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IoT and enabling technologies for precision agriculture

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ABSTRACT

IoT has rapidly changed the growth of every field. IoT refers to network of objects or Things that are connected to internet for making interaction with each other. Things always refer IoT devices, Home appliances and everyday objects which have unique identity. These Things are able to do remote sensing, monitoring and controlling capabilities. These objects have various interfaces for sensor connectivity, internet connectivity and storage. IoT is a predominant technology that automates the traditional activities of each and every filed. It is an umbrella technology that includes various technologies for its effective implementation. The objective of this paper is to present an overview of IoT and its various enabling technologies for an implementation of IoT in traditional agriculture. IoT technologies are broadly classified in to three major categories. They are IoT software, IoT Hardware, IoT Connectivity. IoT technology adaption will perform drastic changes in traditional agriculture. Precision Agriculture using IoT helps the farmers to predict the exact requirement of water, fertilizer and pesticides that are directly related to the growth of the crops. Precision Agriculture also helps to predict the climate change, soil nutrition, plant growth and plant disease for enhancing the productivity and profit. Precision Agriculture is suitable for Indian Agriculture to optimize the scared agricultural resources for obtaining high yield. Precision Agriculture uses various sensors such as Temperature, Humidity, Pressure, Soil Moisture and Light intensity for gathering parameters directly from the farm land. These parameters are sent to the cloud database through local gateway for further processing. The collected data are analyzed in the cloud database for taking predictive decision. Precision Agriculture insists the farmers to react quickly for optimizing the scared natural resources, monitoring their plant growth, quality and diseases for achieving high yield and profit.

Keywords: *Sensors, Cloud computing, IoT platform, Edge AI/Analytics, Machine Learning, Deep Learning, FPGA, IoT Connectivity*

1. INTRODUCTION

IoT is an environment that brings both communication and computation together under a single roof. Internet of Things consists of huge collection of connected devices network that bring billions of devices together in internet.

IoT is an eco system comprises of devices, objects, Actuators, people. Each of them in a system having unique identifier. IoT framework helps these devices to make an interaction with each other without any human intervention.

IoT eco system is built with layered architecture approach. The system may be built with four layered or above based on the application requirements. The major application areas are home automation, smart cities, manufacturing, energy management, transportation, automobiles, health care, and agriculture supply chain logistics.

The eco system is made up of three major components. The components are as follows.

- IoT Hardware
- IoT Software
- IoT Connectivity.

Indian economy is mainly depended on agriculture. India is a global agricultural power house. India is the largest supplier of various grains, pulses and spices in the world. More than 60 percent of Indian population is belonging to Agriculture for their livelihood. Agriculture pays a major contribution to GDP growth rate. Agriculture outcome is the major backbone of Indian economy. Indian Agriculture faces several challenges in the past decades due to urbanization, poor income and unpredictable climate changes.

The farmers are not aware of using the scared resources such as water, fertilizer and pesticides in an appropriate manner. They could not predict the climate change in advance. The farmers are struggled to produce high yield for meeting the global food demand. Agriculture sector is not modernized after green revolution.

Indian agriculture requires a sustainable modern approach to meet the gap in food supply and demand. Adoption of digital technology in agriculture transforms the economy of our farmers as well as our country. Internet of Things (IoT) is a new technology that can transform the traditional agriculture to meet our challenges. IoT helps to connect devices, machines and tools with internet by wireless technology. IoT have broad range of interactions. IoT interacts between devices, things and people. IoT helps to automate various activities by taking predictive decision from the rich set of data. IoT has several applications. Precision Agriculture is one the prominent application to people. This paper presents an overview of IoT and its various enabling technologies for agriculture sector. Agriculture using IoT guarantees high yield, profitability and pollution free environment.

Precision Agriculture adopts Internet of Things (IoT) technology for achieving high yield and optimization of limited natural resources. Precision Agriculture uses sensors, satellites and IoT enabling technologies to monitor and control the agriculture activities. Precision Agriculture insists the farmers to apply required level of water, pesticides and fertilizers to their agricultural land. Precision agriculture mainly concentrates on conservation of limited natural resources. It also helps to identify the variability in farm land. Precision Agriculture also helps to identify the growth rate of plants. Precision Agriculture helps to increase the yield by using limited natural resources by applying required water, fertilizer and pesticides. Precision uses cloud database for taking efficient predictive decisions. This paper concludes the importance of adoption of IoT in traditional agriculture and its real impact.

