International Journal of Agricultural Sciences
Volume 20 | Issue 1 | January, 2024 | 315-323
ISSN : 0973-130X
DOI:10.15740/HAS/IJAS/20.1/315-323
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A Review

SMART farming - A new prospect in Agriculture Sector under Cold Arid Region of Ladakh, India

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Abstract : Indian agriculture has achieved many milestones from traditional to subsistence, and from modern to the emerging 'Smart Farming' era. This has eventually propelled the country into the ranks of food-sufficient nations, ensuring food security for all of us. Smart farming is the management of farms that uses technologies such as the Internet of Things (IoT), robotics, drones, and artificial intelligence (AI) to increase the quantity and quality of products while decreasing the amount of human labour required for production. Smart farming is paving the way for the country's agricultural production to become more productive and sustainable, based on a more accurate and resource-efficient method. The paper provides a detailed analysis of various smart farming technologies, with a particular emphasis on IoT and their applications.

Key Words : Artificial intelligence, Robotics, Drones, Sustainable, Productive, Smart farming, Food security

View Point Article : Angchuk, S., Lamo, K., Safal, R., Dorjay, S., Namgail, D., Tundup, Phuntsog (2023). SMART farming - A new prospect in Agriculture Sector under Cold Arid Region of Ladakh, India. *Internat. J. agric. Sci.*, **20** (1) : 315-323, **DOI:10.15740/HAS/IJAS/20.1/315-323.**

Article History : Received : 01.09.2023; **Accepted :** 25.09.2023

Introduction

Ladakh with its unique terrain and weather offers a tough life managed with meager resources. The principal industry in this region, agriculture, has contributed both directly and indirectly to the region's survival. The region's farming industry must be improved with cutting-edge technology and inputs in order to keep up with the current era of change and progress. Farmers in the field appear to perform repetitive and labor-intensive tasks including planting, weeding, fertilizing and watering. However, prior decision-making is necessary before starting the real actions in order to increase the agricultural cycle's effectiveness. This is being handled by a collection of interconnected technologies that address all pertinent demands of farming communities, including seed selection, sowing, harvesting, storing, processing, value addition, marketing, weather parameters and all other relevant needs of the farming communities. This set of interrelated technologies also aids in decision-making and is referred to as Smart Farming. Smart farming is a type of agriculture management that makes use of contemporary technologies to boost the quantity and quality of agricultural products (Shrivastava *et al.*,2020). Smart agriculture helps to address the aforementioned problems by reducing crop waste, making better use of fertilizer

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thereby increasing the yield of the crop. Smart Farming is being practiced using different tools and technologies.

The Internet of Things (IoT) refers to a network of interconnected computing devices, digital and mechanical equipment, humans or animals, and objects that can perceive, gather, and transmit data over the internet without human intervention. It is a technology that aims to connect everything on the planet to the Internet. The main goal of the Internet of Things is to connect everything in our environment and enable seamless communication between them with minimal human intervention. It emphasizes the ability to communicate with anyone, at any time, from anywhere. It enables real-world physical objects (e.g., sensor nodes) to collaborate to create an information-based system that maximises benefits while minimising risks (e.g., improved agricultural production) (e.g. environmental impact).

The Internet of Things (IoT) aids in crop productivity by predicting crop yield, crop pricing, soil temperature, real-time data on air quality, water level, and crop delivery scheduling. The need for food increases along with the global population, and IoT in agriculture is a major factor in providing that need. IoT-based agriculture is booming in wealthy nations, but it is still in its infancy in India. The main issue we are dealing with is farmers' lack of knowledge about technical equipment. The cost of implementation is also a major problem in India (Sen and Madhu, 2017). As a result, we should focus on developing more specialised and efficient sensors and putting them into use with the proper methodology.

Problem faced by farmers :

Agriculture, like in the rest of the state, is the main source of income in this district. Of the 45167 hectares, the area under cultivation in this district is 10542 hectares as per the revenue department village paper. As land holdings are small (0.68 ha.)(District Statistical Handbook, 2019), more people are working invariably on farms in rural areas, and with conventional manual methods, outdated equipment limits the production thereby reducing revenues from farming. The main issues that farmers in this region face are (Annual Progress Report, 2020).

– Extreme climate, harsh winters, high temperature variation, and extremely arid conditions, with negligible rainfall and inhospitable weather conditions.

