CHAPTER 1

INTRODUCTION

1. INTRODUCTION

1.1. GENERAL INTRODUCTION

Agriculture has always been the backbone of human civilization, providing essential resources for survival. However, challenges such as water scarcity, soil degradation, and climate change necessitate smarter farming techniques to ensure food security and sustainable resource management. Precision farming, powered by the Internet of Things (IoT), is emerging as a transformative solution, enabling farmers to monitor and manage their fields with greater accuracy and efficiency.

This project introduces a scalable IoT-based precision farming system that integrates multiple sensors to monitor essential environmental and soil parameters. These include a temperature sensor, humidity sensor, NPK sensor for nutrient levels, and a soil moisture sensor. The data collected is displayed in real-time on a mobile application via Bluetooth connectivity, providing farmers with an intuitive interface to make informed decisions. The system also features a robotic car for mobility across the field, ensuring comprehensive data collection from multiple locations.

In addition to monitoring, the project includes an automated irrigation system controlled via the mobile app. A water pump can be activated remotely based on real-time soil moisture readings, ensuring optimal water usage while reducing manual labor. This modular design ensures scalability, allowing for the integration of additional sensors or functionalities in the future.

By combining IoT, automation, and data analytics, this system provides farmers with actionable insights to optimize resource utilization, improve crop health, and enhance overall productivity. The solution is cost-effective, user-friendly, and designed to be adaptable for various farm sizes and requirements. Future extensions of the project could include

Internet-based remote monitoring, AI-driven crop recommendations, and integration with weather forecasts for predictive decision-making, making this an innovative step toward smarter and more sustainable agriculture.

1.2 PROBLEM STATEMENT

Traditional farming practices often rely on manual observation and generalized decision-making, leading to inefficiencies in resource utilization, such as water, fertilizers, and labor. Farmers face challenges in monitoring environmental and soil conditions across large or diverse fields, resulting in overwatering, under-irrigation, or improper nutrient application. Additionally, climate variability and soil degradation exacerbate these issues, affecting crop yields and sustainability.

Despite the availability of advanced farming technologies, most solutions are expensive, complex, or lack scalability, making them inaccessible to small and medium-scale farmers. There is a growing need for an affordable, easy-to-use, and modular system that enables farmers to monitor and manage field conditions effectively.

To address these challenges, this project proposes a scalable IoT-based solution that combines real time monitoring of key agricultural parameters—such as temperature, humidity, soil moisture, and nutrient levels (NPK)—with automated irrigation control. The system is designed to be mounted on a robotic car for mobility, ensuring comprehensive data collection from different field locations. It utilizes Bluetooth connectivity to display sensor data on a mobile application, allowing farmers to make informed decisions and control irrigation remotely.

This approach aims to optimize resource usage, reduce manual effort, and improve crop productivity. By offering a cost-effective and scalable solution, this project seeks to bridge the gap between traditional practices and modern precision farming technologies, empowering farmers to achieve sustainable agriculture.

1.2 PROJECT OBJECTIVES

The main purpose of this project is to develop a flexible IoT system that helps farmer monitor real time conditions.

1. **Real-Time Monitoring**: To provide real-time monitoring of critical agricultural parameters such as temperature, humidity, soil moisture, and soil nutrients (NPK) for informed decision-making.

2. **Automated Irrigation Control**: To enable efficient water management by remotely controlling a water pump based on real-time soil moisture data through a mobile application.
3. **Mobility for Comprehensive Data Collection**: To ensure accurate and widespread field monitoring by utilizing a robotic car capable of gathering sensor data from multiple field locations.
4. **Cost-Effective and Scalable Design**: To develop an affordable system that can be easily scaled or customized by integrating additional sensors or features as needed.
5. **User-Friendly Interface**: To simplify farming operations by providing a Bluetooth-based mobile application for real-time data visualization and control of the irrigation system.

1.3 BLOCK DIAGRAM AND DESCRIPTION

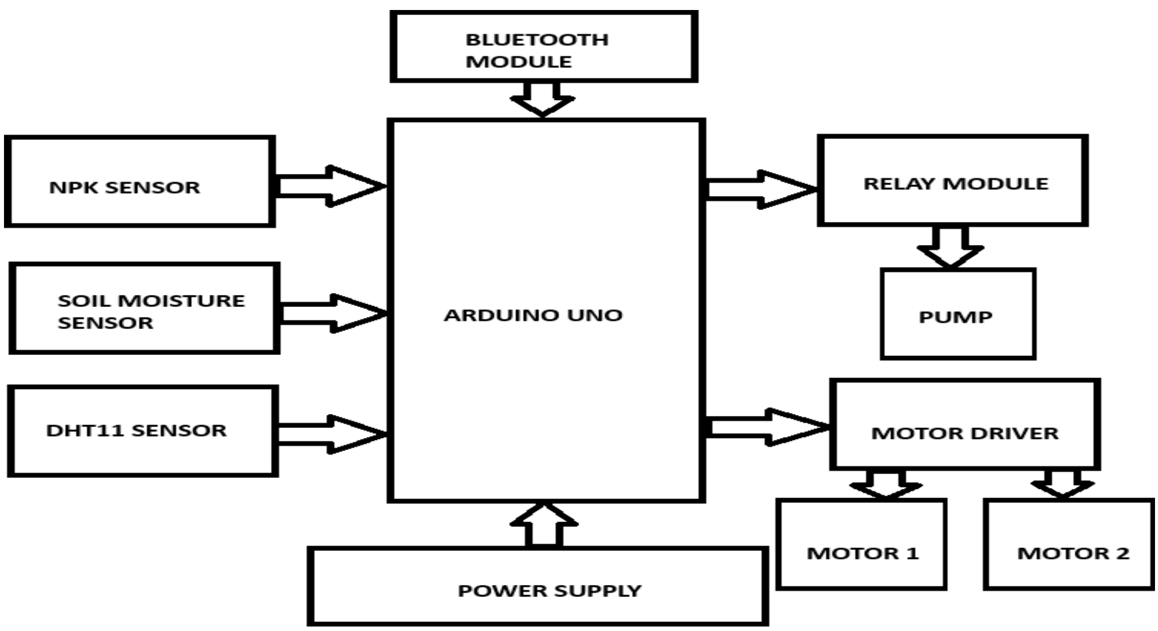

Fig 1.4 Block Diagram of Scalable IoT For Precision Farming

The Scalable IoT for Precision Farming system is designed to integrate multiple sensors, a robotic car, and a Bluetooth-based mobile application to monitor and manage farming activities effectively. The system's core components include a temperature sensor, humidity sensor, NPK sensor, and soil moisture sensor mounted on a robotic car. The car's mobility allows it to traverse the fie collecting data from different locations, ensuring comprehensive monitoring.

The sensors are connected to a microcontroller (Arduino or NodeMCU), which processes the data and transmits it via Bluetooth to a mobile application. The mobile app serves as the user interface, displaying real-time values of temperature, humidity, soil moisture, and nutrient levels in a clear and accessible format. Farmers can use this data to assess environmental conditions and soil health, making informed decisions about irrigation and fertilization.

The system includes an automated irrigation mechanism controlled via the mobile app. When the soil moisture sensor detects low moisture levels, users can remotely activate the water pump through the app, ensuring precise and timely watering. This feature not only conserves water but also reduces manual labor. The robotic car is powered by a motorized system, enabling it to move autonomously or as directed by the user. Its mobility ensures that data is gathered from multiple points in the field, providing a holistic view of the conditions. The design is modular and scalable, allowing additional sensors or advanced functionalities, such as internet connectivity or AI-based crop recommendations, to be integrated in the future.

This IoT-based system combines real-time monitoring, automation, and mobility, making it a practical, cost-effective, and sustainable solution for modern precision farming.

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1.4 CHAPTERS OUTLINE

The problem definition, project objectives and block diagram and description of the project has been compiled into several chapters as discussed here under:

- **CHAPTER 1** Is an introduction chapter with general introduction, problem definition, objective of work carried out during project and the block diagram.
- **CHAPTER 2** Involves the literature survey of the project for the practical implementation.
- **CHAPTER 3** Involves the description of the hardware design. The chapter comprises of general operation and the use of components.
- **CHAPTER 4** Involves the circuit diagram and operation.
- **CHAPTER 5** Involves the applications, advantages and disadvantages.
- **CHAPTER 6** Involves the result and discussion of the project.

CHAPTER 2

LITERATURE SURVEY

2. LITERATURE SURVEY

Internet of Things for Precision Agriculture: Applications and Technologies [1] presents a detailed overview of how IoT is transforming precision agriculture by enabling real-time monitoring and control, focusing on optimizing resource use like water and fertilizers to improve crop yields.

Big Data in Smart Farming – A Review [2] explores the role of big data in agriculture, particularly how IoT devices generate large volumes of data to enhance decision-making processes, while discussing the challenges and opportunities in smart farming.

Internet of Things-IoT: Definition, Characteristics, Architecture, Enabling Technologies, Application & Future Challenges [3] introduces IoT, explaining its architecture and applications in agriculture, emphasizing how IoT aids farmers in monitoring crops and livestock to improve efficiency and reduce costs.

IoT Based Monitoring System for Agriculture [4] discusses the development of an IoT- based system for real-time monitoring of soil moisture, temperature, and other factors aimed at improving irrigation efficiency and crop health.

A Review on the Practice of Big Data Analysis in Agriculture [5] explores the potential of big data in enhancing agricultural productivity by analyzing data collected from IoT sensors to optimize farming operations.

Smart Irrigation System Based on Deep Learning Neural Network [6] proposes a system that combines IoT sensors and deep learning algorithms to predict optimal irrigation schedules, improving water usage efficiency and crop health.

Smart Farming Revolution: Harnessing IoT for Enhanced Agricultural Yield and Sustainability [7] focuses on the transformative impact of IoT (Internet of Things) on modern agriculture. It explores how smart farming technologies, powered by interconnected sensors and devices, enable real-time monitoring of environmental factors such as soil moisture, temperature, humidity, and crop health. This real-time data allows farmers to make data-driven decisions, optimizing water usage, fertilizers, and pesticides, leading to more efficient resource management.