2. LITERATURE SURVEY

Parul Goyal et al 2020[1] elaborated the significance of Internet of Things and Enabling Technologies in their journal paper **"Internet of Things: Architecture and Enabling Technologies".** The authors gave an overview of IoT and its growth in various domains. They also emphasized the need for adoption of this technology is unavoidable. The authors explained various components of IoT and its architecture in a detailed manner. This journal paper gave a clear road map on various enabling technologies and their direct impact on applications. They also suggested the growth of enabling technologies is giving more sophistication to experience IoT in a better way.

Sjaak wolfert et al 2017[1] emphasizes the adoption of IoT in traditional agriculture in their review article **Big Data in Smart Farming**. It ensures that Precision Agriculture with Big Data technology will increase the production massively. It influences the entire food supply chain. It also elaborates various processes involved in precision farming which transforms the traditional agriculture. Precision Agriculture helps the farmers for improving their yields with minimum expenditure for meeting the global food demand. Precision Agriculture uses IoT for monitoring the data directly from the farm. Huge volume of data collected through several sensors for every second.IoT devices contribute the generation of Big Data. These data need to be stored for further analytics. The collected data are sent to cloud database through gate way for analytical processing. These Big Data are stored in the cloud. These data can be accessed for data analytics. Precision Agriculture manages variations in the field accurately to increase the production with minimum environment pollution. This review article elaborates the state of the art of IoT and Big Data applications in farming. This article concludes that the adoption of IoT and Big Data in farming is still in development stage. Most of the foreign countries implemented Precision Agriculture for their massive yield.

Antonis Tzounis et al 2017[2] have clearly mentioned in the review article "**Internet of Things in Agriculture recent advances and Future challenges"** the adoption of IoT technology advancement in agricultural sector. Adoption of IoT in traditional agriculture will guarantee the massive yield in the agriculture. Precision Agriculture is mainly used to automate the processes of agriculture and predict the outcome of yield in early stage. Precision Agriculture uses IoT technology, sensors for generating huge volume of data directly from the farm land. The collected data are sent to the cloud database for data analytics purpose. The data analytics tools access the data from the cloud for predicting the outcome. The predictive decision is sent to the farmers through message alert. The farmers can monitor and control various activities without visiting their farms in person. The authors emphasized the importance of adoption of Meta processing model in basic monitoring system. They summarized various IoT devices, technologies, sensors, Micro controllers used in the market for the past decades. They gave various guidelines for an effective implementation of precision Agriculture using Edge computing devices and Micro controllers in an appropriate manner. They urged the need of adopting Edge computing for taking immediate decisions from the farm it selves. They elaborated various agriculture applications controlled environment agriculture, live stock applications, food supply chain tracking etc. The authors discussed several challenges and issues such as sensor management, network connectivity, energy efficiency etc in the implementation of Precision Agriculture. Precision Agriculture is a predominant technology that optimizes high yield in traditional agriculture. It achieves high yield in the form of variable rate farming by applying agricultural inputs in a precise manner. Precision Agriculture enhances the conservation of water resource and reduces the impact of environment pollution.

Jira pond Muangprathub et al 2019[3] elaborated the significance of precision agriculture in their journal paper **"IoT and agriculture data analysis for Smart Farm"**. This system was developed to optimize the usage of water in agriculture field based on soil moisture level. It was developed with a control system using various sensors, hardware equipments, web application and smart irrigation system. Temperature, Humidity, soil moisture sensors were used to monitor the environment factors in the farm field. The data collected from sensors are transferred to web application for further data processing. Web application collects the data and manipulates the data using several data mining algorithms for taking predictive decision. Water irrigation system is activated through a smart phone based on predictive data analysis. This system was implemented with DHT22 sensor, soil moisture sensor, ultra sonic sensor, solenoid valve and Node MCU. These environment data are analyzed by web application for accurately predicting the growth of plants, water level etc. Automatic water irrigation system was actuated through smart phone. Graphical representation of environmental factors was sent as notification to the farmers along with message alert. The farmers can take the decision and control their farms through their mobile phones. They can opt either manual or

automated irrigation system according to their requirements. The authors concluded that Precision Agriculture is used to improve the crop yields, improve quality with minimum expenditure and minimum environment pollution.

