e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
Volume:02/Issue:09/September -2020 Impact Factor- 5.354 www.irjmets.com

# PRECISION AGRICULTURE: A REVIEW ON ITS TECHNIQUES AND TECHNOLOGIES

**Apeksha Ravi Kumar*1, Divya T.M*2, Lekha Yadav B*3, Jayasudha B S K*4, P.N. Sudha*5**

*1, 2,3,4,5 Department of Electronics and Communication, KS Institute of Technology, Bangalore, Karnataka, India

## ABSTRACT

The population has always been a major factor that has led to the growing need for improvements in the field of agriculture. As the population throughout the world keeps increasing every year, the demand for food also increases. This paper mainly focuses on some of the techniques and technologies that help improve the effectiveness and sustainability of farming. A modern farming method such as Precision Agriculture has been considered in this paper. Hydroponics, Aquaponics, and Aeroponics are the soil-less farming techniques discussed to increase the production of crops at a faster rate. These techniques prove to be better than soil-based farming as the amount of water, space, and electricity consumed is lesser. Since precision agriculture is technology-driven it uses technologies such as GPS, GIS, and IoT based irrigation systems. These technologies help set new businesses for small scale farmers, as farmers gain the ability to make the right decisions. In order to enhance the techniques and technologies in precision agriculture, we make use of smart farming. Smart farming makes use of digital technologies like Big Data, IoT, Cloud computing, and Blockchain. The usage of these technologies helps in collecting, analyzing, filtering data and ensuring increase in food quality and security.

**Keywords:** Soil-less farming, IoT, Hydroponics, Aquaponics, Aeroponics, Smart farming.

## I. INTRODUCTION

It is being said that by the year 2050, even with moderate growth in the economy, population growth will stimulate demand for food and more than 70% of food must be produced as compared to today [1]. Hence, the adoption of new agricultural technologies and practices has been considered one of the effective means for acquiring economic growth and agricultural evolution. To provide a stable food supply efficiently, modern farming practices like precision agriculture is implemented. We must also keep in mind that as food productivity increases the available resources must be used effectively. Some of the resource-conserving techniques that can be used in precision agriculture are aquaponics, hydroponics, and aeroponics. These techniques consume less water and space. Along with these techniques, some of the technologies that define precision agriculture are GPS, GIS, and Irrigation systems. The use of just these technologies is not enough to reach the goal of efficient farming; it also requires proper data management.

Data management provides information to the farmers that allow them to monitor and analyse their fields better. With the pressures of increasing food demand, industry leaders are seeking assistance from technology forces such as Big data, IoT, cloud computing, and blockchain.

This paper mainly discusses some of the techniques and technologies used in precision agriculture as mentioned above.

## II. PRECISION AGRICULTURE

Precision agriculture is an agricultural process that is technology-driven to reduce any wastage of resources and focuses on increasing the crop yield by helping the farmers make better decisions to improve the efficiency of farming.

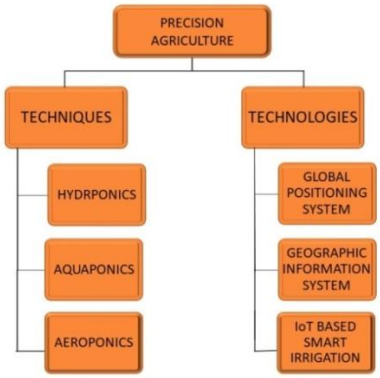


**Figure 1:** Precision argiculture techniques and technologies.

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
Volume:02/Issue:09/September -2020 Impact Factor- 5.354 www.irjmets.com

Precision agriculture can be divided into two parts, one emphasizing the techniques used and the other on the technologies incorporated.

**PART I: PRECISION FARMING TECHNIQUES**

***A. Hydroponics***

As we know that with an increase in population, there is a decrease in land needed for cultivation. To overcome this requirement the method of hydroponics is being adopted. Hydroponics is a technology where plants are grown in water instead of soil. This technique is preferred because water has all the nutrients that are required for plant growth and unlike soil, it does not consist of any chemicals [2]. And by research, it is also shown that plants grown with hydroculture require fewer resources as compared to traditional growing methods and are also of good quality. This method of growing plants using hydroponics is faster compared to soil. The quality of the output is controlled and it also increases the nutrient content in the plants. It also eliminates the threat of pests [3].