Monitoring and Automation in Agriculture using IoT [8] discusses the automation of processes like irrigation and pest control through IoT, showing how it reduces manual labor while enhancing farming efficiency.

Review of IoT Applications in Agro-industrial and Environmental Fields [9] reviews IoT applications in agriculture, emphasizing its use in soil analysis, weather forecasting, and smart greenhouse management while highlighting environmental benefits.

A Survey on Applications of IoT in Precision Agriculture [10] explores various IoT technologies used for monitoring soil, weather, and crop conditions, addressing challenges such as scalability, energy efficiency, and data security in IoT-based systems

CHAPTER 3

NPK NUTRIENT

REQUIREMENTS FOR MAGOR CROPS

3.1 Introduction

Agricultural productivity relies heavily on the availability of essential nutrients. Among these, Nitrogen (N)**,** Phosphorus (P), and Potassium (K**)**—collectively referred to as NPK—are the primary macronutrients required for healthy plant growth and development. These nutrients significantly influence crop yields and soil health, making their proper management critical in modern farming systems.

Nitrogen (N)

Role in Plant Growth:

- Nitrogen is a key component of chlorophyll, enabling photosynthesis, the process through which plants produce energy.
- It supports rapid vegetative growth, contributing to the development of leaves and stems.
- Nitrogen is an essential building block of proteins, enzymes, and nucleic acids.

Impact on Yield:

- Enhances biomass production and improves crop yields.
- Critical for cereal crops like rice, wheat, and maize, where grain production depends on sufficient nitrogen.

Deficiency Symptoms:

- Yellowing of older leaves (chlorosis).
- Stunted growth and reduced yields.

Phosphorus (P)

Role in Plant Growth:

- Phosphorus is critical for root development, ensuring plants can access water and nutrients efficiently.
- It plays a vital role in energy transfer within the plant, particularly through the formation of ATP (adenosine triphosphate).

- Supports the growth of flowers, seeds, and fruits, influencing both quantity and quality.

Impact on Yield:

- Particularly important for leguminous crops like soybean and groundnut, which fix atmospheric nitrogen in the soil.
- Improves crop resilience to cold temperatures and drought conditions.

Deficiency Symptoms:

- Purplish discoloration of leaves.
- Poor root development and delayed maturity.

Potassium (K)

Role in Plant Growth:

- Potassium helps regulate water uptake and retention, improving plant tolerance to drought and other stresses.
- It activates enzymes involved in photosynthesis and protein synthesis.
- Enhances the overall quality of produce by improving size, color, and disease resistance.

Impact on Yield:

- Plays a crucial role in fruit-bearing crops like tomatoes, bananas, and potatoes.
- Improves crop shelf life and market value by enhancing quality.

Deficiency Symptoms:

- Weak stems, brown leaf edges, and poor fruit or grain development.
- Weak stems and vulnerability to pests and diseases.

Significance of NPK in Agriculture

1. **Balanced Plant Nutrition:** Adequate levels of NPK ensure that crops receive the nutrients required for their specific growth stages.
2. **Soil Fertility Maintenance:** Sustained use of NPK fertilizers helps maintain the soil's nutrient balance, preventing depletion.

Crop	**Duration**	**NPK Ratio (kg/ha)**	**Key Notes**
Sugarcane	12-15 months	300:100:200 (Sugar Mills), 225:62.5:200 (Jaggery)	N: 2.0-5.0%, P: 0.5-1.0%, K: 1.0-2.0%. Foliar Urea: 1-2.5%, Potassium: 2.5%
Wheat	4-5 months	120:50:40	High nitrogen for protein, moderate P and K for growth.
Rice	4-5 months	100:60:40	Balanced NPK ensures good yield and grain quality.
Maize	3-4 months	150:60:40	High N demand for rapid growth.
Cotton	5-6 months	80:40:40	Phosphorus supports flowering; K enhances fiber strength.
Soybean	4-5 months	20:50:40	Requires less nitrogen due to nitrogen-fixing capability.
Groundnut	3-4 months	20:40:40	Requires phosphorus for pod development.
Tomato	3-4 months	120:50:100	High K essential for fruit formation.
Potato	3-4 months	100:60:120	Requires high potassium for tuber quality.
Banana	9-12 months	200:50:200	High N and K for growth and fruit quality.

Table 3.1 NPK Requirements for Major Crops

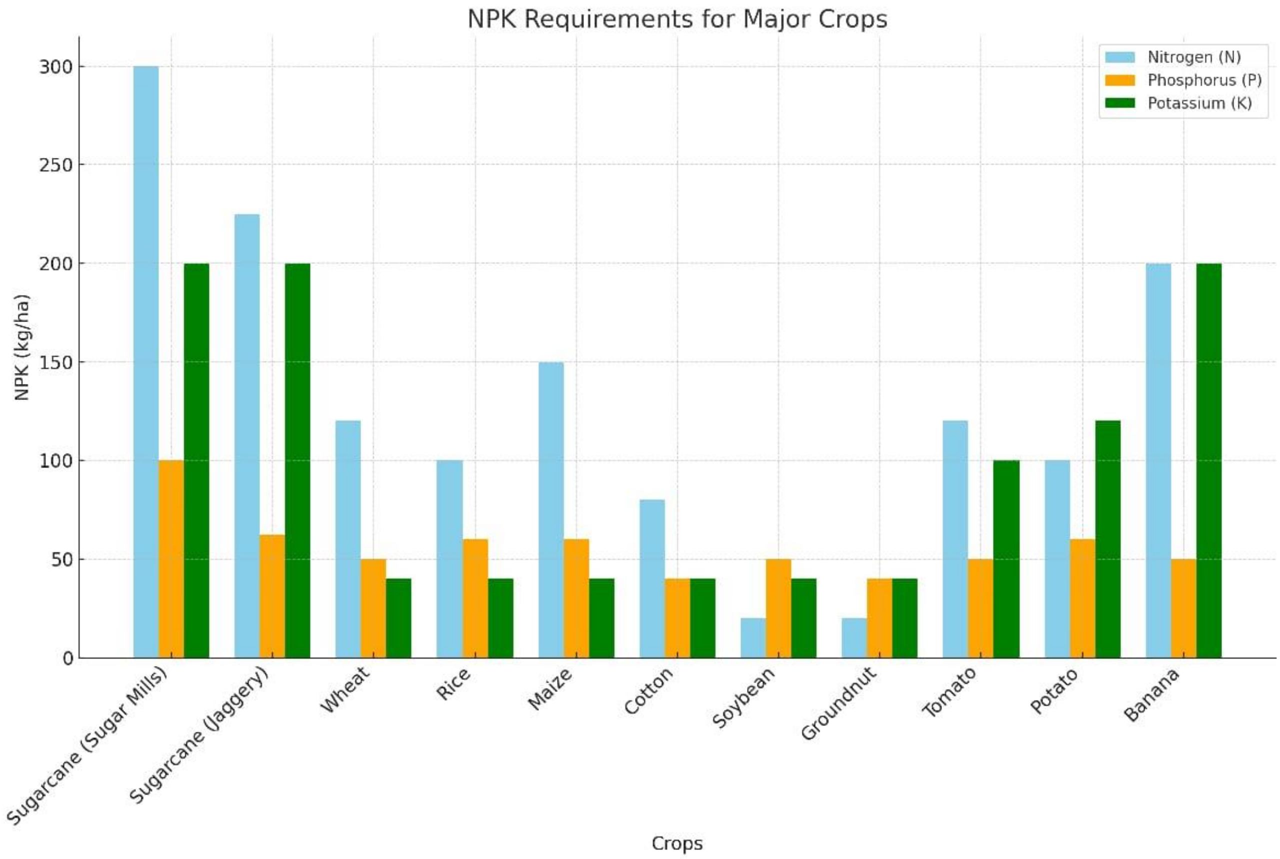

Fig 3.1 NPK Requirements for Major Crops

From the NPK values provided, we observe that different crops have distinct nutrient requirements. High nitrogen (N) is essential for crops like wheat, maize, and sugarcane, promoting leaf and stem growth. Phosphorus (P) plays a key role in flowering and pod development, evident in crops like cotton and groundnut. Potassium (K) is crucial for fruit and tuber quality, highlighted in crops such as tomato, potato, and banana. Nitrogen-fixing crops like soybean require lower N levels due to their ability to fix atmospheric nitrogen. Balancing NPK ratios ensures optimal growth, yield, and quality for each crop.

CHAPTER 4

HARDWARE COMPONENTS

4. HARDWARE COMPOPMENT

4.1 ARDUINO UNO

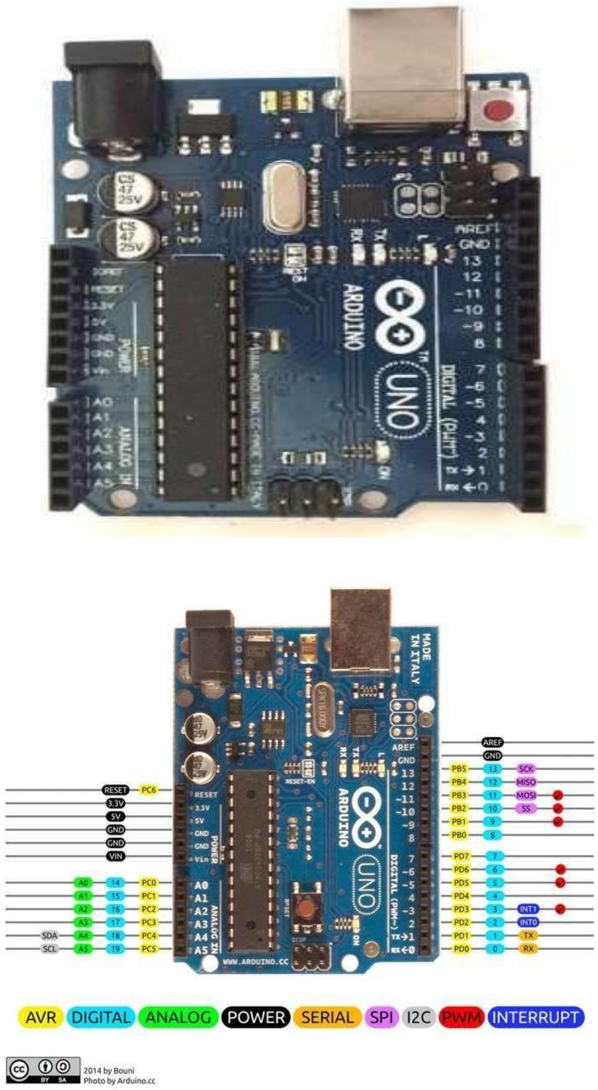

Fig 4.1 Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328P, ideal for DIY electronics, robotics, and IoT projects. It features 14 digital I/O pins, 6 analog input pins, and supports various communication protocols like USB, UART, SPI, and I2C. The board can be powered via USB or an external power source, and is programmable using the Arduino IDE, supporting C, C++, and a simplified version of C++.

