*Article*

# Fusion of Multiple Sensors to Implement Precision Agriculture using IOT Infrastructure

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**Abstract:** Precision Agriculture is the ability to handle variations in productivity within a field and maximize financial return, optimize resource utilization and minimize impact of the environment. It is also the process of automated data collection, cloud storage and utilization to build robust decision support system. In case of Ethiopia, due to poor communication infrastructure coverage and absence of the state-of-the-art technology in the agriculture sector, implementing precision farming system is a challenging tasks in the domain area. In this work, we proposed a fusion of multiple sensors using IOT and IIOT infrastructure to collect critical data from farming fields to develop precision farming facility for decision makers. The main purpose was to monitor weather variability, automate irrigation process, extract critical soil properties. In addition, we have used time series data collected from sensor devices to build forecasting model. Fusion of multiple IoT device provide a mechanism in the agriculture area to deal with real-time monitoring of crops. It is cost-effective technology and required low-energy with edge computing sensor device. We employed the Message Queuing Telemetry Transport (MQTT) protocol to connect the Industrial/Internet of Things (I/IoT) to the cloud server. The communication between system user and sensor device has been done via cloud using Node-RED platform, web android APIs. The cloud-based Eco-system allows us to aggregate, visualize, and analyze live streams output from each sensor in real-time manner. Finally, we have built time series forecasting model using records collected by each sensor device. Using the multi-variate time series data-set, we have obtained about 99 forecasting accuracy on some important variables. Finally, we have developed mobile and web-based application for the end-user to monitor the proposed system remotely.

**Keywords:** Sensor Fusion; IIOT; IOT; Precision Agriculture; Time Series data; Predictive model

## 1. Introduction

According Mahmoud A. and his colleague [1], Precision farming is an approach which uses information technology (IT) to improve the quality of crops production and yield estimation. Precision Agriculture has been defined as maximizing yields using minimal resources such as water, fertilizer, pesticides and seeds according to Spyridon [2]. Similarly, Alaa A.[3] defined Precision agriculture as the farm management system using information technology to identify, analyze and manage the variability of fields to ensure profitability, sustainability, and protection of the environment. In addition, Precision Agriculture (PA) can also be defined as the use of computer vision (CV) [4–6] and machine learning models to determine soil properties [7], hi-tech farming approaches to improve efficiency[8,9]. According to Kariheinz Knickel et, al[9], since 1950s and 1960s, agricultural modernization are vigorously entrenched and established a form of agriculture that is capital-intensive,

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high-input, high-output, specialized and rationalized system by industrial countries. To achieve sustainable agricultural output [3], precision agriculture was used and it is the technology that enhance the agricultural process[10]. Precision farming enable user to control weather variables, optimize resources utilization, enhance early intervention to minimize environmental impacts, and efficient real-time data collection through cloud server infrastructure.

But due to poor infrastructure and lack of state-of-the-art technologies in the agriculture sector, getting precise and real-time information about crop growth status remain as a challenging task for decision makers. In addition, Precision Agriculture is a capital-intensive, but its return on investment is very high. Currently, state-of-the-art in the domain of Industrial Internet of Things (IIOT) or Internet of Things (IOT) brought a solution of low-cost sensor device to implement data-driven methodologies.

PA was a promises mechanism to transform agriculture sector to ensure high productivity and reduce the environmental impact on agriculture[1]. Yash B. and his colleague[11] argue that, crop yield can be maximized with the help of precision farming technology. Currently, IOT and IIOT sensor devices plays a significant role in controlling environmental variability and helps to assess suitable environment for different crop variety. Analysis and insight can be obtained from IOT sensor would help to select environmentally friendly crops for specific farming field. In case of precision agriculture, collecting relevant features such nitrogen content, potassium content, moisture content in the soil and monitoring environmental factors is critical to design sound system in the domain area [11]. An IOT embedded devices allows domain expert to optimize resources utilization such as water, fertilizer, pesticides and seeds[2].

Similarly, a lot attempts has been made to minimize the perturbation factors of precision agriculture using different machine learning approaches. In this regard, Halimatu Sadiyah and Mustpha Zubair [7] proposed Convolutional Neural Network (CNN) [12,13] approach to improve pre-planning and post-harvest processing. Similarly, Enhanced Back-propagation neural network (NN) for automatic change detection (CD) using remote sensing (RS) image data has been explored by Dalmiya C.P et al [14]. In addition, Deep Convolutional Neural Network (DCNN) [15] has been proposed by J.P. Cobena Cevallos et al[16] to improve, evaluate, and estimate PA based on the information obtained from remote sensing data. Computer vision approach has been inspired by Eusebio L. Mique et al[17] to detect rices diseases affect by insects and wheat rust diseases by Tagel, A. and his colleague [18]. In addition, Image based crop weed classification, detection [19] and segmentation methods have been explored by Junfeng Gao et al [20]. In addition, precision spraying and a novel method for recognition of broad-leaf weeding in pasture were explored by Wenhao Zhang et al. Lorick Jain et al proposed CNN model to perform real-time image classification system to identify plant diseases. Halimatu Sadiyah and Mustpha Zubair [7] proposed plant disease recognition and classification [21] system using CNN approach. These days, the role of technology is increasing rapidly in every sector. Smart agriculture is one of the sectors, where technology is playing a significant role to modernize the agriculture sector. Its key purpose is to use the state-of-the-art technologies to increase the quality and quantity of agricultural products.

