WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

The Role of Internet of Things (IoT) in Revolutionizing Agriculture.

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ABSTRACT:

This automation through Smart IoT is proved to be a new hope for changing the face of agricultural field with productivity, efficiency and sustainable standards across the globe. This paper covers three areas through which IoT can be put to practical use in agriculture: precision farming, cattle tracking, supply chain. This also gives an insight into the future of IoT as an area of study considering the pro and con as well as the future trends. Especially, HIOM(Home Intelligent Operation Module) focuses on the automatic water pump switch on/off system as the key reason to implement the IoT concept in the promotion of agriculture improvement.

KEY WORDS: Internet of Things (IoT), agriculture, precision farming, livestock monitoring, supply chain optimization, sustainability, efficiency, automatic water pump.

1. INTRODUCTION:

I chose agriculture as one of the key and indispensable sectors which satisfy the human needs at the basic level providing people with food. However these involve several steps such as climatic change, resource availability being a limiting factor and consumer demands due to population bounce. All of these challenges can be met and solved with assistance of IoT as a system which communicates and provides new directions and methods in the sphere of agriculture. IoT refers to a system of connectors, particulars, instruments and other proper apparatus through conveying and assembling specific information for various uses.

2. REVIEW OF LITERATURE:

Literature Review:

IoT is playing a very important role in agriculture industry as it helps in increasing precision, efficiency and productivity of the different practices being involved in the agriculture practices.

Precision Farming

- **Soil Health Monitoring**: Terra and soil moisture sensors detect the unique pH of the soil, moisture level, and nutrients then apply the proper amount of fertilizer and water for increased crop yield.
- **Climate Monitoring**: There were also losses incurred as a result of higher the losses occasioned by unfavourable weather hence IoT stations offer real-time weather data to be used in planning activities in the farming sector.
- **Irrigation Management**: The computer controlled systems employ soil moisture detail for efficient water supply for irrigation, consequently reducing water consumption.

Livestock Monitoring

- **Health Monitoring**: Signs of diseases are detected early by wearable sensors used on animals to monitor their vital indicators such as those relating to livestock.
- **Behavioral Analysis**: People employ IoT systems by controlling the behavior of animals to detect any disease incidence or stress levels.
- **Geolocation**: Such gadgets help prevent loss and theft of livestock by tracking them using GPS devices.

Supply Chain Optimization

- **Cold Chain Management**: With the assistance of IoT sensors, it is possible to accurately control temperature and humidity levels in storage and during transportation of short-life products.
- **Inventory Management**: Another benefit is timely tracking since it eliminates occurrences like overstocking or running out of supplies.
- **Traceability**: Disadvantages IoT and blockchain help to improve product tracking, which increases confidence in consumers.

Automatic Water Pump Systems

- **Operational Efficiency**: Irrigation robotic pumps minimize grade work and allow the efficient use of water through information on the moisture content of the soil.
- **Cost Savings**: Optimal control of water pumps can drastically reduce the costs of water and energy.
- **Environmental Impact**: Ensures that hills, lawns and gardens are not over-watered thus conserving the soil.

3.SOMETIMES, IOT IN AGRICULTURE CAN BE APPLIED IN THE FOLLOWING WAYS:

A. Precision Farming

IoT cause can be effective in areas like precision farming since fields are governed, and managed to a high degree of accuracy. It is a box that has some tapes that are inserted on the ground to analyze ground wetness, nutrient status and temperature. The use of aerial images captured by built-in multispectral cameras in drones to track the condition of crops and determine sufficiency or insufficiency, withered symptoms, pest attack, and water scarcity. All of these sensors and all such drones relay their information to the major systems where complex programs analyse the information.

1. **Soil Health Monitoring:** This are Ph, moisture and nutrient in the soil and hence farmers can use the sensors to control the amount of fertilizer they add and the times they water the soil [1]. It also has benefits of stopping the crop yields from being trampled upon by livestock and being washed away by rain since hiring the farmers does help in reducing the rate of over-grazing and erosion.

