Review Article

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Integration of IoT and Modern Technology in Agriculture: A Review

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ABSTRACT

As the world progresses towards the modern era of science, a decrease in the death and disease rate has led to a tremendous increase in the population, which has stressed existing capabilities of resources, one of which is agricultural land and its production capacity. This phenomenon has highlighted the need for more efficient management methods to reduce stress on the field and effectively use the existing land resources. Modern agriculture has witnessed an integration of technology tools like IOT, GPS Monitoring, use of Robotics, Arduino and Drone usage into everyday operations like spraying, seeding, disease monitoring etc and the approach of Precision Farming. These technologies are helping to pave a way for a more efficient, time saving and labor saving farming style and can aid the aging farmer populations. This review aims at giving an insight summary into the modern world of agriculture and a description of the various technologies involved, hinting the way in which technology might show a potential to keep up with the need of the ever-growing global population and also discusses the scope of micro-algae cultivation through integration and implementation of IoT.

Keywords: IOT, Modern Agriculture, Precision Farming, GPS, Drone, Smart Farming, Micro-algae, Algae Biomass, Biomass Monitoring0

INTRODUCTION

Decrease in the death and disease rate has led to a tremendous increase in the population, which has stressed existing capabilities of resources, highlighted the need for more efficient management methods to reduce stress on the field and effectively use the existing land resources. Integration of technology tools like IOT, GPS Monitoring, use of Robotics, Arduino and Drone usage into everyday operations, are helping to pave a way for a more efficient, time saving and labor saving farming style and can aid the aging farmer populations.[5,6] Technologies like drones in military have been adapted into modern agriculture.[7] Livestock management, fertilizer management, green house management are some of the complex tasks that can be easily handled using automation, as part of precision agriculture, close real time monitoring is under taken by automation and IoT. Arduino in agriculture is used in the form IOT in automated circuits to monitor farming more closely and in real time, application of IoT is utilized in gathering, storing and analyzing of data using various sensors and instruments and applying algorithms to suggest the best possible action to be taken by the farmers.[3, 4, 9] Compartmentalization and

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localized management of an agricultural field aims at increasing yield efficiency, reducing chemical inputs and enabling micro-level localized management of a crop field. Modern technology in agriculture will be initially met with hesitation due to challenges like initial high investment costs, learning and handling of technology etc.[16]

Precision framing, IOT, Automation are all tools in the modern age of agriculture which are creating reduction in operation costs for farmers, environmental benefit to the global environment crisis.[16] The immense demand on the agricultural resources to keep up with the population is the major need of the hour, integration of modern technologies and approaches like precision farming in agriculture are shedding a light of hope on the scenario and show promising results.[8]

Although implementation of modern technologies and approaches like precision agriculture will take time to be scaled in the mainstream and come together with various challenges[14, 16,18] but with the help of governing bodies, scientists, and upcoming open minded farmers, when given the proper assurance, financial aid, insurance and guidance will be capable of making these ideas into a reality. The field of micro-algae cultivation for production of bio-fuel and livestock feed will not only provide a path towards a more sustainable future but will also be accelerated and scaled up by the integration of IoT, modern technologies and real time monitoring for cultivation of algal biomass.[13] Incorporation of smart farming methods and technologies in algae farming will also be a significant boost in making a move towards increased biomass achievement.[14]

LITERATURE REVIEW

AUTHOR	TITLE	YEAR	SUMMARY
Subeesh, Mehta	Automation And Digitization Of Agriculture Using Artificial Intelligence And Internet Of Things	2021	Integration Of IoT And AI In Agriculture And It's Advantages
Katre et al.	Farm Automation	2019	Overview Of Automation Technologies
Merwe et al.	Drones In Agriculture	2020	Significance Of UAVs And Their Advantages In Agriculture
Negrete	Arduino In Agriculture And The Teaching Of Mathematics	2023	Relevance And Importance Of Arduino In Modern Farming
Verdouw et al.	Internet Of Things In Agriculture	2016	Applications Of IoT In Agriculture And Iot Based Systems
Dhal et al.	Internet Of Things In Digital Agriculture: An Overview	2023	Upcoming Applications Of IoT In The Modern Age Of Agriculture
Singh et al.	Farm Automation, Ai Edge And Iot Based Smart Agriculture	2022	Integration Of AI And IoT In Modern Agriculture
Meena, Dudwal	Precision Farming; Their Tools And Techniques	2021	Concept Of Precision Farming And Technologies Involved
Abdulshafy	Review On Arduino And Its Application In Agriculture	2023	Introduction Of Arduino And It's Capabilities For Enhancing Agricultural Systems
Barsanti, Gualtieri	Algae: Anatomy, Biochemistry, And Biotechnology. Second Edition	2014	Algae Anatomy And Zoology
Borowitzka	High-Value Products From Micro-Algae. Their Development And Commercialization	2013	Overview Of Commercial Importance Of Micro-Algae

