DESIGN AND DEVELOPMENT OF DATA ACQUISITION SYSTEM FOR MONITORING, RECORDING AND CONTROLLING OF SOIL MOISTURE FOR TEA GARDENS

A Thesis

Submitted in Partial Fulfilment of the Requirements for the Degree of

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CERTIFICATE

This is to certify that the thesis entitled "**DESIGN AND DEVELOPMENT OF DATA ACQUISITION SYSTEM FOR MONITORING, RECORDING AND CONTROLLING OF SOIL MOISTURE FOR TEA GARDENS**", submitted by **YASHU PRADHAN** (FINAL/05COM0002), a research scholar in the Department of Computer Science and Technology, Bodoland University, Kokrajhar, for the award of the degree of Doctor of Philosophy, is are cord of an original research work carried out by him under my supervision and guidance. The thesis has fulfilled all requirements as per the regulations of the institute and in my opinion has reached the standard needed for submission. The results embodied in this thesis have not been submitted to any other University or Institute for the award of any degree or diploma.

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DECLARATION BY THE CANDIDATE

This Ph.D. thesis entitled **“DESIGN AND DEVELOPMENT OF DATA ACQUISITION SYSTEM FOR MONITORING, RECORDING AND CONTROLLING OF SOIL MOISTURE FOR TEA GARDENS”** submitted by me for the award of the degree of Doctor of Philosophy is an original work and has not been submitted so far in part or in full for any other degree or diploma to any other University or institution

Date:

Place: Kokrajhar **Yashu Pradhan**

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ABSTRACT

The objective of this research is to propose a low cost, robust wireless sensor network using wireless communication technology for tea gardens. Using this network with soil moisture sensors, an improved irrigation system has been designed for tea gardens. The effect of this irrigation system on productivity of tea gardens has been discussed in detail, which shows section of tea garden with improved irrigation system has better productivity compared to section of tea garden with conventional irrigation system. The improved irrigation system depends on wireless sensor network hence the approach and methods of selecting suitable wireless sensor network has also been discussed in detail which includes discussion on embedded systems and sensor technology. There are also discussion about the conventional irrigation system, specific requirements of tea plants and tea industry in this research. Web based monitoring system is introduced for effective and quick viewing the action of solenoid valve and soil moisture data through moisture sensors. The improved irrigation system also has sufficient flexibility to meet the requirements of GSM and database creation for future reference. The major contributions of the thesis are as follows:

1. Design a model of WSN.
2. Design a database which handled the sensor collected data from the field.
3. Design a GUI for user, from which user can communicate easily with the hardware and software.
4. Design a World Wide Web based monitoring and controlling system.
5. Analysis of protocol available for low energy power consuming protocols and fast transferring in the scope of wireless sensor network. Analysis about the correlation between productivity of tea and different parameters of tea production.

Keywords: ***Wireless, ZigBee, Sensor, Communication, Embedded, GSM, GUI, World Wide Web.***

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LIST OF ABBREVIATION

GSM	Global System for Mobile
pH	Potential of Hydrogen
RF	Radio Frequency
H_N	Null Hypothesis
H_A	Alternate Hypothesis
LCD	Liquid Crystal Display
C-DAC	Centre for Development of Advanced Computing
GUI	Graphical User Interface
CMS	Central Monitoring Station
GPRS	General Packet Radio Service
GPS	Global Positioning System
WSN	Wireless Sensor Network
EMI	Electromagnetic Induction
TDR	Time Domain Reflectometry
RTOS	Real Time Operating System
IDE	Integrated Development Environment
VWC	Volumetric Water Content
FDR	Frequency Domain Reflectometry
PCB	Printed Circuit Board
IC	Integrated Circuits
ADC	Analog to Digital Convertor
DAC	Digital to Analog Convertor

I would like to dedicate this thesis

***to my beloved Family*.**

1

INTRODUCTION

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1.1. INTRODUCTION OF THE STUDY

The significance and role of tea industry in the development of Assam and its inhabitants is undeniable. Among all the activities happening in tea gardens, the most significant task is watering of tea plants, demanding huge electric power, man power and natural resources. Among all necessary requirements, the most important requirement for healthy tea gardening system is the presence of soil moisture in proper and accurate level. Presence of soil moisture in tea plants in high or low levels will influence on the desired production output of the garden. Hence an intelligent system that monitors the task of watering will be a modernization leap in tea industry. Therefore, to achieve this we need to understand in detail about the link between tea plants and the method of watering being used. In this case any control on soil moisture level which tea plants depends on for their nutrition will pave a way for maximizing tea production. For obtaining this goal, the smart data acquisition system will be operating on a precise parameter i.e. soil moisture control; which has significant affect on health, growth and productivity of tea plants.