In this regard, precision agriculture technology aimed to control and monitor critical variables which affect crop productivity and yield loss. The analysis of changes in variability and its significant impact on the plant health status. We have consider farmer question regarding the yield production improvement by controlling the variability's. Jacopo Aleotti and his colleague proposed Smart Precision-Agriculture Platform controlled and monitored in real-time using the mobile application [22]. Wen-Liang, C. and his colleague [25] proposed RiceTalk AI enabled IOT project to detect non-image rice blast disease. Similarly, a reliable and affordable IoT framework has been proposed by Swagatam, B. and his colleague [26] to impact and digitally revolutionize the farming ecosystem; optimize irrigation, monitoring of sensor signals which is essential for guarantee the control of soil variables [27]. Therefore, the application of IIOT and IoT would help to optimize the utilization of scare resources to enhance production quality and productivity [24]. According to Mahmoud A., agriculture is one of the domains that have been affected by IOT infrastructure and lead to a coined new area that named Precision Agriculture [1].

From the review of related studies, we have assessed the research gaps in the case of Ethiopia. Due to infrastructure and technology limitations, decision maker suffers to get precises information about weather condition, water content levels, soil properties information, crop health indexing measurements, fertilizer requirements, and prediction of natural disasters which affect crops health. Therefore, in this study, we proposed fusion of multi-sensor to implement precision farming system using IIOT and IOT sensor device infrastructure.

The main objective of the current study was to extract weather variability and soil properties through sensor devices to design automate system in the agriculture domain. Well-designed PA system would help to understand the associate biotic properties of crops with spectral signature to assess crop health status. Therefore, the proposed precision agriculture system was considered to handle the following aspects:

- First, we identified determinant sensor devices to collect signal records about weather variability and soil properties;
- Second applying the IIOT and IOT infrastructures to design cloud based eco-system for precision agriculture;
- Third, designing remotely and web-based platform and APIs for the end user to access data and visualize the trends of changes in variability's in real-time manner.
- Finally, we employed machine learning approaches to build forecasting model using time series data-set collected by each sensor.

## 2. Materials and Methods

### *2.1. Experiment setting*

In this study, we have simultaneously utilized industrial Internet of Things (IIOT) and Internet of Things (IOT) devices to collect signal records about weather variability and soil properties respectively. The IIOT embedded device were used to collect data from farming filed and IOT was used to collect data from controlled environments. To implement the experiment, Debre-Zeyit Agriculture Research Institute, Asella Agriculture research center and Ambo Agriculture research center have been selected on the basis of availability of domain expert support in ground truth knowledge. But due to financial constraints, prototype demonstration has been made only at Debre-Zeyit Agriculture Research Institute. The Institute has well organized greenhouse under controlled environmental condition. The main limitation of this institute was, they employed old-aged devices to control their environment which is prone to data accuracy. We have deployed the IOT infrastructure in the center to control and manage the over-all environmental variability, smart irrigation system, and to assess the soil properties as well.

Designing Precise and real-time data acquisition and visualization mechanism have a significant contribution in agriculture system. This process enable farmer to make early identification of some anomalies due environmental effect. For instance, Soil moisture sensors, are used to estimate the moisture levels through the dielectric constant of the soil, which changes as the soil moisture level is changing [2]. Currently, precision agriculture come into existence to revolution the agriculture industry that promotes the monitoring of activities necessary to transform agricultural methods to ensure food security in an ever-changing environment. In the next subsection, we have dealt with the detail implementation of PA using IOT Infrastructures.

### *2.2. Proposed Model Architecture*

We have crafted the following system architecture to deploy the proposed Fusion of Multiple Sensors to Implement Precision farming using IIOT Infrastructure. The architecture briefly describes the major components and operation and configurations used to proposed PA system. As we mentioned in the background section, we implemented both IIOT and IOT facilities to collect out-door and in-door data records respectively.


**Figure 1.** General IIOT System Architecture

Primarily groov RIO has been used as edge I/O in IIOT application in the case of agriculture. As you can see on Figure 2 above, edge I/O bridges the operations technology (OT) world of sensors and actuators, shown at the bottom of the diagram, and the information technology (IT) world of computers and corporate software, at the top. Groov RIO's embedded software and protocol support make it possible to exchange data between these two realms more easily and securely. We have utilized Embedded software and protocol support such as groov manage to configure groov RIO I/O, Node-RED for creating simple data flows to send data to cloud services, databases, other I/O channels, and APIs. Pre-built nodes make flow creation easy. Thirdly, MQTT protocol an efficient publish/subscribe protocol for exchanging data.