2. Climate Monitoring: Farms, which use IoT sensors in weather stations provide details of the climatic factors including the temperature, humidity, rain fall and wind speeds within the farm, this help the farmers in planning their activities depending on the type of weather which is lingering on IOT Agriculture 6 [2]. For instance describing properly when to embark on planting or when to exercise the act of harvesting would assist greatly in increasing production and minimizing losses.

3. Irrigation Management: Weather and Crop Information through the use of automated systems controls the quantity of water to be supplied and the time at which they are supplied with the of help of soil moisture sensors the supply the plant with water in the right measures [4]. Sub-irrigation systems can also be used to provide inputs of weather forecasts, so as to increase the accuracy of the rates in a way that would prevent over or under irrigation.

B. Livestock Monitoring

As it would be seen, the innovative usage of IoT technology can help in evaluating the current health status of the cattle. It is made of an array of health sensors worn on animals for monitoring the various health rates such as the heart rate, body temperate, and activity levels. These sensors play a good role in allowing farmers to notice the time when the animals are developing different diseases so that they can be treated as soon as the diseases crop up.

1. Health Monitoring: Using Internet of Thing (IoT) for health monitoring in agriculture means placing various sensors and devices across the field, crops, animals, and the general conditions with the main aim of helping to monitor and check on the health conditions of the crops, the animals, and the general atmosphere in the farms. It also assists in decision making, and the reduction of expenses, time, and energy to achieve optimum productivity[4].

2. Behavioral Analysis: They allow IoT systems to gather and, as a rule, analyze the information about the animals to identify the best feeding and breeding strategies. For example, changes in feeding pattern, or a reduction in physical activity might be indicative of disease, stress, or illness infecting animals and such irregularities warrant correction, for the best interest of the animals[5].

3. Geolocation: GPS in Tracking Systems: In this application, GPS is employed in ascertaining the location of animals like cattle that sometimes wander or can be stolen [6]. This technology is most useful where there are many herds in large scale farming practices because tracking all the animals would otherwise be gen('"narrative'': The major area of application of this technology is where there are many herds in extensive farming practices to track all the animal and it will be cumbersome.

C. Supply Chain Optimization

It is also beneficial for the agricultural supply chain as it entails real time extent of availed product concerning its status as well as location. This makes it possible for crops and livestock to be captured and transported in the right environment, thus reducing losses arising from post-harvest destruction in the value chain and at the same time have better track and trace from farm gate to the consumer plate.

1. Cold Chain Management: Thus, by implementing IoT sensors, it is possible to maintain storage and transportation chambers' temperature and humidity levels steady not to allow perishable products to spoil [7]. For example, thermal equipment within cold platforms such as trucks can sound alarms when temperatures rise to dangerous levels thus the necessary adjustments are made to avoid spoiling goods.

2. Inventory Management: They recommended that through the tracking of the stock as it is taken through the bin, then there is better management of the stock and little cases of wastage of the products. Automated ordering of supplies is also simpler when due implying that the farmers shall hold possession of all the input that they require without holding more than what they require [8].

3. Traceability: Frequently used in agriculture, technology manages to employ both blockchain and IoT with the purpose of tracking goods and enhancing their quality as well as safety when consumed [9]. Some aspects, which are easily explainable by the use of a simple QR code include, the source, the process it undergoes, and the mode of transport, these aspects create trust and reduce decisions making complexity among the consumers.

D. AUTOMATIC WATER PUMP SWITCH ON/OFF SYSTEM

Another component that is encapsulated in precision irrigation embraces automatic water pump switch on/off stations. In the study conducted by [7] and [8], the authors explained the concept of IoT smart water pump that are worked in sequence to switch ON or Off at specific time in accordance with the value generated by the moisture sensors covered in the soil and weather prediction.

1. Operational Efficiency: These systems ensure that water is supplied only that is needed hence reducing wastage of water while at the same time meeting the water demand of plants. The only plus in this type of operation is that it is fully automatic and this means that there are few, if any, manual operations that are frequently requiring manpower and time.

