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Development of a Cloud Based real time system for Soil testing and Crop management – A Review.

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Abstract - *The desire to farm efficiently and in a green manner has made smart technology which utilizes data a little more significant to more farmers. In order to satisfy this requirement, this project develops a cloud-based system that monitors soil in real time, measures it and assists farmers with making decisions on how to cultivate crops. The system employs soil sensors, which are related to the Internet, cloud computing, and convenient mobile or web application. Whenever you desire it, it monitors such crucial soil facts as pH, moisture, temperature, and nutrients. The sensors collect data in the field and transmit them to the cloud where smart algorithms run on them. The findings provide the farmers with clear guidelines on what to plant, when to irrigate, quantity of water, and the appropriate quantity of fertilizer. In case the soil shifts, notifications are immediately sent to the phones or tablets of the farmers and they can review the records of the previous seasons, compare them and modify the future arrangements with clever guesses. Continuous remote control and automatic data acquisition minimizes manual labor and eliminates errors, which are associated with the previous agricultural practice. It also ensures that there is prudent use of water and fertilizer to ensure that crops grow well and also to conserve the environment. This solution will ease farming, reduce expenses and increase precision farming efficiency and thus farmers can change to smart and green farming.*

Key Words: **Crop prediction, Wi-Fi Module (ESP32), NPK Sensor, Moisture Sensor, DHT-11 Sensor,**

1.INTRODUCTION

More folks are hungry these days, while farmable land as more people face hunger while good land shrinks from climate shifts and worn-out soils. Old-school methods still help, but they usually rely on hunches or quick checkups - too weak for problems like dry spells, tired dirt, bugs running wild, spotty harvests, or lopsided nutrients. A better fix? Try an online tool that tests soil live and guides planting choices with solid science instead of guesses. It keeps watch nonstop, shoots off warnings when needed, works across different crops. The setup links smart ground sensors, internet hubs, wireless signals, plus brainy number- crunching tools. These par Farming's getting toughs team up to track water levels, acidity, heat, nitrogen-potassium- phosphorus counts, compost content, and tiny minerals hiding in earth. These gadgets sit right in the field, grabbing soil details nonstop while sending updates to online screens for checking and choices. Thanks to web access, growers and farm pros check live crop and dirt stats from anywhere, making quick calls based on facts rather than guesses. One solid perk? The warning function - it pings people fast if something's off, like water sinking too low, pH shifting weirdly, nutrients running short or piling up, or heat jumping high enough to hurt plants. Warnings come via texts, phone apps, or display panels so farmers react without delay, dodge harm, save yield, and keep crops strong. The system works well for managing watering schedules, showing exactly when to irrigate - these cuts down wasted water, saves power, while helping grow healthier crops. Not just tracking, it gives tailored advice for each plant using live soil readings, weather updates, time-of-year trends, and local farming habits. Rather than one-size-fits-all tips, it delivers specific steps per crop on sowing, feeding, watering, bug control, and prepping land. Handling many crops at once lets growers' pair suitable types, make better use of inputs, boosting earnings over time. Past plus current info saved online allows spotting patterns, forecasting harvests, watching soil condition year after year. Embedded systems using machine learning spot early clues of poor nutrients, forecast possible diseases, notice odd changes in soil, or suggest ways to prevent problems. Alerts mixed with smart predictions and custom advice turn it into a handy helper for on-the-spot choices, pushing farm decisions rooted in real data. Running through the cloud means anyone from solo growers to big co-ops can use it without hassle, scaling up as needed. It cuts down excess fertilizers, reduces harmful spills into nature, saves water, while also keeping dirt alive - backing eco-friendly farming tied to worldwide climate efforts. Blending old-school growing know-how with today's tech reshapes agriculture into something leaner, greener, tougher - ready to feed more people ahead.