Among the soil properties, moisture holding capacity has fundamental and even a direct relation to tea plant's growth, tea estate production and plant health; hence true potential of being a parameter for soil moisture monitoring system. For real time implementation of smart monitoring system, the selected parameter has reliable, accurate and flexible qualities which can be used for sensing the parameter from soil properties in real time.

The selected parameter has abundant advancement options available, if it becomes necessary for increasing the efficiency of proposed system. For instance GSM based notification system [1, 2] and Web based database management and monitoring program. Another requirement may be storing soil moisture data in periodic interval for future analysis.

1.2 TEA GARDENS OF ASSAM AND INFLUENCE OF CLIMATE ON TEA PALNTS

Assam is world famous for its quality of tea as well as the natural beauty of the tea plantation area. Assam is the world's largest tea growing region, producing more than 400 million of kgs. of tea annually. Beautiful tea estates of Assam cover about 2,16,200 hectares of land [4]. Assam today comprises of more than 100 tea estates. Cropping season normally begins from March and lasts by mid December. The first plucking starts in March and continues for around two months. The second plucking season starts from June. Nowhere in the world does the tea grow in such a large quantity as in Assam.

Tea drinking first originated in China [5]. It was in 1823 the first tea plants were discovered in Assam by Major Robert Bruce [6]. He discovered the existence to Tea in Assam.

The leaves of these plants were sent to the botanical gardens, which were later on classified as to be of the same species as the china tea plant. It was in 1839, when the first company for growing and making tea was set up in India, Assam tea was set up.

In 1862, Assam Tea industry comprised of 160 gardens, which were owned by five public companies and 57 private companies [6]. Later on the government appointed a special commission to enquire about all the aspects of the company. From then the company start growing and now it is one of the major companies generating huge amounts of revenue.

The tea crop goes through two types of stresses in its life cycle-biotic and abiotic. Events such as droughts and floods make up abiotic stress, which in turn results in creating biotic stress for the crop in the form of increased pest attacks. Due to erratic climate patterns, the stresses have become more pronounced and profuse on the crop. More biotic stress compels cultivators to use more pesticides and fertilizers while increased abiotic stress demands for more irrigation, though tea is traditionally a rain-fed crop. This only increases the associated costs.

Currently the major tea growing states of India are Assam, West Bengal, Tripura, Tamil Nadu, Kerala and Karnataka, Himachal Pradesh and Uttaranchal, Arunachal Pradesh, Manipur, Sikkim, Nagaland, Meghalaya, Bihar, Orissa, etc. Among these states Assam is the major producer contributing about 52% of the total Indian production followed by West Bengal about 22 %, Tamil Nadu about 16%, Kerala about 8 % and others about 2%. The given pi diagram depicts the state wise tea production in India [7].

