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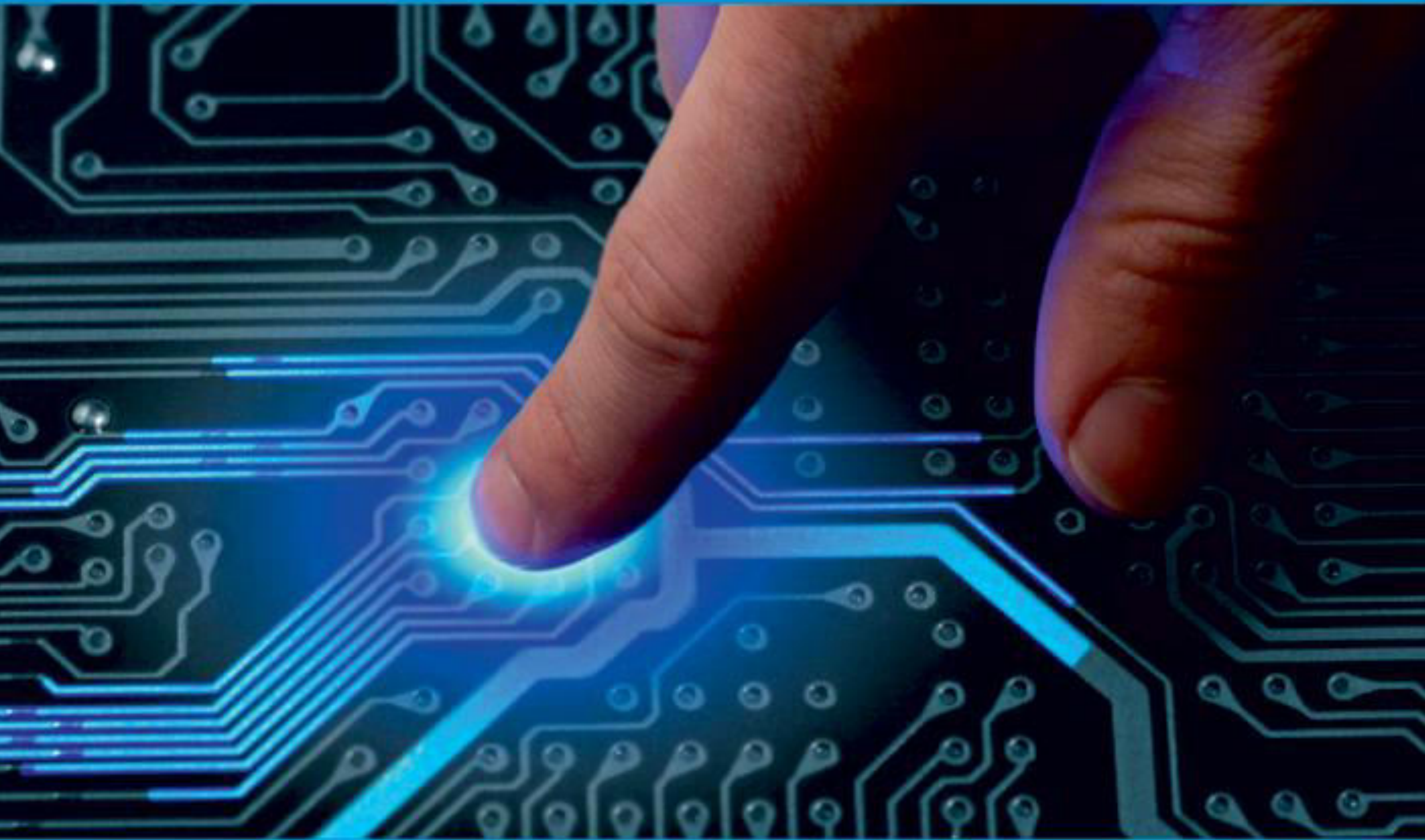

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Soil Sampling: The Crucial Techniques for a Smart Agriculture

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ABSTRACT: Smart agricultural methods depending on the Internet of Things (IOT) are the most potential for increasing food output while reducing resource usage, such as fresh water consumption. The Internet of Things (IOT) is a rapidly emerging paradigm that aims to connect various smart physical elements in order to modernise multiple domains. The necessity of soilless agriculture is highlighted in this study, as the expansion of liveable zones has resulted in the depletion of agricultural lands and an increase in food consumption. Furthermore, combining hydroponics with IOT technology significantly increased production by automated the collecting of occasional data of selected elements for optimum crop nurturing.Smart farming technologies dependent on the Internet of Things have the best chance of increasing food output while reducing resource usage, such as freshwater resources. The Internet of Things (IOT) is a developing paradigm that aims to connect various smart physical elements in order to modernise multiple domains. The necessity of soilless agriculture is highlighted in this research, as the development of habitable zones has resulted in agricultural land degradation and rising food consumption. In addition, combining hydroponics with IOT technology significantly increased production by automated the collecting of occasional data of specified elements for optimum crop nurturing.

I. INTRODUCTION

The growing need for food, especially in terms of reliability and quantity, has hastened require for agricultural industrialization and intensive techniques of production. A rising Internet of Things (IOT) market is proposing various unique ideas at the vanguard of the new agricultural era. Integrating with IOT allows scientific associations and research institutions to expand their reach and speed, bringing technologies and goods to a variety of farm sectors. With the invention of the Auto-ID at MIT and following market research findings, the IOT concept acquired traction (Bu and Wang 2019).These devices interact, sense, and engage with external state and internal state integrated technology in the Internet of Things (IOT). IOT is commonly regarded as the next generation of technologies, with applications in practically every sector of the market and the ability to raise the degree of integration of end goods, services, and systems. Security facilities, agricultural systems,

Healthcare services, agricultural systems, and smart communities, and are all good candidates for IOT technology (Mekala and Viswanathan 2017).

Agriculture indirectly or directly employs 65-75 percent of the Indian population (estimated worth). This has an impact on India's food safety and financial development. Precision allows agriculture processes to readily track or analyse crop production depending on data gathered from a farm land (growing conditions and meteorological data). This system, also known as site-specific crop management (SSCM) or satellite farming is unable to gather environmental data automatically due to the difficulty of the work(Pathan et al. 2020).Because there aren't enough soil analysis facilities in all of the regions, new farmers are starting out with little understanding of soil physical properties. So, what role does the Internet of Things play in agriculture? Automated information gathering is the alternative; nevertheless, it poses a risk to farmers as well as crop field activities. As a result, achieving ideal levels of productivity for farmers is tough. Internet of Things (IOT) has been the only way to solve this issue. It is crucial in the collection of data. With unique diverse strategies, the Internet of Things (IOT) is already on the rise(Nuvvula et al. 2017).

Crop rotation has conventionally been used by farmers to increase output. Farmers are finding it increasingly challenging to choose the most lucrative crop for another season as the existing weather changes. Crop yields are influenced by environmental factors and also soil properties. Both soil sampling or examining the climate patterns of the surroundings can provide a comprehensive understanding of the crops(Varman et al. 2017). It would be ideal to create a system that incorporates other environmental factors and quality of the soil.Developing a method that forecasts the best crop for the area would allow the farmer to prepare his upcoming rotations ahead of time. Freshwater scarcity

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affects the majority of developing nations. Countries that rely on agriculture as their main source of income lose large amounts of water due to a shortage of water managing systems. Irrigating the field just when necessary and until the optimal demand is met would save a massive quantity of freshwater(Partey et al. 2018).

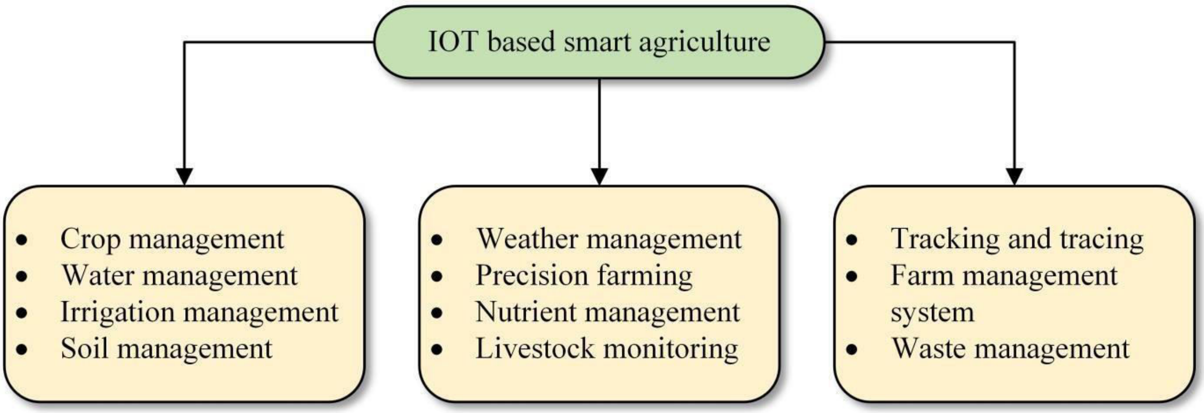

Figure 1: The Internet of Things' Role in Smart Agriculture

Rapidly expanding IOT technologies provides a plethora of creative approaches and prospects for growth, notably in the agriculture industry. Latest advances in protocols and

communication systems have also aided us significantly, particularly at the lower layers, such as the link layers, physical, and network. Aside from that, the protocols in the network's upper levels are crucial for efficient collecting information and transmission. In the agriculture industry as a complete, there are numerous techniques, methods, and patterns that could be applied(Salam 2020).Network architecture and implementations, safety difficulties and device design, are all continuing advancements in IOT agricultural technology. In addition, numerous IOT principles and rules have been established in agriculture by a number of countries and organizations across the globe. Furthermore, despite the fact that a significant lot of investigation has been performed on IOT, there is still a significant demand for more study in the agricultural industry(Ayaz et al. 2019). This research report looks at a variety of smart agricultural difficulties and developments. The rest of this paper is formalized as follows; section 2 defines the related works on soil sampling for smart agriculture using different methods. Section 3 designates in detail the workflow of the proposed algorithm. Section 4 represents the discussion of smart agriculture by IOT applications. Finally, section 5 concludes the study.

II. RELATED WORKS

The agriculture implementation of wireless sensor networks for crop field management was suggested in articles(Liqiang et al. 2011). These devices come with 2 different kinds of sensors nodes that detect temperature and humidity, as well as an imaging detecting node that compares data by capturing pictures of plants. Variables are critical in generating smart decisions for a productive harvest in a timely manner. Humidity, temperature, and pictures are the variables. Using these strategies, great sensing reliability can be achieved with little energy usage. It has been a long time since the farm field area has been monitored.The article (Keerthi and Kodandaramaiah 2015)presented a cloud-based greenhouse surveillance technology depends on agriculture IOT. Sensor gadgets including such soil moisture sensors, relative humidity sensors, light sensors, and temperature sensors can be used to properly detect diverse environmental variables in greenhouses. The detectors gather knowledge from the farm field area every thirty seconds, which is logged and uploaded online utilising the Internet - Of - things and cloud technology. (Ogunti 2019) The articles describe a Irrigation Automation system and Crop-Field Monitoring based on the Internet of Things. In their study, they devised a system that uses detectors to analyse crop fields, and the watering method is mechanized depending on decisions made by a webserver dependent on collected data. The detected data is transferred to the web server databases via wireless transmission. If watering is mechanized, this implies that if the temperature and humidity fields fall under the possible limit, the watering will be turned off. With the help of a programme that offers a web connection, the user can immediately track and operate the device.A smart drip irrigation device was suggested in (Kaur et al. 2016). An Android smartphone application is utilised in this to eliminate human participation and to monitoring and regulating the agricultural field electronically. Freshwater losses could be reduced by using a drip watering method that uses data from water level sensors. Environmental parameters are monitored using a variety of

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detectors. (Parameswaran and Sivaprasath 2016)Suggested Internet of Things-based smart irrigation technologies. Wireless sensors are required to estimate soil moisture and water

level. Utilizing a gateway named Generic IOT Border Router Wireless Br 1000; the detected information is transferred via a computer network to a smart gateway. The data is subsequently sent through a network from the gateways to a web application.(Brajović, Vujović, and \DJukanović 2015) To gain a deeper understanding of the IOT based developments in agricultural with cloud service technology, we performed a study on Smart Agriculture Watering Technologies.

III. PROPOSED METHODOLOGY

We discussed many components of the architecture and deployment of IOT implementations in this part. IOT's solution includes software for automatic monitoring and controlling. The goal of this project is to create a management mechanism that is simple to operate, efficient, and dependable. It aids in the reduction of power and water consumption. Agriculture is a source of livelihood for more than 50% of the globe populations. Furthermore, at a reasonable and affordable expense, this technology will boost production for farmers. This part begins with a discussion of proposed system, followed by an explanation of the architectural concept's functional and non-functional needs.

