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A STUDY ON DEVELOPMENT OF SOIL MOISTURE DETECTION SYSTEM USING SENSORS FOR PRECISION AGRICULTURE APPLICATIONS

Reddyvari Jahnavi[1], **Sneha Zille**[2], **Sreenidhi**[3], **Shamshad Banu**[4]

Dept. of AIML, Dayananda Sagar Academy of Technology and Management, Bengaluru, India[1-4]

Abstract: A huge step in the field of precision farming has been made with the creation of this soil moisture detection system, which enables farmers to maximize water use, decrease resource waste, and boost yields of crops. Additionally, it promotes environmentally friendly farming methods by lowering water use. The use of this sort of equipment is anticipated to increase agriculture's productivity and profitability while fostering sustainable management of resources. Soil moisture sensors, a data processing unit, and a user-friendly interface accessible through mobile or online platforms are key components of the system. Soil moisture sensors are carefully positioned across the field to collect data on soil moisture content at various depths.

Keywords: smart irrigation; Soil health; soil moisture sensor; machine learning; Soil properties; Data analytics; Crop management; Smart farming

I. INTRODUCTION

The development of a sensor-based optimal soil moisture detection system has the potential to transform agricultural precision applications. Farmers may easily change watering levels based on exact measurements using contemporary sensors, considerably reducing water loss and improving crop yields. Many soil moisture sensors can provide data to a computer in near real time, allowing farmers to more accurately track soil conditions. When constructing a soil moisture monitoring system, it is critical to consider the environmental effect of installing sensors directly into the soil. Additive manufacturing, which employs material- and energy-efficient printing processes, can aid in the development of low-cost, green sensors. The extensive deployment for sensors necessitates a responsible approach to the whole life cycle of these systems, from building to disposal, while adhering to circular economy principles. The structure and material composition of soil moisture sensors should emphasize environmental protection to reduce the possible danger of polluting the environment with any undesired elements.

Sensor units should be designed so that components can be reused and main parts can be easily replaced in the event of damage. Soil moisture levels from the soil may be acquired using many existing methods such as gravimetric, tensiometric, neutronic, gamma-ray attenuation, dielectric, Wenner or resistive, and light method infrared . However, conductivity-based sensors have significant drawbacks, including a lack of dependability and durability . Different approaches are used by commercial soil monitoring sensors to estimate the water content of the soil. Insights gained from this data can lead to better decision-making, leading in greater resource use, profitable yield, and even yield growth. Soil moisture sensors are frequently used in conjunction with digital data systems, which supply farmers with vital field, crop, and meteorological data for study.

II. RELATED WORKS

[1] Smart Irrigation

Creating a Soil Moisture Detection System for Precision Agriculture with sensors is a fantastic concept since it can assist optimize water consumption, enhance crop yields, and decrease resource waste. Outline the goals of your soil moisture detecting system. Determine the crops to be monitored and the precise soil conditions to be monitored. Determine the frequency and accuracy of data collecting. Based on your project needs, select appropriate soil moisture sensors. Sensors that are often used include resistive, capacitive, and Time Domain Reflectometry sensors. Consider sensor accuracy, robustness, and compatibility with the crops and soil types you want to use.

Soil health

Growers can keep the ideal soil moisture content with the use of moisture sensors for soil, which is essential for fostering soil health. Managing the fertility of the soil and structure depends on microbial activity, nutrient availability, and root development, all of which are supported by appropriate water levels. Producers may reduce soil erosion by modifying irrigation operations by precisely monitoring soil moisture levels. Sufficiently damp soil resists wind and water erosion better, maintaining soil structure and avoiding the loss of important top soil. Farmers are able to minimize waterlogging and drought stress by accurately managing irrigation with the help of soil moisture sensor devices. This aids in maintaining the right soil structure, which is necessary to encourage root growth and absorb nutrients. It also ensures sufficient aeration and water penetration.

If under-irrigation may lead the soil to become too thirsty and difficult, excessive watering can cause the soil to become compacted. With the use of moisture sensors in the soil, farmers can more carefully control the amount of water they apply, reducing the chance of compaction and maintaining soil porosity a vital component of microbial life and good root growth. The process of vital nutrients being washed out of the root zone by excessive irrigation or rainfall is known as the leaching of nutrients, and it may be minimized with proper soil moisture management. Farmers may decrease nutrient loss, ensuring that nutrients stay accessible to plants, and lessen the need for extra fertilizers by maintaining ideal moisture levels. Maintaining soil moisture levels that support microbial activity is made easier with the help of soil moisture monitors.