2. Cost Savings: This way the complexity of these systems provides one cut operational costs of the kind that would be needed to provide water and energy. Due to high precision involved in water pumping, one can achieve significant great reduction of costs when water is required in large quantities for irrigation purposes.

3. Environmental Impact: Other application of auto watering systems is also helpful in issues of soil conservation when it comes to delivery of water since it is a way of preventing the common issue of over irrigation that poses various challenges through water logging. So, when only these systems use water only in extremes where it cannot be avoided, they support water conservation and soil care.

4. Integration with Other IoT Systems: To achieve the intelligent farming concept, they can be interfaced with other IoT devices such as weather stations and the crop health monitoring system. Irrigation control: It integrated various data source that lead to right decisions concerning irrigation hence making Farm management accurate.

METHODOLOGY AND TECHNICAL IMPLEMENTATION

A. also known as system design, reflects the structural organization of a system and its parts.

The normally used Automatic water pump switch on/off system is usually the combination of sealing moisture sensers, a microcontroller – perhaps Arduino or Raspberry Pi – a relay module, and a water pump. Sensors relay information to the microcontroller to indicate whether it needs to actuate the relay switch to turn the pump on or off.

B. Working Code

Below is a sample code for an automatic water pump switch on/off system using an Arduino microcontroller:The following is an example of the code which implements an automatic water pump switch on/off based on the Arduino microcontroller.

Here is the code snippet in the Arduino language:

```
// Include necessary libraries

#include <Wire.h>

#include <Adafruit_Sensor.h>

#include <Adafruit_BME280.h>


// Define the pin connections

const int moistureSensorPin = A0;

const int relayPin = 7;


// Threshold value for soil moisture

const int moistureThreshold = 500;

Adafruit_BME280 bme; // Create a BME280 object

void setup() {
```

```
  // Initialize serial communication
  Serial.begin(9600);

  // Initialize the relay pin as output
  pinMode(relayPin, OUTPUT);
  digitalWrite(relayPin, HIGH); // Ensure the pump is off at startup

  // Initialize the BME280 sensor
  if (!bme.begin(0x76)) {
    Serial.println("Could not find a valid BME280 sensor, check wiring!");
    while (1);
  }
  Serial.println("BME280 sensor initialized successfully!");
}
void loop() {
  // Read soil moisture value
  int moistureValue = analogRead(moistureSensorPin);

  // Print the soil moisture value to the serial monitor
  Serial.print("Soil Moisture: ");
  Serial.println(moistureValue);

  // Control the water pump based on soil moisture
  if (moistureValue < moistureThreshold) {
    digitalWrite(relayPin, LOW); // Turn the pump on
    Serial.println("Pump ON");
  } else {
    digitalWrite(relayPin, HIGH); // Turn the pump off
    Serial.println("Pump OFF");
  }

  // Read and print the BME280 sensor values
  float temperature = bme.readTemperature();
  float humidity = bme.readHumidity();
  float pressure = bme.readPressure() / 100.0F;

  Serial.print("Temperature: ");
  Serial.print(temperature);
  Serial.println(" °C");
```

```
  Serial.print("Humidity: ");
  Serial.print(humidity);
  Serial.println(" %");

  Serial.print("Pressure: ");
  Serial.print(pressure);
  Serial.println(" hPa");

  // Delay for a short period before the next reading
  delay(2000);
}
```

Explanation:

1. Libraries: Contained all needed dependencies for handling the sensor and for interaction with other modules.

2. Pin Definitions: Define the concrete analog pin that will be used by the implemented moisture sensor and concrete digital pin that will be used by the relay.

3. Threshold: Select a depth at which the soil moisture can be regulated whereby you switch on or off the pump to water the plants.

4. BME280 Initialization: First, begun with the identification of the BME280 sensor and then proceeded to verifying if the sensor is properly interfaced.

5. Soil Moisture Reading: Without a doubt, decipher the water level reading from the soil moisture sensor and 'ON/OFF' the relay as the scenario demands.