Pin Category	Pin Name	Details
Power	Vin, 3.3V, 5V, GND	Vin: Input voltage to Arduino when using an external power source. 5V: Regulated power supply used to power microcontroller and other components on the board. 3.3V: 3.3V supply generated by on-board voltage regulator. Maximum current draw is 50mA. GND: ground pins.
Reset	Reset	Resets the microcontroller.
Analog Pins	A0 – A5	Used to provide analog input in the range of 0-5V
Input/output Pins	Digital Pins 0 - 13	Can be used as input or output pins.
Serial	0(Rx), 1(Tx)	Used to receive and transmit TTL serial data.
External Interrupts	2, 3	To trigger an interrupt.
PWM	3, 5, 6, 9, 11	Provides 8-bit PWM output.
SPI	10 (SS), 11 (MOSI), 12 (MISO) and 13 (SCK)	Used for SPI communication.
Inbuilt LED	13	To turn on the inbuilt LED.
TWI	A4 (SDA), A5 (SCA)	Used for TWI communication.
AREF	AREF	To provide reference voltage for input voltage.

Table 4.1 Pin Description of Arduino Uno

Microcontroller	ATmega328P – 8 bit AVR family microcontroller
Operating Voltage	5V
Recommended Input Voltage	7-12V
Input Voltage Limits	6-20V
Analog Input Pins	6 (A0 – A5)
Digital I/O Pins	14 (Out of which 6 provide PWM output)
DC Current on I/O Pins	40 mA
DC Current on 3.3V Pin	50 mA
Flash Memory	32 KB (0.5 KB is used for Boot loader)
SRAM	2 KB
EEPROM	1 KB
Frequency (Clock Speed)	16 MHz

Table 4.2 Arduino Uno Technical Specifications

4.1.1 PROGRAMMING ARDUINO

Once Arduino IDE is installed on the computer, connect the board with computer using USB cable. Now open the Arduino IDE and choose the correct board by selecting Tools>Boards>Arduino Uno, and choose the correct Port by selecting Tools>Port. Arduino Uno is programmed using Arduino programming language based on Wiring.

Once the example code is loaded into your IDE, click on the ‘upload’ button given on the top bar.

4.2 LCD

Fig 4.2 16x2 LCD Module

LCD modules are very commonly used in most embedded projects, the reason being its cheap price, availability and programmer friendly. Most of us would have come across these displays in our day to day life, either at PCO’s or calculators. The appearance and the pin outs have already been visualized above now let us get a bit technical.

16×2 LCD is named so because; it has 16 Columns and 2 Rows. There are a lot of combinations available like, 8×1, 8×2, 10×2, 16×1, etc. but the most used one is the 16×2 LCD. So, it will have (16×2=32) 32 characters in total and each character will be made of 5×7 Pixel Dots. A Single character with all its Pixels is shown in the below picture.

Now, we know that each character has (5×7=35) 35 Pixels and for 32 Characters we will have (32×35) 1120 Pixels. Further, the LCD should also be instructed about the Position of the Pixels. Hence it will be a hectic task to handle everything with the help of MCU, hence an **Interface IC like HD44780**is used, which is mounted on the backside of the LCD Module itself. The function of this IC is to get the **Commands and Data** from the MCU and process them to display meaningful information onto our LCD Screen. You can learn how to interface an LCD using the abovementioned links. If you are an advanced programmer and would like to create your own library for interfacing your Microcontroller with this LCD module then you have to understand the HD44780 IC is working and commands which can be found its datasheet.

Features of 16×2 LCD module

- Operating Voltage is 4.7V to 5.3V
- Current consumption is 1mA without backlight
- Alphanumeric LCD display module, meaning can display alphabets and numbers
- Consists of two rows and each row can print 16 characters.
- Each character is built by a 5×7 Pixel box
- Can work on both 8-bit and 4-bit mode
- It can also display any custom generated characters
- Available in Green and Blue Backlight

Pin No:	Pin Name:	Description
1	Vss (Ground)	Ground pin connected to system ground
2	Vdd (+5 Volt)	Powers the LCD with +5V (4.7V – 5.3V)
3	VE (Contrast V)	Decides the contrast level of display. Grounded to get maximum contrast.
4	Register Select	Connected to Microcontroller to shift between command/data register
5	Read/Write	Used to read or write data. Normally grounded to write data to LCD
6	Enable	Connected to Microcontroller Pin and toggled between 1 and 0 for data acknowledgement
7	Data Pin 0	Data pins 0 to 7 forms a 8-bit data line. They can be connected to Microcontroller to send 8-bit data. These LCD's can also operate on 4-bit mode in such case Data pin 4,5,6 and 7 will be left free.
8	Data Pin 1	Clear display screen
9	Data Pin 2	Return home
10	Data Pin 3	Contrast setting for display
11	Data Pin 4	Decrement cursor
12	Data Pin 5	Shift display right
13	Data Pin 6	Increment cursor
14	Data Pin 7	Shift display left
15	LED Positive	Backlight LED pin positive terminal
16	LED Negative	Backlight LED pin negative terminal

Table 4.3 LCD Pin Configuration

4.3 NPK Sensor

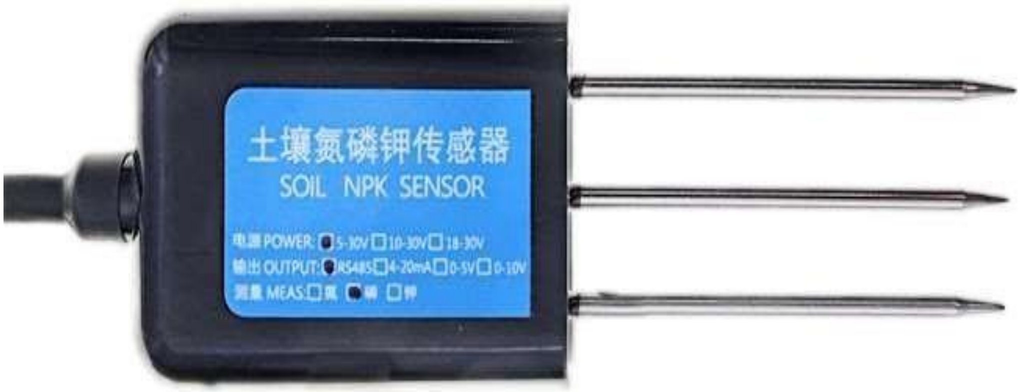

Fig 4.3 NPK Sensor

The letters NPK stand for the three major nutrients that plants require to grow and thrive:

- Nitrogen
- Phosphorus
- Potassium

Nitrogen is responsible for the growth and greenness of plant leaves. Phosphorus helps the plant grow strong roots, fruit, and flowers.

Potassium improves the overall health and hardiness of a plant.

4.3.1 JXCT Soil NPK Sensor

- The JXCT Soil NPK sensor is a low-cost, quick-responding, reasonably accurate, and portable sensor. It aids in the real-time monitoring of NPK nutrient content in soil for smart agriculture.

- The soil NPK sensor can detect the levels of nitrogen, phosphorus, and potassium in the soil (not in water). It helps determine soil fertility, allowing for a more systematic assessment of soil condition.

- The sensor operates on 5-30V and consumes very little power. According to the datasheet, it is capable of measuring nitrogen, phosphorus, and potassium with a resolution of up to 1 mg/kg (mg/l).

- The sensor includes a stainless steel probe that is rust-proof, electrolytic resistant, and saltalkali resistant. It can therefore be used with any type of soil, including alkaline soil, acid soil, substrate soil, seedling bed soil, and coconut bran soil.

Fig 4.4 NPK Sensor Probes

The probe is sealed to the body with high-density epoxy resin to prevent moisture from entering the body.

- The best part is that the sensor has an IP68 rating, which means it is protected against dust and moisture, allowing it to operate normally for a very long time.

- To be used effectively over long distances, the sensor features the RS485 communication interface and supports the standard Modbus-RTU communication protocol.

- It should be noted that the sensor cannot be used with an Arduino directly. To communicate with Arduino, you'll need an RS-485 transceiver module that converts a UART serial stream to RS- 485.

1. Power	5V-30V
2. Measuring Range	0-1999 mg/kg (ml/l)
3. Operating Temperature	5-45 °C
4. Resolution	1mg/kg (ml/l)
5. Precision	±2% F.S.
6. Output Signal	RS485
7. Protection Class	IP68

Table 4.4 Technical Specification

The sensor comes with a 2m cable with tinned copper wires. The pin out is shown in the figure below.

Fig 4.5 NPK Sensor Pin out

VCC is the VCC pin. Connects to 5V – 30V.

A is a differential signal that is connected to the A pin of the MAX485 Modbus Module.

B is another differential signal that is connected to the B pin of the MAX485 Modbus Module.

GND is the Ground pin.

As previously stated, the NPK sensor cannot be used directly with an Arduino. To communicate with Arduino, you’ll need an RS-485 transceiver module that converts a UART serial stream to RS-485, such as the one shown below.