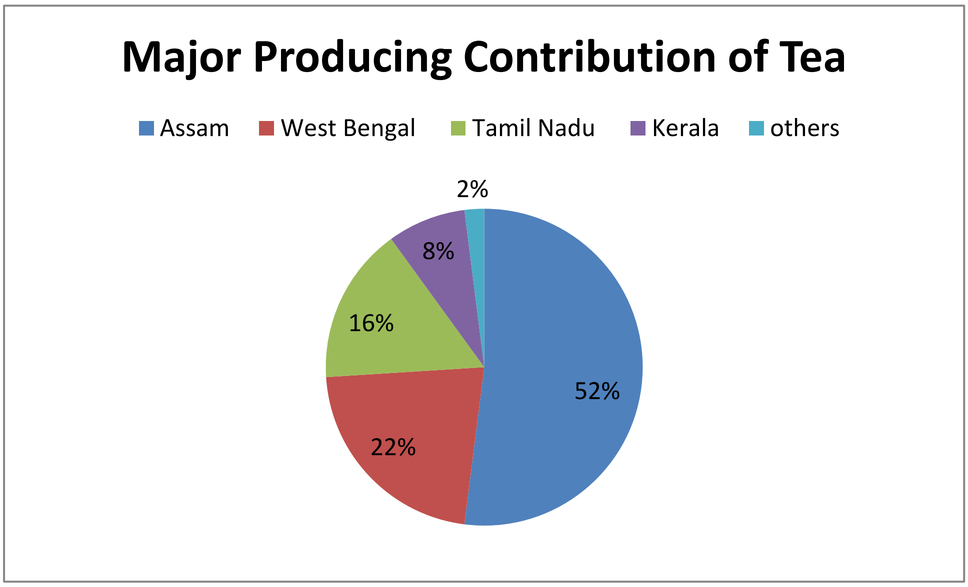

Figure 1.1: Major producing contribution of tea

1.3. FEATURES OF TEA PLANTATION

Production of tea depends mainly on the climatic conditions. The temperature may vary from 20°C to 32°C and annual rainfall should be 1250 to 1500 mm, which is well distributed over 8 to 9 months in a year. The atmospheric humidity should be always around 70% to 80% during most of the time. Very dry atmosphere is not suitable for tea.

There are some important physical parameters of soil to improve the plant growth and productivity of tea yielded. These are soil temperature, soil moisture, bulk density.

The average annual rainfall in North East India ranges from 2000-4000 mm. However, more than the total amount, the distribution of rainfall matters a lot for sustained high yield of tea throughout the season. In the North East India, the rainfall distribution is not even. Excess rainfall in the monsoon month of June- September causes drainage problems. The average monthly rainfall during November to march is less than the evapotranspiration loss and the resulting soil moisture deficit affect tea bushes [8].

Tea grows best within a pH range 4.5 to 5.5. The pH value of a soil is exceed of 6 is not suitable for tea [9]. Soil samples should be analyzed regularly for assessment of acidity status so that necessary corrections can be carried out.

1.4. ORIGIN OF RESEARCH PROBLEM

Due to rising problems of climatic turbulence, changing water requirement of plants; poor maintenance of agricultural soil and tea plants in the past, the health of tea industry is at risk. The evidence of such destructive change can be apparently judged by gradual decline of productivity and quality of tea leafs. Therefore, the present scenario demands for an intelligent system that can monitor and provide accurate information regarding water requirement for individual tea plant, i.e. there is need of control of watering in plants which will be efficient in terms of cost, water and electric power. However, in practice, it seems to be quite impossible to care for each nook and corner of the vast wide spread tea garden by human workforce. Hence, a network of wireless communication will help in solving this problem in vast tea gardens. In addition to it when software based platform for database development of garden soil condition will be interfaced with the system. It will facilitate long run decision making process by statistical analysis of the database information.

Tea gardens are spread over very vast area; this makes the task of monitoring and caring for plants a challenging one. Therefore the mandatory task of watering tea plants demands large amount of water, electric power and man power. Moreover, water requirement of soil for different areas in tea garden are different. The inaccurate information about amount of water required for different plots results in insufficient and excess distribution of water in different plots; which in both cases is harmful for plants. It is evidently wastage of water and electrical power in tea gardens, happening in areas as vast as tea gardens, results in huge wastage of natural resources and energy. Moreover, till date, there has been no tool developed that monitors the health of garden soil; no attention has been paid in soil condition of tea garden which directly affect the quality and productivity of tea estate. Therefore, an intelligent platform with facilities for statistical analysis of soil condition in the past; will positively drive the decision making process, in long term planning, in favor of the tea industries.

And so, through this present study, an attempt is made to design and develop a smart data acquisition system so that we can monitor the level of soil moisture online; we can record the online data for further study and analysis, and even we can monitor the soil moisture online too.

1.5. OBJECTIVES OF THE RESEARCH WORK

1. Development of software platform for operation on collected data for maintaining soil moisture through Radio Frequency (RF) wireless network.
2. Minimisation of water wastage in watering process; reduction in labour and management cost.
3. Analysis of the production yield of tea.
4. Database development through wireless data acquisition from sensors for statistical analysis of soil moisture.