On the other hand, we have utilized IOT devices such as Arduino, ESP32/8266 and Raspberry Pi 4 Microcomputer to collect in-door signal records. Based on the purpose of the current work, we have used the following sensor devices such as temperature, humidity, moisture, gas, and light respectively. But we can increase the numbers of sensor device depending on objective of the proposed system. The following figure 2 illustrates the proposed system architecture.

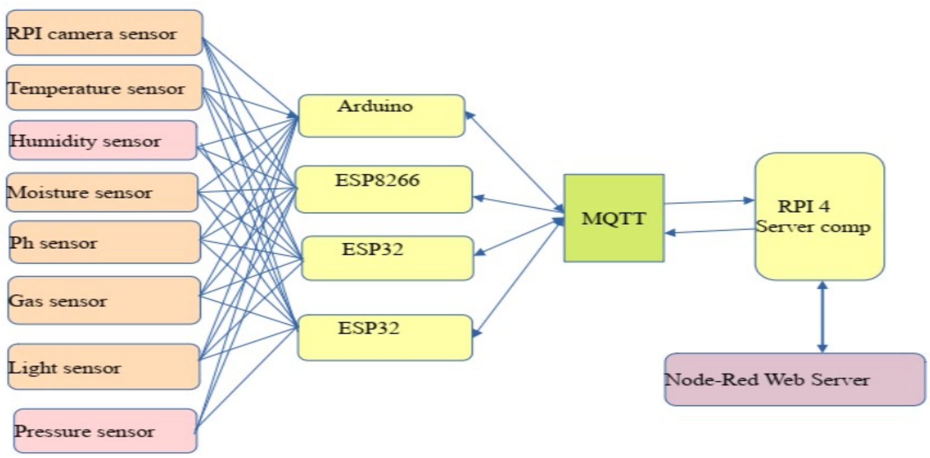


**Figure 2.** Proposed System Architecture using IOT Infrastructure

Fusion of multiple IoT device provide a mechanism to deal with real-time monitoring of crops, with cost-effective and low-energy consuming edge computing sensor devices. In this study, we have employed both the IIOT and IOT infrastructure with similar procedure. In addition, as the name indicates, IIOT infrastructure were used to automate industry including smart farming technology. PA would help the farmer for early intervention

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and optimal resources utilization purpose. Optimal utilization of agriculture input would enhance production quality.

Smart agriculture heavily depends on specific equipment and information technology to acquire relevant signal records which could be used as a features to build precision farming system. As we mentioned earlier, we have employed and integrate IIOT and IOT devices to extract critical feature about water management, soil management, and controlling weather condition. Farmers can swiftly react to any substantial change weather condition, humidity and temperature level, soil properties in the farming field with real-time data visualization. For instance, we can NPK sensor has been used to detect soil fertility. A major component of soil fertility is nitrogen, phosphorus, and potassium. The knowledge of the soil nutrient concentration can help to learn about nutrient deficiency or abundance in soils used to endorse plant production. Therefore, a successful deployment of IOT sensor don't require any chemical reagent. Most of IOT device has a high measurement accuracy, fast response time, and good data interchangeability. it can be used with any micro-controller and groov RIO edge device. Similarly, Moisture and temperature interact, and one controls the other. As temperature changes, so does the amount of evaporation and moisture, or humidity, in the air. Thus, temperature, evaporation and moisture are interrelated environmental phenomena. Humidity increases as temperatures cool and air approaches its dew points. The dew point is the temperature at which the atmosphere becomes saturated, and knowing it is critical to being able to measure humidity.

Therefore, the ground truth knowledge justifies that, when plants lack water, photosynthesis decreases; when leaves are wilted due to severe water shortage, photosynthesis declines sharply or even stops. Soil water conditions also affect the photosynthesis of plants. The decrease in soil water content causes a decrease in leaf water potential and an increase in stomatal resistance, which ultimately leads to increased leaf diffusion resistance, hindered CO2 diffusion and reduced photosynthetic rate. We understood that, water is the medium for material transformation and transportation, and it also directly participates in certain biochemical reactions. Hence, PA enable the farmer to optimally utilize and monitor water resources to enhance productivity. Similarly, light sensor can be used to detect the amount of light penetrated into greenhouse would help the farmer to get more insight on the effect of light in plant food preparations. To conclude this section, we have made in-depth discussion with domain expert to evaluated the significance of each sensors in designing robust PA system.

The proposed Fusion approach provides a multi-purpose solution by improving environmental monitoring and agriculture digitization process. One of the significant contributions of this study was real-time and accurate weather data collection from sensor device. In addition, PA system are promising approach to ensure robust monitoring of the environmental impact on farming field. Figure 3 below, illustrated the overall architecture of cloud-based IOT system we have used to build PA.

The fusion of sensor using the embedded IOT infrastructure allow the system user to control the overall activities of precision agriculture from anywhere with robust performance.