– Geographically challenging area, disadvantaged in terms of demographics and politically sensitive.

– Scarcity of high-quality planting material both in Agricultural as well as Horticultural crops.

– Inadequate irrigation and electricity supply.

– Low fertility status of soil.

– Farmers lack the technological expertise necessary for agriculture and allied sector.

– Poor marketing facility (Due to which local produce do not fetch a genuine price.).

– Lack of network, cooperative societies for storage, marketing, supply of farm inputs, etc.

– Lack of feed and fodder.

– Lack of mechanization in agriculture.

– Inaccessibility to villages hampers in transferring of technology.

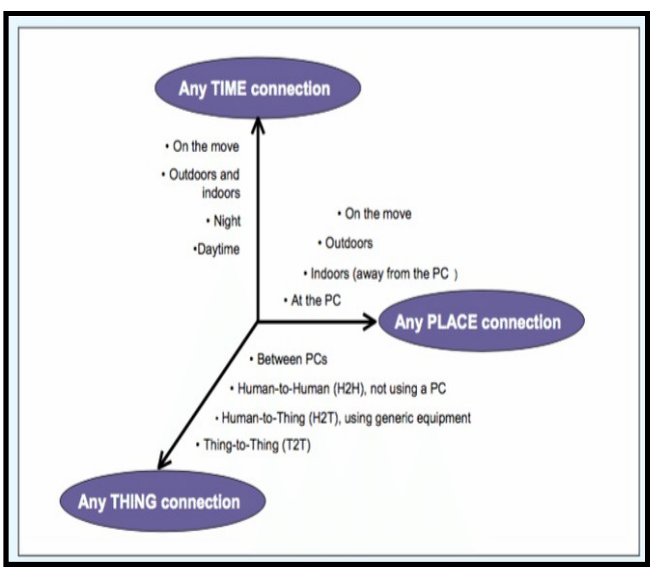

Fig. 1: Internet of things (2)

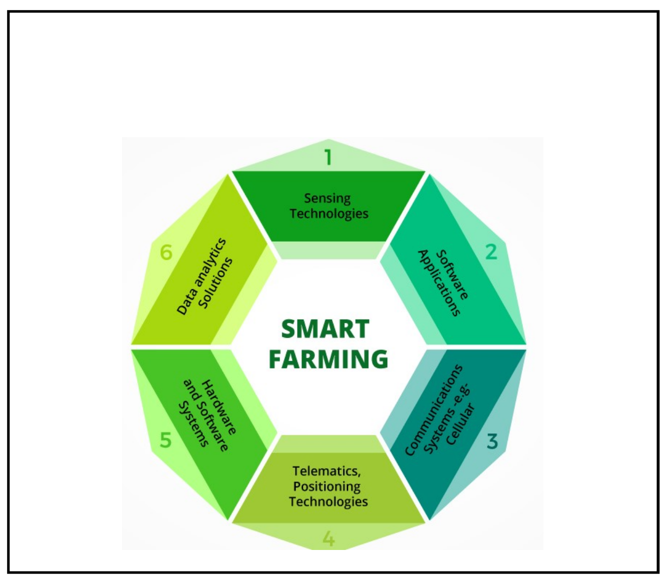

Fig. 2 Smart farming [7]

Smart Agriculture :

Smart Farming or Smart Agriculture is the modern practise of using advanced technology and equipping farms. Smart farming is a modern information and communication technology concept that aims to increase the quantity and quality of goods produced in order to control farm management. IoT-controlled smart farming can be called a wireless system designed to automate the irrigation process and to monitor the field using different sensors. These different sensors may be light, temperature, humidity, soil, etc (Anandteerth *et al*., 2018). Smart farming (or Precision agriculture) has the potential to significantly increase agricultural production in terms of both sustainability and productivity (Lytos *et al.,* 2020). The adoption of smart farming techniques is constantly growing and the market is still dynamic for these connected devices. By adopting various smart agriculture gadgets, farmers have become more efficient in raising livestock and growing crops, making it more predictable and efficient. Smart farming is a term that refers to the use of modern technologies in agriculture. The smart agriculture industry is growing very fastly and constantly. By using the advanced technology they are gaining better control over the complete production efficiently (Jatana and Soni, 2018).