5. Ease of accessibility to monitor and control water moisture level of soil even out of field using GSM service.

1.6. HYPOTHESIS

a) **Working Hypothesis**: Data Acquisition System (Soil moisture) has influences the tea productivity in tea garden.

Null Hypothesis [H_N]:

Data Acquisition System (Soil moisture) doesn't have any significance in Tea productivity in tea Garden.

Alternate Hypothesis [H_A]:

Data Acquisition System (Soil moisture) has significance in Tea productivity in tea Garden.

b) **Working Hypothesis**: Data Acquisition System (Soil moisture) has influences on minimisation of water wastage in watering process in tea garden.

Null Hypothesis [H_N]:

Data Acquisition System (Soil moisture) doesn't have any significance in minimisation of water wastage in watering process.

Alternate Hypothesis [H_A]:

Data Acquisition System (Soil moisture) has significance in minimisation of water wastage in watering process.

1.7. ORGANIZATION OF THE THESIS

Chapter 1: INTRODUCTION

This first chapter provides an introduction to the topic of research. The Chapter contains Objectives, problem definition, hypothesis etc.

Chapter 2: REVIEW OF LITERATURE

A comprehensive review of some relevant literature is presented in this chapter i.e. the review of research paper, books and research article etc.

Chapter 3: RESEARCH METHODOLOGY AND SYSTEM DESIGN

This chapter provides the methods of approaching the goal and objective of the thesis. This chapter contains method to achieve the objective of the research and the algorithm and system module and its organization of the system.

Chapter 4: ANALYSIS OF ROUTING PROTOCOL

In this chapter, the analysis of different routing protocols which are used in wireless transmission are discussed check their energy consumption and packet delivery ratio.

Chapter 5: RESULT AND DISCUSSION

This chapter provides the summary of the outputs of the system and its discussion.

Chapter 6: CONCLUSION AND FUTURE SCOPE

The details in this chapter provide a summary of Conclusions based on the study.

2

REVIEW OF LITERATURE

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2.1. REVIEW OF LITERATURE

This chapter is an overview and highlights the essential characteristics of the different soil moisture measurement techniques, in relation to estimating the spatial and temporal variation of soil moisture measurement techniques. This chapter allows the development of soil moisture estimation techniques in later on, which will be applicable to the soil moisture measurements available.

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 nourishing and caring of tea plants. However a recent research development work in drip irrigation has been done by *K. Prathyusha, M. Chaitanya Suman*[10] 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. Another similar work in the field of tea industry at Tocklai tea estate by C-DAC, Kolkata and Tocklai Experimental Station [11] 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.

Another milestone using ZigBee Wireless Sensor has been accomplished by *N. Krishna Chaitanya, G. Anand Kumar , P. Aruna Kumari* Department of ECE G.V.P. College of Engineering Visakhapatnam, AP, India. Here ARM7 based 16/32-bit Microcontroller is used for monitoring and measuring the humidity, temperature and soil. The parameters acquired from soil are transmitted using a ZigBee module and the receiver here is also a ZigBee feeding processing part of the system. The received data has been displayed in GUI and saved in the recording system for further analysis.

R. G. Evans and W. M. Iversen et. al. [12] successfully designed a site-specific irrigation system using six sensor station implemented across agricultural field. The system monitors field condition based on soil property map. The next step is to periodical sample inputs from sensor and transmission to the base station via wireless bluetooth medium.

G. V. Satyanarayanads et al. [13] this system shows advanced development in wireless sensor networks for observation of different parameters involved in agriculture. Parameters such as humidity, moisture and temperature, were remotely observed using miniaturized sensor devices a wireless sensor network based on Zigbee helps Central Monitoring Station (CMS) to use General Packet Radio Service (GPRS) or Global System for Mobile (GSM) technologies. The system could also obtain Global Positioning System (GPS) parameters and forward it to a central monitoring station.