Similarly, we employed the Message Queuing Telemetry Transport (MQTT) protocol to connect the Internet of Things (IoT) devices based on Wireless Sensor Network (WSN) approach. This protocol is lightweight, simple, and can be run on a small bandwidth compared to Hypertext Transfer Protocol (HTTP). According to Nurzaman, A. and his colleagues [27] Wireless sensor network (WSN) is proven to be an economically viable solution for the agriculture domain. Visualization, controlling and commanding of the fusion are performed from node-red web-server interface. The cloud-based Eco-system easily also allows us to aggregate, visualize, and analyze live streams output from each sensor in real-time via the web interface or mobile application.

Firebase back-end platform has been used to build the Web apps, Android and IOS applications. It offers real time database, different APIs, multiple authentication types and hosting platform. The Firebase Real-time database lets you build rich, collaborative

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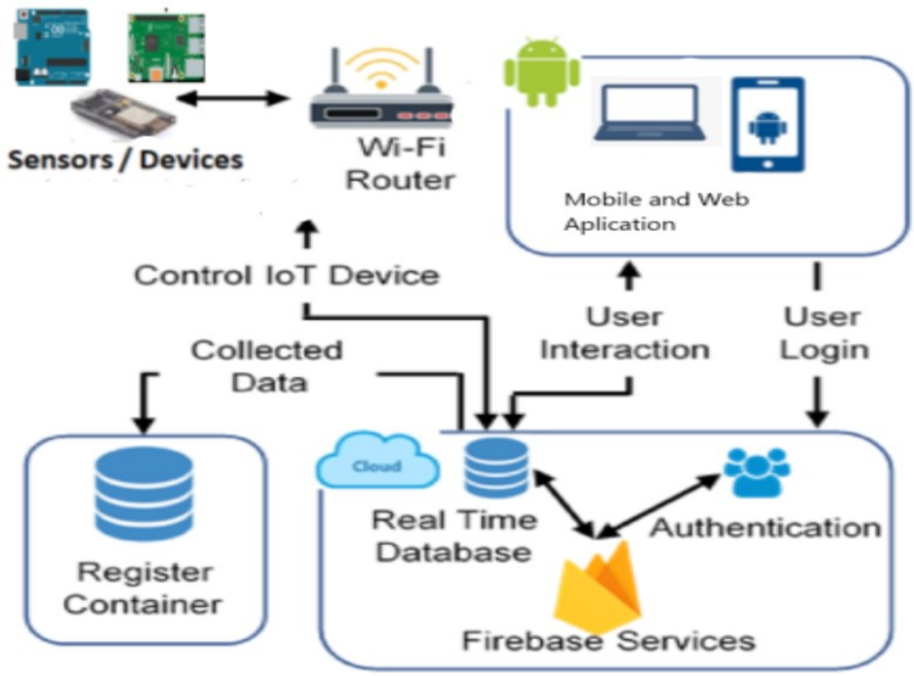


**Figure 3.** Functionalities of the proposed system

applications by allowing secure access to the database directly from client-side code. Data is persisted locally, and even while offline, real-time events continue to fire, giving the end user a responsive experience. When the device regains connection, the Real-time Database synchronizes the local data changes with the remote updates that occurred while the client was offline, merging any conflicts automatically. It is Firebase that supports JSON data and all users connected to it receive live updates after every change. The Real-time Database provides a flexible, expression-based rules language, called Firebase Real-time Database Security Rules, to define how your data should be structured and when data can be read from or written to. When integrated with Firebase Authentication, developers can define who has access to what data, and how they can access it.

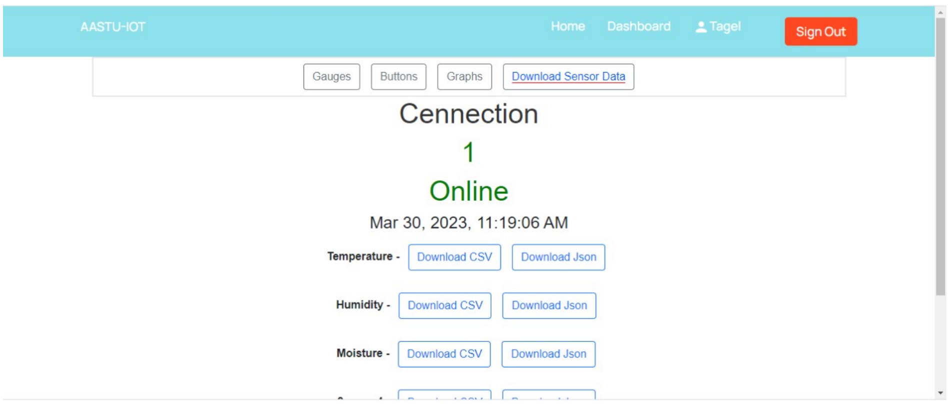


**Figure 4.** Real-time Data Access from the Firebase Cloud Server

The integration of IOT device with cloud server simplified the process of manually acquisition of signal data sources generated by each IOT sensors. Once, we download dataset, the next step was to combine it into single CSV file to proceed the feature engineering task. Finally, we have data converted into the appropriate file formats to perform further features engineering tasks. Once everything successfully deployed, then the end

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user will get access to visualize the trends of each variability in real-time using web-based platforms or mobile APIs.

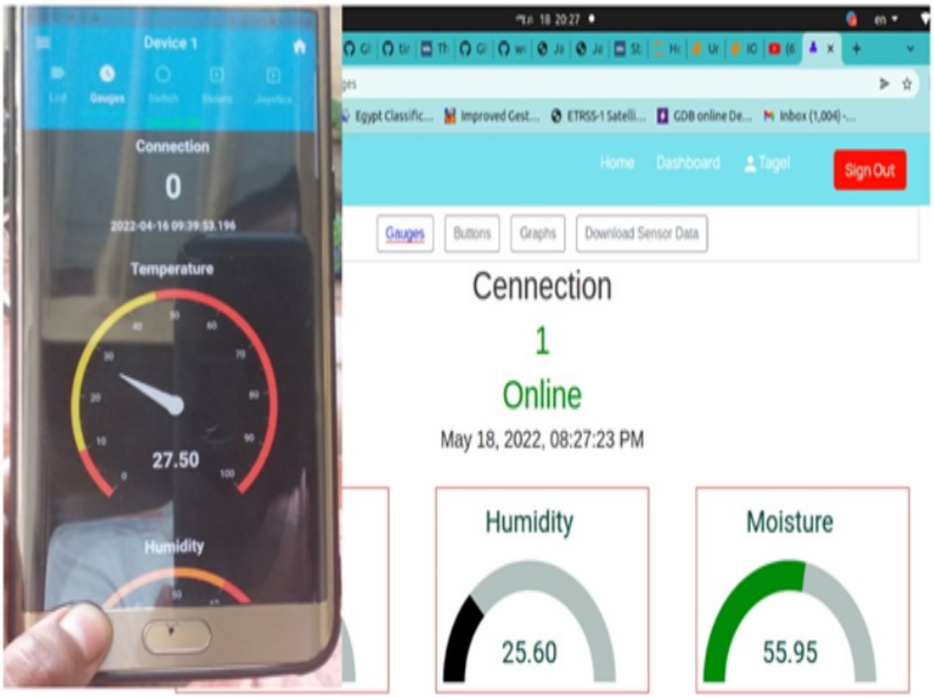


**Figure 5.** Real-time Weather Variability Visualization

From Figure 4 above, we have used Laptop and smartphone platforms to visualize time series streaming from each IOT devices to easily understand the trends in real-time manner. In addition, LCD display has been used as alternative solution for visualization purposes.

Finally, IIOT or IOT infrastructure enables a user to remotely control and monitor the PA system using a button function in either from your smartphone or web-based platform.

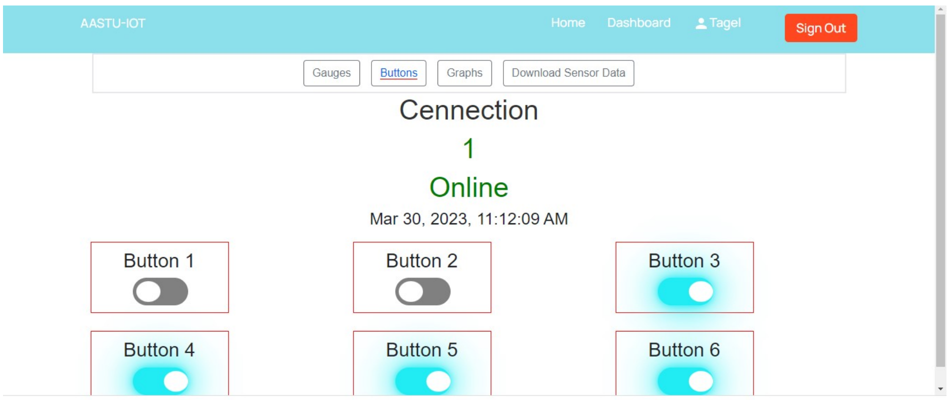


**Figure 6.** Application of button function

A button function is user-friendly to control IOT devices based on incoming prompt alarm message from the sensor. For instance, when the soil moisture level rich a certain threshold, you will get alarm to open or close the irrigation pump. Similarly, you make your fun ON/OFF based on an alarm message from temperature sensor's detection. Therefore, without having any programming or technical skill, user can button function to control the overall activities of precision agriculture system.

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## 3. Building Forecasting Model using Machine Learning Approaches

In this study, our final objective was to build machine learning model using time-series data collected from IOT devices. We are inspired to make some computation using signal records being collect over a certain period of times. The main object was to provide insight about the trends of variability's over-time and forecasting upcoming trends based on the historical data-set.