2.LITERATURE REVIEW

a) Sonia Wadhwa suggested a study which incorporates a clever tool that tracks dirt nutrients, dampness - even air patterns. Sensors feed data to a tiny processor, then share it online. Farmers log in whenever they want to see current info - so they know exactly when to irrigate or add nutrients. That way, resources go further without being wasted. Less runoff

happens while harvests grow bigger. Updates pop up fast, no confusion involved. In short, this makes farms run smoother, yield more, and harm nature less.

b) **Sonia Wadhwa (2024),** This project checks if tech can boost crop growth on farms. Lots of growers stick to outdated ways that fall short. Crops rely on stuff like nitrogen, phosphorus - also potassium - to stay strong; lacking any weakens them. A solution here is building a clever tool that tracks dirt nutrients, dampness - even air patterns. Sensors feed data to a tiny processor, then share it online. Farmers log in whenever they want to see current info - so they know exactly when to irrigate or add nutrients. That way, resources go further without being wasted. Less runoff happens while harvests grow bigger. Updates pop up fast, no confusion involved. In short, this makes farms run smoother, yield more, and harm nature less.

c) **Yudhishthir Pandey & it's Team (2023),** The study showed the updated IoT watering system reduces excess water use by monitoring soil moisture in real time, preventing both over- and under-watering. Yet it stayed effective at protecting plants from damage caused by damp conditions while using resources more wisely. Since it uses wireless signals, growers can view data and tweak settings from a distance via smartphone. So routine checks became simpler without needing constant physical presence. Besides this, figuring out what grows well while giving proper food kept soil in decent shape. Simply put, smart gadgets connected online are shifting how farms work now - especially once they include better crop monitoring plus detailed ground scans down the line.

d) **Manju G & it's Team (2024),** The research showed soil quality along with surrounding conditions heavily affect how well crops grow - while machine learning helps farmers pick the right plants for their land. Instead of guessing, a smart tool looked at details like acidity, salt levels, organic matter, plus key nutrients such as nitrogen, phosphorus, potassium, boron, sulfur, manganese, iron, zinc, and copper - to suggest best-fit crops pretty accurately. Out of several methods tried, K-Nearest Neighbors (KNN) worked best, hitting 84% correctness when tested. Besides forecasting trends, the built-in sensors kept track of vital live soil data - like acidity levels, heat, moisture, electrical conductivity along with key nutrients helps track soil condition nonstop. Findings show mixing smart software with internet-connected sensors can boost farm choices. Adding live weather updates, info on bugs and plant illnesses, plus smarter math models might make forecasts way better. This setup could become a solid helper for picking crops wisely while lifting harvest output.

e) **MD Shaifullah Sharafat (2025)** The study showed old-school learning tools perform just like modern neural nets when spotting crops on regular hardware, helping move smart farming ahead. Even though deep learning worked decently, classic models outdid them - with Random Forest nailing almost 96% accuracy. Close behind, Gradient Boosting landed near 95.5%, while a fused SVC approach edged up to 95.9%. Since it was faster than the rest, Random Forest became the go-to choice for running on a Raspberry Pi 5 system. Tab Net did best in the test, hitting nearly 92% accuracy. When checking with LIME, nitrogen and rainfall stood out as key factors. While farmers liked how it worked, they noted a few areas to fix. According to specialists, quick decisions get easier because of real-time updates. Together, these tools offer strong help for farming that lasts. Adding federated learning at some point could speed things up while keeping results sharp. Edge computing might reduce lag when handling data from the field. Tiny AI versions tend to work more smoothly on weak hardware. Tacking on pest monitoring later can make it way more helpful. Future upgrades might bring tools that spot plant diseases. Soil differences help forecasts hit closer to home - nutrient tracking boosts smart farming tricks.

f) **Dhananjay Kumar & Sakshi Balyan (2025)** The results suggest taking care of soil and how we handle nutrients matters a lot when growing food without harming future harvests - since these factors shape how well crops grow and how the land holds up over time. Good dirt relies on active microbes, solid texture, enough compost-like material, along with steady recycling of big and tiny plant feeds. Using mix-and-match methods like checking soil levels, giving just enough fertilizer, adding compost or manure, switching what's planted each season, keeping ground covered between cycles, and disturbing the earth less helps build better topsoil while cutting down waste from washing away, sliding off fields, or escaping into air. Data shows new tech aids and flexible farming choices let growers adjust fast to changing field needs and feed plants only what they need. Even if shifting from old-school farming ways to healthier soil methods means spending more at first, you'll get stronger dirt, save cash on supplies later, grow better crops - while doing less harm to nature. In short, what works best relies on keeping an eye on things regularly, tailoring approaches per location - but also teaming up between growers, scientists, and leaders - all aimed at growing good food without wrecking the planet.