Hydroponics uses many techniques such as Deep Flow Technique (DFT), Dynamic Root Floating (DRF) technique, Nutrient Film Technique (NFT), etc. which enhances the plant growth.

Some of the important parameters that must be considered while practicing the technique of Hydroponics are [4]:

•Nutrient solution: Plants that are grown without soil also require essential elements such as nitrogen, calcium, sulphur, iron, etc. But the requirements of the quantities in which these elements are needed for the plants does not change irrespective of whether they are grown in soil or water. So, the concentration of all the elements in the nutrient solution must be maintained.

•pH level: The pH of the nutrient solution is what controls the availably of all the essential elements of the plants. The pH usually depends on the species of plant that is being cultured.

•Electrical conductivity: An ideal electrical conductivity must be maintained to obtain quality output. Imbalance of the electrical conductivity may obstruct the intake of the nutrients.

All these parameters such as controlling pH level, temperature, humidity, amount of nutrient solution in hydroponics system requires the farmers to collect the data, check the statistics, and perform analysis. This can be done with the help of IoT. This also makes it easier for the farmers to trace the present situation of the crops [2].

Figure 2 shows coriander being grown hydroponically indoors.

**Figure 2:** Hydroponically grown coriander.

***B. Aquaponics***

An agricultural method that integrates the benefits of hydroponics and aquaculture is known as aquaponics. It is sustainable farming with low consumption of water, no fertilizer utilization, and eco-friendliness. The basic idea of aquaponics is that the waste produced by the fish feeds the plant, and freshwater is returned to the fish tank. In this process, biofilter-media is necessary for aquaponics because nitrifying bacteria break nitrates on the surface of the media. The second essential component is that grow beds where plants grow [5]. They have media-filled filtration, which provides the foundation for plants and their ability to effectively drain nutrient-rich water. The deep root system is also included in this method where is responsible for clean water. Radial flow filter is used to remove the messy substances from the water and re-circulated to the aquaculture. It is a

closed-loop production system. Usually, aquaponics is the potential for growing leafy vegetables because low and medium nutrients obtain from nitrates. Other factors involved in the aquaponics are pH value which preferably 6.5-7.0 which is the more alkaline environment and it controls all the kind of the nutrients, the temperature should be consistent for fish health and humidity of the aquaponics [6]. This method of growing plants is faster than traditional growing plants. In this way, aquaponics allows food security, water conversation, and more crop production.

### *C. Aeroponics*

Aeroponics is another soil-less method of growing plants that can be considered similar to hydroponics, but this method does not require any growing medium. The roots of the plants are kept in growth chambers, where they are left to hang in the air. The growth chambers are used to prevent the roots from being exposed to light and they consist of misting devices that are used to mist a solution onto the roots. This solution contains nutrients that are required for plant growth. The remaining portion of the plant above the root is not included inside the growth chamber. Since the roots are exposed completely to oxygen, the plants grow much more quickly than compared to the plants that are grown using traditional farming methods. Also, the roots absorb maximum nutrients so there is no wastage of nutrients [7].

Aeroponics is excellent for indoor farming and is one of the methods used in vertical farming. It consumes less water and space and can provide more crops within the minimal space (According to AgriHouse, growers choosing to employ the aeroponics method can reduce water usage by 98%, fertilizer usage by 60%, and pesticide usage by 100%, all while maximizing their crop yields by 45%-75%) [8].

To ensure efficient yield, some parameters have to be taken into consideration like nutrient and air temperatures, oxygen (O2) and carbon dioxide (CO2) concentrations, pH, EC concentration, humidity, and light intensity [9]. These parameters can be monitored and controlled using sensors and actuators. The role of the sensors is to collect all the information on the various parameters, including any changes in the value of the standard ranges. This information is given to the actuators, which are used to control the changes observed. It is important to make sure that the exact parameter ranges are followed to avoid any harm to the plants [9].

### *Soil-less and Soil-based farming*

Due to the increase in urbanization globally, the availability of land for cultivating crops has reduced. This is one of the main reasons that have led to the practice of soil-less farming.

Soil-less farming is preferred over soil-based farming for numerous reasons, some of them being:

1. The percentage of water saved by soil-less farming is around 87% compared to soil-based farming.
2. In soil-less farming, the crop yield is higher since there is an increase in the growth rate.
3. Plants grown using soil-less farming have greater nutrient content as fewer fertilizers are used.
4. By implementing soil-less vertical farming a considerable amount of space is saved when compared to traditional soil-based farming.
5. Soil-less farming need not depend on soil fertility.
6. Watering plants can be managed with the help of sensors; as a result, no labor is required for monitoring the water supply.

Table 1 shows four plants that are commonly grown using hydroponics, aquaponics and aeroponics, along with a few of the required parameters.

**Table 1.** Parameters of common plants grown in soil-less techniques

| Parameters | | Growth time | Temp. | pH | Sunlight required/ day |
|---|---|---|---|---|---|
| Lettuce | Hydroponics | 1-2 months | 68-75°F | 6.0-7.0 | 10-14 hours |
| | Aquaponics | 1 month | 70-74°F | 5.5-6.5 | |
| | Aeroponics | 28 days | 55-65°F | 5.8-6.3 | 6-8 hours |
| Tomatoes | Hydroponics | 1-2 months | 55-85°F | 5.5-6.5 | 8-10 hours |
| | Aquaponics | 8 weeks | 65-85°F | 5.6-6.8 | 4-6 hours |
| | Aeroponics | 1 month | 60-65°F | 5.5-6.0 | 8-10 hours |
| Pepper | Hydroponics | 3 | 65-80°F | 5.5-7.0 | 6-8 hours |

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
Volume:02/Issue:09/September -2020 Impact Factor- 5.354 www.irjmets.com

| | | | | | |
|---|---|---|---|---|---|
| | | months | | | |
| | Aquaponics | 2-3 months | 57-83°F | 5.5-6.6 | Full day |
| | Aeroponics | 1-2 months | 65-75°F | 5.5-6.5 | Full day |
| Basil | Hydroponics | 1 month | 65-80°F | 5.8-6.2 | 10-12 hours |
| | Aquaponics | 6 weeks | 60-80°F | 5.5-6.5 | Full day partially exposed |
| | Aeroponics | 6 weeks | 65-80°F | 5.5-7.0 | Full day |

**PART II: PRECISION FARMING TECHNOLOGIES**

***A. Global Positioning System (GPS)***

Global Positioning System (GPS) enables the users to determine the absolute or relative location of a feature on or above the earth's surface.

GPS orbiting around the earth at an altitude of 12,550 miles, these satellites are in predictable locations; hence, we refer to the system of satellites as the GPS constellation. Precision agriculture is an integrated crop management system that endeavors to match the kind and amplitude of inputs with the genuine crop needs for minute areas within a farm field [10]. GPS sanctions farmers to work during low overtness field conditions such as rain, dust. GPS has withal given ascend to field mapping which is a system for computer availed field data amassment that takes several factors into account such as inventory of crop types, ascension levels, field boundaries, nearby roads, irrigation systems, etc. The precision of GPS sanctions farmers to engender farm maps with precise acreage for field areas, road locations, and distances between points of interest. GPS sanctions farmers to accurately navigate to categorical locations in the field, year after year, to accumulate soil samples or monitor crop conditions [11]. The tractor guidance sets off, steering automatically. It moves up and down the field utilizing the minimum quantity of fuel. And virtually none of the seed is misplaced. The earth is orbited by 24 different GPS satellites. Computer vision will permit appropriate pesticide use & weeds and crops can be more easily differentiated. The object of soil sampling was to determine the average soil test level for the field. The result is the faculty to apply fertilizers in areas where utilization will be maximized and dollars spent minimized.

Individual map layers can be engendered for each nutrient. Advantage of GPS is providing better farm records essential for sale and succession.t is a novel method which guides farmer for better agriculture and farming. It provides better information for management decisions.

***B. Geographic Information System (GIS)***

Geographic Information System (GIS) is extensively used in the field of agriculture. GIS collects, manages, and analyzes data provided by geographically obtained information. GIS mainly focuses on analyzing spatial data which is nothing but the information based on geographic space. This spatial data is handled by GIS, which provides data management, manipulation, and analysis [12][13].

There are five main components required for the working of GIS; these components are [14]:

a. Hardware – Hardware comprises of the system a GIS operates on. GIS can run on the hardware used at the industrial level as well as the individual computers present in the office of an agricultural field manager.

b. Software – To store, analyze, and display the geographic information obtained, GIS requires software. The components of software include database management system (DBMS), graphical user interface (GUI), and tools for manipulation, supporting queries, analysis, and visualization of geographic information.

c. People – People are required for managing the GIS systems and for applying the developed plans.

d. Methods – Well-designed plans and methods are necessary for the successful operation of GIS. These methods differ from each industry, farm, or organization.

e. Data – Data is the most important component of GIS. GIS makes use of spatial data. The data is what gives the required information and is used for manipulation and analysis. DBMS is utilized to organize and manage the data.

GIS helps farmers manage the resources in their land which increases crop production at a reduced cost.

***C. IoT Based Smart Irrigation***

Water scarcity has now become a global problem exceptionally in the Mediterranean countries. The agricultural sector is largely being affected by this. Hence a few smart irrigation techniques are adopted and

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
Volume:02/Issue:09/September -2020 Impact Factor- 5.354 www.irjmets.com

practiced. Commercial sensors for agricultural irrigation being one of the techniques are very expensive for smaller farmers. However low-cost sensors have now come into the picture that is easily affordable and used for irrigation management and agricultural monitoring [15]. IoT nodes such as Arduino boards are utilized for IoT based irrigation systems.

As obtained from the paper [16], with the help of soil moisture sensors the status of the moisture content in the soil is obtained. Using this technique of smart irrigation, the water sprinkler is automatically switched on/off. This technique minimizes water wastage. In the absence of such a technique, excess water can drain deep into the soil layers. This pollutes the groundwater as the excess water reaches the root sector which consists of vital nutrients. The latter may bring about under irrigation which generates a big reduction in the crop quality as well as quantity [17]. Sensors are being used in various aspects of agriculture such as water management, soil monitoring, weather monitoring, etc.

All these techniques enable farmers to produce high-quality food, in a short period with high crop yield.

## III. SMART FARMING

Smart farming is a concept that uses digital technologies, that supports farmers to make better decisions. Some of the technologies involved in smart farming are mentioned below.

### *A. Big Data*

In the current world of technology, the conceptualization of big data is being made in the agricultural sector as well. During field management, a massive amount of data is produced so it is necessary to implement some technology to extract the functioning information from the bulk data [18]. Hence, the concept of big data is being adopted. Farmer's primary concerns and the possibility of crop failures can be reduced owing to the adoption of big data in agriculture.

In general, the characteristics of big data are given by the five V's (dimensions) [19].

1. Volume: refers to the set of data whose size surpasses the ability of software tools to analyze and manage the information.
2. Velocity: refers to the pace at which the rapidly growing data must be transmitted, stored, and processed. This rapidly growing data may be obtained from various sources like networks, social media sites, mobile devices, etc.
3. Variety: refers to the different forms in which the data is obtained. It may be in the form of images, emails, graphs, etc. The data can be structured or unstructured.
4. Veracity: refers to the accuracy in the data being obtained. Veracity completely depends on the source information. It is the most difficult part of information analysis.
5. Value: refers to the actual valuable information from the bulk data being obtained which helps in inspecting and processing the current situation.

All the above characteristics must be acknowledged to use big data in the field of agriculture.

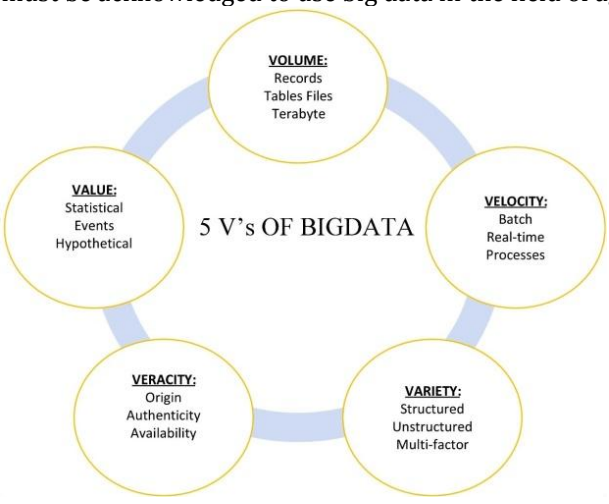


**Figure 3:** The five V's of Big Data.

### *B. IoT and Cloud Computing*

Internet of things (IoT) enables connection to many physical devices like vehicles, buildings, embedded electronics, and sensors to send and receive data. IoT provides device-to-device (D2D) services [20]. The database is collected from many IoT devices and stored in computing services called cloud computing. The

computing service provides more flexibility in processing, analyzing data, and gives better security for the data. Using IoT architecture and cloud computing precision agriculture can be implemented for more crop production. Many IoT nodes are utilized for observing and receive data like temperature, humidity, air, and soil quality, and it is sent to a gateway device which connected to cloud services [21]. The cloud gives a comparative study for the data received from the environment and pre-defined information using these data farmers can utilize proper fertilizers and other chemicals to the crops.
Visualization and management of the data through an app and send it to the application server. Also, IoT and cloud computing is an improved monitoring system, and it is cost-effective.

### *C. Blockchain*

Blockchain records or holds all the transactions made by entrants efficiently. It provides a trustworthy environment for farmers and investors in agriculture. Blockchain builds trust between food supply chains and consumers. Blockchain technology enables better productivity and sustainability [22].
Due to the increasing population, the food market is facing numerous problems like food safety, quality, traceability, and inefficiencies. Blockchain technology helps overcome these issues. It establishes transparency by providing the product information, thereby avoiding any chances of fraud and low-quality products sold to the consumers.
Instead, it encourages suppliers to improve the quality of agricultural products [23].
Blockchain provides a sense of security as the data and information it stores cannot be tampered with. Besides, blockchain also provides agricultural insurances to farmers in the case of any climatic extremities [23].

## IV. CONCLUSION

All the above discussions lead to one conclusion that the adoption of new technologies leads to sustainable and efficient agriculture. Precision agriculture techniques help save resources along with increasing the crop yield. Techniques like Hydroponics, Aquaponics, and Aeroponics consumes less water and space and has a high growth rate compared to traditional farming techniques. Technologies like GPS and GIS help farmers make better decisions based on the data collected and analyzed. IoT based smart irrigation with the help of sensors used for monitoring reduces water wastage. Crops grown using precision agriculture produce a huge amount of data; a technology like Big Data is used to extract beneficial information from the bulk data obtained. IoT and cloud increase agricultural efficiency. Blockchain improves the quality of food by reducing any chances of fraud. These are some of the methods used to help overcome the inefficiencies in farming and helps meet the demands of today's competitive world.

## V. REFERENCES

[1] De Clercq, M., Vats, A., & Biel, A. (2018). Agriculture 4.0: The future of farming technology. Proceedings of the World Government Summit, Dubai, UAE, 11-13.
[2] Tambakhe, M. D., & Gulhane, V. S. (2020). A survey on techniques and technology used in hydroponics system (No. 3628). EasyChair.
[3] Shubham, S. N., & Shrimanth, V. L. A Survey on Hydroponics based Smart Agriculture.
[4] Pradhan, B., & Deo, B. (2019). Soilless farming- the next generation green revolution. Current Science (00113891), 116(5).
[5] Diver, S., & Rinehart, L. (2000). Aquaponics-Integration of hydroponics with aquaculture. Attra.
[6] Sophia Abiezz. Just the pHacts: pH and Aquaponics - Project Feed 1010, 14 November 2016. Available online: http://www.projectfeed1010.com/blog/2016/11/14/just-the-phacts-ph-and-aquaponics/
[7] Lakhiar, I. A., Gao, J., Syed, T. N., Chandio, F. A., Tunio, M. H., Ahmad, F., & Solangi, K. A. (2020). Overview of the aeroponic agriculture–An emerging technology for global food security. *International Journal of Agricultural and Biological Engineering*, *13*(1), 1-10.
[8] Gurley, T. W. (2020). *Aeroponics: Growing Vertical*. CRC Press.
[9] Lakhiar, I. A., Jianmin, G., Syed, T. N., Chandio, F. A., Buttar, N. A., & Qureshi, W. A. (2018). Monitoring and control systems in agriculture using intelligent sensor techniques: A review of the aeroponic system. *Journal of Sensors*, *2018*.
[10] Siddesha S, SK Niranjan, VN Manjunath Aradhya .(2016,November). "Chapter 1: A Study of Different Color Segmentation Techniques for crop Bunch in Arecanut." IGI Gobal.
[11] Agricultural Applications – GPS.gov, 6 March 2018. Available online: https://www.gps.gov/applications/agriculture/
[12] Sharma, R., Kamble, S. S., & Gunasekaran, A. (2018). Big GIS analytics framework for agriculture supply chains: A literature review identifying the current trends and future perspectives. *Computers and Electronics in Agriculture*, *155*, 103-120.

[13] Zhang, F., & Cao, N. (2019, July). Application and Research Progress of Geographic Information System (GIS) in Agriculture. In *2019 8th International Conference on Agro-Geoinformatics (Agro-Geoinformatics)* (pp. 1-5). IEEE.
[14] Leena Kanickaraj. Geographic Information Systems (GIS) Defined, 2 January 2018. Available online: https://www.arcweb.com/blog/geographic-information-systems-gis-defined
[15] García, L., Parra, L., Jimenez, J. M., Lloret, J., & Lorenz, P. (2020). IoT-Based Smart Irrigation Systems: An Overview on the Recent Trends on Sensors and IoT Systems for Irrigation in Precision Agriculture. Sensors, 20(4), 1042.
[16] Ogedengbe, T. I., Eta, O. M., & Ogunbiyi, A. A. (2020). Development of a Model and Sensor Based Smart Irrigation System. Journal of Applied Sciences and Environmental Management, 24(5), 909-915.
[17] Iyer, S., Patro, P., Kapadia, R., Das, A., Cheriyan, S., & Ansari, N. (2020). IoT based Cost- effective Centralised Smart Irrigation System using LoRa. Available at SSRN 3565531.
[18] Saiz-Rubio, V., & Rovira-Más, F. (2020). From smart farming towards agriculture 5.0: a review on crop data management. Agronomy, 10(2), 207.
[19] Arjun, S., Joshi, A., Das, H. P., & Amutha, R. Big Data Analytics for Agricultural Development in India.
[20] Kalyani, V., Gaur, P., & Vats, S. (2015). IoT:'machine to machine'application a future vision. J Manag Eng Inf Technol (JMEIT), 2, 2394-8124.
[21] Mekala, M. S., & Viswanathan, P. (2017, August). A Survey: Smart agriculture IoT with cloud computing. In 2017 international conference on microelectronic devices, circuits and systems (ICMDCS) (pp. 1-7). IEEE.
[22] Kamilaris, A., Fonts, A., & Prenafeta-Boldú, F. X. (2019). The rise of blockchain technology in agriculture and food supply chains. *Trends in Food Science & Technology*, *91*, 640-652.
[23] Hang Xiong, Tobias Dalhaus, Puqing Wang and Jiajin Huang. Blockchain Technology for Agriculture: Applications and Rationale, 21 Februrary 2020. Available online: https://www.frontiersin.org/articles/10.3389/fbloc.2020.00007/full