Smart technologies are not only confined to the agriculture sector but these find a wide application in other sectors too. These technologies are used to locate the location of the accident and the information of the location can be sent through the GPS to the emergency offerings for assistance (Praveen *et al*., 2020). Data mining is another field where the use of smart technology is on the rise. Data mining is an analytic process that is used to investigate data (business or market related) in search of consistent patterns or to find out the systematic relationship between variables and to validate the findings (Ali Aleem, 2012).

Among the advanced smart farming technologies some available technologies in the present scenario are:

- Sensor-based technology: soil scanner, water and light management, temperature control, etc.

- Software-based technology: specialized software solution system

- Communication-based technology- cellular communication

- Positioning related technology: including Global Positioning System

- Hardware and software related systems: it is related to robotics and automation

- Data analysis related technology: decision making and prediction processes.

Major factor for smart farming using IoT :

IoT has transformed the old agricultural perspective into advanced agriculture, which is geared towards the information network and involves automation, the usage of intelligent devices, and their networking in the agricultural production process. The following are some of the key points for Smart farming.

- An irrigation system can be used to provide water to the plant as and when required. The moisture sensor detects moisture in the plant and supplies water appropriately, reducing water usage to a bare minimum. Smart sensors are implanted in the soil. This sensor can quickly detect moisture levels and helps the farmer in sprinkling the correct quantity of water on the land.

- Farmers can use mobile applications to remotely track and manage yields, costs, and other vital farm metrics.

- Sensing technology (on-field sensors, such as soil moisture measurement) has shown to be quite beneficial, and smart positioning technologies (GPS) for making agricultural methods smarter have grown in popularity.

- When combined with weather data, it may provide farmers with weather forecasts.

- Set temperature, humidity, and other variables for agricultural storage to trigger alerts and alarms.

- Telematics (the transmission of data across vast distances) and advanced data analytics tools and platforms have also been important components of smart agriculture (Mudholka and Mudholkar, 2017).

Uses of internet of things (IoT) in agriculture :

Farmers that rely on manual methods for crop monitoring, disease detection, and other tasks have several disadvantages, including the fact that it takes a long time, that they must physically show themselves on the farm, and that they are unable to identify the precise condition (Kamienski *et al.,* 2019). Farmers want very fundamental information of agriculture such as soil information, seed type, required pesticide for the specific crop at all stages of growth, fertilizer type, crop diseases, and crop selling. The following are the questions that must be addressed to improve crop output.

- Basic knowledge, such as which crop to plant?

- What seed varieties should be used?

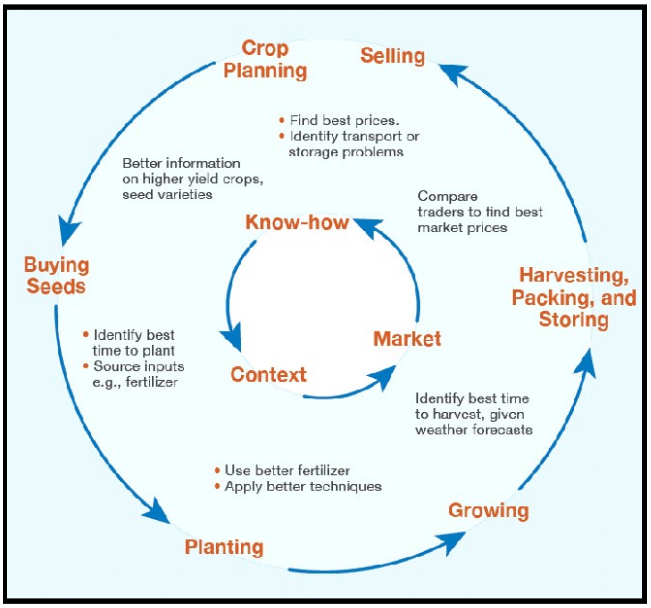

Fig. 3 : IoT application in agriculture (Mittal *et al.*, 2010)