Zulhani Rasin et al. [14] a feedback control system in real time which monitors and controls all the activities of drip irrigation system efficiently has been accomplished. It has GSM based Zigbee Controlled Solenoid Valve for drip irrigation system and can minimise manpower, water requirement and power consumption. Electricity consumption has been cut down by between 20% and 30% when compared to other Zigbee technology for monitoring irrigation [14]. The prime objective was to keep water content upto suited level. The result obtained has established the suitability of Zigbee for monitoring big area.

A.N. Jyothipriya el al. [15] suggested a drip irrigation control system using GSM based ZigBee. Results obtained demonstrate the system is capable in water preservation.

Aqeel ur-Rehman et al. [16] provided an evaluation on WSN usage for irrigation, fertilization, pest control, and horticulture. General concepts and brief description were introduced yet it highlighted benfits for using WSN in agriculture.

Zegelin et al. [17] many techniques for measuring soil electrical conductivity have been proposed. It highlightes principal advantages of the electrical conductivity probe for measuring soil moisture content are its ease of use, simplicity, low cost of equipment, for the relatively large volume of soil sampling.

Brocca, L et al. [18] The major advantages of EMI are that it does not need to be inserted in the ground, it is easy and quick to operate, and can provide estimates over large areas and substantial depths (of order 10 m). A disadvantage of this method is that the task of isolating the effects from soil moisture content at a particular depth is difficult.

B. P. Ladgaonkar et al. [19] To monitor humidity for a HighTech Polyhouse Environment‖ wireless sensor was built with AVR ATmega8L microcontroller and RF Zigbee module for protected data transmission. To develop the precision and reliability for monitoring humidity on base station use of smart sensor module has a benefit.

Prof C. H. Chavan et al. [20] The system develop an application for observing various factors such as soil moisture, humidity and give remote monitoring using zigbee which sent data wirelessly.

Aniket H. Hade et al. [21] the system helped to automate irrigation process remotely which is built on embedded system to save farmers time, water and resources brought with money. The important tasks like soil test for water content, salinity, chemical constituents is collected wirelessly and processed further to come up with better drip irrigation plan. This automatic monitoring system model using Wireless Sensor Network (WSN) helped farmer community to improve the yield.

Aji Hanggoro et al. [22] The system developed by Aji Hanggoro and Rizki Reynaldo is based on Greenhouse monitoring and controlling using Android mobile application. It monitors and controls the humidity inside a green house with android mobile phone and Wi-Fi connection via serial communication to a microcontroller and to a humidity sensor.

Swarup S. Mathurkar et al. [23] Smart sensor based monitoring system remotely monitors various agricultural parameter and proposes inductor model for monitoring with wireless protocol implemented using field programmable gate array (FPGA) which was used for the analysis and monitoring of data , a display element and a relay as a control unit.

Guobao Xu et al. [24] it aims to provide real time monitoring of marine environment and provide advantage of easy deployment. The architecture of WSN-based oceanographic monitoring systems is provided with a general architecture of an oceanographic sensor node, sensing parameters and sensors, wireless communication technologies, deployment of wireless sensor networks for marine environment monitoring.

Anjum Awasthi et al. [25] the design is based on low-power Zigbee wireless communication technology for monitoring. The wireless sensor nodes transmit real time soil temperature, soil moisture and humidity to the base station using Zigbee. The data was continuously monitored and displayed at base station and if it exceeded the desired limit, a message was sent to farmer mobile through GSM network requesting control actions. It has advantages of flexible networking, convenient installation and removal of equipment, low cost reliable nodes with high capacity.

S. Thenmozhi et al. [26] Monitoring greenhouse environment parameter is manually controlled with Zigbee network where the status of agricultural environment parameter was transmitted to the control room. The microcontroller based circuits were used to monitor values of parameter, continuously modified and controlled in order to achieve maximum plant growth and yield. The controller communicates with a variety of sensor modules in order to control the light, drainage process efficiently inside a greenhouse by actuating cooler, fogger, dripper and lights according to the needs of the crops.

Ms. Shweta S. Patil et al. [27] it is based on modernizing the irrigation technology using ARM7TDM1 core and GSM. This project helped to detect the exact field condition as well as weather condition in real time. The information was given on user request in the form of SMS. The standard sets of AT (Attention) commands were used to control majority of the functions of GSM modem.

