Intelligent Crop Growth Management System using Internet of Things

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Abstract*—Now-a-days a crucial development of advanced technologies leads a world in an innovative manner as well as the technical development creates new ideas to make the manual work more smarter compare to the regular perspectives. The Internet of Things (IoT) is the powerful medium, in which it incorporates many commercial and non-commercial organization boundaries into it. Many applications and smart devices adopts the purpose of Internet of Things to provide the range free communication services without any delay. In other case, agriculture and farming is the most important and food is the basic need for every living being, in which the agriculture remunerates the food to all. So, agriculture is considered to be the backbone of any country as well as it plays a vital role in country's economy. However, the cultural differences leads many people to come out from the field of agriculture and leads a work free life as well as many people in villages want to deviate and relocate their presence from there to cities. Due to this kinds of reasons the nature of agriculture is down and many people are not interested to do such things. This paper is intended to motivate the nature of agriculture by doing it in a smart way without any hurdles as well as this paper introduce a new methodology called Intelligent Crop Monitoring Scheme (ICMS), in which it integrates many unique approaches to provide ultimate support to farmers to do agriculture without any complexities even from a remote place as well. The major integrations bounding with this proposed approach of ICMS are Internet of Things (IoT), Deep Machine Learning Principles with effective prediction strategies and emergency alerting port. These all are integrated together over the proposed approach and provides the good outcome in results as well as the proposed approach of ICMS assures the accuracy levels of predictions. This system place a small smart device over the agricultural field, in which the device is interconnected with internet by using Internet of Things to accumulate the data and placed it into the global server for monitoring. The details of the smart device and the specified details are clearly described over the following summaries. For all the proposed approach eliminates the hurdle in agriculture field and provides efficiency to do such things in easy way without any complexity.

***Index Terms*— Intelligent Crop Monitoring Scheme, ICMS, Deep Learning Principle, Internet of Things, IoT, Crop Growth Monitoring.**

I. INTRODUCTION

Agriculture is the most important concern to take care with each and every country as well as it is considered to be the essential source of one's life. In the consideration of Indian economy, agriculture and farming plays a vital role and provides 45% of overall support in economy development. In the past researches, many different kinds of agricultural support devices are introduced and all are strucked up in certain level [1][2]. The implementations such as remote surveillance and SMS based agricultural watering system and management and so on. But all are strucked up in certain range due to its complexity and keep the accuracy of doing such things. In general food is the major consideration and it is more important to each and every individual, so that the development of agriculture is also a concern to get such food in good manner. The cost of food and the raw materials for food is increasing day-by-day due to the low productivity and less interest to farmers. There are many different factors associated with such issue such as: heavy water wastages to plantation, less fertilization level in agricultural field soil,

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abusing over fertilizers, climate conditions, insects problem and many more. It is compulsory to make a good solution to provide an efficient support to farmers to provide fault free as well as failure free agriculture and its associated development.

Agriculture and Farming is fundamental wellspring of traditional People in India and other countries as well. It assumes significant job in economy of nation as like already mentioned and in any case, presently days because of relocation of individuals from rustic to metropolitan there is a block in agricultural development and observing the ecological factor isn't the finished answer for increment the yield of harvests. There are no of elements that decline the profitability generally and thus the systematic needs should be actualized in agriculture to defeat these issues. A programmed water system framework and smart crop monitoring system in this manner with time efficiency, cost effective and intensity of agriculture as well as farming people.

Fig.1 Functional Blocks of Smart Crop Monitoring Device

The classical agricultural field water system and monitoring procedures require manual mediation, in which the computerized innovation of water and monitoring system the manual mediation can be limited. Nonstop detecting an observing of yields by intermingling of sensors with powerful Internet of Things (IOT) and making farmers' to mindful about harvests development, gather time occasionally and thus making high efficiency of harvests and furthermore guaranteeing right conveyance of items to end, buyers at perfect spot and ideal time. So to conquer this difficult a necessary move is required for keen agribusiness strategy to utilize IoT and its benefits. This paper incorporates many innovative technologies in integrated manner to provide good support to farmers by means of adding sensors, for example, temperature, humidity, soil dampness and water level, motor pump control and rain identification for assortment of the field information and handled. These innovative technologies are joined with grounded web innovation as remote sensor organization to distantly control and screen information from the smart device placed over the agricultural field.