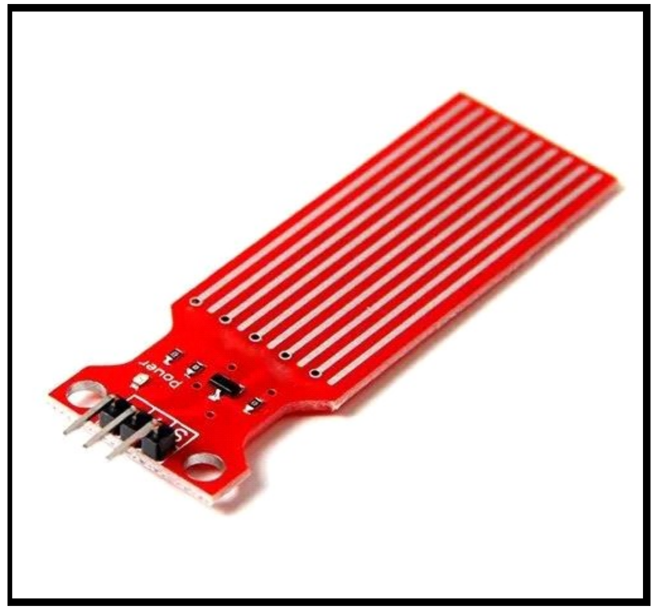

Fig. 4 : Soil moisture zensor (Patel and Patel, 2016)

- What weather information is needed?
- Best farming practices for his crops and soil.

What kind of fertilizer and insecticides will be necessary for the crop?

- Transport prices, demand indicators, and logistical information (Channe *et al.*,2018).

Sensors used in agricultural internet of things :

Sensors are important tools used in IoT. Sensors are devices that gather and analyze data to produce the necessary analysis. Sensors are mostly used in agriculture to obtain readings for measuring NPK levels, detecting diseases, and determining soil moisture content.

Soil moisture sensor :

A soil moisture sensor is shown in Fig. 4. is used to determine the volumetric water content of the soil. It determines the moisture content of the soil based on soil characteristics such as resistance, dielectric constant, and neutron interaction, as well as ambient factors such as soil type, temperature, and electrical conductivity. It has two probes that are placed into the field, and when a current is passed through the probes, moisture % is determined based on resistivity. Soil moisture analysis enables water to be applied just when it is required, reducing water waste.

Temperature sensor :

A temperature sensor is a device that measures how hot or cold an object is. This sensor is more accurate than the thermistor, which was used to monitor the temperature in the beginning. This sensor is resistant to overheating since it has three terminals: input, output, and ground. Temperature sensors come in a variety of shapes and sizes. The LM-35 IC, as illustrated in Fig. 5, is one form of a temperature sensor.

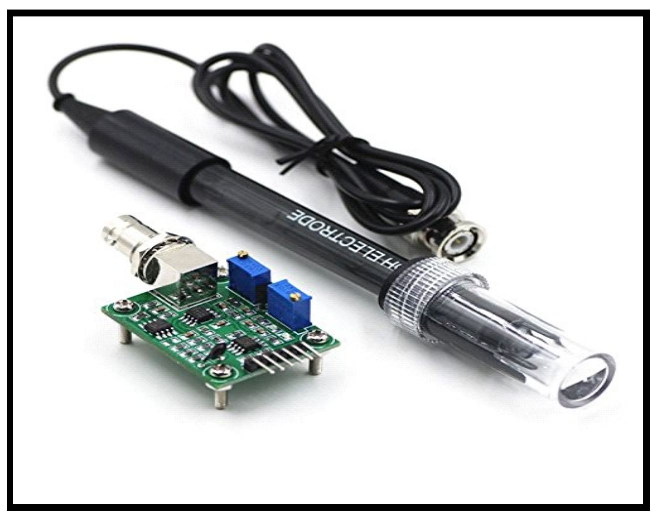

Fig. 5 : Temperature sensor (Patel and Patel, 2016)

Private infrared (PIR) sensor :

All things with a temperature greater than absolute zero produce heat energy in the form of radiation. Fig. 6

Fig. 6 : PIR sensor (Patel and Patel, 2016)

shows a PIR (private infrared) sensor that detects infrared radiation produced or reflected from an object. It's used to track the movement of humans, animals, and anything else. The temperature at the spot will rise from room temperature when any impediment passes through the field. It is converted to a voltage by the sensor, which then activates the detection.

Water level sensor :

Fig. 7 shows a sensor that detects the amount of water or other fluids. It comes with a detecting probe that can detect the surface level of almost any fluid, including water, salt water, and oils. This sensor is not readily broken, and it connects to Aurdino with ease. It includes two buttons, one for recording the lowest fluid level and the other for recording the highest fluid level. The voltage will be used to determine the level.

pH sensor :

The pH sensor in Fig. 8 is being used to measure the pH value of a solution. The pH scale ranges from 0 to 14, with 0-6 being acidic, 7 being neutral, and 8-14 being non-acidic or basic. It calculates the pH value depending on the concentration of hydrogen ions, which is detected using a pH electrode. The response time is more than 2 minutes. The temperature range is about 600 degrees Celsius, the input voltage is 5 volts, and the output voltage is 414.12 volts.