Siuli Roy, Somprakash Bandyopadhyay [28] The real-time and automatic monitoring of site specific environmental and soil conditions using different sensors was presented a test bed influencing crop yield. The system addresses practical issues and technical challenges including the integration of sensors, placement of sensors in outdoor environment, energy management scheme and actual power consumption rates.

N. R. Patel et al. [29] In this review system various agricultural parameters was monitored and controlled by using peripheral devices like valve, watering pump etc. where monitoring was done automatically by using microcontroller to improve the farmer yield.

Xiu-Hong Li et al. [30] this system was presented for monitoring the life conditions of greenhouse vegetables based on Wireless Sensor Network. The whole system architecture included a group of sensor nodes, a base station, and an internet data centre. A GSM- SMS based interface was developed for sending real-time environmental measurements and for alarming when a measurement is beyond some pre-defined threshold.

LIU Yumei et al. [31] a soil monitoring system based on wireless sensor networks using a wireless sensor network as information acquisition and processing platform. The system was a set of low cost, low power consumption, flexible automatic networking temperature humidity monitoring system of soil. Also the system was capable of data acquisition, storage, reporting, solution with man-computer exchange interface.

Joaquín Gutiérrez et al. [32] this system is used for optimizing use of water for irrigation. It has soil moisture and temperature sensors that interact with microcontroller based control unit for water supply

Teemu Ahonen et al. [33] this system could measure four climate variables using three commercial sensors and collected data was used to evaluate the network reliability and its ability to detect the microclimate layers, which typically existed in the greenhouse between lower and upper flora. The network could detect the local differences in the greenhouse climate caused by various disturbances, as direct sunshine near the greenhouse walls. This was the first step in the area of greenhouse monitoring and control, and all depended on the developed sensor network feasibility and reliability.

For WSN one of the most fundamental and difficult problems is localization. Node localization is the problem of determining the location of each node in the system. For example, important points to consider include: the cost of extra localization hardware, communication ranges, location accuracy required, is the system indoors/outdoors, how long should it take to localize, does the system reside in hostile or friendly territory and is the system subject to security attacks.

Depending on the activity level of a node, its lifetime may only be a few days if no power management schemes are used. At the hardware level it is possible to add solar cells or scavenge energy from motion or wind since most systems require much longer lifetime.

The hardware and software platforms allow multiple power saving states (off, idle, on) for each component of the device (each sensor, the radio, the microcontroller) such that only the components required at a particular time is activated. At the software level power management includes (i) minimizing communications to save energy, and (ii) creating sleep/wake-up schedules for nodes.

2.2. INTRODUCTION OF EMBEDDED SYSTEM

An embedded system is a special-purpose system that performs one or a few predefined tasks, usually with very specific requirements, unlike a general-purpose computer. Design engineers can optimize it, reducing cost of the product and the size [35].

An Embedded System has three components

1. Hardware.
2. Application software.
3. Real Time Operating system (RTOS), which holds the instruction set that are given to hardware component to achieve the desire goal of the embedded systems.

2.2.1. CLASSIFICATION OF EMBEDDED SYSTEM

1. **Small Scale Embedded System**
   These require less power and may even be activated by a battery, designed with a single 8 or 16-bit microcontroller. The main programming tools used are editor, assembler, cross assembler and integrated development environment (IDE) [35].

2. **Medium Scale Embedded System**
   These have a 16 or 32 bit microcontroller, RISCs and have both hardware and software complexities for achieving advance solutions.

The main programming tools are C, C++, JAVA, RTOS, debugger, source code engineering tool, simulator and IDE [35].

3. **Sophisticated Embedded System**

   These types of embedded systems are expensive and have enormous hardware and software complexities that may need ASIPs, IPs, PLAs, scalable or configurable processors [35].

2.3 INTRODUCTION OF SENSORS

A sensor is an electronic device which sense real life parameters like temperature, moisture in our environment. The circuitry of a sensor develops a corresponding electronic signal which may be voltage or current [36] [37].

2.3.1 SOIL MOISTURE SENSORS

These sensors could sense water present in surrounding environment called volumetric water content θ. mathematically [38].

$$\theta = \frac{V_W}{V_T}$$

Equation 2.1: Mathematical formula of Volumetric Water Content

Where,

V_W is the net water volume and

V_T is the total volume i.e. soil and water volume

Soil moisture sensors are classified according to how they measure the soil moisture content. Depending on the requirement of real time application selection from a variety of moisture endorsement can be made.