g) **Denis Magnus & Ken Amara (2025),** Agriculture's grown nonstop over years, just to keep up with how much food, cloth, and animal goods people need - yet that push tends to wreck nature by draining and breaking down dirt. Farming the same land again and again, particularly heavy feeders such as sugarcane, strips away topsoil, washes out key elements, and weakens earth's ability to grow things well - problems that blow up during harsh storms or droughts. Today's idea of healthy soil isn't only about bigger harvests; it also means protecting texture, keeping nutrients steady,. Though

sugarcane matters a lot for feeding populations and supporting local jobs, it sucks minerals from warm-region soils fast, making output drop unless those lost bits get put back. To boost soil quality, growers might try eco-friendly steps - like mixing in compost or planting cover crops instead of relying only on lab-made plant food. Stuff from nature, such as rotted waste, animal droppings, bird litter, or leftover seed pulp keeps dirt damp while feeding helpful microbes underground. Tiny life forms like Azotobacter, Acetobacter, bug strains that unlock phosphorus, critters fixing nitrogen, plus root fungi slowly free up nourishment, cutting down toxic runoff if used after checking earth samples. That way, plants get what they need at the right time, grow stronger, and make more sugar. Down the line, scientists could dig into smarter mix-ups of feeds, sharper ways to save ground and liquid resources, along with custom care plans depending on dirt kind and cane type.

h) **Yuliyan to & it's Team (2025),** The research showed a smart farming tool using machine learning helps countries grow enough food by picking the right crops for local soil and climate. Instead of guessing, it uses data patterns from 1,100 fake but realistic farm setups covering 11 different crops. With the KNN method, it worked best once the number of neighbors - called K - was fine-tuned. To create those test cases, values followed a bell curve pattern, tweaked slightly with 5% random noise. Then, they used a limit check to keep numbers within real-world sense. When tested, the model did well - nearly 97% correct picks, on average feeling about 83% sure of its choices. For example, it pushed rice during heavy rains, chose soybeans when things got drier, yet went with mung beans where drought hit hard. This proves KNN can give solid advice just by reading nature's signals.

i) **Vishal Singh & Yogesh Kumar (2024),** The Soil Test Crop Response technique figures out fertilizer amounts by linking lab soil checks with real crop growth data - so yields hit targets without guessing. It looks at dirt nutrients, acidity levels, plus how plants soak up food, then sets exact feed rates depending on existing supply and what crops need to grow well. Core idea? More nutrients usually mean higher harvests in a steady climb - that trend lets experts mix natural and synthetic feeds smartly. Benefits stack up: less runoff, lower spending on inputs, safer groundwater, steadier outputs, better pay for growers when nourishment fits local land traits. Still, there are some downsides - like needing good soil tests, skilled advice, careful sample collection, or regular check- ups, things tough for smallholders lacking lab help. All in all, STCR offers a down-to-earth, workable, money- friendly method to boost harvests while protecting dirt quality on heavily used farms

j) **Dattarao Bhise & Manish Kharat (2024),** The results suggest good fruit and vegetable farming depends mostly on strong soil plus giving plants the right mix of nutrients to grow well and deliver top-notch harvests. Research points out dirt quality gets better with smart steps like checking soil levels, adding compost, managing water wisely, switching crops regularly, tilling less, keeping acidity in check, along with handling nutrients and pests together. These methods boost root space, food supply, moisture holding, mineral access - while also cutting down pollution from spills or seepage. It's clear that matching fertilizer use to what each plant actually needs, using suitable soil fixes, helps get the best possible output. Farmers can keep their land healthy over time by using smart practices like planting cover crops or managing fields more thoughtfully. In general, results show that mixing careful soil care with good nutrient choices helps growers succeed - not just in yield but also in protecting nature while making solid profits.

3. DISCUSSION AND RESEARCH GAP

Illustrates how the combination of IoT sensors, ML models, and SMS messages can enhance farming operations and decision-making by making it possible for farmers to measure soil and environmental conditions remotely and receive alerts and updates in real time via both an internet- based dashboard or SMS text messages without needing internet connectivity for timeliness. The use of automated irrigation systems allowed for less waste of water because the watering schedule is adjusted based on current live measurements of moisture, temperature, pH, and nutrients present in the soil, while remote controlling the irrigation system also allowed for improved management of fields, thereby lessening the amount of manual labor required by farmers. In addition, the proposed framework provides farmers with multiple recommendations regarding which crops to plant based on environmental patterns, indicators of soil fertility, recommended crop rotation intervals, etc. Tests conducted by farmers show that the soil-monitoring device is effective at providing accurate and reliable readings and is easy to operate. The machine-learning models further improved the quality of decision making, with KNN achieving an overall accuracy of 84% on the primary datasets and the classical ML models such as Random Forest and Gradient Boosting performing over 95% accurately on larger datasets, making them ideal for deployment on devices such as the Raspberry Pi 5 and other edge devices. Thus, the overall integrated IoT-ML framework delivered in real-time soil assessment through the integrated use of IoT and ML technology, providing support for intelligent watering management through SMS alert systems, as well as multiple alternatives for crop planting through the integration of various environmental factors that give farmers the information needed to make smarter, more sustainable and productive farming practices.