[2] Soil moisture sensor:

Choosing the correct soil moisture sensors is a vital stage in the creation of a Soil Moisture Detection System for Precision Agriculture. These [2] access soil moisture content, allowing farmers to make intelligent irrigation and crop management decisions. The electrical resistance between two electrodes is used to assess soil moisture in these sensors. Resistance reduces as soil moisture increases. They are inexpensive and frequently used, however varied soil types may necessitate calibration. Capacitive sensors assess soil moisture by measuring changes in capacitance. When compared to resistive sensors, they are more precise and less sensitive to salt. They are appropriate for precision agriculture. Time Domain Reflectometry devices emit electromagnetic pulses into the soil and time how long the pulse takes to bounce back. This approach delivers accurate measurements and is appropriate for research and precision agricultural applications.

[3] Machine learning:

[3] can significantly enhance the capabilities of a Soil Moisture Detection System for Precision Agriculture. It can help in making more accurate predictions, optimizing irrigation, and providing insights into crop health.

Compile a complete dataset that includes soil moisture measurements from your sensors, as well as important environmental and crop data (and past irrigation techniques). Data Preparation To manage missing values, outliers, and noise, clean and prepare the data. To ensure that all features are on the same scale, normalize or standardize the data. Engineering Features Create relevant features from the raw data that can assist enhance model performance. For example, you may calculate rolling averages of soil moisture over time or extract characteristics relating to the soil's texture and content.

In order to offer real-time predictions of soil moisture levels, include your trained machine learning model into your soil moisture sensing system. Integrate it with your user interface to provide farmers access to these forecasts. Optimization and the Feedback Loop To keep your model up to date, continuously gather fresh data from sensors and add it into your dataset. Using the feedback loop, you may retrain your machine learning model on a regular basis, enhancing its accuracy and dependability.[3] may be used to develop decision assistance systems for farmers.

For example, the technology may provide notifications when soil moisture levels fall below or exceed particular thresholds, allowing farmers to make more informed irrigation decisions. Analyze the association between soil moisture levels and crop health using machine learning. This can aid in the early detection of trends and possible difficulties, allowing for proactive responses. Irrigation System Integration Integrate machine learning algorithms into your irrigation system to optimize watering schedules based on expected soil moisture levels, weather forecasts, and crop requirements.

[4] Soil properties:

Soil texture is classified depending on the interaction of mineral particles in the soil with various retrieval mechanisms. Soil texture is classified into four types (sand, loam, clay-loam, and clay) and 13 levels according to the international classification system. Soil electrical attributes include the natural electric field (electric potential), resistance (conductivity), electroosmosis, and dielectric constant of soil, which differ from its electrochemical properties. Soil resistance is also the inverse of soil conductivity. It is typically used to detect soil moisture or salinity, as well as the distribution boundaries of certain soils. These soil parameters form the theoretical foundation for assessing soil moisture.

Soil texture refers to the relative quantities of sand, silt, and clay particles in the soil. Different textures have different water-holding capabilities and drainage qualities. Sandy soils drain rapidly but may not store moisture effectively, whereas clay soils may keep water but may drain poorly. Knowing the texture aids in determining how rapidly soil moisture levels fluctuate and how frequently watering is required. The bulk density of dry soil is the mass per unit volume. It has an impact on the circulation of water through the soil. Root development and water penetration might be hampered by high bulk density, resulting in uneven moisture distribution. Aeration and water flow are improved with lower bulk density. The proportion of pore space in the soil is referred to as porosity. Higher porosity soil may store more water and has greater root aeration. Understanding porosity aids in calculating the water- holding capacity of soil.

Data analytics

The analysis of data and the creation of sensor-based soil moisture detection systems for precision agricultural applications are closely related fields. This is how data analysis enhances the effectiveness and effectiveness of these kinds of systems. Large volumes of data are produced by soil moisture meters on the moisture content of the soil at different places in agricultural regions. The data from various sensors is gathered, combined, and arranged using data analysis methods to give a thorough understanding of the fluctuation of soil moisture during the agricultural process. Farmers may quickly identify shifts and patterns in the moisture level of the soil by using data analysis to enable real-time monitoring of soil moisture levels. Farmers may take proactive control measures by using sophisticated computerized techniques to enable them to get timely warnings and messages on departures from acceptable moist rates.