Koksaal 2019[4] clearly depicts in the journal **"Architecture design approach for IoT based Farm Management Information Systems"** to focus on smart farming architecture design. Precision Agriculture lays the foundation for the adoption of automation in traditional farming. This journal also gives the guidelines to choose the appropriate network layered architecture according to the user requirements. It also defines the step by step procedure for designing IoT based FMIS architecture. Precision Agriculture represents the adoption of ICT in to agriculture. It uses several sensors, hardware devices, IoT, cloud computing and big data. Precision Agriculture helps the farmers for increasing their production, optimize the quality of the crop with minimum resources and with less environmental pollution. The authors concluded that Precision Agriculture is the one stop solution to increase yield with minimum resources and environment foot print.

Chandra shekhara K.T et al 2017[5] presents the importance of adoption of IoT in agriculture in their journal **Precision Irrigation using Integrated Intelligent Systems**. This journal presents an alternative and efficient way to solve the issues in traditional agriculture. Precision Agriculture system collects the data from environment, analyses data and monitors the data in a feedback loop and activates the control unit on a pre determined threshold value. Precision Agriculture uses sensor networks such as temperature, Humidity, Ph level, soil moisture and light intensity sensors for collecting environmental data directly from the farm.The collected data are processed, analyzed and the decision is taken on the basis of the threshold value. The actuator irrigates the water based on the predictive decision. This work clearly demonstrates that automatic irrigation system is more efficient and suitable than scheduled irrigation system. Precision Agriculture increases production, improve quality, optimizes the chemical usage with less environment pollution.

Subrata KR Mandal et al 2013[6] demonstrated in their review article **"Precision Farming for small agricultural Farm: Indian Scenario"** the significance of modern technology adoption in farming practice. Precision Agriculture provides an environment by applying IoT technology in traditional agriculture. This article explains the benefits of Precision Agriculture by implementing various processes involved in it. Precision Agriculture gives the guidelines for utilizing the right resource in right time for massive yield with minimum environment pollution. Precision Agriculture gives the step by step procedure for applying Precision Farming techniques in the traditional agriculture. Precision Agriculture clearly dissects the agriculture in to various components. The components sensors, IoT devices are interconnected with wireless network. The components are simply classified in to farm components, data processing components and data analytics components. Precision Agriculture connects farm components with the cloud database using GPS and GIS mechanism. The farm data Temperature, Humidity, Soil moisture, Soil nutrition are directly collected from farm and transferred to cloud database via wireless network. The sensor data are stored in the cloud database for further analytics. The data extracted from cloud for applying some data mining procedures. The predictive analysis is carried out on the cloud data. The predictive decision is taken through efficient algorithms. The decision is sent to the farmers through mobile phones.

The authors concluded that Precision Agriculture is mandatory to optimize the yield with minimum resources and reduced environmental impact.

3. PROPOSED SYSTEM

3.1 Internet of Things (IoT)

Internet is made up of huge collection of networks that are interconnected with each other. The scope of the internet is being widened beyond the machines and devices. Internet is used to connect physical objects in and around us. Internet of Things (IoT) is a network of devices embedded with sensors connected through internet. IoT helps to connect devices, machines, sensors, objects through internet by wireless technologies. Embedded systems, cloud computing, big data, machine learning and wireless sensor networking are IoT enabling technologies. IOT is an interaction between the physical and digital world using sensors and actuators with unique identifiers. It enables objects to collect and exchange data. It is needed to interact, contribute and collaborate to things. IOT will connect 50 billion devices to the internet by 2020.IOT can be used in various sectors.