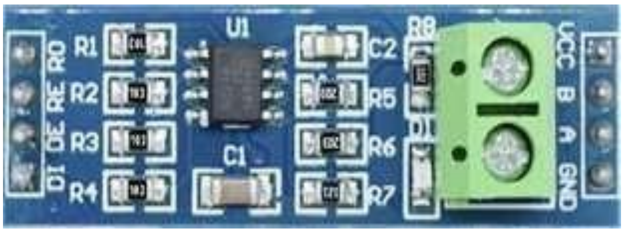

Figure 4.6 Transceiver Module

- The soil NPK Sensor has four wires. The power wire is brown and should be connected to the 5V-30V power supply. The ground wire is black and should be connected to a common ground.
- The yellow wire of the NPK sensor should be connected to the RS485 module’s A pin, and the blue wire should be connected to the RS485 module’s B pin.
- Connect the RS485 module’s R0 and DI pins to the Arduino’s digital pins 2 and 3, respectively. These digital pins will be used as virtual RX and TX serial lines.
- The RS485 module’s VCC pin should be connected to the Arduino’s 5V output, and the DE and RE pins should be connected to digital pins 7 and 8, respectively.
- Finally, make sure your circuit and Arduino share a common ground.

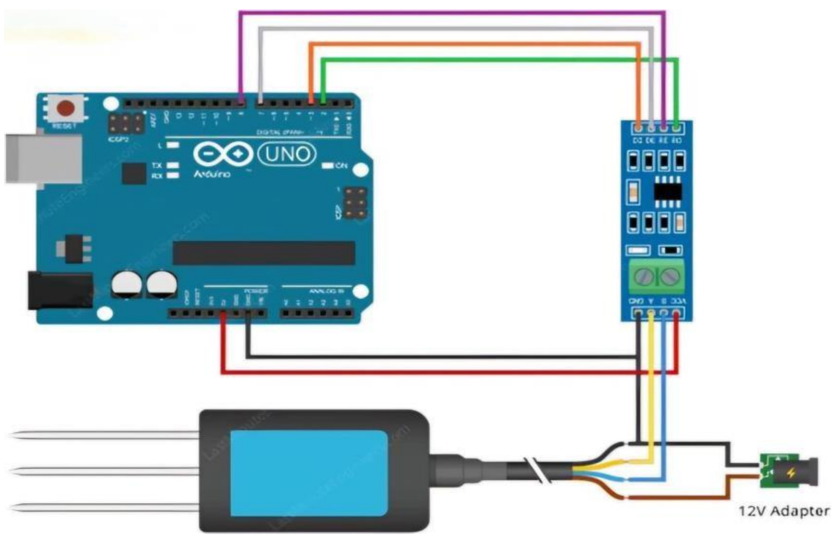

Fig 4.7 Wiring of NPK Sensor With Arduino

4.2.2 Usage Instruction

Choose an appropriate measuring location, avoid stones, make sure the steel probe does not come into contact with any hard objects, and insert the sensor vertically into the soil.

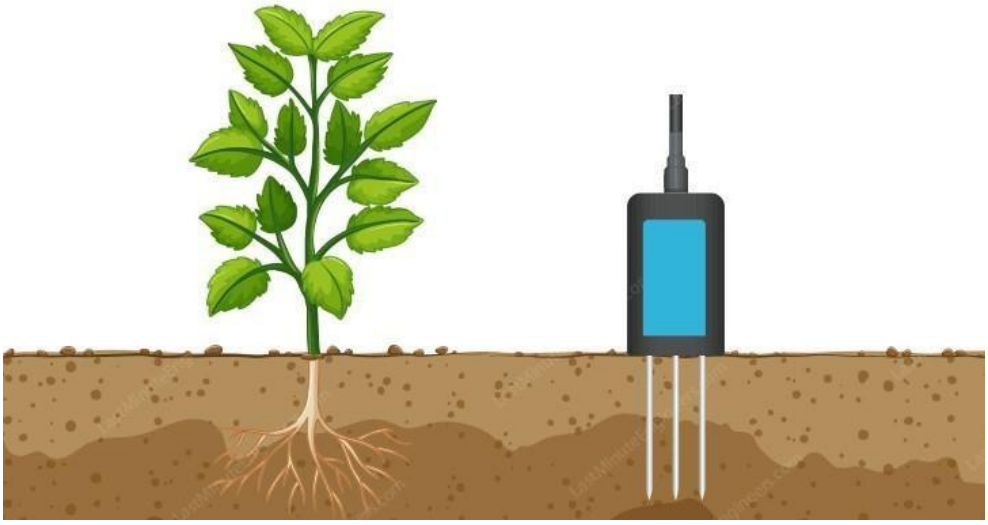

Fig 4.8 Probe Insertion

Optionally, the sensor can be inserted horizontally into the pit, in which case the pit is excavated vertically with a diameter greater than 20 cm before being tightly backfilled.

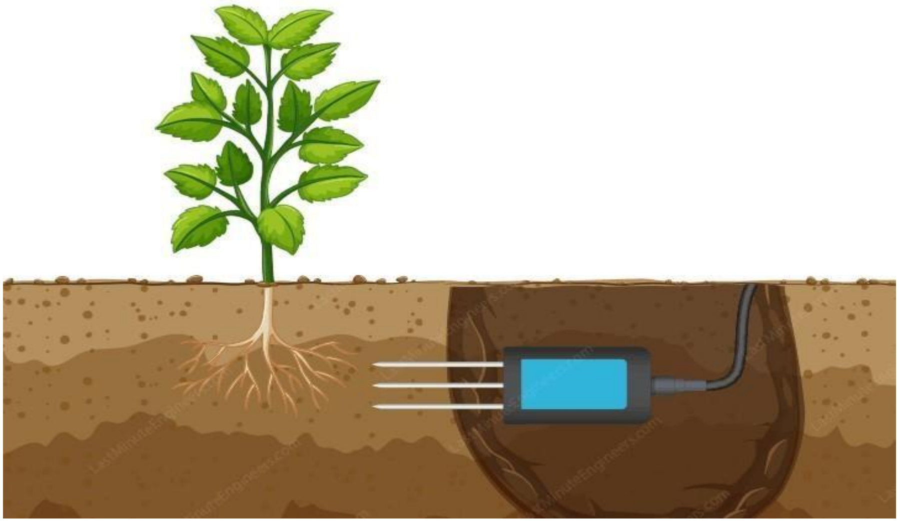

Fig 4.9 Probe Insertion Variant

4.4 RELAY MODEL

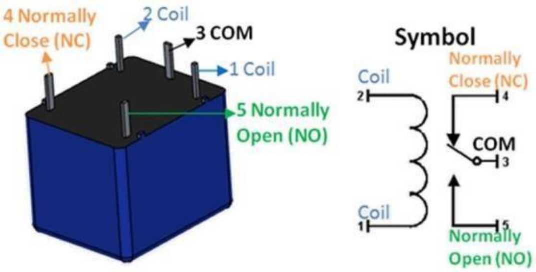

Fig 4.10 Relay Model

Relays are most commonly used switching device in electronics. There are two important parameters of relay, first is the Trigger Voltage, this is the voltage required to turn on the relay that is to change the contact from Common → NC to Common → NO. The other parameter is your Load Voltage & Current, this is the amount of voltage or current that the NC, NO or Common terminal of the relay could withstand, in our case for DC it is maximum of 30V and 10A. Make sure the load you are using falls into this range.

Pin Number	Pin Name	Description
1	Coil End 1	Used to trigger (On/Off) the Relay, Normally one end is connected to 12V and the other end to ground
2	Coil End 2	Used to trigger (On/Off) the Relay, Normally one end is connected to 12V and the other end to ground
3	Common (COM)	Common is connected to one End of the Load that is to be controlled
4	Normally Close (NC)	The other end of the load is either connected to NO or NC. If connected to NC the load remains connected before trigger
5	Normally Open (NO)	The other end of the load is either connected to NO or NC. If connected to NO the load remains disconnected before trigger

Table 4.5 Pin Configuration Model

The diagram is for **relay triggering circuit.** Since the relay has 12V trigger voltage we have used a +12V DC supply to one end of the coil and the other end to ground through a switch. For switching we are using a transistor as a switching device. You can also notice a diode connected across the coil of the relay; this diode is called the Fly back Diode.

The purpose of the diode is to protect the switch from high voltage spike that can produced by the relay coil. As shown one end of the load can be connected to the Common pin and the other end is either connected to NO or NC. If connected to NO the load remains disconnected before trigger and if connected to NC the load remains connected before trigger.

4.5 Soil moisture Sensor

Fig 4.11 Soil moisture sensor Module

This soil moisture sensor module is used to detect the moisture of the soil. It measures the volumetric content of water inside the soil and gives us the moisture level as output. The module has both digital and analog outputs and a potentiometer to adjust the threshold level.

Pin Name	Description
VCC	The Vcc pin powers the module, typically with +5V
GND	Power Supply Ground
DO	Digital Out Pin for Digital Output.
AO	Analog Out Pin for Analog Output

Table 4.6 Soil Moisture Sensor Specifications

This Moisture sensor module consists of a Moisture sensor, Resistors, Capacitor, Potentiometer, Comparator LM393 IC, Power and Status LED in an integrated circuit.

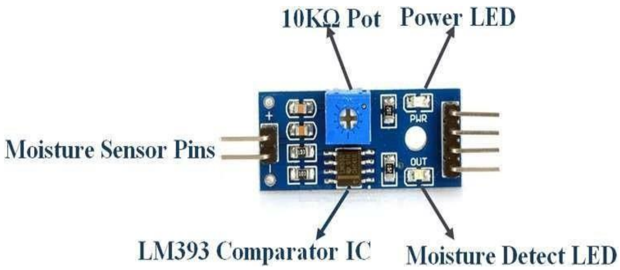

Fig 4.12 Soil Moisture Sensor module

LM393 Comparator IC is used as a voltage comparator in this Moisture sensor module. Pin 2 of LM393 is connected to Preset (10KΩ Pot) while pin 3 is connected to Moisture sensor pin. The comparator IC will compare the threshold voltage set using the preset (pin2) and the sensor pin (pin3).