6. BME280 Readings: To read the temperature, pressure, and humidity from BME280 sensor, follow the steps below: Click on the 'Subscribe' button, and you will see the temperature, pressure, and humidity value displayed in the Serial Monitor for a particular interval of time.

7. Pump Control: Used a relay to switch on/off the water pump based on vicinity of soil moisture level to a certain predetermined limit.

C. Connection Diagram

The following diagram illustrates the connections required for the automatic water pump switch on/off system:The following is the wiring diagram that defines the required connections in the automatic water pump switch on/off system:

• **Moisture Sensor**: This should be connected to A0 pin of Arduino board for the analog output cable.

• **Relay Module:** Map the control signal to pin number 7 via arduino board of the system.

• **Water Pump:** Correct power supply to the pump is established once the usb module is connected to the relay module.

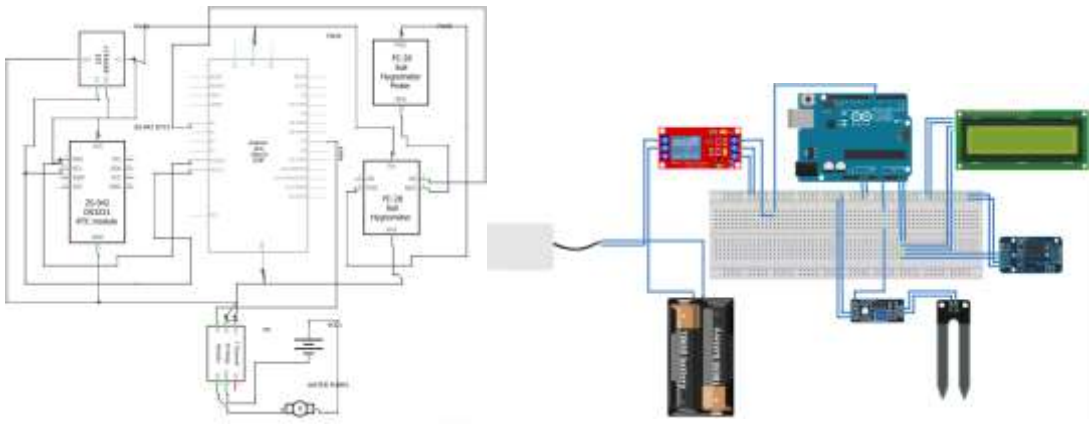

Fig:1 Connection cercute diagram

4. THE BENEFITS THAT CAN CAREFULLY BE ACCRUED FROM THE USE OF IOT IN AGRICULTURE

The integration of IoT in agriculture offers numerous benefits:The main advantages of the integration of IoT in the agricultural sector include:

1. Increased Efficiency: It saves a lot of time for health workers in terms of time and physical efforts in extending collection, storage, processing as well as distribution of medical products, constant monitoring of patients and samples, and analysis of results. For example, use of IoT in tractors, harvesters, or any such equipment like can do some work with very little or no intervention from human interference [10].

2. Cost Savings: Such as if the farming form involves minimal use of water, fertilizers, and pesticides the cost involved in the recurring purchase of the same as inputs is curbed. Both help reduce wastage where the wrong dosage is given and greatly enhance the level of productivity [11].

3.Sustainability: IoT promotes eco-friendly disposals as wastage behaviour and even the impacts of the farming processes on the environment are well controlled. For example, the use of precise irrigation equipment is considered to effectively reduce water consumption [12].

4. Improved Yield: Working together with the analytical processes, decisions are made regarding better yields to be obtained from cropping of crops and the animals. As mentioned earlier, farmers are able to a certain extent diagnose crop health and the condition of the soil, so an additional correction [13].