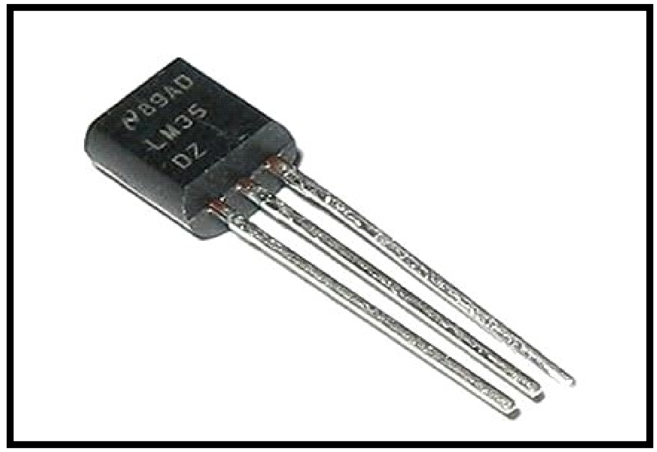

Fig. 8 : pH sensor (Patel and Patel, 2016)

Temperature and humidity sensor :

In Fig. 9, the DHT11 is a simple, low-cost digital temperature and humidity sensor. This sensor has two components, a capacitive humidity sensor, and a thermistor. Both moisture and air temperature are sensed, measured, and reported by the humidity sensor.

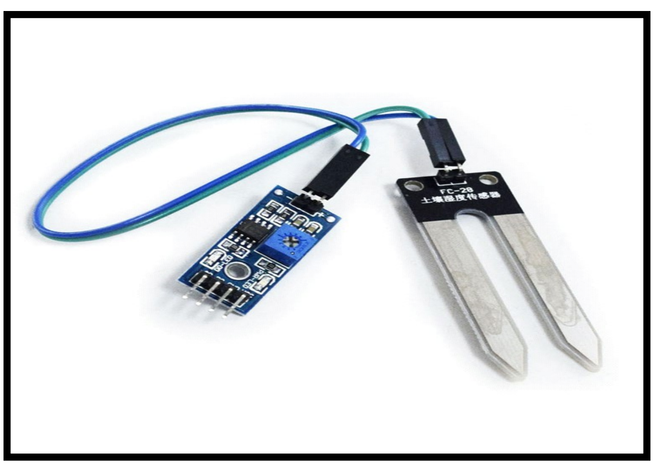

Fig. 7 : Water level sensor (Patel and Patel, 2016)

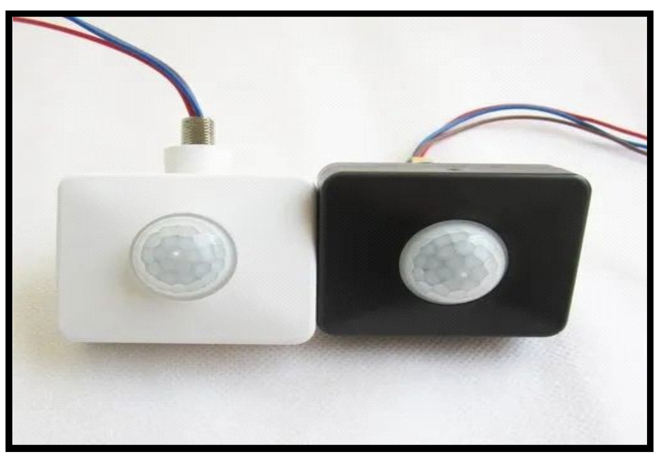

Fig. 9:Temperature and humidity sensor (Patel and Patel, 2016)

Temperatures range from 0°C to 50°C, with humidity levels ranging from 20% to 90%. These sensors are mostly used in the Internet of Things. There are many other sensors in addition to these; however, DHT11 is the most common temperature sensor.

