conditions. Such automation and insights help AI systems benefit farmers directly by increasing yield levels (Khare and Seth, 2020).

Assessing the water balance, groundwater availability and surface water availability help in improving crop planning and optimizing irrigation schedules for the involved cropping systems.

Irrigation management using artificial intelligence

Intelligent irrigation system is known to calculate water requirement for a farm based on the real time data and forecasts available for different weather parameters. Similar impact on tomato crop yield (33.3 mg/ha) was observed by irrigation using soil moisture sensors wherein significantly higher yield levels were observed even with reduced amount of irrigation water (125 mm) as compared to sub-surface drip irrigation and fixed time irrigation (Dukes *et al.* 2017). In a field experiment conducted by Migliaccio *et al.* (2010) soil moisture tension-based irrigation schedules were found to be more efficient than set interval irrigation in terms of yield levels (1,23,550 fruit number per hectare) and crop water use efficiency (15701 metric ton/m^3). Blueleaf® is a smartphone application and acts as a decision support system to provide irrigation schedules based on soil, climatic and crop data. Blueleaf® when used to provide irrigation schedules in durum wheat resulted in a grain yield (4.63 t/ha) that was at par with farmer's knowledge even while using a less amount of water (203 mm) (Saab *et al.,* 2019).

CONCLUSION

Tech-based revolution is currently the need of the hour because of climate change, poverty, increasing population and hunger. Artificial intelligence with its capability of automation and perform tasks on its own can tackle much of the problems we are facing currently whereas the problem of data load can be managed using ICTs. Smartphone apps such as Bluleaf app are certain examples of software which automate the farming operations using variable rate applicators. Intelligent irrigation systems are found to be more productive both in terms of enhancing yield levels and saving water when compared to manually controlled irrigation systems. By producing more with least use of resources (water) productivity as well as efficiency per unit input is enhanced which is a desirable trait in times of shrinking resources base.

So, digital technologies are a must in coming times to tackle up the need of increased productivity levels along with least use of resources.

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