4. PROPOSED METHODOLOGY

The soil sensors out in the field keep checking key things like dampness, acidity, heat, along with nutrients - no pause. Those numbers go straight to a small device, often something like an ESP32, Arduino . below the figure.

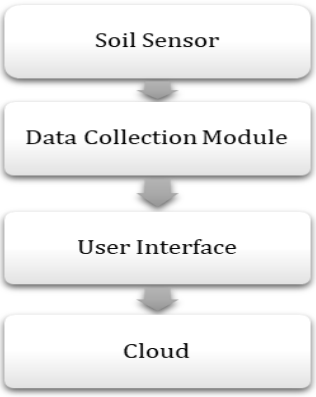

Fig -1: Soil Sensor to Cloud Data Flow

That gadget takes what it gets, turns analog signals into digital code, also beams everything up online. Once there, the system holds onto that info, studies patterns on the fly, plus figures out practical takeaways for growing crops better. On phones or screens, folks see clear updates through apps or dashboards showing live soil details, warnings when trouble's near, alongside tips so farmers can tweak watering, feeding plants, picking what to grow next.

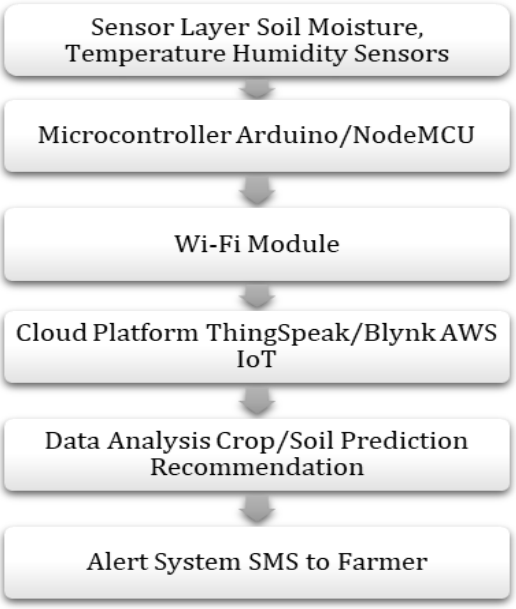

Fig -2 : Flow Diagram for IoT-Based Smart Soil Monitoring, Alert, and Real-Time Crop Recommendation System

Above the flowchart illustrating the complete process from sensor measurement to sending farmer alerts. See the block diagram for the major hardware/software interactions and data flow in the system.

The setup starts with sensors tracking soil dampness, heat, and air moisture - grabbing live info from the ground. That data moves into a small brain, maybe an Arduino or Nedelcu, for sorting. Once sorted, it travels via Wi-Fi up to a web- based hub such as Thing Speak, Blynk, or AWS IoT - to land safely and show up as charts. On the digital side, numbers get checked to judge earth quality, hint at good plants to grow, and offer smart tips for running the farm. After checking everything, automatic warnings pop up as texts to the farmer, giving quick advice on watering choices, what to plant next, plus keeping dirt strong.

5. CONCLUSION

Finally, this paper demonstrates that the integration of IoT sensors with machine-learning models and SMS notifications can greatly enhance the contemporary farming to the point of improving it. The system aids farmers to make decisions much faster and more precise even in places with low internet connection, by encouraging them to watch soil and environmental conditions in real time and provide prompt notifications. The automated irrigation system proved to save a lot of water by using the water only when it was needed, the remote control provided the option to have the fields easily managed and less work-consuming. Smarter crop planning was also supported by the fact that the system made recommendations of various crops that were appropriate depending on the soil conditions. The field trials established that the soil-monitoring instrument was reliable and easy to use by farmers. The machine-learning models were particularly the Random Forest and Gradient Boosting models which were very accurate in prediction thus making the system dependable to use in the real world. On the whole, the research shows that the combination of IoT and ML can result in the more efficient utilization of the resources, the improvement of the productivity, and the development of more sustainable agricultural systems that help prolong the health of soil and crops.

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