In order to create prediction models, analytics methods like machine learning and predictive modeling may evaluate past soil moisture data in addition to other pertinent agronomic elements (like the kind of crop, the environment, and soil type). By predicting future soil moisture levels, these models assist farmers in planning ahead for irrigation requirements and maximizing the use of water techniques

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Through the analysis of soil moisture data and other contextual details, data analytics are essential to the optimization of irrigation techniques. Analytics algorithms may recommend customized irrigation schedules and rates based on trends and associations found in the data, which are then matched to the needs of individual crops and the surrounding environment.

Crop management

There is great potential in the development of sensor- based soil moisture sensing systems for precision agriculture applications. These methods help with crop management in the following ways. Farmers are able to customize irrigation schedules and quantities to the unique requirements of their crops thanks to the real-time data on moisture levels provided by soil moisture sensors. By doing this, overwatering and underwatering are avoided, which promotes healthier plants and increased yields. Through precise monitoring of soil moisture content, farmers may reduce water waste by only irrigating when required. This lessens the negative effects of agriculture on the environment and supports attempts to save water.

Plant health and growth depend on the soil's moisture content being maintained at ideal levels. By identifying patches of the field that could be under stress from water, soil-water monitoring devices enable producers to take preventative action, such as modifying irrigation schedules or adding soil nutrients to promote crop health. To improve the use of fertilizers, soil moisture measurements may be coupled with other agricultural information. By guaranteeing that plants had sufficient moisture, the roots can absorb fertilizers more efficiently, which lowers the discharge of fertilizer and improves nutrient use performance.

The amount of water in the soil may impact which pests and illnesses are more common in crops. Farmers can detect conditions that are favorable for the growth of diseases or insect infestations by keeping an eye on the moisture in the soil. Based on this information, they can modify irrigation programs or planting timetables. More accurate production projections are made possible by accurate moisture level data, which enables farmers to choose agricultural products, plant populations, and other aspects of managing their farms with knowledge.

Smart farming:

The term "smart farming" describes the use of contemporary technologies—such as technology, statistical analysis, and sensors—to optimize agricultural operations and raise sustainability, production, and efficiency. Smart farming concepts would include combining soil moisture sensors with other smart technologies to build a holistic solution for controlling irrigation and crop wellness in the backdrop of developing a soil wetness detection device for precision agricultural applications. Combination Farmers may make educated decisions regarding crop care and timing of irrigation by connecting moisture in the soil sensors to an Internet of Things platform, which allows for real-time monitoring and remote access to data from any location. By analyzing soil moisture information and other environmental elements using cutting-edge statistical techniques like algorithms powered by machine learning, it is possible to get insights into crop water requirements and optimize irrigation tactics.

Water efficiency may be increased and the need for manual labour can be decreased by putting in place automatic irrigation systems that are activated in response to readings from soil moisture sensors. creating systems for decision-making that use prediction models and information on moisture levels in the soil for offering farmers advice on when to apply fertiliser, when to irrigate, and various other agronomic techniques. The rainfall sensing system can be easily integrated into current crops and expanded or upgraded in the future if it is designed to be scalable and compatible with other smart farming techniques.

III. METHODOLOGIES

Define the goals and specifications of your soil moisture detecting system. Determine which crops, soil types, and environmental variables will be addressed by your system. Determine the level of precision and accuracy required for soil moisture readings. Sensor Choice Based on your project needs, select appropriate soil moisture sensors. Evaluate sensor type reliability, endurance, and compatibility with your target soil and crops.

Soil moisture sensors across the root zone at different levels in the soil's profile to collect data on soil moisture. Make sure that sensors are calibrated properly so that raw data can be transformed into useful soil moisture levels. Collect and save sensor data using a data logger or microprocessor. Preprocessing of data in order to manage missing values, outliers, and noise, clean up and preprocess the obtained data. To guarantee uniform scale for additional analysis, normalize or standardize the data. Integration Data from soil moisture sensors should be combined with other pertinent environmental information, such as temperature, humidity, and rainfall. To get a comprehensive knowledge of soil illnesses integrate this data.