Benefits of adopting IoT in Agriculture (District Statistical Handbook 2019) :

Climate condition :

In farming, climate plays a very important role. Climate change has a direct impact on all agricultural aspects. It has an immediate impact on crop quality and yield. As a result, an immediate solution to this problem is required. IoT solutions allow us to know the weather conditions in real-time. Sensors are placed both within and outside of agricultural areas. Environmental data are gathered by using these sensors, which are then used to choose the best crops for growing and sustaining under the given climatic conditions. The whole Internet of Things comprises sensors that can reliably monitor real-time weather variables such as humidity, rainfall, temperature, and more. A wide range of sensors is available to detect all of these characteristics and adjust them to meet the needs of smart farming. These sensors help in monitoring the health of crops as well as the weather conditions around them. When unexpected weather conditions are found, an alarm is sent. The necessity for human presence during inclement weather is removed, thus allowing farmers to enjoy additional agricultural advantages and enhance productivity.

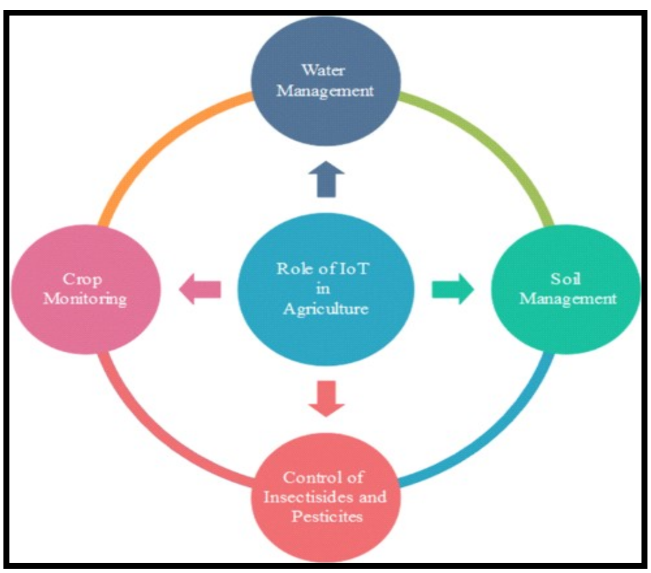

Fig. 10 : Role of IoT in Agriculture (District Statistical Handbook 2019)

Disease detection and diagnosis :

Plants like any other organisms are vulnerable to many diseases. Diseases in plants occur when external factors like pathogens and environmental conditions disturb the normal natural structure and function of the plant. There are numerous type of diseases which affect the plant species and the factors responsible for these diseases are all different. Diseases may affect any part of the plant including root, stem, leaf, flower, and fruit. While disease grows within the plant, external factors like rain, wind, water, soil aids in transmitting these diseases to the neighboring plant. Many crops get spoiled due to a lack of proper pesticide control mechanisms. With the help of IoT enables systems, images of plant leaves are captured and investigate for diseases, which can then be preprocessed and transmitted to remote laboratories. To decrease the cost of transmitting diseased leaf images to plant pathologists in remote laboratories, image preprocessing is required. Further clustering techniques aids in the segmentation of leaf images.

Fertilizer calculator :

The soil fertility and soil type play a very important role in agriculture. Based on the type of soil, fertilizer can be injected into the soil for better crop yield production. Fertigation assure equal distribution of fertilizers to all of the vegetation and better absorption of nutrients. Based on recent technology, the climatic condition like temperature, humidity, moisture, and Ph in the soil can be analyzed and fertilizer like nitrogen, phosphorous, and potassium is injected into the flora. Fertilizer application is a crucial farming activity that can greatly boost agricultural production. For each crop, farmers must make judgments about which chemicals to use and in what quantities (Barah and Malakrishnan, 2017). An IoT-based automated fertigation machine that reduces water and fertilizer wastage can be used to overcome these short comings.

Study of soil :

Another essential aspect of farming that has a big influence on agricultural performance is soil. Soil monitoring with IoT allows the farmers and producers to enhance output, decrease disease and optimize resources by leveraging technology. IoT sensors can be used to detect soil temperature, NPK, volumetric water, photosynthetic radiation, water potential of the soil, and soil oxygen levels. The data from the IoT sensors is subsequently sent to a centralized location (or the cloud) for analysis, visualization, and trend analysis. The information gathered may then be utilized to improve agricultural operations, and make minor modifications to improve crop output and quality.

Crop water estimation and water study :

Water quality has a great impact on farming and agricultural output. Farmers must make prior decisions about how much water their crops require. Crop water needs are determined by several factors including crop type, season, climate, and crop growth stage. Crops lose water due to transpiration, while the canopy loses water due to evaporation. Using sensors, water management can be done efficiently using IoT with no wastage of water.