IOT applications are integrated applications. The major applications of IOT are

- Smart Parking
- Traffic congestion
- Smart Grid
- Smart Agriculture
- Earthquake detection
- Health care
- Home Automation
- Smart cities
- Industrial control

3.1.1 IoT Hardware

IoT Hardware includes a wide range of devices such as sensors, micro controllers, actuators and devices for routing, bridges etc.

1. Sensors

Sensors are the important components in the IoT system. It could be a single device or a combination of energy modules, power management modules, RF modules and sensing modules that collect data directly from the environment.

Sensors are devices that convert physical parameters in to an electric signal for further processing. They are classified in to various types based on the nature of data it measures. The major classifications are

- Analog Sensor and Digital Sensor
- Active Sensor and Passive Sensor
- Electrical Sensor and Mechanical Sensor

2. Micro Controllers

Microcontroller is a device designed to perform a specific function on embedded system. It consists of processor, memory, Input/output integrated on a single chip. The selection of Micro Controller is based on its processing, storage and Input/output interface capabilities. The following are identified as the most powerful Micro controllers.

- Node MCU
- Arduino
- Raspberry PI
- Beagle Bone Black
- Intel

3. FPGA

Field Programmable Gate Arrays (FPGAs) are digital ICs that enable the hardware design engineer to program a customized Digital Logic. The term "Field Programmable" implies that the Digital Logic of the IC is not fixed during its manufacturing but rather it is programmed by the end-user.

It consists of programmable logic blocks and routing blocks for making interconnection between the blocks. Input/output blocks for providing external interconnection.

3.1.2 IoT Software

1. Cloud Computing

Cloud Computing provides data storage, servers, database, networking and software through the internet on the basis of demand. The services of the cloud are broadly classified in to the following categories. They are

- Software as a Service (SaaS)
- Platform as a Service (PaaS)
- Infrastructure as a Service (IaaS)

Cloud computing is the back bone for IoT data storage. Massive amount of data are generated through IoT are stored, processed and decisions are taken.

2. IoT Platform

IoT platforms are software components that connect everything in an IoT system. It facilitates device management, communication, data flow and management of applications. It also enables cloud, edge communications for efficient delivery of data.

IoT platforms perform the following tasks.

- Connect hardware
- Deals with different communication protocols
- Device authentication, security
- Collect, analyze and visualize data
- Integrates the application with other web services

IoT platform technology plays a vital role for improving customer experience in smart applications such as Smart Home, Smart Retail services, Smart Agriculture and Smart Transportation etc.

The most famous IoT platforms are

- KAA IoT
- ZETTA
- Device Hive
- Thing Speak
- Microsoft Azure
- IBM
- Google Cloud Platform
- CISCO
- Oracle Corporation

3. Edge / AI Analytics

Edge AI means the deployment of AI applications at the device edge for taking quick decisions with low network latency. It improves the computing performance at the edge itself.

Edge AI provides the following benefits to the users.

- Intelligence
- Real time processing
- Reduced Cost
- Improved privacy
- High availability
- Quick Response

Edge analytics use several Deep learning and CNN algorithms for efficient decision making. The most famous Edge/AI platforms are as follows.

- Flex Logix
- MAVENIR
- Anagog
- Cloudera
- Imagimob

4. Containers

Containers are the collection of software that is packaged with code, libraries and runtime environment for executing the application in any platform.

They provide an environment for executing the application quickly and reliably without any dependencies.

We can transform the code from one environment to another environment.

The most popular container orchestration tools are as follows.

- Docker
- Kubernetes
- Microsoft Azure
- Google cloud platform

3.1.3 IoT Connectivity

IoT connectivity deals with connection between sensors, devices, routers, gateways, platforms and other applications which are connected in eco system.

The connectivity technology will be classified in to either wired type or wireless type. The selection of connectivity is purely based on power consumption, range, bandwidth, security and cost.

The wired communication sends the information from source to destination via wired communication medium such as USB cable, Ethernet etc.

The wireless communication mediums are classified into three categories such as short range, medium range and long range communication.

The most popular wireless communication mediums are as follows.

1. LPWANs - Low Power Wide Area Networks
2. Cellular (3G/4G/5G) ...
3. Zigbee and Other Mesh Protocols. ...
4. Bluetooth and BLE. ...
5. Wi-Fi. ...
6. RFID.

3.2 Precision Agriculture

Precision Agriculture uses IOT and its various enabling technologies to monitor and control various activities of farmland. Precision Agriculture mainly focuses on bridging the gap between supply and demand in agricultural sector. It also helps the farmers to optimize the usage of natural resources with minimum environment pollution impact. Precision Agriculture is the technique of observing, measuring and responding to variability in the crops. Precision Agriculture will be more suitable for small and marginal size fields or farms. It is a dominant technology that modernizes the agriculture processes with minimum inputs for obtaining high yield.

Fig 3.2.1 Precision Agriculture using IOT

Precision Agriculture uses various improved sensors, devices, actuators, processors, GPS, cloud database and various technologies for its implementation. It uses information technology and management to control and manage variability within farm fields for obtaining optimum production. It provides an environment for sensor based water irrigation, precise Fertilizer management, and crop monitoring and market demand analysis.

Temperature and Humidity Sensors, Soil moisture sensors, Optical Sensors, Electrochemical Sensors, Mechanical Sensors, ironic sensors and Air flow sensors are used in Precision Agriculture. These sensors are useful for identifying various problems that affect the crops directly. Sensors produce enormous amount of data for control hardware unit. The sensor data are in a streaming fashion.

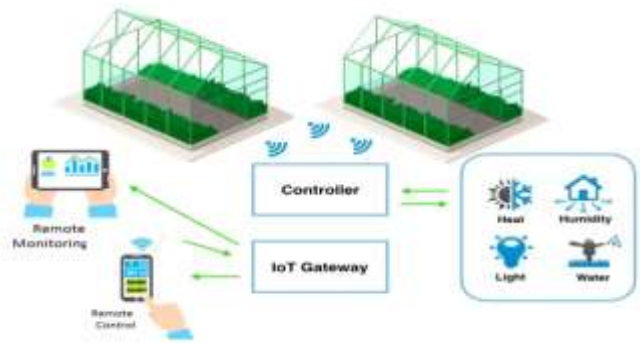

Fig 3.2.2 Sensors used in Smart Agriculture

Precision Agriculture uses agricultural equipments, GPS, GIS, variable rate farming equipments for its implementation. It also applies required quantity of water, fertilizer and pesticides depends on soil moisture and nutrient. It provides homogeneous water level, soil condition to all crops equally in the farm. The crop growth deficiency will be eliminated through this homogeneous level. It restricts the excessive use of fertilizers and wastage of water in the farms. It also enhances the productivity by preventing soil degradation without any pollution. The outputs of rain fall, leaf wetness humidity and temperature sensors are collected and recorded periodically.

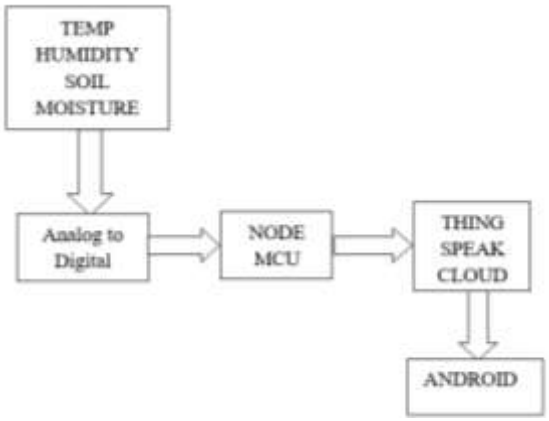

Fig 3.2.3 Architecture Diagram

3.3 Prototype Model

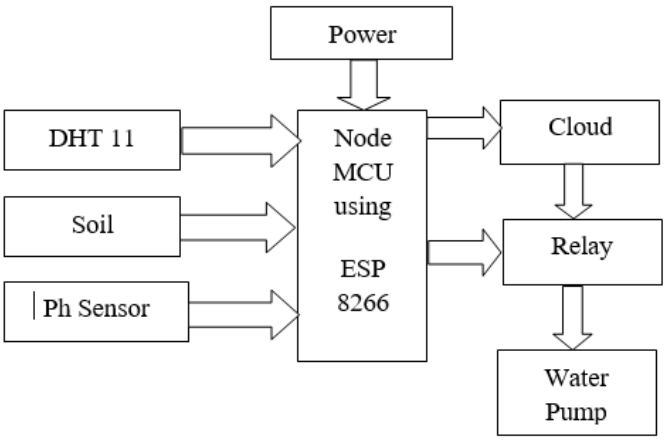

Fig 3.3.1 Overview of Model

3. 4 Implementation

Climate, weather and soil moisture condition are the most important factors in the production of crops. Sensing the environment factors is the primary task of Precision Agriculture. Environment data such as Temperature, Soil Moisture, Humidity, Ph, Water Level and soil nutrition that are directly related to the growth of the crops. These inputs are crucial for taking the correct and precise decision for increasing the production. Information on crop growth, development of crops at each location is obtained through several sensors in a streamed fashion. Massive amount of data are sent from various sensors continuously.

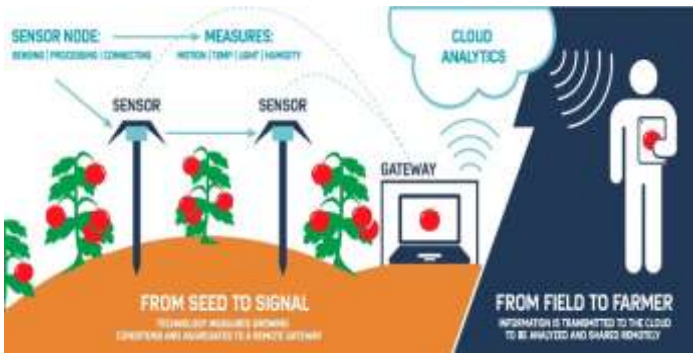

Fig 3.4.1 Overview of Implementation

Agriculture data collected from various sensors are sent to Node MCU ESP 8266 for further processing. All sensors, devices, GSM module and actuators are interconnected with ESP 8266. Data collected from sensors are recorded continuously then the data are sent to cloud database for taking efficient decision.

Smart Agriculture defines Decision Support System by using big data techniques to maximize the agricultural yields by minimizing various valuable resources.

3.5 Benefits

- Optimized water usage
- Restricts the excessive use of fertilizers and pesticides
- Sustain high yielding
- Improves product quality, nutrients and taste
- Minimizes the environment pollution

3.6 Success parameters

- Effective irrigation
- Improved soil fertility
- Crop protection
- Plant growth
- Plant disease identification

3.7 Results and Discussion

Sensors used in the prototype model were installed in farms directly. The data is collected periodically from the farm for taking predictive decision. The output of the test result is shown in the below table.

Date	Temperature ©	Humidity (%)	Soil Moisture
22-Aug	30	40	22
23-Aug	33	44	19
24-Aug	32	45	21
25-Aug	35	42	21
26-Aug	27	44	23

Fig 3.7.1 Sensor output

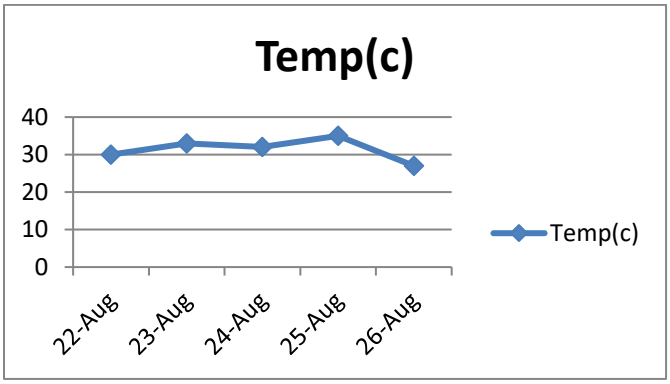

Fig 3.7.2 Temperature Sensor output (c)

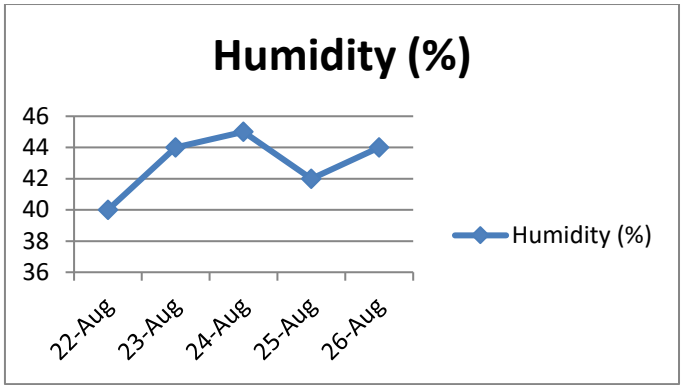

Fig 3.7.3 Humidity Sensor output (%)

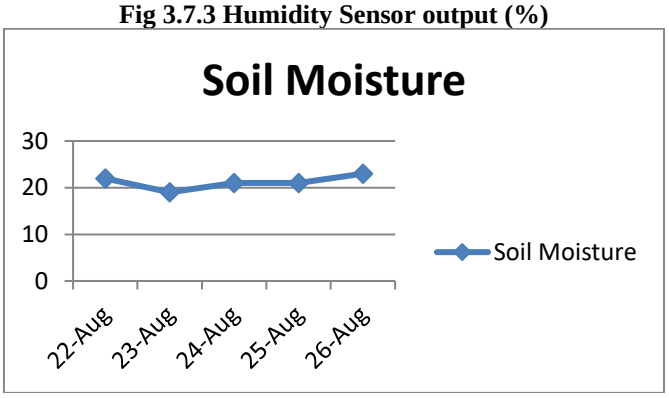

Fig 3.7.4 Soil Moisture Sensor output (15 cm (%))

4. CONCLUSION

Adoption of IoT technology in agriculture will transform the traditional agriculture processes. IoT plays a major role in Indian agriculture sector in future. Existing research works focused only on monitoring the farm land and efficient water irrigation activities. This paper gives more focus on plant growth and soil nutrition. The growth of the plant is closely monitored through sensors and IoT technologies. The collected data are processed for further predictive decision using Machine Learning. Precision Agriculture guarantees high yield and quality in agriculture products. Precision Agriculture helps the farmers for improving their economical status with minimum expenditure. It also assures eco friendly environment by optimizing the usage of limited natural resources.

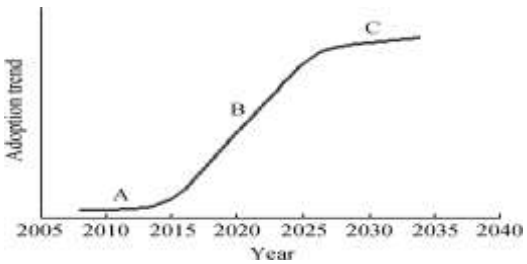

Fig 4.1 Proposed PA adoption trend in India

5. REFERENCES

[1] Parul Goyal et al. "Internet of Things: Architecture and Enabling Technologies", 23rd April 2020, https://doi.org/10.1016/j.matpr.2020.04.678.

[2] Sjaak Wolfert et al, "Big Data in Smart Farming – A Review", Agriculture Systems 153(2017) 69-80, Elsevier.

[3] Antonis Tzounis, et al, "Review Internet of Things in agriculture, recent advances and future challenges", Bio systems engineering 164(2017) 31-48, www.elsevier.com/locate/issn/15375110

[4] Jira Pond Muangprathub et al, "IoT and Agriculture data analysis for Smart Farm", December 2018, Elsevier.

[5] Koksaal.B.Tekinerdogan, "Architecture Design approach for IoT based farm management Information Systems", Precision Agriculture (2019) 20:926-958, Springer.
[6] Chandrashekhara K .T et al, "Precision irrigation using intelligent systems", June 2017, ISSN 2277-9655, CODEN IJESS7.
[7] Subrata KR. Mandal et al, "Precision Farming for small agricultural farm" Indian Scenario", American Journal of Experimental Agriculture3 (1):200-217,2013, Science Domain.
[8] electronics FOR YOU," An EFY GROUP publication vol 50 No12 ISSN 0013-516X"
[9] www.GeeksforGeeks.org
[10] www.iotforall.org
[11] https://thinger.io
[12] www.iot-analytics.com