A. Importance of Smart Agricultural System

The following summary illustrates the importance of smart agriculture and its benefits. Based on these strategies the proposed approach is designed and the following points illustrate the needs of proposed approach in detail.

(i) The appliance of smart device is easy to locate into the farm/agricultural field without any complexity as well as the size of the device is so compact.
(ii) Requires less power consumption, so that the farmers can use small batteries or else solar power source for the smart device, even the power supply from government is also not required, because with the power voltage of 12v DC current from battery runs the device for two to three consecutive days without any hurdle.
(iii) Power consumption is less, so that the cost savings are good enough.
(iv) The smart irrigation system provides sufficient level of water to the crops as per the requirement, in which the automation system takes care of such things without any human intervention.
(v) To provide correct water supply at correct time to preserve water source in farming agri-land.
(vi) Motor pump controlling are in dual mode, in which the smart device system can automatically control the water pump at required time as well as the farmer can operate the pump via remote manner through their mobile phone or computer.
(vii) Crop can easily monitored by the farmers on remote end without any delay, if any problem over the growth of crop, it can easily be identified and rectified based on such systems.
(viii) Rain flow can easily be monitored by smart device, so that the water dispense can be automatically controlled accordingly.
(ix) Machine learning based Smart Farming and Corp monitoring model provides better prediction in results with proper accuracy.
(x) Overall time savvy process provides best performance and improves the standard of farmers in next level.

B. Inspiration of Smart Crop Monitoring Scheme

There are several motivational and inspirational aspects regarding to the nature of smart agricultural crop monitoring scheme, in which it beyond the limits of individual aspects as well as the proposed approach of smart crop monitoring adapts all latest innovative technologies on it and provides a best service to farmers to improve their life style.

(i) Compare to several fields, the agriculture space is generally investigated territory of concerning the use of Internet of Things (IoT) in improving the conventional strategies for cultivating [3]. The fast development in nano devices and its associated technologies that occurred in a decade ago, has empowered the formation of little and modest smart-sensors.
(ii) The independent idea of activity, along with particular estimated equipment stages, attractive and practical advances, has empowered the Internet of Things as a possible device towards the objective of coordinated by itself, dynamic and mechanization in the agriculture' cum cultivating industry. In such manner, agricultural accuracy [4][5][6], robotized watering and planning [5][7], streamlining of plant development [5][6], land observing [8], green house checking [3][6] and cultivating creation and handling [8] in yields, are among a couple of key applications.
(iii) However, Internet of Things is in incipient phase of improvement, subsequently it has a couple of restrictions, for example, interoperability, heterogeneity, memory obliged equipment stages and security.

(iv) These impediments acquire difficulties in the plan of Internet of Things and its associated applications in agriculture. Most important part of agricultural field is the benefits of Internet of Things based applications are focused and implemented on several stages. For instance, Internet of Things for natural condition checking with data of soil supplements is applied for foreseeing crop wellbeing and creation quality over the long run. Water system and maintenance is anticipated with IoT's by checking the moisture level of soil and climate conditions [9].

(v) Being versatile, the presentation of a current Internet of Things based application can be improved to screen more boundaries by just including extra sensor hubs to the current engineering [10].

(vi) The issues present in such applications are fixated on the gadget interoperability, innovation heterogeneity, security, estimation stretch and steering conventions.

II. RELATED STUDY

Bhanu.K.N'et al., 2020, proposed a paper related to the advancements of smart agricultural crop monitoring system with respect to Internet of Things (IoT) [1]. In this paper [1], the authors illustrated the interconnectivity benefits of multiple sensors associated on the smart device with the remote server, in which the remote server connectivity enables the agricultural people to monitor the status of the crops on the field instantly without any delay at anytime from anywhere in the globe. This paper describes the power of Internet of Things association in agricultural field as well as this kind of approaches provides better yielding in crop maintenance and modernize the field and nature of agriculture in good way. In this paper [1], the authors considers the major factors such as sunlight, temperature control, moisture level of the soil, required protein supplements to the soil, climate conditions and so on. Multiple category of sensors are associated over the smart device and provide the proper communication services with the help of Internet of Things and enable the farmers to monitor the crops without any hurdle. The major advantage noticed in the paper [1] is the systematic monitoring and accumulating the modern technologies over the approach to provide support to the farmers in an efficient way. However, the limitations need to resolve in this paper is the remote monitoring of crops in visualized way as well as the missing of Artificial Intelligence association on the proposed approach. As well as the external third party support is accumulated for remote server maintenance such as ThinkSpeak and so on, which will be not possible to customize easily on client end and complex in working.