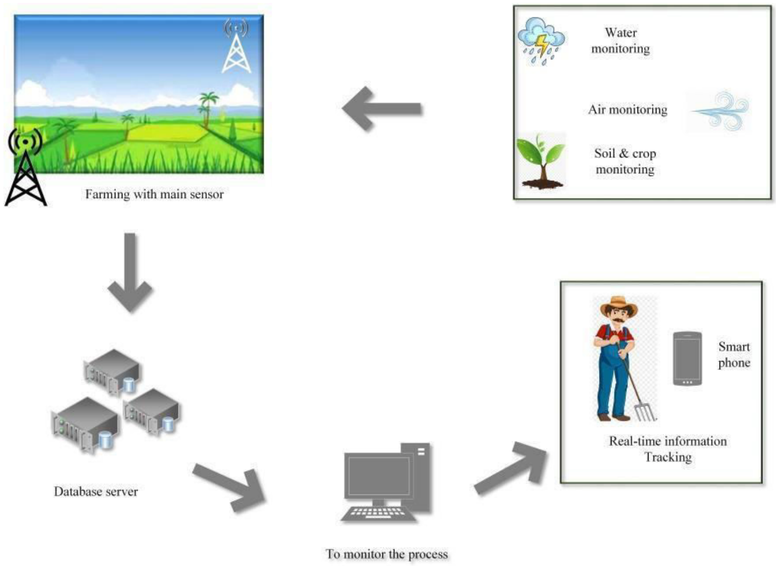

Figure 1: Block diagram for the proposed model

IV. SYSTEM ARCHITECTURE

The proposed structure is patterned employing an environmental humidity/temperature sensor for obtaining ambient humidity and temperature, an agricultural production database that integrates directly to a light density detector, an air toxicity sensor for determining oxygen levels and carbon monoxide, and a soil humidity detector for determining volumetric level of water(Qiuping, Shunbing, and Chunquan 2011). Furthermore, this technology could constantly monitor water level, temperature, and the quantity of light hitting the crops, all of which are critical in greenhouses. Humidity and temperature measurements are necessary for evaluating the plants' environmental atmosphere. The optimal humidity and temperature limits for different plant varieties are

different.To safeguard crops from shortages and high temperature levels, it is necessary to examine and adjust the humidity and temperature of their environment. The humidity and temperature detector that was used is given below. Moreover, the detector is necessary for gathering data on the amount of light obtained by the plants. This device includes a variety of detectors(Salazar et al. 2013). A detector for air toxicity is also included in the device. The air Toxicity Detector is designed to detect toxicity in the environment; it simply detects the presence of alcohol and carbon monoxide, both of which are extremely harmful to plants development.The microprocessor in the Farming based database allows us to connect all of the detectors and exhibit the sensors' readings on the LCD panel. In addition, the

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touchscreen LCD display can be used as an input method. The input from the touchscreen LCD is processed through an UI. The device also includes a Wi-Fi module that provides sensed data to the webserver via the wireless connection(Antonacci et al. 2018). The end user can also retrieve the sensor information at any time through the webserver.

1. Functional Requirement

The functions and components of the proposed model are specified in the following specifications. They describe the system's behaviour in relation to implication:

- Take a temperature reading.
- Measure the amount of moisture in the air.
- Calculate the water level.
- Calculate the amount of light available.
- Detect Toxicity in the Air.
- On the LCD panel, show the sensor readings
- Allows the user to change the sensor's ideal values.
- Recognizing and responding to sensor readings by sending user alerts.

2. Non-functional Requirement

The following are the work's non-functional specifications:

- Accessibility: The suggested manoeuvre was always effective.
- Quality: The system has a longer life cycle and precise measurements.
- Consistency: The proposed system might be easily improved by combining components with new functionalities.
- Convenience of usage: The suggested scheme is simple to understand and utilise. The device's operation does not necessitate any previous information.