The moisture sensor consists of two probes that are used to detect the moisture of the soil. The moisture sensor probes are coated with immersion gold that protects Nickel from oxidation. These two probes are used to pass the current through the soil and then the sensor reads the resistance to get the moisture values.

Using the onboard preset you can adjust the threshold (sensitivity) of the digital output

Using a Moisture sensor module with a microcontroller is very easy. Connect the Analog/Digital Output pin of the module to the Analog/Digital pin of Microcontroller. Connect VCC and GND pins to 5V and GND pins of Microcontroller. After that insert the probe inside the soil. When there is more water presented in the soil, it will conduct more electricity that means resistance will be low and the moisture level will be
high.

Soil Moisture Sensor Module Features & Specifications

- Operating Voltage: 3.3V to 5V DC
- Operating Current: 15mA
- Output Digital - 0V to 5V, Adjustable trigger level from preset
- Output Analog - 0V to 5V based on infrared radiation from fire flame falling on the sensor
- LEDs indicating output and power
- PCB Size: 3.2cm x 1.4cm
- LM393 based design
- Easy to use with Microcontrollers or even with normal Digital/Analog IC
- Small, cheap and easily available

4.6 DHT11 Temperature and Humidity Sensor

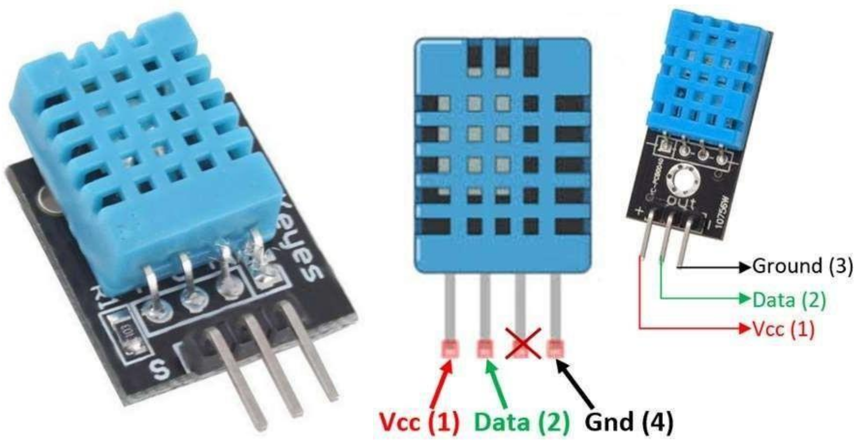

Fig 4.13 Temperature and humidity sensor

The **DHT11 sensor** can either be purchased as a sensor or as a module. Either way, the performance of the sensor is same. The sensor will come as a 4-pin package out of which only three pins will be used whereas the module will come with three pins as shown above.

The only difference between the sensor and module is that the module will have a filtering capacitor and pull-up resistor inbuilt, and for the sensor, you have to use them externally if required.

No:	Pin Name	Description
For DHT11 Sensor		
1	Vcc	Power supply 3.5V to 5.5V
2	Data	Outputs both Temperature and Humidity through serial Data
3	NC	No Connection and hence not used
4	Ground	Connected to the ground of the circuit
For DHT11 Sensor module		
1	Vcc	Power supply 3.5V to 5.5V
2	Data	Outputs both Temperature and Humidity through serial Data
3	Ground	Connected to the ground of the circuit

Table 4.7 Pin Identification and Configuration

DHT11 Specifications:

- Operating Voltage: 3.5V to 5.5V
- Operating current: 0.3mA (measuring) 60uA (standby)
- Output: Serial data
- Temperature Range: 0°C to 50°C
- Humidity Range: 20% to 90%
- Resolution: Temperature and Humidity both are 16-bit
- Accuracy: ±1°C and ±1%

The **DHT11 sensor** can either be purchased as a sensor or as a module. Either way, the performance of the sensor is same. The sensor will come as a 4-pin package out of which only three pins will be used whereas the module will come with three pins as shown above.

The only difference between the sensor and module is that the module will have a filtering capacitor and pull-up resistor inbuilt, and for the sensor, you have to use them externally if required.

The **DHT11** is a commonly used **Temperature and humidity sensor.** The sensor comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data. The sensor is also factory calibrated and hence easy to interface with other microcontrollers.

The sensor can measure temperature from 0°C to 50°C and humidity from 20% to 90% with an accuracy of ±1°C and ±1%. So if you are looking to measure in this range then this sensor might be the right choice for you.

4.7 DC MOTOR

Fig 4.14 DC Motor

It is any of a class of electrical machines that converts direct current electrical power into mechanical power. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor. Most types produce rotary motion; a linear motor directly produces force and motion in a straight line.

DC motors were the first type widely used, since they could be powered from existing direct- current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight motor used for portable power tools and appliances. Larger DC motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.

DC Motors convert electrical energy (voltage or power source) to mechanical energy (produce rotational motion).

A direct current, or DC, motor is the most common type of motor. DC motors normally have just two leads, one positive and one negative. If you connect these two leads directly to a battery, the motor will rotate. If you switch the leads, the motor will rotate in the opposite direction.

To control the direction of the spin of DC motor, without changing the way that the leads are connected, you can use a circuit called an H-Bridge. An H bridge is an electronic circuit that can drive the motor in both directions. H-bridges are used in many different applications, one of the most common being to control motors in robots. It is called an H-bridge because it uses four transistors connected in such a way that the schematic diagram looks like an "H."

No:	Pin Name	Description
1	Terminal 1	A normal DC motor would have only two terminals. Since these terminals are connected together only through a coil, they have not polarity. Revering the connection will only reverse the direction of the motor
2	Terminal 2	

Table 4.8 Pin Description of DC Motor

Motor Specifications

- Standard DC motor
- Recommended/Rated Voltage: 12V
- Current at No load: 60mA (max)
- Shaft diameter: 6mm
- Torque: 3Kg-cm
- No-load Speed: 100 rpm
- Loaded current: 300mA (Max),
- Rated Load: 10g*cm

4.8 L298N Motor Drive Module

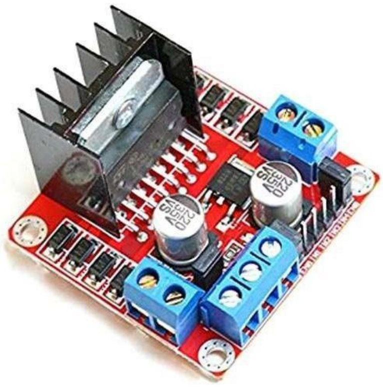

Fig 4.15 L298N Motor drive Module

This **L298N Motor Driver Module** is a high power motor driver module for driving DC and Stepper Motors. This module consists of an L298 motor driver IC and a 78M05 5V regulator. **L298N Module** can control up to 4 DC motors, or 2 DC motors with directional and speed control.

Pin Name	Description
IN1 & IN2	Motor A input pins. Used to control the spinning direction of Motor A
IN3 & IN4	Motor B input pins. Used to control the spinning direction of Motor B
ENA	Enables PWM signal for Motor A
ENB	Enables PWM signal for Motor B
OUT1 & OUT2	Output pins of Motor A
OUT3 & OUT4	Output pins of Motor B
12V	12V input from DC power Source

Table 4.9 L298N Motor Pin Configuration

L298N Module Features & Specifications

- Driver Model: L298N 2A
- Driver Chip: Double H Bridge L298N
- Motor Supply Voltage (Maximum): 46V
- Motor Supply Current (Maximum): 2A
- Logic Voltage: 5V
- Driver Voltage: 5-35V
- Driver Current:2A
- Logical Current:0-36mA
- Maximum Power (W): 25W
- Current Sense for each motor
- Heat sink for better performance
- Power-On LED indicator

CHAPTER 5

SOFTWARE TOOL

5. Software Tools

Software tools helps in building the project as per the aim. Following is the software tools used for the project

5.1 Arduino Software (IDE)

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

Arduino IDE is open source software that is mainly used for writing and compiling the code into the Arduino Module.

It is official Arduino software, making code compilation too easy that even a common person with no prior technical knowledge can get their feet wet with the learning process It is easily available for operating systems like MAC, Windows, Linux and runs on the Java Platform that comes with inbuilt functions and commands that play a vital role for debugging, editing and compiling the code in the environment. A range of Arduino modules available including ArduinoUno, Arduino Mega, Arduino Leonardo, Arduino Micro and many more. Each of them contains a microcontroller on the board that I actually programmed and accepts the information in the form of code.

The main code, also known as a sketch, created on the IDE platform will ultimately generate a Hex File which is then transferred and uploaded in the controller on the board.

The IDE environment mainly contains two basic parts: Editor and Compiler where former is used for writing the required code and later is used for compiling and uploading the code into the given Arduino Module. This environment supports both C and C++ languages.

You can download the Software from Arduino main website. As I said earlier, the software is available for common operating systems like Linux, Windows, and MAX, so make sure you are downloading the correct software version that is easily compatible with your operating system.

If you aim to download Windows app version, make sure you have Windows 8.1 or Windows 10, as app version is not compatible with Windows 7 or older version of this operating system.