KasaraSai PratyushReddy'et al., 2020, proposed a paper related to agricultural field monitoring system using Internet of Things (IoT) [2] as well as this paper provides a detailed summary of economic growth with respect to agriculture as well as the job opportunities in it in significant manner. The headway in imaginative cultivating procedures is bit by bit upgrading the harvest yield making it more beneficial and decrease water system wastages and the proposed model [2] is a savvy water system framework which predicts the water necessity for a yield, utilizing Artificial Intelligence procedures. Moisture level, temperature and stickiness are the three most fundamental boundaries to decide the amount of water needed in any agriculture field. This framework involves temperature, stickiness and moisture level sensor, conveyed in a rural field, sends information through a chip and building up an Internet of Things gadget with cloud. In this paper [2] Decision Tree approaches are considered, an effective Artificial Intelligence approach is applied on the information detected from the field in to foresee results productively. The outcomes got through decision tree estimation are sent through a mail caution to the respective people or farmers, in which it helps in dynamic with respect to water supply ahead of time. The major advantage identified from this paper [2] is the efficiency and the improvement of latest technology adaptation in crop estimations over agricultural field. The limitations identified on the

paper is need to properly analyze the time complexities and fast response mechanisms by adding some features associated with deep learning principles.

BaranwalT'et al., 2016, proposed a paper related to smart security feature enhancements and monitoring system provisions over agricultural industry by using latest technologies of Internet of Things (IoT). In this paper [3], the authors described such as the farming areas being the foundation of the Indian economy and it merits security. Security not as far as assets just but rather additionally farming/agri items needs security and insurance at starting stage, similar to assurance from assaults of rodents or creepy crawlies, in fields or crop storage areas. Such difficulties should likewise be contemplated and the security frameworks which are being utilized now-a-days are not adequately shrewd to give ongoing notice in the wake of detecting the issue. The coordination of classical technique with most recent advances as IoTs and WSNs can prompt agrarian modernization and keeping this situation in one's brain as it is planned, tried and examined an IoT based gadget which is equipped for dissecting the detected data and afterward communicating it to the client. This gadget can be controlled and observed from far off area and it very well may be actualized in rural fields, crop storage areas and cold-storages due to security reason. This paper [3] is situated to highlight the strategies to tackle such issues like recognizable proof of rodents, dangers to crops and conveying continuous notice dependent on data examination and preparing without human intercession. In this gadget, referenced sensors and electronic gadgets are coordinated utilizing Python contents and in view of endeavored experiments, the option had to make progress in 84.8 percentage testing scenarios. The major advantage found over the paper [3] is it attains the maximum accuracy levels of above 88 percentage and low error rate. However, the paper has certain limitations related to time estimations and cost expensiveness during the implementation.

III. PROPOSED SYSTEM METHODOLOGIES

This paper introduced a new approach of improving the agricultural field with respect to latest technologies, in which it is helpful to maintain the agricultural field with human free nature as well as providing abilities to monitoring the crops on remote places without any timing and range restrictions. The proposed scheme called Intelligent Crop Monitoring Scheme (ICMS) adapts several latest technologies to provide intelligent support to the farmers to improve their lives in good manner. The connected technologies of Intelligent Crop Monitoring Scheme are summarized as follows: Internet of Things (IoT), Smart Irrigation Management System (SIMS), Remote Cloud Server Optimization (RCSO) and Periodical Crop Monitoring (PCM). In which these technologies are integrated together and perform tasks for a smart agricultural crop monitoring and automation system using Artificial Intelligence strategies.

These innovative technologies are assembled with some important sensors and such sensors are arranged in a smart and compact port called Smart Crop Monitoring Device, in which it positioned into the respective agricultural field for monitoring and controlling the agricultural activities as well as crop's day-by-day development without any range and time considerations. The integrated sensors are pH Level sensor, Soil Moisture Sensor, Rain Sensor, Temperature and Humidity Sensor. All these sensor details and the respective function of each and every sensor modules are clearly explained over further summaries. The following figure, Fig-2 illustrates the associated sensors connected with the Smart Crop Monitoring Device (SCMD) and the specification for both transmission and receiving ends. In which the details presented in the figure can be categorized into three areas, such as: Master IoT Smart Device block, in which it is also known as Transmission Block, Server Manipulation Block, in

which it is used to manipulate the incoming data based on proposed ICMS methodology and the final one is the receiver block, in which provides facility to end user to monitor the crop related data.