IV. COMPARATIVE STUDY

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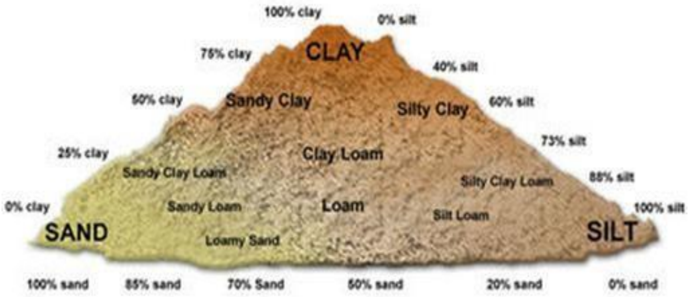

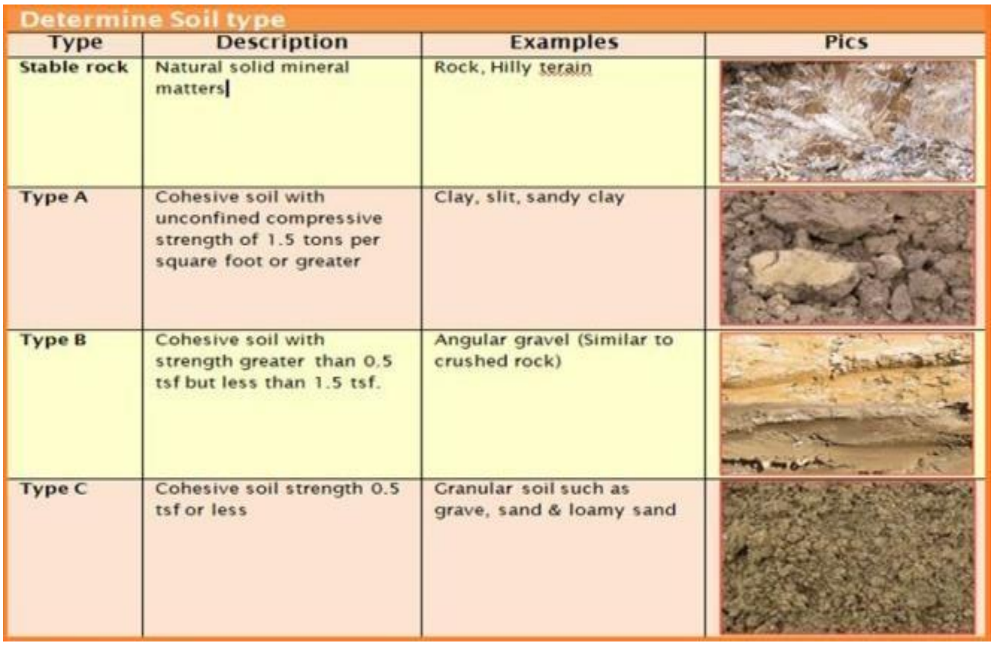

Determine Soil type

Type	Description	Examples	Pics
Stable rock	Natural solid mineral matters	Rock, Hilly terain	
Type A	Cohesive soil with unconfined compressive strength of 1.5 tons per square foot or greater	Clay, slit, sandy clay	
Type B	Cohesive soil with strength greater than 0.5 tsf but less than 1.5 tsf.	Angular gravel (Similar to crushed rock)	
Type C	Cohesive soil strength 0.5 tsf or less	Granular soil such as grave, sand & loamy sand	

V. CONCLUSION

In conclusion one important breakthrough in contemporary sensing systems for precision agricultural applications. These systems are essential for maintaining soil health, improving agricultural yield, encouraging sustainable development, and microprocessor. managing soil moisture. These devices allow farmers to arrive at well-informed decisions about irrigated scheduling, so crops receive the proper quantity of water at the correct time, by data., giving real-time data on soil moisture levels. By doing this, you standard the may avoid over-irrigation, which can cause water waste, soil erosion, and nutrient leaching, in addition to improving water To usage efficiency. By enabling targeted irrigation and fertilizer delivery, soil moisture sensing devices help precision farming by lowering the cost of inputs and mitigating negative environmental effects including runoff of nutrients and groundwater pollution.

In addition, by fostering soil durability and wellness, these structures assist responsible agricultural operations. Farmers may promote beneficial microbial activity and nutrient cycling in the soil, as well as minimize compacting, erosion, and deterioration of the soil, through preserving ideal moisture levels. Moreover, farmers may monitor and control soil moisture levels over vast agricultural regions with greater efficacy and effectiveness by integrating soil moisture meters with additional equipment like remote sensing, data analytics, and IoT (Internet of Things) platforms.

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