Analysis of crop produce readiness :

Farmers that are provided with crop pricing information ahead of time may sell their harvests at a specified time and earn a high profit. To detect the freshness of fruits, a unique application of smartphone-based sensors is employed. To evaluate maturity levels and ripeness of green fruits, an IoT-based application, and a smartphone camera are used to collect pictures of fruits under white and UV-A light sources. Farmers should use these methods in their fields by sorting crops based on ripeness levels before shipping them to market.

Use of smart phone in agriculture :

The fast expansion of mobile telephony and the advent of mobile-enabled information services have made it possible to overcome current information asymmetry in the fields of agriculture, healthcare, and education. There is a significant gap between the availability and distribution of agricultural inputs and agricultural infrastructure, which mobile technology can help to bridge. A smartphone is a device that is used to make phone calls and includes additional features and abilities such as the ability to send and receive an email, Wi-Fi and modem capabilities, internet access, Office documents, easy touch screen control, and, most significantly, the ability to run custom software. Another essential feature of a smartphone is its user interface. A smartphone includes a touch screen and the ability to zoom in and out using basic interface buttons, menus, and forms, as well as the support of a “qwerty” keyboard, making it straight forward to use for those who are unfamiliar with ICT technology and even not having enough educated. The program must be simple to use and the farmer must give only the information needed to complete an operation or procedure. The price of a smartphone ranges between low and expensive. As a result, farmers may easily purchase any type of smartphone that fits within their budget.

Smartphones and IoT are interrelated to each other:

As a result, it is important in smart agriculture. Farmers can easily afford smartphones now that they are more affordable on the market. Furthermore, its computational capability allows users to develop a diverse range of useful apps. The android mobile application, also known as the android app, allows the user to monitor and operate the field from any location. An internet connection is required to monitor and operate the field. Rural farmers who formerly had limited access to up-to-date agricultural information (e.g., market, weather, and crop disease news) and assistance from agricultural experts and government extension workers now have new options, thanks to low-cost smartphones with a variety of sensors on the market. Even though all information is available in the public domain, accessing it is a time-consuming job for farmers. Mobile or Smartphone applications may provide all of this information with changing seasons and climate. One of the platforms where a farmer may obtain all solutions and information in one touch is the mobile app. Farmers can use their Smartphones to monitor their equipment, crops, and livestock remotely, as well as to obtain information on livestock nutrition and productivity. They may even utilize this technology to provide statistical forecasts for their crops and cattle (Patel and Patel, 2016). Smartphone apps revolutionized connectivity and are used for sending agri-information to farmers. Farmers will also be notified via smartphone if an emergency arises on their farms.

Some of the android based mobile apps for agriculture are:

- Agri App: Smart Farming App for Indian Agriculture.
- Kisan Suvidha.
- Damini.
- KVK Sandesh.
- MKisan Application.

- Agrimarket.
- Pashu Poshan.

Challenges in implementing IoT :

Farmers residing in rural areas are unable to take the benefit from IoT technology due to a lack of network infrastructure. As a result, they have limited access to the internet. A farmer needs consistent access to agricultural data at all times and from any place, thus a faulty connection renders an advanced monitoring system worthless. In addition, the types of equipment required to implementing IoT systems in agriculture are costly. Further, most people in this region still feel agriculture belongs to their forefather generation; therefore they are hesitant to enter this industry. However, IoT should be brought closer to the primary sector by combining with complementing instruments to develop more efficient products. In this context, commercials and on-air promotions about new technology might be beneficial. To achieve an aggregated output, information from one farm can be shared with other farms.

Conclusion :

Although IoT in agriculture is still in its early stage in India, how we are adopting this technology gives us reason to be optimistic in this area. The use of IoT in this cold arid region of Ladakh which remains inaccessible for half of the year from the rest of the country and physically reaching farmers in inaccessible areas is a real problem that has very good prospects. The use of the different types of sensors and other artificial intelligence devices can help ineffective ways of controlling, monitoring, and managing the farms. This will make the farmers in the region improve quality, quantity, minimize risks and wastes thereby making food items more accessible to customers and saving farmers time and money. Smart farming technology will also reduce the environmental effect of farming in this fragile region, ensuring long-term sustainability. What is required is to impart training to the farmers about these technologies so that they can perform their agriculture tasks quite easily without even reaching their field.

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