5. SOME OF THE PROBLEMS THAT ORSTWEN IN THE AMBITION OF CONNECTING IOT IN AGRICULTURE.

Despite its potential, there are several challenges to the widespread adoption of IoT in agriculture:

1. High Initial Costs: Nevertheless, the adoption of IoT systems in farms could prove to be costly and er even if costly, costly to the small farmer. They consist of such things like the sensors for data acquisition,the UAVs(drons) which can aid in reaching certain parts,storage of the data,and the offing which is used in analyzing the data. Additionally, and sometimes more significantly, are the costs incurred in the actual setting up of these systems and the implementation that is with general maintenance and occurrences of periodic updates [14].

2. Data Security: Data security in the agriculture world What exactly does this mean for the agriculture world and with the implementation of IoT or the 'Internet of Things' on an agricultural plane? Sensors, drones, and smart agricultural machinery and equipment are helping farmers to gather a vast amount of data on soil health, weather conditions, crop development, and condition of livestock and products. Security of this data means applying of strong encryption practices to enhance the protection of this data when in transit or stored. Security measures such as access controls and authentication procedures in addition to examining IoT network vulnerabilities periodically is paramount to defending against cyber threats. In this respect, it is crucial for stakeholders to be explained the Best Cybersecurity Practices in order to minimize the risks of becoming targets of attacks or data breaches Agriculture, should therefore/, stay abreast with developments in IoT as well as other emerging technologies with potentials for symbiosis with devices and software -, however, this should be done while observing the required security and compliance standards over the big data customer data that is being gathered, monitored and processed. [15].

3. Technical Complexity: As a result, farmers need the technical capability to Repairs, upgrade and analysing data from such IoT systems. Large awareness and need levels in the areas of Training and Support. In summary, challenges can be grouped into seven broad categories, and interoperability and collaboration of numerous IoT devices such that they present high complexity are among some of the major issues [16].

4. Connectivity Issues: In all probability, the most significant driver towards the adoption of IoT is comprised of smart systems that utilise dependable internet facilities which are conspicuous by their absence in the countryside areas. In the case that there is inadequate infrastructure to facilitate IoT, the IoT solutions can be either harmed or at best remain unbenefited. In courses like IoT, it is essential to have effective and consistent communications because intermittent communications or unreliable links interfere with the continuous operation of IoT applications in the rural areas [17].

6. FUTURE PROSPECTS:

There are high risks for IoT in the future of the agricultural operations, as technology advances and acknowledgement of the application of IoT sparks. The advancements' in AI, ML are projected to bring about improved IoT systems since AI and ML already form part of the IoT systems' architecture.

1. AI and ML Integration: By AI and ML, immense amounts of data which receive continuous data from IoT can be processed for the generation of constant reports and decision making outcomes. For example: AI can detect pests or disease outbreaks and this assists in the kind of action to be undertaken [18].

2. Advanced Robotics: Since required activities like planting, weeding, and even harvesting will be done neatly using IoT sensors fixed on robots, it will be done carefully. Actually, some of these robots are able to run for 24 hours and thus within this they will be able to perform human-labor competition with regard to productivity on the farms [19].

3. Sustainable Practices: Based on the findings, IoT will have a key constituent in the real farming by reconstructing the repute efficiency and cost with respect to environmental portion. For instance, IoT can contribute in reducing the instances when water is used when it is not supposed to be used and in making use of fresh water in the most efficient manner [20].

4. Worldwide Collaboration: Measures that will enable networks and data on different aspects to be openly shared will enable farmers from around the globe to collaborate and share practices that are enhancing the progress of agriculture within different regions of the world. There has also been noted the fact that being able to gather data of farms and equipment from different production stands as well as their analysis, enables the generation of specific information which may be useful for the farming fraternity as a whole [21].

7. CONCLUSION:

Assuming that Internet of Things can make a difference in the agriculture industry there is high probability that it can bring opportunities, efficiency and possibilities to the field. Sure, the same must not be forgotten about the fact that it is possible to find certain drawbacks connected with its use, however, the latter appears to be quite outweighed by the number of advantages. With innovation changing to advancement, IoT will ascend on a progressively principle in obligation outlining to feed the world in 21st century security difficulties. The adoption of IoT in the agriculture value chain is one of the major milestones towards achieving better profitability in agribusiness.

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