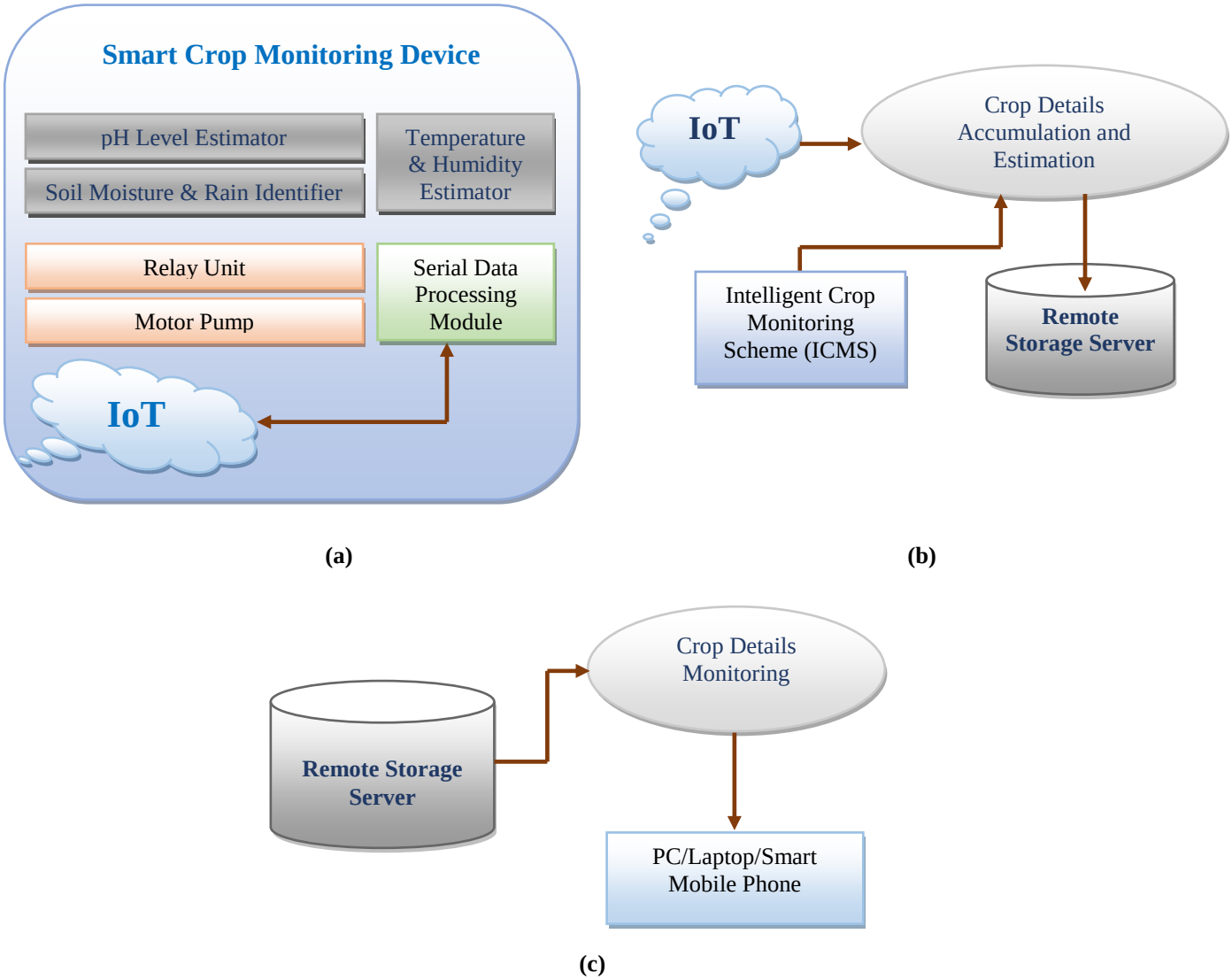

Fig.2 Proposed Approach Architectural Design (a) Transmission and Master Smart Device block, (b) Server Processing Module w.r.t. ICMS and (c) Receiver end Monitoring and Controlling System.

In the above figure, the transmission end fully follows the wireless communication technology with respect to Internet of Things norms. The smart sensors associated with the proposed approach accumulates the data from agricultural field and operates the motor pump accordingly as well as the live data of the crops are pushed into the remote server with the help of Internet of Things module presented in it. The second phase of work begins with data processing, in which the accumulated data will be handled by means of ICMS. In this approach the proposed Machine Learning principle process the incoming data with the trained model and once if any harmful changes in the coming model available it will be immediately notified to the

respective farmers accordingly. As well as the third phase module shows the respective affection state to the farmers with corresponding details, so that the farmers can view that by means of Smart Phones or Computer.

A. Intelligent Crop Monitoring Scheme (ICMS)

The proposed approach of Intelligent Crop Monitoring Scheme (ICMS) provides several interesting features to the agricultural system enhancement by means of its drastic technologies. The association of Internet of Things (IOT) accumulates the crop related data with photograph to the respective remote server. In remote server end, the proposed approach training model operates with proper frequency, in which all the previously accumulated data will be considered as a trained sample and the present coming data is considered to be the testing sample. If the crop testing data matched with the trained dataset, the automation system immediately identifies the problem status and alert the respective farmer accordingly as well as the Smart Crop Monitoring Device performs the required action accordingly. The pH sensor connected with the smart device provides the acidity level of water supplied to the crops, the temperature and humidity level monitoring are handled by means of DHT11 sensor, in which it is a common well-known sensor for identifying the environmental temperature and moisture level. The rain identification sensor cross verifies the soil moisture sensor indications and operates the motor pump accordingly. All these information are properly passed to the remote server end with the help of IoT module associated with the smart crop monitoring device. The following table, Table-1 shows the view of accumulated agricultural crop related data from the sensor enabled smart device maintained into the server.

Table-1 Data Samples Maintained into Server

Date & Time	Soil Moisture	Rain Status	pH Level	DHT11 Values
2020-12-05 10:15:20 UTC	256	NO	7.01	23▫C,31▫F
2020-12-05 10:15:25 UTC	260	NO	7.16	22▫C,32▫F
2020-12-06 10:15:30 UTC	265	NO	7.05	23▫C,31▫F
2020-12-06 10:15:35 UTC	282	NO	7.16	22▫C,30▫F
2020-12-06 10:15:40 UTC	301	NO	7.07	21▫C,34▫F
2020-12-06 10:15:45 UTC	306	NO	7.21	23▫C,31▫F
2020-12-06 10:15:50 UTC	308	NO	7.26	22▫C,33▫F

The following formulation is used to analyze the crop harvesting duration with required water consistency level of the soil with respect to the artificial intelligence based data optimization strategies as well as this formulation allows the farmer to maintain the crops safely for coming years against the temperature constraints.

$$T^{x} = \sum_{t=1+\square}^{T+t\square} \left(\frac{Q}{T}\right)\square a \leq R^{n-k} < \beta < \infty \qquad (1)$$

Where R indicates the water consistency weight factor level, T indicates the temperature level of the agricultural field environment ∞ indicates the water flow level and β indicates the soil type.

The limitations of rain and water flow measurements to the crops are estimated with the help of following function.

$$W_{Min} \rightarrow R_T \leftarrow T_{Max} ¥ \{T_{Min}+\triangle R_{x1}+\triangle R_{x2}+\triangle R_{x3+\ldots}+\triangle R_{xn}\} \quad (2)$$

Where W_{Min} and T_{Max} indicates the water flow minimum level value and the temperature maximum level, R_{x1} to R_{xn} indicates the rain quantity during crop harvesting period and the extended limit of the crop watering level is formulated by means of

$$\sum_{t=1+\square}^{T+t\square}\left(\frac{Q}{T}\right)\square a \leq 1+\frac{W1}{T1}+\frac{W2}{T2}+\frac{W3}{T3}+\cdots, \; -T\infty R^{n-k} \quad (3) \qquad (3)$$

$$\sum_{R=1+\square r}^{R+T\square}\left(\frac{R}{T}\right)\square a \leq R^{n-1} \qquad (4)$$

Additionally the crop growth rate and the soil irrigation level, water flow rate according to the irrigation level and water quality level are all positive real values and this is indicated as:

$$T_R; S^{Irg}; W_{Flow}; Q_W \geq 1 \qquad (5)$$

IV. Results and Discussions

In this section, the performance ratio of the proposed approach Intelligent Crop Monitoring Scheme (ICMS) is experimentally analyzed in clear manner and the performance results of the implementation are estimated with respect to cost efficiency, server processing time and crop data maintenance accuracy level. The proposed model of ICMS is implemented clearly with the all mentioned sensors such as pH, Rain Flow Identification Sensor, DHT11 Sensor and the Soil Irrigation Sensor. These all are placed into the agricultural field for more than three months of time and tested it clearly with all perspective parameters as well as the positioning of Smart Crop Monitoring Device is placed in several climate conditions such as too hot, too cold, warm and mild climates. The connected sensors of SCMD provides readings with respect to good accuracy levels and the performance metrics are really good while testing and the measurements of water supply and cut offs are perfect during analysis. The following figure, Fig.3 illustrates an experimental analysis of periodical crop monitoring device control with cost efficiency as considered with traditional manual operating model with proposed ICMS.

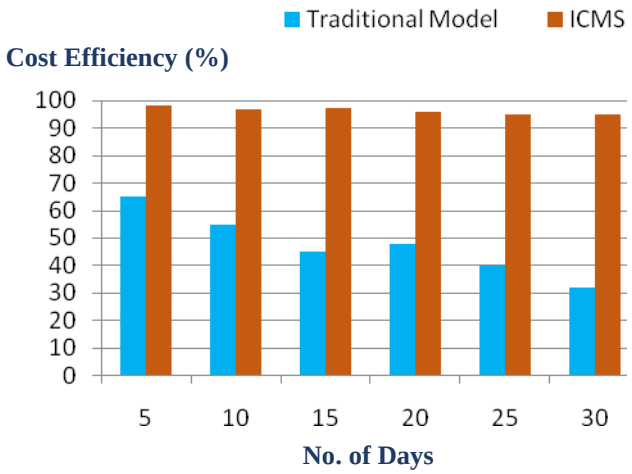

Fig.3 Evaluation of Cost Efficiency

The following figure, Fig-4 describes the crop growth related information handling accuracy levels with proper parametric values as well as the information handling accuracy ratio is evaluated with respect to analyze the number of information or records accumulated from the Smart Crop Monitoring Device and number of records properly stored into the remote IoT server. In this condition, a special concentration is needed to analyze the information duplication removal over the server end as well; because the remote server optimization law of the proposed approach of Intelligent Crop Monitoring Scheme minimizes the remote IoT server data duplications and preserves the robust duplication-free data into the server, but the information which is coming after the threshold time limit, which will be stored properly into the remote server.

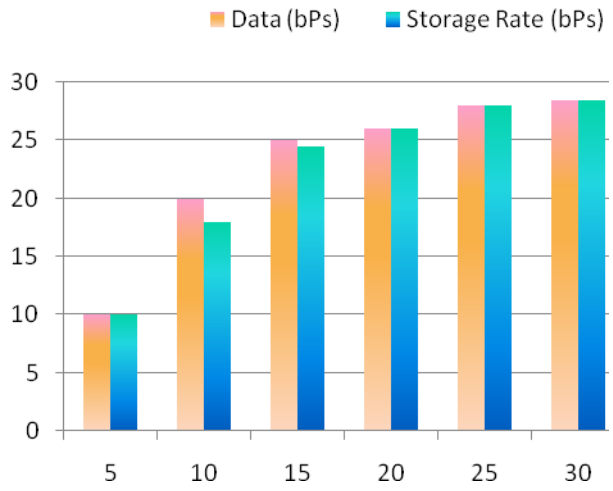

Fig.4 Crop Data Maintenance Accuracy on Remote Server

The following figure, Fig.5 illustrates the proposed approach time efficiency, in which the average time required to accumulate the SCMD sensor data and process it based on the values, in which it is stored it into the server and providing the proper acknowledgement for the storage is considered over this process of estimating the time efficiency. In past several time optimization algorithms are available to process the data with respect to time principles, but all are strucked up with certain

concern. Similarly, the SCMD requires operating based on the Internet of Things option, in which it collects the trigger coming from server end and process the total SCMD with respect to the received trigger. This process is analyzed clearly based on the efficiency of time and provide the resulting scenario as below.

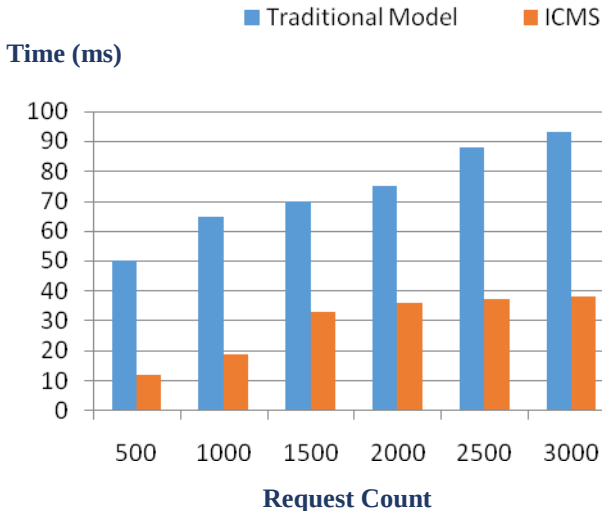

Fig.5 Evaluation of ICMS Time Efficiency

The following figure, Fig-6 illustrates the Crop Growth Level Measurement analysis with respect to the used watering level on the agricultural field. Over three months period the evaluations are collected properly and maintained into the remote server for analysis and based on that the moisture level of the agricultural field is displayed properly over the following figure, in which it shows the details clearly with proper mentioning of X-axis indicates number of days and in the Y-axis the mentioned level of watering ratio as compared to the past day analysis and crop growth rate based on the present system Smart watering level in %.

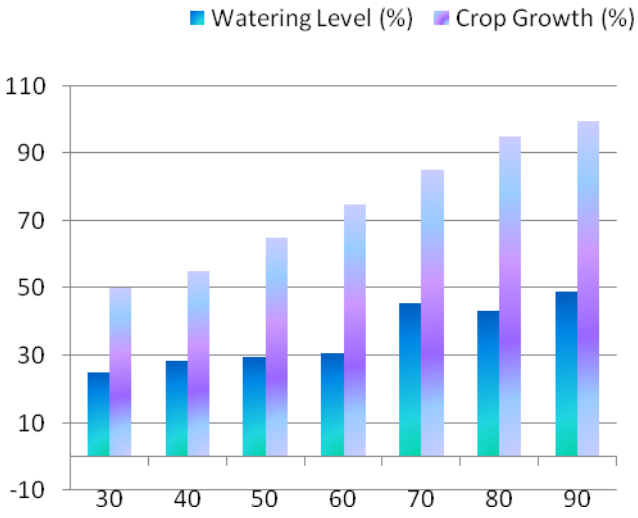

Fig.6 Evaluation of ICMS Performance with respect to watering level difference and Crop Growth Ratio

V. Conclusion and Future Scope

In this paper, a new methodology of Intelligent Crop Monitoring Scheme (ICMS) is introduced based on remote server management scheme with respect to Internet of Things strategies. This IoT based Smart Crop Monitoring Device enabled agricultural crop monitoring system improves the efficiency of farmers to monitor the crop details as well as the agricultural field details instantly without any manual interventions and range limitations. An instant alert mechanism raises an alert to the respective farmers immediately if any problematic scenario occurred into the respective agricultural land as well as the Server Optimization Strategies allows the system to maintain the error free crop information into the server end to minimize the timing problems and enhance the performance of the entire system. The Intelligent Crop Monitoring Scheme allows the farmer to monitor the agricultural land and the corresponding information from their smart mobiles, computer and laptops. All these features are integrated based on Internet of Things assistance, in which the IoT module is integrated into this system to provide sufficient support to the farmers to improve their life with the help of latest technologies without any hurdles.

In future, the work can further be extended by means of adding some deep machine learning techniques to classify the stored crop images and identify the crop has any affections or diseases. If any crop is affected, the deep machine learning principle classifies the required affected data and identifies the other details such as which category of affection or disease the plant gets suffered. As well as this kind of deep machine learning strategies are really useful for predicting the future climate conditions and provide the accurate summary based on the predictions, so that the farmers can do some precautions to manage such situations. The leaf disease prediction strategy allows the farmers to analyze the diseased plants and remove them to prevent affection for further plants or else provide some sufficient precautions to do so.

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