Depending on the configuration of time stamp, we adjust the server to update of logged signal from each sensor. In order to get reasonable datasets, we have configured the sensor to update logged file on six hourly bases. Once we get the logged files, then the next step was converting the signal data into JSON or CSV file which is used to train forecasting models. Time Series (TS) data must be re-framed as a supervised learning dataset before we can start using machine learning algorithms. This is parts of feature engineering in the case of time series data. Over the last 13 months, around five thousand observations (rows) features have been collected. For the purpose of experiment demonstration, we have selected only three variables as multivariate time series data-set were to build forecasting model. About 70% of the datasets has been used to training the model. Whereas, the remaining 30% has been used to test prediction/forecasting performance. During data prepossessing, some of the outliers have been removed manually from the data-set to maintain variance. In addition, date time formatting and standardizing has been done. The distribution of training data shows that Humidity and temperature distribution are close to normal curve. In the case of moisture sensor data, we have put the sensor on a dry area for long time that why it shows the soil moisture properties is 100%. When we start irrigating, then the value will be show you less value to justify that the soil has a water content.

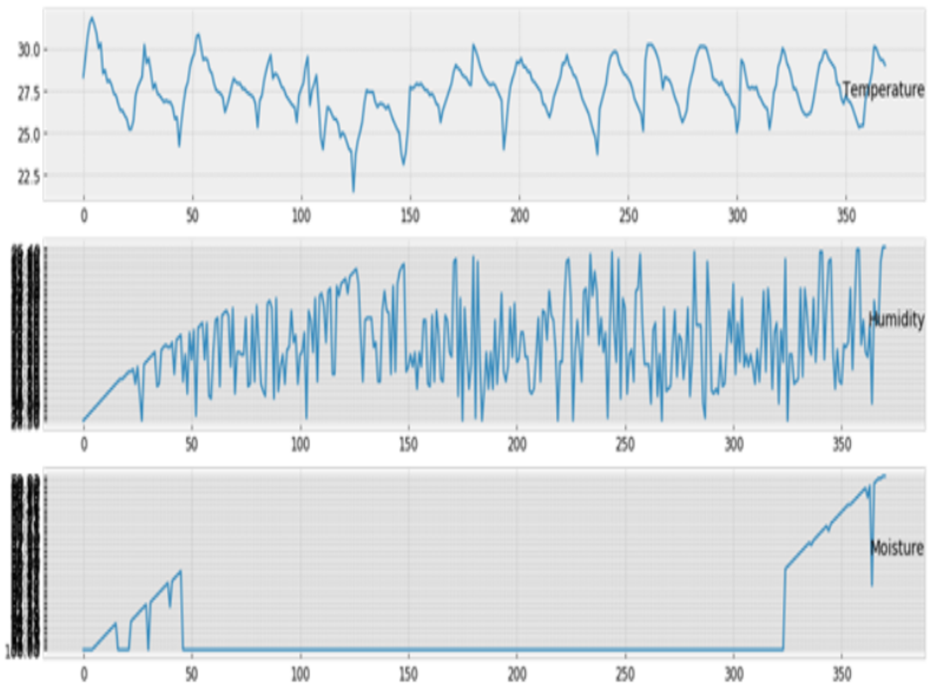


**Figure 7.** Forecasting model using Time Series data-set

Time series analysis involves working with time-based data in order to make predictions about the future. In this work, a uni-variate and Multivariate time series has been utilized to build a weather forecasting machine learning model. Each variable depends not only on its past values but also has some dependency on other variables. The covariance of two random variables is a measure of their linear dependence. The population (theoretical) covariance of two random variables, Xi and Xj , is defined by

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$$(Xi, Xj) = (Xii)(Xjj).$$

where, i = (Xi) and j = (Xj ); E denotes expectation. (1)

If Xi and Xj are independent of each other, their covariance is necessarily equal to zero, but the converse is not true.

On the other hand, We have assessed the Stationary of time series datasets using very strict criterion to understand the pattern of weather variability over a period of time. However, for practical purposes we can assume the series to be stationary if it has constant statistical properties over time. First-order differencing does not stationarize the time series and therefore the data is differenced another time to generate a stationary time series. To handle this limitation, We initialized Augmented Dickey Fuller test and obtained about 0.02 P-value. Accordingly, When the P-value of the ADF is less than 0.05, then the time series is stationary. Without the lags, we can define a Dickey Fuller test as follows:

$$Deltay_t = \alpha + \theta y_{t-1} + e_t$$

testing whether =0 where =1 obtained by subtracting yt1 from both sides (2)

The time series resulting from second-order differencing have N - 2 observations. It is almost never required to perform differencing of order higher than second order. In addition, we are interested in the observations made at prior times, called lag times or lags. Times in the past are negative relative to the current time. For example, the previous time is t-1 and the time before that is t-2. The observations at these times are obs(t-1) and obs(t-2) respectively. Times in the future are what we are interested in forecasting and are positive relative to the current time. For instance, the next time is t+1 and the time after that is t+2. The observations at these times are obs(t+1) and obs(t+2) respectively.