Soil Sampling and Mapping

Soil is a plant's "stomach," and sampling was the initial phase in obtaining field- specific knowledge, which would be used to generate numerous key choices at different phases. The major goal of soil testing is to evaluate a field's nutritional condition so that appropriate steps could be implemented if nutritional deficits are discovered. Complete soil testing should be performed once a year, particularly in the springtime; (Chi, Chen, and Gao

2008)but, depending on soil characteristics and temperature fluctuations, they can be performed in the winter or fall. Topography, irrigation level, fertiliser application, Soil type, and cropping history, etc. are all important aspects to consider when analysing soil nutritional quality(Charumathi et al. 2017).These characteristics provide information about the physical, biological, and chemical conditions of a soil, allowing for the identification of restricting parameters so that plants could be managed appropriately. Soil mapping allows you to sow several crop kinds in the same region to improve match soil attribute such as seed compatibility, seeding season, and also planting depths, as certain crops are deep-rooted while others are not(Sudhakar and Swathi 2016). Moreover, cultivating several crops simultaneously could result in more efficient agricultural practises, just by getting the most of available materials.Industries are continuously offering a variety of development tools and detectors to help producers monitor quality of the soil and, depending on the information, provide solutions to prevent deterioration. These devices enable the tracking of soil qualities like absorption rate, texture, and water-holding capacity which helps to reduce pollution, acidification, salinization, erosion, and densification (by avoiding excessive use of fertilizer). Agro-Cares' Lab-in-a-Box soil analysis equipment kit is regarded a comprehensive laboratory in and of itself due to the capabilities it provides (Sinha and Dhanalakshmi 2022). Any farmer, regardless of lab knowledge, can use this to evaluate up to 100 examples each day (total, more than 22,000 nutritional samples each year) without needing to attend a laboratory.

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Time Period	Parameters	Information types
Days to weeks	Weather	• Rainfall and temperature were recorded. • Daily forecasts are available up to a week in advance. • Extreme weather events are forewarned in advance.
Months to years	Climate variability	• Seasonalrainfall and temperature conditions are forecasted. • Climate variables that are specific to specific agricultural risks. • Variability in climate factors across time.
Decades or longer	Climate change	• Rainfall and temperature forecasts for the future. • Temperature and rainfall trends over time. • Extreme occurrences have changed throughout history.

Table 1: How farmers all across the world use climate and weather data to make choices

IV. EXPERIMENTAL RESULTS AND ANALYSIS

Graph readings are displayed to demonstrate the operation of specific detectors included in our gadget. The following graph depicts temperature readings from the Node10

sensor over the course of a year and at various time intervals. The time is generally expressed in hours, and the temperature is expressed in degrees Celsius. The graphic shows that as the summer progresses, the temperatures continue to rise steadily. It achieves a maximum temperature of 34°C in the summertime and a minimum of 24°C in the winter(Angelopoulou et al. 2019).During the autumn, and monsoon season, temperatures rise by 5°C –10°C until 14:00, after which they drop significantly until 20:00, and then remain steady until 00:00. Due to high lands and winds masses, the threshold temperatures lingered until 14:00 in the summertime. Furthermore, it retained an advantage over others until 20:00, when it began to wane(Chen and Jin 2012). The water levels to be regulated could be determined based on the device's temperature measurements. Maximum and minimum temperatures forecasted from (01-06-2019 to 07-06-2019 ….30-06-2019).

Node type	Maximum	Minimum
Node 10	31.54	16.25
Node 11	31.06	16.10
Router 1	32.20	16.48
Node 20	31.31	16.03
Node 21	31.42	15.40
Router 2	30.87	16.15
Co-ordinator	30.34	16.15

Table 2: predicted Temperature

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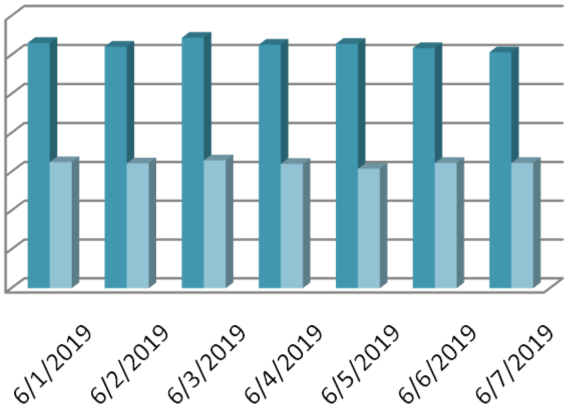

Figure 3: Temperature predictions

The graph below depicts humidity readings from the Node11 sensor over the course of a year and at various time intervals. The time is generally expressed in hours, and the temperature is expressed in degrees Celsius. The accompanying picture shows that throughout the winter, the humidity percentage drops to 34 percent around 01:00 and progressively rises as time passes. It achieves a peak humidity of 85 percent in the winter, resulting in low temperatures(Rekha et al. 2017).Moreover, the humidity variations in the fall and monsoon are similar. Unless in winter season, when the atmosphere is dry and moisture values are low, we noticed that humidity variations remain nearly constant until 10:00 in all seasons. As a result of the action of the Sun throughout the afternoon, the graph drastically

declines from 10:00 to 15:00. Then, until night 22:00, we noticed a sudden growth in humidity of 25–35 percent, which remained consistent afterwards. According to the humidity measurements from the devices, the farmer may adjust the air conditioning accordingly. Maximum and Minimum Humidity Calculated from (01-06-2019 to 07-06-2019 ….30-06- 2019).

Table 3: predicted Humidity

Node type	Maximum	Minimum
Node 10	67.60	54.72
Node 11	67.60	55.37
Router 1	67.06	54.40
Node 20	67.71	53.88
Node 21	66.65	54.83
Router 2	67.65	53.82
Co-ordinator	68.06	55.30

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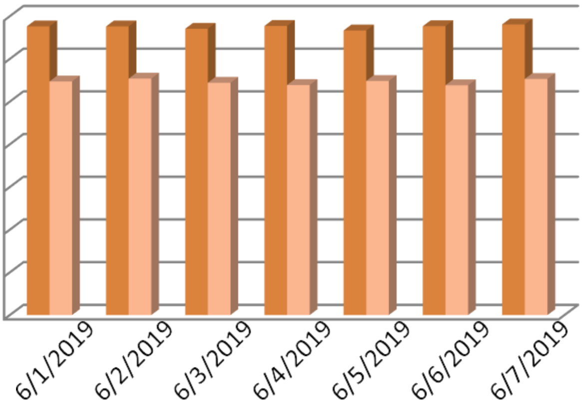

Figure 4: Humidity predictions

The graph below depicts soil moisture temperature readings obtained from a detector over various terrains and time intervals. The time is generally expressed in hours, while the moisture is expressed in volumetric moisture concentration. The figure shows that moisture content in dry area is lower than humidity in the soils in moist area(Huuskonen and Oksanen 2018). If the readings are logged in the gadget, we can see that the soil humidity fluctuates each hour. The farmer might adjust the water level based on the soil moisture measurements from the gadget. When the water content in the soil falls below a certain level, the gadget starts the water source to keep the soil hydrated. Maximum and minimum soil temperatures estimated from (01-06-2019 to 07-06-2019… 30-06-2019).

Node type	Maximum	Minimum
Node 10	30.80	17.17
Node 11	30.70	16.51
Router 1	31.06	16.83
Node 20	31.00	16.57
Node 21	31.75	16.22
Router 2	30.70	17.40
Co-ordinator	31.02	17.56

Table 4: predicted Soil Temperature

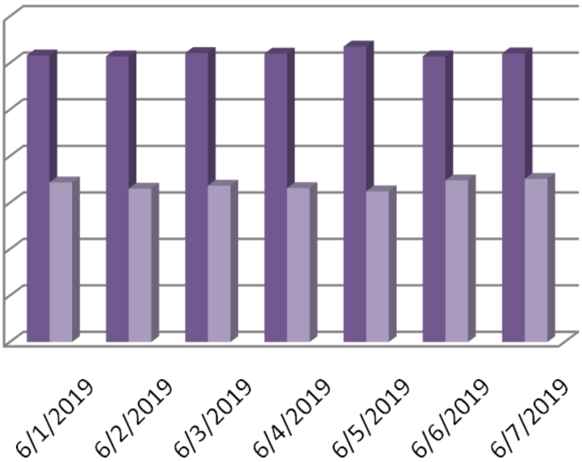

Figure 5: Soil Temperature predictions

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V. CONCLUSION

A whole chain of actions was provided in this paper, from ploughing through various soil sampling, to build a top soil mapping with monitoring areas for accurate agricultural objectives. The IOT application's user interface (UI) was functional and took the user to all of the instance regions. It was feasible to gather data samples when utilizing software, and the software only required minimal user input. To increase the user experiences, certain changes could be performed. During extreme climate circumstances, additional researches on protective covering of nodes are essential. Renewable energy, batteries, or other continuous resource of power must be scrutinised.Replaceable or auxiliary detectors can be attached to the system depending on the situation. In light of the foregoing, it may be argued that integrating distant and proximal detecting techniques is essential for developing expense and precise tracking methods with high spatial resolution for property decision-making. End users will find the gadget to be reasonably simple to operate, and it may be used in both minimal and massive agriculture.

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