AUTHOR	TITLE	YEAR	SUMMARY
Hermadi et al.	Development Of Smart Algae Pond System For Microalgae Biomass Production	2021	Pilot Study On Effectiveness Of Integration Of IoT, Real Time Monitoring And Smart Control System For Efficient And Increased Algae Cultivation
El-Moustaqim et al.	Enabling Smart Agriculture Through Integrating The Internet Of Things In Micro-algae Farming For Sustainability	2024	Stages Involved In a Move Towards Smart Algae Farming Using IoT And Current Scenario And Benefits Of Adoption Of Smart Farming
Lim et al.	Smart Microalgae Farming With Internet-Of Things For Sustainable Agriculture	2022	Implementation Of IoT In Micro-algae Farming and Technologies And Challenges Involved
Shinde et al.	Iot Based Detection Of Microbial Activity In Raw Milk By Using Intel Galileo Gen II	2017	IoT And Gas Sensor Detection System For Microbial Load In Raw Milk
Sharma	Precision Agriculture: Reviewing The Advancements, Technologies, And Applications In Precision Agriculture For Improved Crop Productivity And Resource Management	2023	Methods And Practices In Precision Agriculture
Broom	Coronavirus Has Exposed The Digital Divide	2020	Overview Of Internet's Role During Covid-19 And The Uneven Distribution Of Internet Facilities Among Developed And Developing Countries
Dhanaraju et al.	Smart Farming: Internet of Things (IoT)-Based Sustainable Agriculture	2022	Methods, Technologies And Challenges Of IoT Based Agriculture

AUTOMATION IN AGRICULTURE: DRONES, LIVESTOCK MONITORING, FERTILIZER MANAGEMENT AND GREEN HOUSE MANAGEMENT

Automation using upcoming technologies developed initially for non agricultural applications like the use of drones in military has greatly been adapted into modern agriculture and is proving to be significantly effective in management of farm resources and increase of yield. Drones are Unmanned Aerial Vehicles which are controlled via remote and are used for overhead monitoring and assessment of field health via aerial imagery or by modifying them into precision chemical sprayers for agricultural applications. The data from drones is remotely transmitted and upon analysis the desired outcome can be programmed.[1] The general simplified flow of automation and monitoring is as follows:

- **Input** of signal from sensors like moisture sensor, temperature sensor etc
- Comparison of values with set and desired values
- **Suitable Output** to achieve the desired values, for example, switching on of water sprayer to regulate temperature
- **Data Monitored,** stored and analyzed using **Machine Learning and AI**[2]

Livestock management, fertilizer management, green house management are some of the complex tasks that can be easily handled using automation, for example in livestock monitoring, animal data using smart collars is transferred to the data

devices which then compare parameters and alert the farm owner about potential risks or stresses in animals and transmit vital physiological data, meaning in the area of pesticide management data analyzed using aerial footage and density maps can guide farmers how to correct the quantity for a particular segment of land as part of precision agriculture, similarly close real time monitoring of green house vital parameters are under taken by automation and IoT which control climate based on real time data.[3]

ARDUINO

Arduino is a micro-controller that is Open Source and used for controlling simple operations using a programmable integrated circuit board and a software. Arduino takes simple inputs in the form of data from sensors to give a suitable output to another piece of hardware to perform a command. Arduino in agriculture is used in the form IoT in automated circuits to monitor farming more closely and in real time.[9] The open-source nature makes it easily modifiable for researchers to work and experiment with. Arduino is actively utilized in experimental and modern agriculture in a smart tailored manner, for example tailored field irrigation according to moisture levels in soil which are measured using soil moisture probe sensors and data integrated and sent to systems like the Raspberry Pie.[4] The inputs from the senors embedded in crucial systems like temperature and moisture send signals as input and then the Arduino, depending upon the programming, transmits output signals to various mechanisms like water spray systems etc to maintain stable and desired programmed conditions.[3]

IoT

IoT, Internet of Things, In agriculture, application of IoT is utilized in gathering, storing and analyzing of data using various sensors and instruments and applying algorithms to suggest the best possible action to be taken by the farmers. The data is processed via the intermingling of devices working in tandem (Arduino, temperature sensors, moisture sensors and various others) to suggest suitable steps or even initiate suitable measures. Application of IoT in agriculture includes smart irrigation, drones, livestock monitoring, tank level monitoring and greenhouse management.[5,6] Drones, Unmanned Aerial Vehicles are used in agriculture as a part of the IOT approach of farming and are used as aerial seeding devices, aerial spraying devices, aerial imaging in the form of remote sensing.[7] Aerial imaging is an essential element of modern agriculture so that the farmer can effectively drop seeds, monitor crop health, aerial observation of crop patterns etc and the Data is used for take corrective action.

PRECISION FARMING

Precision farming is an approach of farming that is aimed at compartmentalization and localized management of an agricultural field that aims at increasing yield efficiency, reducing chemical inputs and enabling micro-level localized management of a crop field. This is essential as yield throughout the field is not evenly distributed and each area of an agricultural field is unique and needs individualistic approach. Precision farming evaluates field segments by dividing the field into grids and through the use of modern technology like Global Positioning System, Geographic Information System, Soil Maps, Moisture Maps, Nutrient Maps based on testing of individual samples collected from different grids of the field.[16] Global Positioning System sensors can be mounted locally on tractors or posts and create a grid map with GPS information of each segment of the field and combined with data of yield maps which are created by sensors fixed on harvesters and can sense the flow of grains creating a quantification of the yield being harvested from each area of the field. Remote Sensing is the use of overhead satellite or aerial images taken from aircraft that are used for assessing field health and can be accurate for telling factors like crop pest patterns, plant stress will in advanced. Variable Rate Fertilizer technology controls the spray of fertilizer on crops by correlating GPS data and field soil map to deliver a variable quantity throughout the field as per need.[8]

MICRO-ALGAE FARMING AND MICROBIAL TESTING IN RAW MILK

Micro-algae are microscopic, auto-tropic, photosynthetic, oxygen producing organisms[10]

that offer a wide range of consumer benefits either as food products like *Spirullina species,* bio-fuel production, production of lipids, metabolites and as livestock feed so are of commercial value and provide a more sustainable alternative to conventional sources of food and feed.[11] Micro-algae cultivation through integration of a system of sensors and actuators in a pilot experiment designed by Hermadi *et al*.[12] in 2021 of a raceway cultivation pond incorporated the use of an automated paddle wheel system (which operates according to the intensity of sunlight received for photosynthetic reactions), pH sensor and an automated harvesting system through the detection of turbidity (which was found to be correlated with algal biomass) showed reduced and more efficient use of power resources and positive effects in yield of algal bloom, appropriate time for collection was determined through the use of optical density (OD) as a measure. A positive correlation relationship was found between the algal biomass and the optical density, through which an equation was formed.

Micro-algae cultivation is an intricate farming process that has an important need for frequent and constant monitoring of algal biomass and tweaking of various parameters and physiological conditions continuously in order for cultivating micro-algae in a bioreactor setting. Integration of smart farming methods and technologies in algae farming will be a significant beneficial factor in making a move towards increased biomass achievement.[13] Traditional cultivation of micro-algae in open pond systems has numerous vulnerabilities like change in temperature and pH by environmental influences and requires a labour intensive manual monitoring of algal biomass daily. IoT integration will greatly enhance real time monitoring, efficient production of algal bloom farming, reduction of electricity costs and environmental pressure. Monitoring of parameters like pH, nutrient and biomass concentration still continue to be expensive.[14] IoT systems are also being experimented for use in the milk industry for assessing the microbial quality of milk. Galileo Gen 2 system incorporated with TGS gas sensors is an idea established used to assess the microbial activity in raw milk and the data stored on servers that can be assessed by logging in.[15]

CHALLENGES

Adoption of modern technology in agriculture is initially met with hesitation on the part of the farmers as the farmer cannot afford to experiment with a new approach and prefer to continue with the traditional approaches which they have known for years, second challenge is the initial high investment cost of technologies which is not able to be borne by most farmers. The learning of handling and effective utilization of technology by the producers will also take time,[16] in the case of developing countries a major portion of the population is dependent on agricultural employment thus integration of technology will eliminate need for human labour and input by a large fraction thus threatening the employment sector and taking away livelihood[18] as well as the lack of internet access is a major hurdle in the implementation of IoT in developing countries.[14,17] Maintenance of sophisticated systems and storage of equipment like UAVs needs additional space and protection from the elements thus requiring more capital. In certain areas vandalism and investment of technology for farmers who are working on rented land is also a challenging point.

CONCLUSION

Precision framing, IoT, Automation are all tools and applications of technology in the modern age of agriculture which are aimed at creating reduction in operation costs for farmers by working on the concept of local, need based farming control instead of a general blanket farm management strategy, which is the main driving force of the concept. In addition to reduced of long term costs, environmental benefits are a huge boon to the global environment crisis and can drastically increase the population health, Eco-system health and the planet health. As the population rises the immense demand on the agricultural resources to keep up with the population is the major need of the hour, integration of modern technologies and approaches like precision farming in agriculture are shedding a light of hope on the

scenario and show promising results. Although implementation of modern technologies and approaches like precision agriculture will take time to be scaled in the mainstream but with the help of governing bodies, scientists, and upcoming open minded farmers, when given the proper assurance, financial aid, insurance and guidance will be capable of making these ideas into a reality.

CONFLICT OF INTEREST

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The author of this review article has solely researched, sourced, accumulated, read the literature needed for the writing of this article, searched for a suitable journal and submitted the article.

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