## 4. Result and Discussion

Agriculture sector is a back-bone for Ethiopian economic growth and development. Automating the sector with the state-of-the-art technology will have enormous contribution to assure the over-all food security issue. The primarily objective of the current study was to implementing fusion of multiple using IIOT and IOT infrastructure to provide precises analytical information for domain experts or decision makers. In addition, the proposed system can be used for real-time crop monitoring and optimize resources utilization. To understand the ground-truth, we have made exhaustive discussion with domain expert and review of related works has been made to understand the relevant features. Based on the analogy, we have selected the following features to build the forecasting model. The changes of temperature and humidity above a certain threshold will invoke the fan motor to adjust the temperature.

Therefore, alert message from the server due to deviation in weather condition enforce the system user to take immediate intervention to control the environment. On the other hand, we can also assess moisture measurement; when the level of water content become below the adjusted threshold, command will send to the server to invoke the water pump. To maintain the proportion of water droplet, we have precisely created a hole on the pipe with measurable distance. According to crop expert, under watering or over watering have significant impact on the growth and healthiness of a specific crop.

Third, under the controlled environment crop need adequate light sources to prepare photosynthesis. In this regard, we have integrated light sensor with embedded device

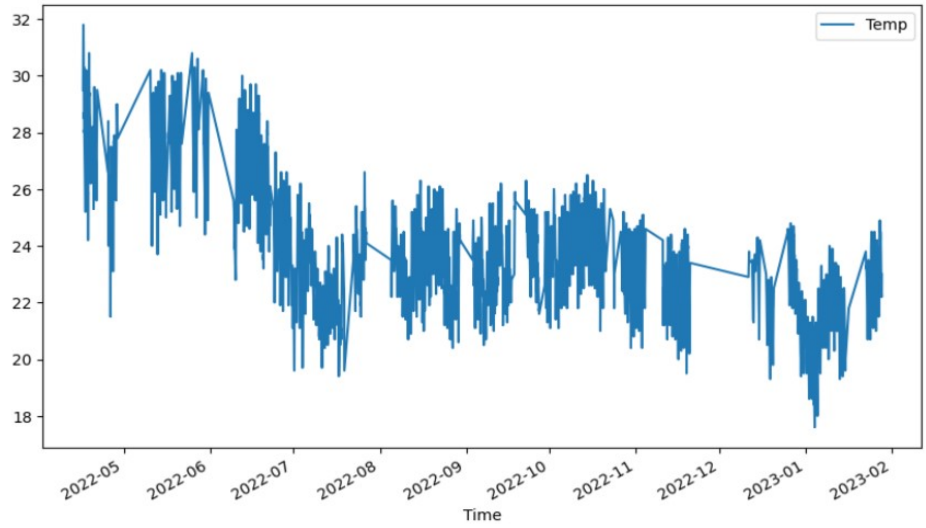


**Figure 8.** The Pattern of Temperature Time Series data-set

to extract about its intensity. This data provides significant information about the plant stress, the chlorophyll contents and the health status of crop growth. Similarly, we have been collected multispectral signature using RPI camera for further analyze of the change of signature as a result of changes in variability. The proposed system architecture has been illustrated on 2Figure 2 show the overall connectivity of signals from the source devices to the destination micro-processor. The MQTT has been used to communicate the input nodes with the output node. For instance, input nodes are subscribed to the temperature, humidity sensors, moisture, etc. These nodes will fetch the data and send it to the gauge node to display the values. Similarly, on 2, the hardware configuration has been done to integrate each Sensors like DHT22, BMP180, light sensor, moisture sensors with ESP8266/32 via Arduino micro-controller. Based on the demand of end user, it possible to increases the number of sensors. On the other, we have used Firebase server infrastructure to build the web and mobile apps. It offers real time database, different APIs, multiple authentication types and hosting platform. The Firebase Real-time database lets you build rich, collaborative applications by allowing secure access to the database directly from client-side code. The platform APIs has been configured to store the logged files in JSON or CSV file format. On Figure 5, we have prepared a simple user interface to download the datasets. Once all the required configuration are successfully completed, visualization of time-series signal can be accessed either from mobile or web application. These apps are designed to control your IOT system remotely from anywhere, it need small capacity Wi-Fi connectivity or mobile data. On Figure 6 and 9, we have discussed how the real-time signal data has been visualized using mobile apps and web-based application respectively. One of the major contributions of the current study was, we have integrated the IOT system with machine learning approach to build the predictive model. In this study, have proposed ensemble learning model to handle the multivariate datasets. In the case of multivariate time series, cross correlation function (CCF) is an important modeling tool and it try to generalizes the ACF to the multivariate case. The main objective is to find linear dynamic relationships in time series data by considering its stationary process. We have utilized multivariate time series data-set to explore and build forecast models. We have demonstrated robust forecasting using a simple SARIMA model using Temp column time series data.

The time series model had made correct predictions and the actual and prediction lines are close together. The SARIMA model has performed well as compared to the ARIMA model. Similarly, the proposed system contribute in to two major approach; common user visualized the time-series data in real-time manner directly from signal records. On

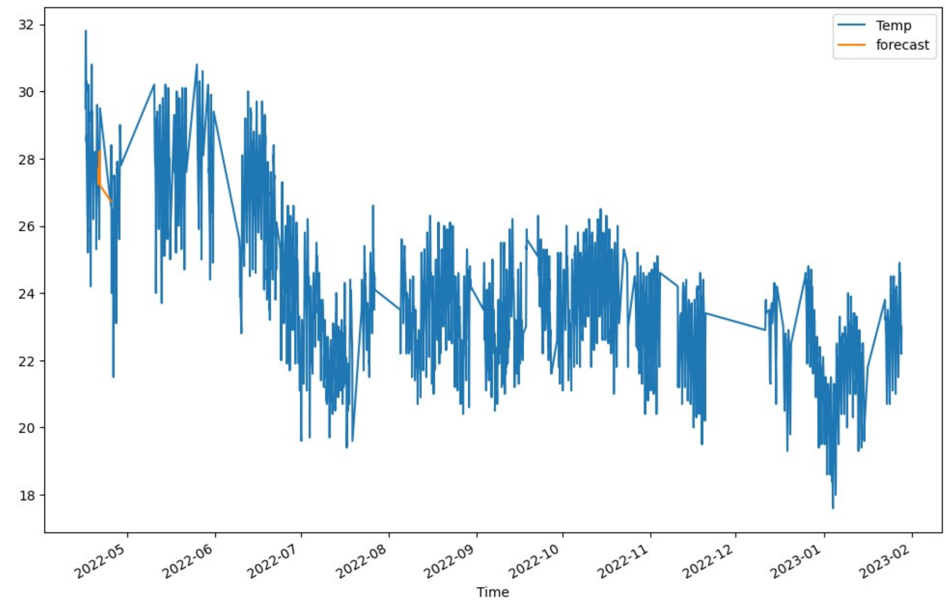


**Figure 9.** Temp Forecasting using SARIMA Model

the other hand, we have built forecasting model for domain expert and researchers as a decision support tools to take early intervention. In addition, getting well labeled training datasets was a challenging task in case of Ethiopia. So, to handle these limitations, the proposed system can be used as a possible solution for researchers in the domain area.

Finally, precise knowledge on the current weather variables its effect on crop growth would support the domain expert and farmer to monitor and take appropriate action as early as possible. For developing countries like Ethiopia, automating the agricultural sector would have paramount impact to assure food security issue. In addition, well organized and precise information support system user to optimize agricultural input utilization and enhanced water resources management purposes.

## 5. Conclusion and recommendation

Ethiopia is the second most populated nation in Africa continent next to Nigeria. Agriculture is the backbone of our economy development and the sector also contribute a large proportion for the national GDP. But the agricultural sector is still suffering due to lack of technology, manual data collection and analysis processes, poor data storage infrastructure and less attention to Precision farming technology. The proposed fusion of IoT based web and mobile application are user-friendly and provide optimized solution for the end user. Cloud-based IOT infrastructure with low-cost embedded device were another breakthrough contribution for developing countries like Ethiopia. On the other hand, the acquisition of well labeled time-series datasets was a bottle-neck to build a weather forecasting model. To address these limitations, the proposed IOT based Fusion system generate accurate datasets via the sensors which is ready to inspire further research in the domain area. Finally, the proposed system provide real-time analytical information for decision maker at different level to control the overall system and to take early intervention. The agriculture sector needs a serious attention from government side and further study and application of state-of-the-art technology to improve productivity. Therefore, we have a plan to further extend the current study. We also recommend interested researcher to further explore on the following issues: Generally, cost of advanced sensor device and limitation of network infrastructure in rural area were the big challenges to implement IoT system for precision Agriculture on large-scale farming. Currently, Ethiopia as one of the developing countries in east Africa have the limitation of network coverage. Expansion work on internet access need due attention from the concerned body. This is a big step to address the above-mentioned limitation and would create a favorable condition to implement IoT based application in a numbers of domain areas. Due to budget and sensor access, we couldn't't incorporate nitrogen sensor in our IOT system, but we followed similar approaches. Nitrogen sensor is significantly relevant to understand the overall soil properties. Finally, the proposed system can be implemented at national level to support the agricultural sector digitization processes.

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**Institutional Review Board Statement:** This studies not involving humans or animals.

**Informed Consent Statement:** This study did not involve humans.

**Data Availability Statement:** We have collected time series signal record directly from our IOT and IIOT devices and stored it on the cloud server. Therefore, we will make the data available for researchers via my personal GitHub repository.

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**Conflicts of Interest:** The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

**Sample Availability:** Samples of the compounds ... are available from the authors.

## Abbreviations

The following abbreviations are used in this manuscript:

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| MDPI | Multidisciplinary Digital Publishing Institute |
| DOAJ | Directory of open access journals |
| TLA | Three letter acronym |
| LD | Linear dichroism |
| PA | Precision Agriculture |
| IOT | Internet of Things |
| IIOT | Industrial Internet of Things |
| TS | Time Series |
| CCF | cross correlation function |
| ACF | Auto Correlation Function |

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