The IDE environment is mainly distributed into three sections

1. Menu Bar
2. Text Editor
3. Output Pane

As you download and open the IDE software, it will appear like an image below

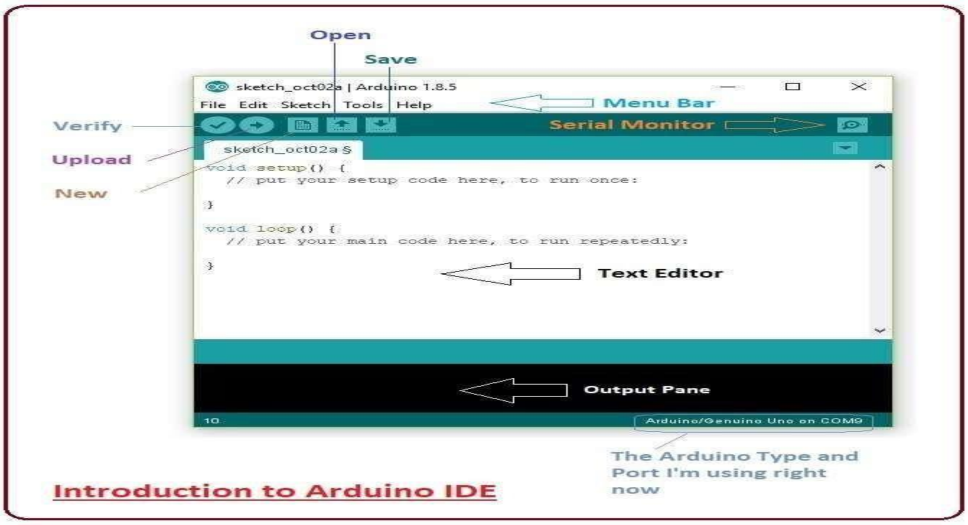

Fig 5.1 Menu Bar

The bar appearing on the top is called **Menu Bar** that comes with five different options. The following table shows the number of further subdivisions the file option is categorized into.

File	
New	This is used to open new text editor window to write your code
Open	Used for opening the existing written code
Open Recent	The option reserved for opening recently closed program
Sketchbook	It stores the list of codes you have written for your project
Examples	Default examples already stored in the IDE software
Close	Used for closing the main screen window of recent tab. If two tabs are open, it will ask you again as you aim to close the second tab
Save	It is used for saving the recent program
Save as	It will allow you to save the recent program in your desired folder
Page setup	Page setup is used for modifying the page with portrait and landscape options. Some default page options are already given from which you can select the page you intend to work on
Print	It is used for printing purpose and will send the command to the printer
Preferences	It is page with number of preferences you aim to setup for your text editor page
Quit	It will quit the whole software all at once

As you go to the preference section and check the compilation section, the Output Pane will show the code compilation as you click the upload button.

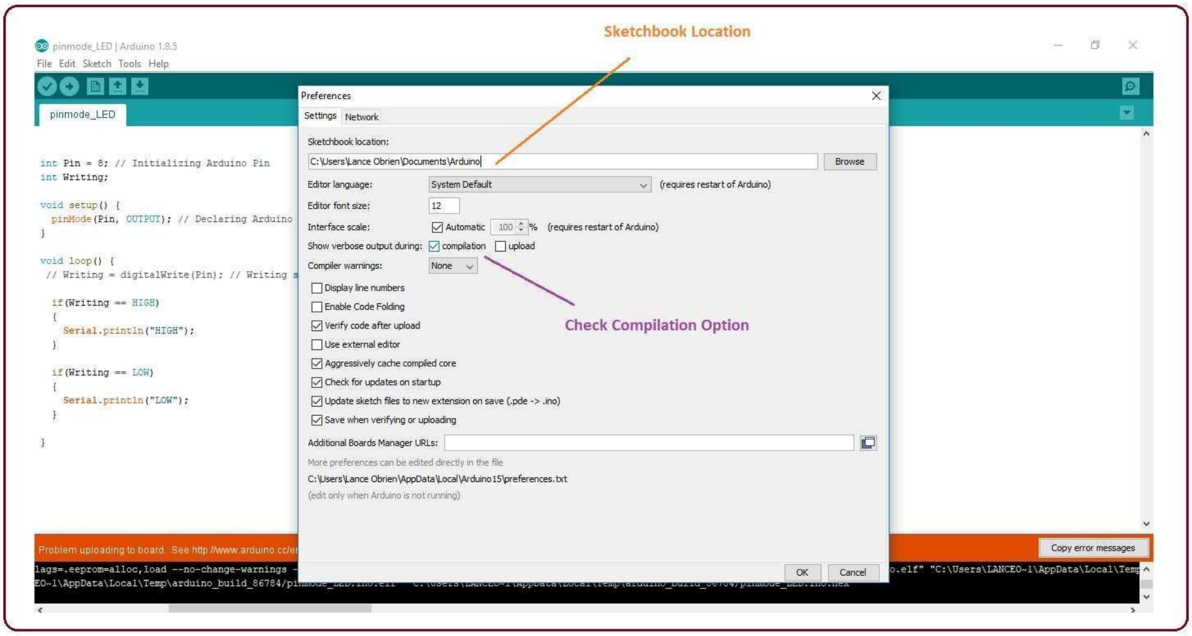

Fig 5.3 Preference

And at the end of the compilation, it will show you the hex file it has generated for the recent sketch that will send to the Arduino Board for the specific task you aim to achieve.

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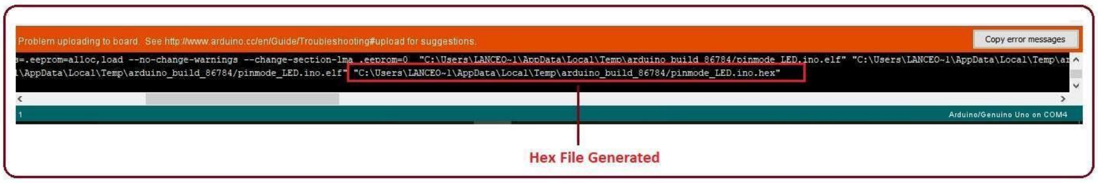

Fig 5.4 Hex File Generation

Edit – Used for copying and pasting the code with further modification for font

Sketch – For compiling and programming

Tools – Mainly used for testing projects. The Programmer section in this panel is used for burning a boot loader to the new microcontroller.

Help – In case you are feeling skeptical about software, complete help is available from getting starts to troubleshoot.

The **Six Buttons** appearing under the Menu tab are connected with the running program as follows.

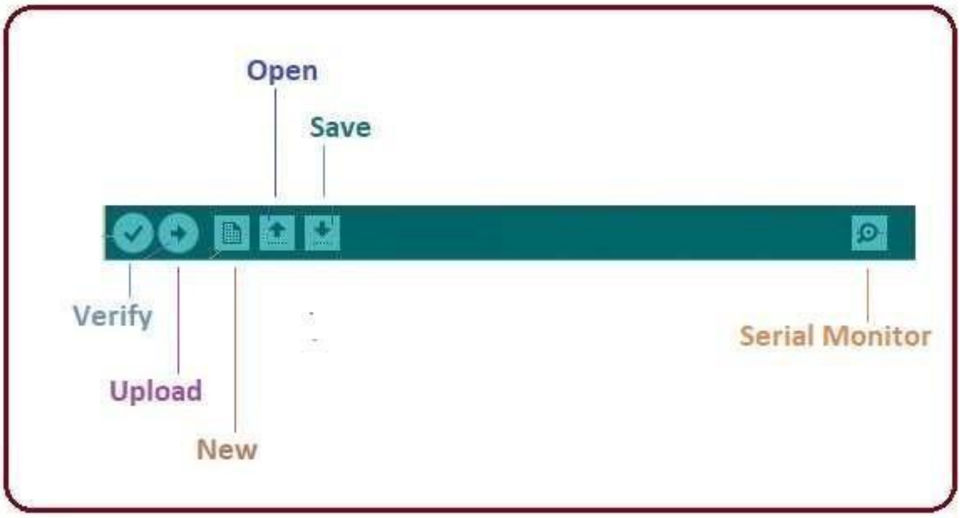

Fig 5.5 Menu Button

The checkmark appearing in the circular button is used to verify the code. Click this once you have written your code.

- The arrow key will upload and transfer the required code to the Arduino board.
- The dotted paper is used for creating a new file.
- The upward arrow is reserved for opening an existing Arduino project.
- The downward arrow is used to save the current running code.

my Arduino Uno Baud Rate is 9600, as you write the following code and click the Serial Monitor, the output will show as the image below.

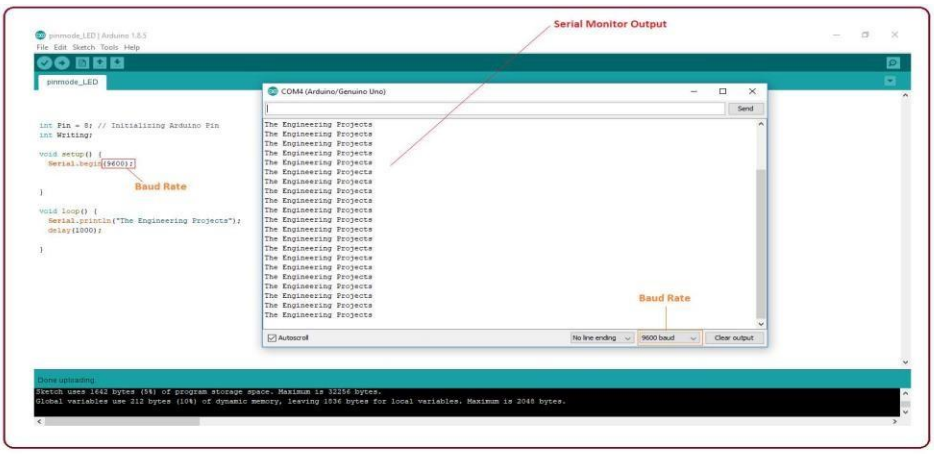

Fig 5.6 Serial Monitor

The main screen below the Menu bar is known as a simple text editor used for writing the required code.

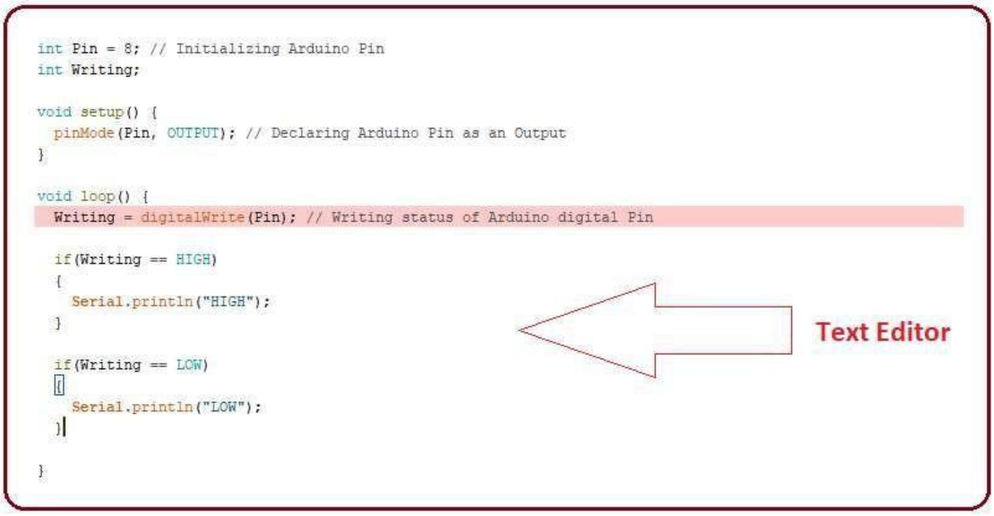

Fig 5.7 Simple Text Editor

The bottom of the main screen is described as an Output Pane that mainly highlights the compilation status of the running code: the memory used by the code, and errors that occurred in the program. You need to fix those errors before you intend to upload the hex file into your Arduino Module.

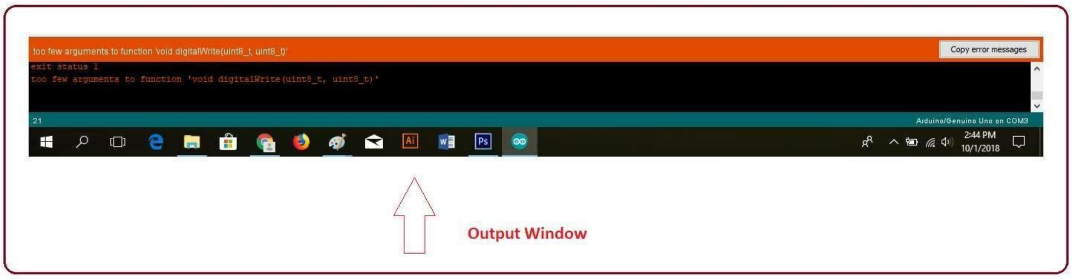

Fig 5.8 Output Window

More or less, Arduino C language works similar to the regular C language used for any embedded system microcontroller, however, there are some dedicated libraries used for calling and executing specific functions on the board.

5.1.1 Arduino Libraries

Libraries are very useful for adding extra functionality into the Arduino Module.

There is a list of libraries you can check by clicking the Sketch button in the menu bar and going to Include Library.

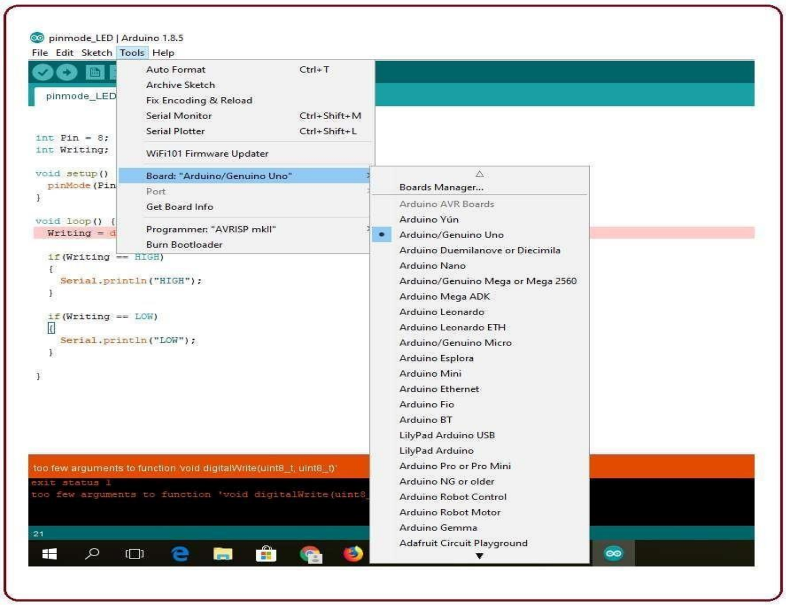

Fig 5.9 Arduino Libraries

As you click the Include Library and Add the respective library it will be on the top of the sketch with a #include sign. Suppose, I Include the EEPROM library, it will appear on the text editor as **#include <EEPROM.h>**

Most of the libraries are preinstalled and come with the Arduino software. However, you can also download them from external sources

Making Pins Input or Output

- The digital Read and digital Write commands are used for addressing and making the Arduino pins as an input and output respectively.
- These commands are text sensitive i.e. you need to write them down the exact way they are given like digital Write starting with small "d" and write with capital "W". Writing it down with Digital write or digital write won't be calling or addressing any function.
- How to Select the Board
- In order to upload the sketch, you need to select the relevant board you are using and the ports for that operating system.
- As you click the Tools on the menu, it will open like the figure below:

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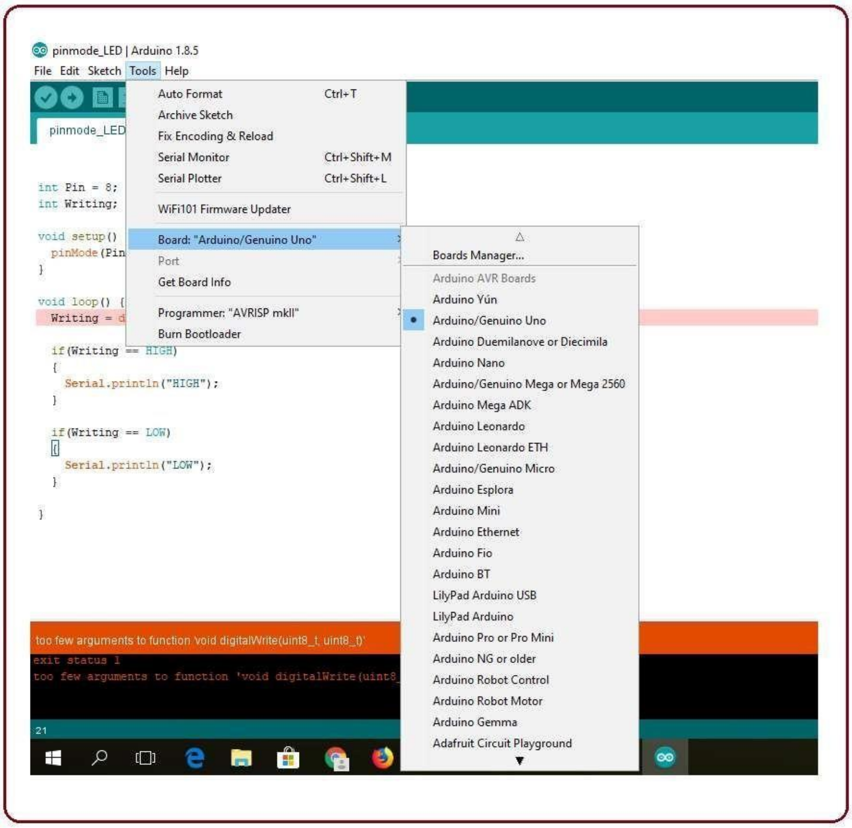

Fig 5.10 Tools

Just go to the “Board” section and select the board you aim to work on. Similarly, COM1, COM2, COM4, COM5, COM7 or higher are reserved for the serial and USB board. You can look for the USB serial device in the ports section of the Windows Device Manager.

The following figure shows the COM4 that I have used for my project, indicating the Arduino Uno with the COM4 port at the right bottom corner of the screen.

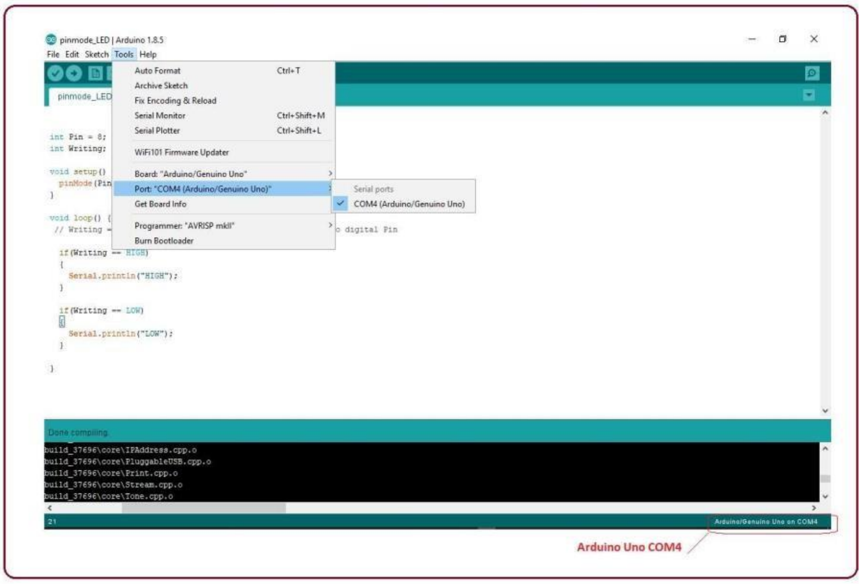

Fig 5.11 UNO

After correct selection of both Board and Serial Port, click the verify and then upload button appearing in the upper left corner of the six-button section or you can go to the Sketch section and press verify/compile and then upload.

The sketch is written in the text editor and is then saved with the file extension .ino. It is important to note that the recent Arduino Modules will reset automatically as you compile and press the upload button the IDE software, however, the older versions may require the physical reset on the board.

Once you upload the code, TX and RX LEDs will blink on the board, indicating the desired program is running successfully.

Note: The port selection criteria mentioned above are dedicated to Windows operating system only, you can check this Guide if you are using MAC or Linux.

5.1.2 BOOT LEADER

As you go to the Tools section, you will find a boot loader at the end.

Fig 5.12 Tool Selection

When you buy the new Arduino Module, the boot loader is already installed inside the controller. However, if you intend to buy a controller and put it in the Arduino module, you need to burn the boot loader again inside the controller by going to the Tools section and selecting the burn boot loader.

5.2 C++ Programming

C++ is a high-performance, compiled, and general-purpose programming language that supports object-oriented, imperative, and functional programming paradigms. It provides low-level memory management and control, making it suitable for systems programming, game development, and high-performance applications. C++ is widely used for building operating systems, device drivers, and embedded systems, and its performance, control, and flexibility make it a popular choice among developers.

4. Object-Oriented Programming (OOP): C++ supports OOP concepts like encapsulation, inheritance, and polymorphism.

5. Compiled Language: C++ code is compiled into machine code before execution, making it faster than interpreted languages.

6. Low-Level Memory Management: C++ provides direct access to memory, allowing for fine-grained control over memory allocation and reallocation.

7. **Multi-Paradigm Programming**: C++ supports multiple programming paradigms, including OOP, imperative, and functional programming.

It Helpful For The

1. Data Acquisition: C++ is used to collect and process data from various sensors, such as temperature, humidity, and soil moisture.

2. Real-time Analytics: C++ algorithms analyze the collected data in real-time, providing insights on soil conditions, crop health, and weather patterns.

3. Automation and Control: C++ programs make decisions based on the analyzed data and automate tasks, such as irrigation control, fertilizer application, and pest control.

4. Integration with IoT Devices: C++ is used to integrate the IoT system with various devices, such as sensors, actuators, and communication modules.

CHAPTER 6

RESULT AND DISCUSSION

6.1 Snapshot of the Result

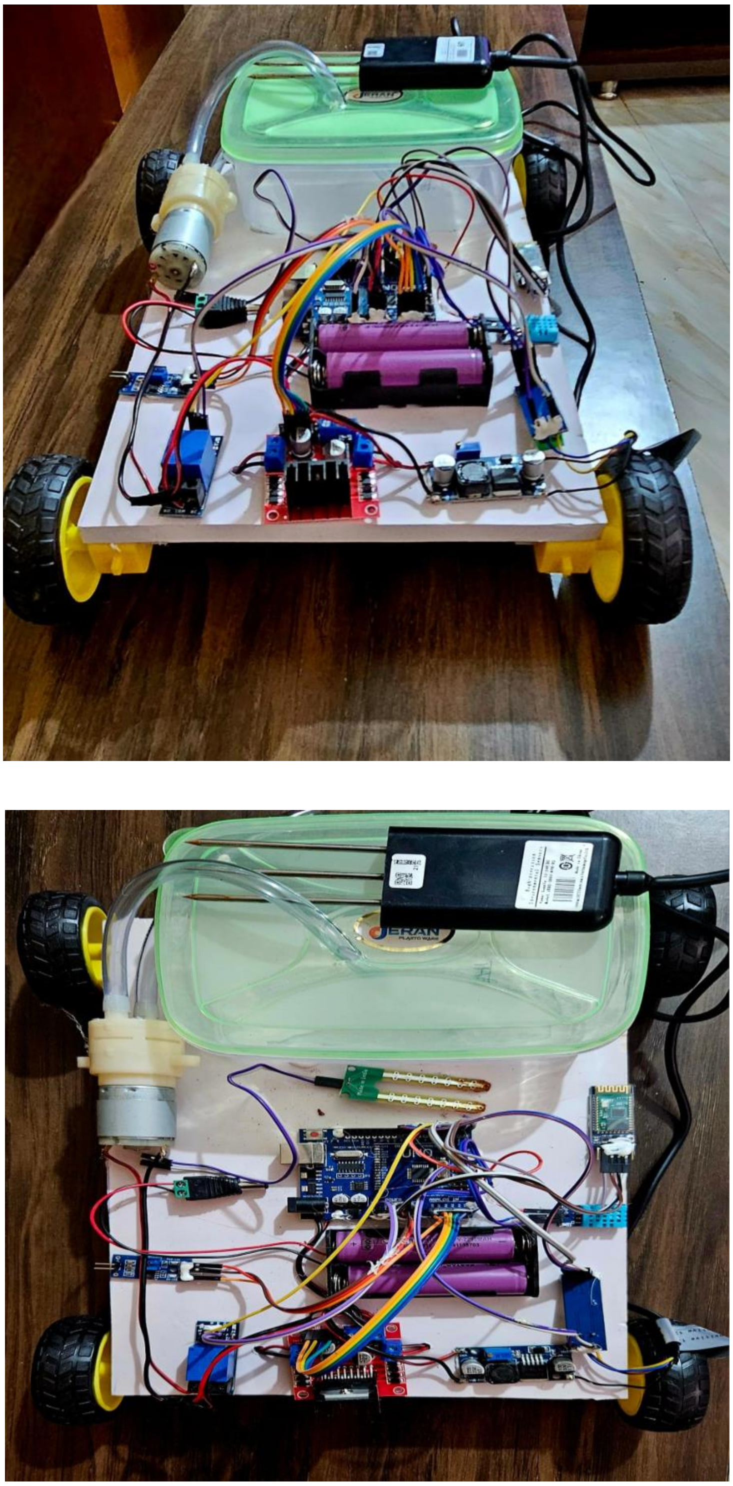

Fig 6.1 Model Of The Proposed System

6.1 Discussion of the Result

The Scalable IoT for Precision Farming system provides actionable insights to farmers, enabling them to optimize their farming practices, reduce costs, and increase productivity. The system's output also includes alerts and notifications for critical events, such as soil moisture levels, temperature fluctuations, and crop health issues, allowing farmers to take prompt action and minimize losses. Overall, the system's output helps farmers make data-driven decisions, leading to improved crop yields, reduced waste, and increased profitability.

The output of Scalable IoT for Precision Farming includes real-time data insights on soil moisture, temperature, humidity, and crop health, enabling automated decision-making on irrigation, fertilization, pest control, and harvesting. This leads to increased crop yields, reduced resource consumption, and minimized waste and environmental impact. Additionally, predictive analytics enable farmers to anticipate and prepare for weather events, pests, and diseases, while real-time tracking and monitoring of crops improve supply chain management.

It Includes

1. Real-time Data Insights: Accurate and timely data on soil moisture, temperature, humidity, and crop health.

2. Automated Decision-Making: Data-driven decisions on irrigation, fertilization, pest control, and harvesting.

3. Increased Crop Yield: Optimized growing conditions and reduced waste lead to higher crop yields.

4. Reduced Resource Consumption: Efficient use of water minimizes waste and environmental impact.

5. Predictive Analytics: Advanced data analysis enables farmers to anticipate and prepare for weather events, pests, and diseases.

6. Improved Supply Chain Management: Real-time tracking and monitoring of crops enable more efficient supply chain management.

CHAPTER 7

APPLICATIONS, ADVANTAGES AND DISADVANTAGES

7.1 Applications

1. Soil and Crop Monitoring
2. Irrigation and Water Management
3. Livestock Monitoring
4. Farm Equipment and Asset Management
5. Data Analytics and Decision Support
6. Scalability and Integration

7.2 Advantages and Disadvantages

7.2.1 Advantages

- Optimized water usage, preventing overwatering or under-irrigation.
- Reduced manual labor through automation and remote control.
- Enhanced crop yield and quality with precise data-driven decisions.
- Cost-effective and accessible for small and medium-scale farmers.
- Scalable and modular design, allowing future enhancements.
- Mobility of the robotic car ensures comprehensive field data collection.
- Easy-to-use mobile application interface for farmers.
- Reduces resource wastage, promoting sustainable farming practices.
- Adaptable for different types of crops and farming requirements
- Real-time monitoring of critical environmental and soil conditions.

7.2.2 Disadvantages

- Limited by Bluetooth range; cannot support long-distance remote control.
- Dependency on a stable power source for the robotic car and sensors.
- Potential difficulties in operation for non-tech-savvy farmers.
- Sensors may require frequent calibration or maintenance for accuracy.

Conclusion

The Scalable IoT for Precision Farming system presents a modern solution to the challenges faced by farmers in managing their agricultural processes efficiently. By integrating IoT technologies with real-time sensor data collection, mobile control, and automated irrigation, the system offers significant improvements in resource management, crop health monitoring, and overall farm productivity.

This system enables farmers to make data-driven decisions, optimizing water usage, fertilizer application, and irrigation schedules based on real-time environmental and soil conditions. The use of a mobile application for monitoring and controlling the system remotely adds a layer of convenience, allowing farmers to operate the system from virtually anywhere. Furthermore, the scalability and cost-effectiveness of the design make it suitable for both small and large-scale farming operations.

The future potential of this system is vast, with possibilities for integrating AI-driven analytics, weather forecasting, and automated crop health monitoring to further enhance farming practices. As technology continues to advance, this scalable and modular IoT solution holds the promise of revolutionizing precision farming, promoting sustainable practices, and improving crop yields globally.

In conclusion, the Scalable IoT for Precision Farming system not only addresses current farming challenges but also lays the foundation for the future of smart agriculture, making farming more efficient, sustainable, and accessible to a wider audience.

FUTURE SCOPE

- **Integration with IoT Cloud Platforms:**

  Incorporate internet connectivity to upload sensor data to cloud platforms for remote monitoring and data storage.

- **AI and Predictive Analytics:**

  Use machine learning algorithms to analyze historical data and provide predictive insights for irrigation, fertilization, and pest management.

- **Advanced Navigation:**

  Upgrade the robotic car with GPS or path-planning algorithms for autonomous field mapping and navigation.

- **Weather Forecasting**:

  Integrate weather APIs to provide real-time and forecasted weather conditions to aid in planning agricultural activities.

- **Energy Efficiency:**

  Utilize solar panels to power the robotic car and sensors, promoting sustainability and reducing operational costs.

- **Automated Crop Health Monitoring:**

  Add cameras with image processing capabilities to detect pests, diseases, or plant health issues in real-time.

- **Scalability for Large Farms**:

  Enhance the system for large-scale farming by deploying multiple robotic cars communicating over a shared network.

- **Integration with Fertilizer Dispensers**:

  Enable automated nutrient distribution based on NPK sensor readings to optimize soil fertility management.

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