2.3.2 SOIL MOISTURE CALCULATION

The volumetric water content is measured based on the following formula

$$Moisture\ Content(in\ percentage = \frac{\text{Weight of fresh soil} - \text{Weight of dry soil}}{\text{Weight of dry soil}} \text{ X } 100$$

Equation 2.2: Soil Moisture calculation.

[Reference [39] : SS Choudhary, Prabha Choudhary, Sunil K Choudhary, Laboratory Guide in Bio-Science, Kalyani publishers]

2.3.3 TYPES OF SOIL MOISTURE SENSORS

2.3.3.1 Electrical Resistance Block Sensors

These sensors use electrical property to determine the volume of water present in soil. It consists of two electrodes, powered by dc voltage, that gets under soil and circuitry is designed to pass electric current between two electrodes. In absence of water there is very less or low current between electrons but presence of water increases the conduction hence the increase in current is a representation of moisture present in soil [36].

Applying Ohm's law:

R=V/I

Equation 2.3: Ohm's Law

Where, R is resistance

V is biasing voltage I is the current flowing through the electrodes

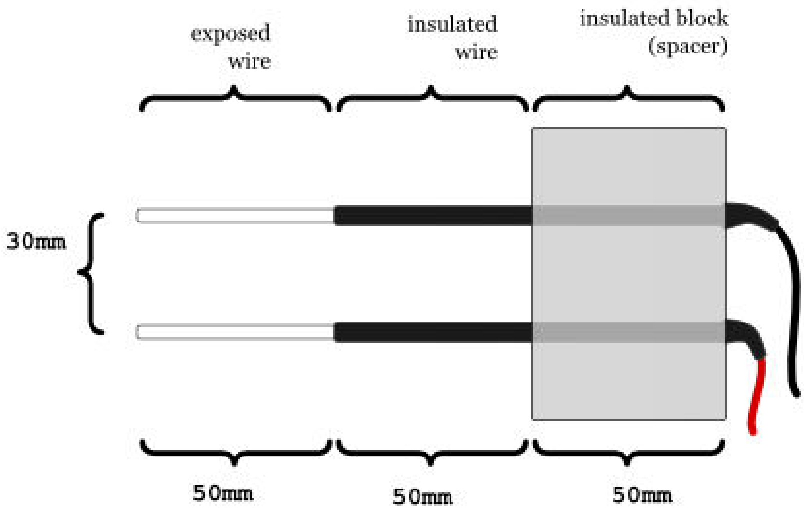


Figure 2.1: Electrical resistance blocks Sensors

2.3.3.2 Dielectric sensors

These sensors measures dielectric permittivity i.e. electrostatic field of the soil. They are available in two types Capacitance sensors and Time Domain Reflectometry (TDR)[40].

2.3.3.3 Capacitance sensors

It has two electrodes, which goes under the soil, and soil becomes between them becomes dielectric medium. The electronic circuitry generate high oscillating frequency, which is applied to electrodes. The frequency change in frequency due to moisture content in soil gives measure of moisture in soil [41]

2.3.3.4 Time Domain Reflectometry (TDR) Sensors

It measures time taken by an electromagnetic pulse to travel along wave guide. The electronic circuitry generates pulse through the electrode inserted in the soil, the return time is high in moist soil .The time taken gives measure of moisture in water [40, 42, 43].

2.3.3.5 Heat dissipation sensors

In most cases heat dissipation sensor are of ceramic kind. The water contained in the medium spaces is directly proportional to the heat dissipated from the medium and soil with high moisture content dissipate more heat than dry soil [45]. The electronic circuitry senses the heat dissipated by soil under test to give measure of moisture content in soil.

2.3.4. SENSOR SELECTION

When deciding on which sensor to use the following factors should be put into consideration [36] [45].

Price: This is the most important parameter when selecting any component. The price of the sensor will ultimately affect the price of the whole system as this is one of the major system modules. Sensor with the most competitive price should be chosen.

Power: In any electrical system power efficiency is critical. Moisture sensor will low power consumption should be selected. