APPENDIX

APPENDIX-A

LIST OF PULICATIONS

Journal Publications

1. "**Wireless Sensor Network for automated Irrigation System in Tea Garden**", Yashu Pradhan, Dr. Manoj Kumar Deka, International Journal of Computer Sciences and Engineering, ISSN-23472693, Volume-04, Special Issue-07, pp.42-46, Dec-2016, publisher: ISROSET, UGC Journal No.:63193.

2. "**Approach to smart watering system in Tea Garden**", Yashu Pradhan, Dr. Manoj Kumar Deka, Journal of Emerging Technologies and Innovative Research, ISSN No.: 23495162, Volume- 2. Issue 3, pp.733-736 March-2015, Publisher: IJPUBLICATION, UGC Journal No: 63975.

Conference Publications

1. **"An Effective Method for Development of Expert System for Irrigation and monitoring of pH value in Tea Garden**", Yashu Pradhan, Dr. Manoj Kumar Deka, Recent Trends & Future Prospects of computer science & Electronics USTM, Techno City, Meghalaya, 21st and 22nd December, 2015.

JCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Volume-4, Special Issue-7, Dec 2016 ISSN: 2347-2693

Wireless Sensor Network for Automated Irrigation System in Tea Gardens

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***Abstract*— The aim of this paper is to propose a wireless sensor network in tea garden to show the path to tea gardeners to replace some of the traditional irrigation technique. The present paper focuses on set of technical skills environments to overcome technical backwardness present in traditional tea garden in terms of Moisture level and P^H value of soil. This paper describes the technical analysis background for development of expert moisture sensor equipped with monitoring and recording system for real time data of tea gardens soil pH in details. The present study introduces about the parameters to be considered for the design of soil moisture sensor & P^H value monitoring system. The cost effectiveness of the sensor/s to be developed and its future perspective of use will depend upon the considering parameters. This paper emphasis only on basic evaluation before development of soil moisture sensor, manageable and workable in tea gardens with minimum cost of production.**

Keywords— Expert system, Soil moisture, P^H value, sensor, WSN.

I. INTRODUCTION

The scenario of tea estate is comprised of vast area for plantation which requires huge volume of water, a key nutrient, which is also a life sustaining natural resource [1]. Due to application of water in almost every sector of industry and rising level of industrial product consumption worldwide, water is quickly becoming a natural resource of utmost urgency of preservation. In this context implementation of smart watering [2] system in agricultural industry can bring retardation in depletion rate of this priceless life supporting natural resource. The key facts that gets easily ignored in the process of watering that any volume of water supplied to plants beyond requirement takes the form of wastage. Also the method of watering in dry season is different compared to other seasons, but the requirement is not same on each day hence neglecting this fact will results in water wastage. Smart watering system takes close notice of key factors in watering and attempts to analyze soil condition and accordingly nurtures plant with minimum wastage of water. For analysis, the vast area can be divided into smaller units which make Smart Watering System more effective as it supplies only necessary areas without wasting resource on adjacent non-demanding areas.

The significance of P^H monitoring is directly proportional to plant health and growth. As P^H directly affects the availability of essential nutrients. For example, though iron, manganese, and zinc become less available as the P^H rises above 6.5, molybdenum and phosphorus become more available. When the soil is acidic, minerals such as zinc, aluminum, manganese, copper, and cobalt become more soluble for plants' uptake. However, an excess of these ions can be toxic to plants. Alkaline soil contains a higher quantity of bicarbonate ions, which interferes with the normal uptake of other ions, harming plant growth.

The periodic record keeping of soil moisture and P^H value forms a database over a period, which can be developed as soil activity chart, valuable for enhancing agricultural soil quality.

II. OBJECTIVE

1. Development of software platform for operation on collected data for maintaining soil moisture.
2. Minimization of water wastage in watering process; reduction in labour and management cost.
3. Data logging for future reference i.e. incorporation of soil P^H and moisture values in statistical analysis of soil health.
4. Database development for faster decisive action in change of gardening techniques based on statistical analysis of soil health.
5. Smart energy efficient system. Ease of accessibility to monitor and control water level of storage tank even at of field using GSM service.

III. BACKGROUND STUDY

The application scenario of sensor based operation for automation is easily available in process, food packaging, aeronautics and other industries etc. Although the history of sensors and their application is very ancient but yet no full-

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fledged establishment has been observed when it comes to irrigation sector. The advancement is very narrow and dim, however, in tea industry the work involved in processing the green leaves to tea has comparatively high standard of automation than any other agricultural product. But no significant work of automation has been done for nurturing and caring of tea plants. However a recent research development work in drip irrigation has been done by K. Prathyusha, M. Chaitanya Suman which features; automated platform with PT1000 as temperature sensor and tensiometer as moisture sensor with 16X1 LCD display for monitoring all the present readings of sensors and current status of control valves. In addition to it a chemical injection unit is used to mix required amount of fertilizers, pesticides, and nutrients with water, whenever required; in addition to flow meter for analysis of total water consumed [2]. Another similar work in the field of tea industry at Tocklai tea estate by C-DAC, Kolkata and Tocklai Experimental Station which features; fully automated, real time, round the clock, online wireless field hourly basis data collection system with help of sensors for ambient & soil temperature, soil moisture and pH, solar radiation, CC camera (infra red imaging even in night) for insect invasion and diseases. Additionally, the system is computer interfaced for enriching database with accurate data; with user friendly online Decision Support System for handling multiple input parameter. [3]

IV. APPROACH FOR EFFECTIVE IRRIGATION SYSTEM

The vastness of tea gardens present the hurdles of effective irrigation system hence transforming the gardens to smaller grids will smooth out operation of irrigation. Also for automation of irrigation system it is essential to have communication between grid networks and since final operation will be on soil i.e. watering on soil hence we need to have a feedback from soil. A moisture sensor can serve as a feedback from soil which is received by a controlling unit in tea garden for making logical decision by computers to start/stop watering process. The feedback from moisture sensor will be stored into database for purpose of statistical analysis at the time of preparing soil health report. In addition to soil moisture values another parameter i.e. P^H value of soil will also be taken into account during preparation of soil report.

SYSTEM DESIGN

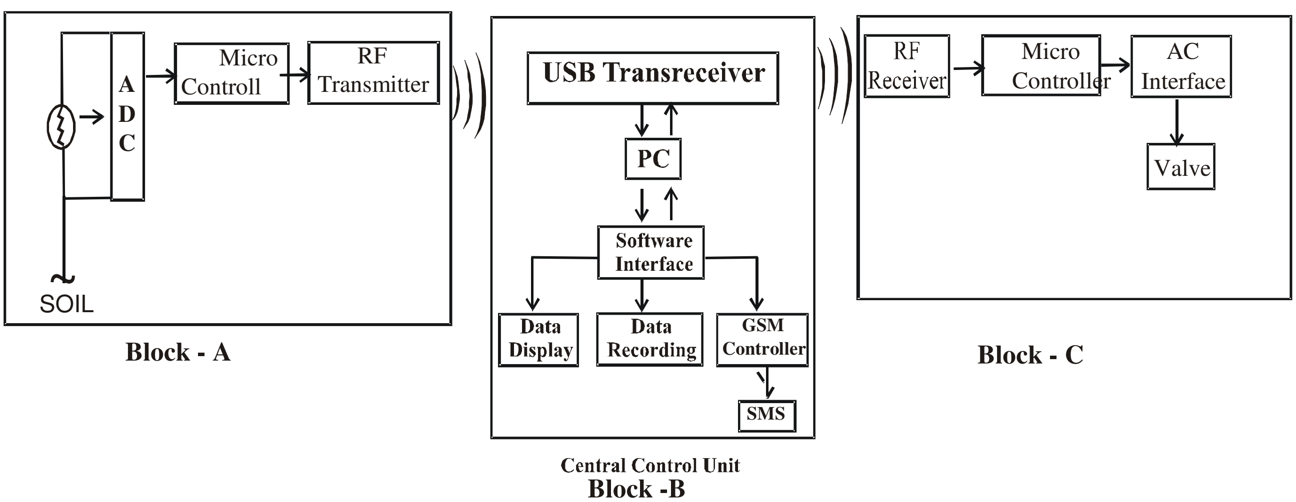

Figure1: Block diagram for Automatic watering system

Block A

The system will acquire soil moisture information from soil individually for different plots through a moisture sensor probe installed in individual plots. The information thus obtained through sensors, will be converted to digital data thorough analog to digital converter. The information signal thus generated by micro-controller will be propagated to central controlling unit and received with wireless RF modem [6].

Block B

The information signal thus received will be provided to the RF trans-receiver which analyses and process the signal for next stage. After trans-receiver the information will be dealt by the software developed in Microsoft platform installed in a desktop PC. This software then delivers the task of monitoring, recording (for database development) and controlling in the field by generating control signals. There will also be a GSM unit that sends whole day summary of data acquired to the owner of estate through an SMS.

Block C

Moreover the task of restoration of soil moisture will be made available in manual and fully automatic mode. In manual mode, the operator needs to authorise the control signal for opening and closing of electric control valve. However in auto-mode, after complete analysis of signal information, the embedded system will self-generate control signal which independently open/shuts control valve.

V. BLOCK DIAGRMA FOR SOIL MOISTURE SENSOR

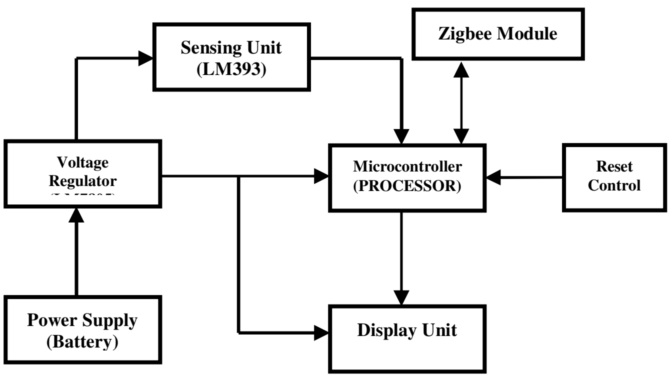

Figure2 : Block diagram for soil moisture sensor

Sensing Unit

The LM393 IC detects change in resistance of soil trapped between two conductive probes and transfers the difference signal for further processing.

Power Supply Unit

A 12V battery will supply necessary voltage for working of the sensor; however all the units of sensor will be using maximum 5V voltage. This exact voltage is provided by voltage regulator LM7805 to avoid possible scarcity of voltage or damage to sensor units.

Processing Unit

The micro-controller performs all the processing on signal from sensor and converts the analog signal to digital form, using the in-built analog to digital converter for digital display, on display unit in percentage level.

Zigbee Module

A ZigBee network is set up to enable data messages to be sent efficiently across the ZigBee network that may extend over considerable distances. With applications including lighting and heating control, the ZigBee network must be able to communicate over distances that may be well in excess of the single hop distance achievable by each individual node.

VI. RESULT AND DISCUSSION

Data Access about GUI

Through the login window user can enter to the sensor application program authentically.

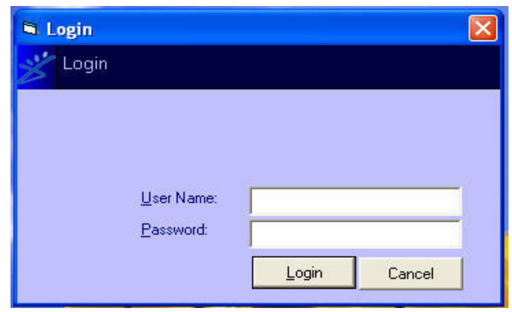

Figure3 : Login Window

Sensor Data Monitoring Window

From this window user can view the date, time Sensor id and receiver value from the sensor. Against this sensor value we can also view the date, time and sprinkler's ON/OFF status. Using this window user can set the sprinkler start and stop value as per the moisture requirement of the plant. We can also select the no of working sensors as per the requirements of the area plot.

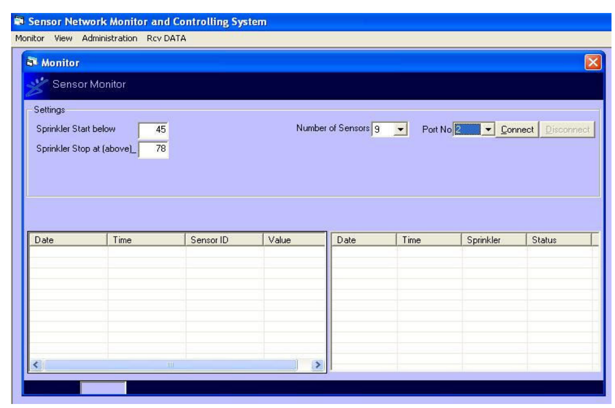

Figure4: Sensor data monitoring window

Sensor Data Log

Using this window we can view sensors previously recorded data by sorting Sensor ID or serial ID.

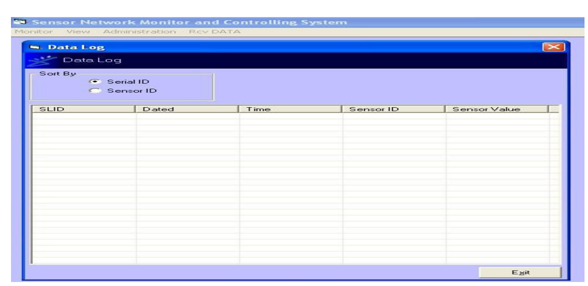

Figure5 : Sensor data log

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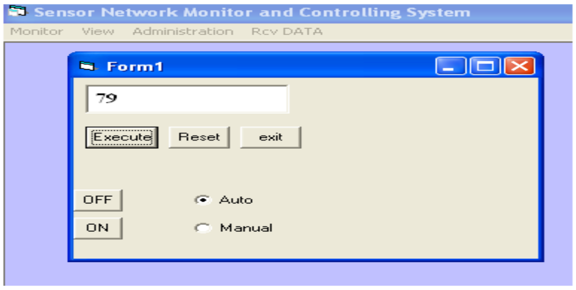

Figure6: *Sprinkler controlling window*

In this window user can able to select the sprinkler mode Auto or Manual Mode. If user selects the auto mode the sprinkler works the set value by the user. If we select the manual mode then sprinkler can works depending on the user. Continuous acquiring of the data by the moisture sensor it was stored in database. A graph was prepared for monthly basis data was collected, four times in month both manually and traditionally. Here is the graph to comparing how accurate sensor collected data to the traditionally collected data.

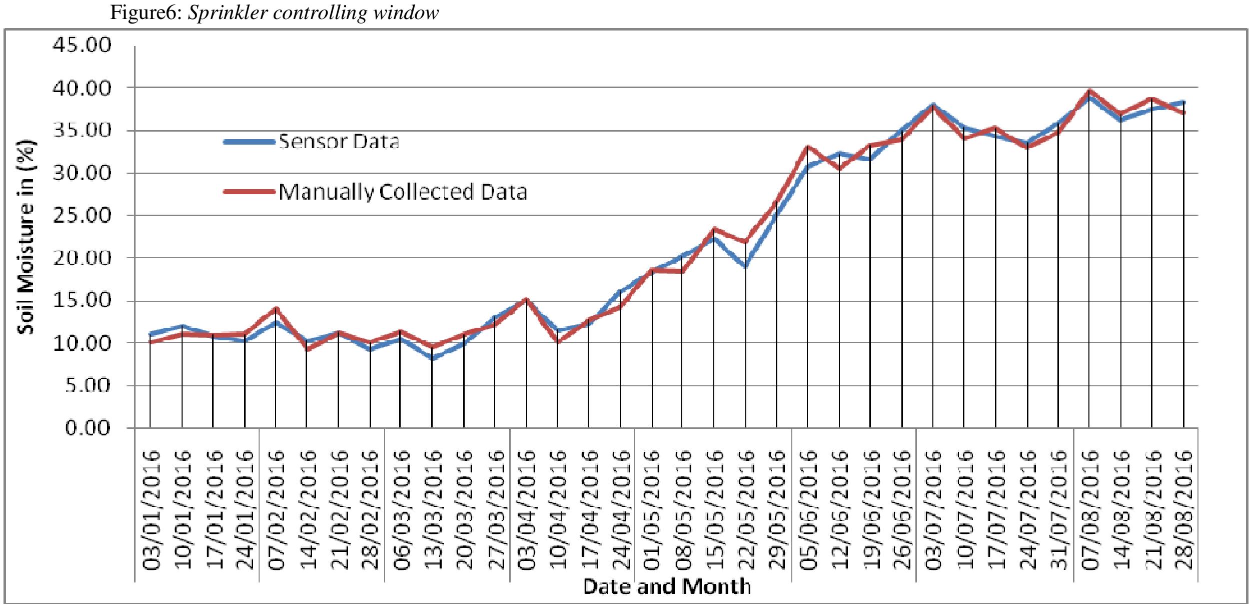

Figure7 : Comparison of sensor generated and manually collected soil moisture data in tea garden

From the above graph we revealed that the sensors acquire data and manually collected data (Laboratory analyzed data) has a closed match. It is tedious job to collect data manually in frequent time duration. But it can be done by the wireless sensor network to get the moisture level of the soil in frequent time duration for proper and better irrigation in the garden.

VII. CONCLUSION

The above paper presents the challenges, significance and advantages of Effective Watering System in tea gardens. Its approach in keeping track record of soil health, with key parameters as soil moisture and pH values, will help agricultural scientists in suggesting progressive measures in favour of both plants and soil. It describes the role of key components in development of such system for tea gardens. Its application in real life will reduce production cost, enhance productivity and introduce automation in tea gardening. However with a proper set of tools this approach can be used as automated platforms with multiple functions like data logging, GSM [7] based monitoring and AI [8] based automated watering and monitoring system.

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AUTHORS PROFILE

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He is presently working as Assistant Professor in the department of IT, in Science College, Kokrajhar, ASSAM. He is also pursuing Ph.D. in the department of Computer Science and Technology in Bodoland University, Kokrajhar, Assam. He completed his MCA degree from SMIT, SIKKIM. He got senctioned one minor research project from UGC.

Dr. Manoj Kumar Deka

He is working at present as Assistant Professor in the department of Computer Science and Technology of Bodoland University, B.T.A.D., Assam. He has completed his Ph.D. research work from Gauhati Universsity in 2011. He achieved INSPIRE Fellowship for his Ph.D. Research work sponsored by department of Science &Technology (DST), Govt. of India.He has already published 19 numbers of international and national papers. He presented large numbers of research papers in International and National Regional conferences and seminars. He participated 5 numbers of National and International workshop till date. Five numbers of research scholars are now pursuing their Ph.D. research work under his guidance.

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Approach to Smart Watering System in Tea Gardens

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Abstract — **In this paper sufficient discussion has been performed on design and development of smart watering system for tea gardens. The main objective of this approach is reduction on water requirement for nurturing tea plants to minimize the effect on water scarcity on people, society and environment. The challenges to be overcome are listed to give a better perception of the purpose of system in real life. However the methods that can be adopted are explained in detail and an approach is also presented with overall system design. The system components along with their significance are also explained in context of real life conditions.**

Index Terms — **GSM, Smart Watering System, Microcontroller, Sensor, Soil Activity Chart, Transducer.**

I. INTRODUCTION

The scenario of tea estate is comprised of vast area for plantation which requires huge volume of water, a key nutrient, which is also a life sustaining natural resource [1]. Due to application of water in almost every sector of industry and rising level of industrial product consumption worldwide, water is quickly becoming a natural resource of utmost urgency of preservation. In this context implementation of smart watering [2] system in agricultural industry can bring retardation in depletion rate of this priceless life supporting natural resource. The key facts that gets easily ignored in the process of watering that any volume of water supplied to plants beyond requirement takes the form of wastage. Also the method of watering in dry season is different compared to other seasons, but the requirement is not same on each day hence neglecting this fact will results in water wastage. Smart watering system takes close notice of key factors in watering and attempts to analyze soil condition and accordingly nurtures plant with minimum wastage of water. For analysis, the vast area can be divided into smaller units which make Smart Watering System more effective as it supplies only necessary areas without wasting resource on adjacent non-demanding areas. However analysis performed forms a database over a period, which can be developed as soil activity chart, valuable for enhancing agricultural soil quality.

II. CHALLENGES IN DEVELOPMENT OF SMART WATERING SYSTEM

1) Development of most applicable sensor.
2) Integrating all the inputs of the applied sensor.
3) Minimise the data loss.
4) Reliability
5) Data logging for future reference.
6) Smart energy efficient system.
7) Cost effectiveness.
8) Robustness and protection against natural phenomenon.

III. BACKGROUND STUDY

The application scenario of sensor based operation for automation is easily available in process, food packaging, aeronautics and other industries etc. Although the history of sensors and their application is very ancient but yet no full-fledged establishment has been observed when it comes to irrigation sector. The advancement is very narrow and dim, however, in tea industry the work involved in processing the green leaves to tea has comparatively high standard of automation than any other agricultural product. But no significant work of automation has been done for nurturing and caring of tea plants. However a recent research development work in drip irrigation has been done by K. Prathyusha, M. Chaitanya Suman which features; automated platform with PT1000 as temperature sensor and tensiometer as moisture sensor with 16X1 LCD display for monitoring all the present readings of sensors and current status of control valves. In addition to it a chemical injection unit is used to mix required amount of fertilizers, pesticides, and nutrients with water, whenever required; in addition to flow meter for analysis of total water consumed [2]. Another similar work in the field of tea industry at Tocklai tea estate by C-DAC, Kolkata and Tocklai Experimental Station which features; fully automated, real time, round the clock, online wireless field hourly basis data collection system with help of sensors for ambient & soil temperature, soil moisture and pH, solar radiation, CC camera (infra red imaging even in night) for insect invasion and diseases. Additionally, the system is computer interfaced for enriching database with accurate data; with user friendly online Decision Support System for handling multiple input parameter. [3]

IV. METHODOLOGY

In order to minimize water wastage, in process of watering tea plants, it is crucial that amount of water provided to soil is accurately sufficient to its requirement. Therefore the method used in data acquisition from soil should have high standard of accuracy. Moreover soil moisture varies from place to place within the tea estate; hence for system to be effective the reference value of moisture requirement will be based on species of tea plant. And being an automated system, it is required to make fast and accurate decision for execution task of watering. The various individual components of the system need to be assembled and integrated properly for process to be completely functional.

The prioritization of events involved in developing a system is mandatory. Hence for a reliable and convenient approach, the important factors of system to be understood prior to moving in development stage are

Sensor and its significance

The entire performance of system is dependent on the reliability and accuracy of signal retrieved by sensor. The readability of fractional differences makes it more accurate in real world. The choice of converting the sensed value into analog or digital form decides the overall design of the system.

Signal processing

The chances of wastage can be brought to lowest level when system responds to each individual requirement strictly based on its location. As demand varies with respect to location, system response needs to be reliable accurate to be effective and applicable in real life. This can be accomplished when each request signal is properly addressed and thus the size of division of location will be based on processing technique adopted by developer. It will also affect the decision making of the system.

Decision making

The decision making process covers the generation of command signals that will be transmitted to controller; programmed with specific action for all type of situation. For total automation, the decision of watering action taken against requirement, need to provide exact address for watering and time period for watering action. The decision can be made using computer with programmed software platform or programmed microcontroller unit [3][4][5]. It depends on the developer’s knowledge, choice and application of the system.
In addition the system can be made more effective when real time feedback from location can be used in decision making process [6]. However for achieving such effectiveness there needs to be a continuous communication between location and control unit.

Execution and Control

It is necessary to ensure that decisions made after processing remain true for all cases of requirement hence the reliability of system in real life is governed by the quality of control supported by system. In general the execution task is accomplished with use of machineries like sprinklers designed for spraying water.

System Design

The block diagram provided below gives the pictorial representation of information flow and block building components.

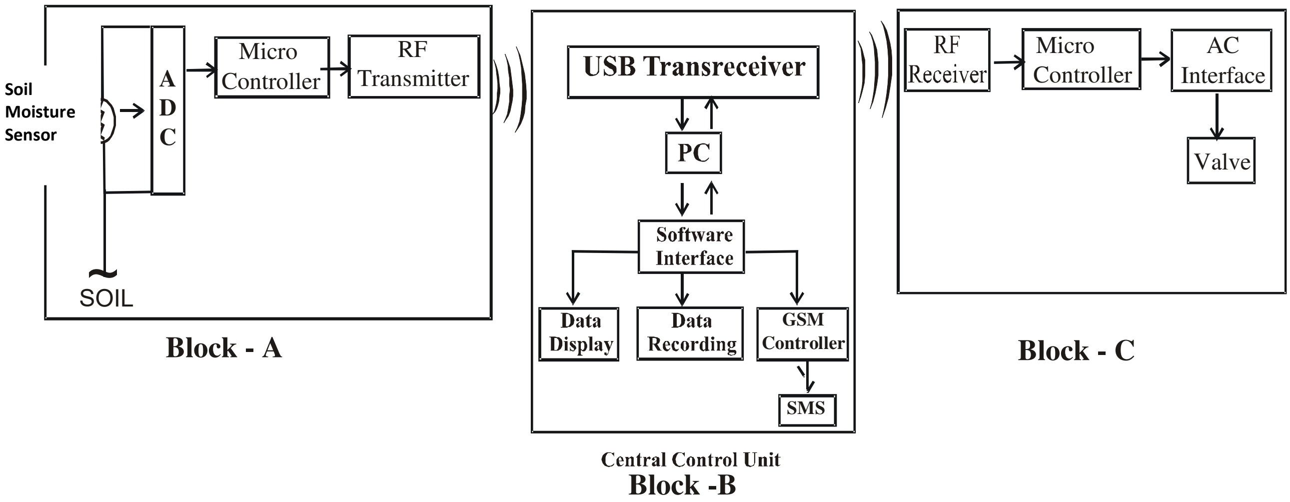

Fig 1: ***Block Diagram of Smart Watering System***

Block A

The system will acquire soil moisture information from soil individually for different plots through a 10HS Decagon moisture sensor probe installed in individual plots. The information thus obtained through sensor will be converted to RF signals, with suitable circuitry developed with universal development board; and each signal will be made unique with help of AVR micro-controller programming [5]. The accuracy and reproducibility of RF sub-units will be tested and their standards will be elevated to cope-up with real-life problem. This will be obtained and assured by lab experimentation of RF sub-units through application of Function Generator and Oscilloscope; powered by constant voltage and current supply equipment. The information signal thus generated by micro-controller will be propagated to central controlling unit and received with wireless RF modem [6].

Block B

The information signal thus received will be provided to the USB RF trans-receiver which analyses and process the signal for next stage. After trans-receiver the information will be dealt by the software developed in Microsoft platform installed in a desktop PC. This software then delivers the task of monitoring, recording (for database development) and controlling in the field by generating control signals. There will also be a GSM unit that sends whole day summary of data acquired to the owner of estate through an SMS.

Block C

Moreover the task of restoration of soil moisture will be made available in manual and fully automatic mode. In manual mode, the operator needs to authorise the control signal for opening and closing of electric control valve. However in auto-mode, after complete analysis of signal information, the embedded system will self-generate control signal which independently open/shuts control valve.

V. CONCLUSION

The above paper presents the challenges, significance and advantages of Smart Watering System in tea gardens. It describes the role of components in development of such system giving a priority based brief structure of system applicable in real world. Its application in real life will reduce production cost, enhance productivity and introduce automation in tea gardening. However with a proper set of tools this approach can be used as automated platforms with multiple functions like data logging, GSM [7] based monitoring and AI [8] based automated watering and monitoring system.

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APPENDIX-B

LIST OF WORKSHOP ATTENDED

1. **National level workshop on Remote Sensing and GIS,** organized by Department of Computer Science & Engineering and Computer Applications, Sikkim Manipal Institute of Technology, Sikkim , Sponsored by ISRO Govt. of India, 18^{th} -29^{th} January, 2016

2. **ISI workshop for North- Eastern Region on Pattern Analysis and Applications**, organized by Computer Vision and Pattern Recognition Unit(CVPRU), Indian Statistical Institute(ISI),Kolkata and Bodoland University, 7^{th} -11^{th} March, 2016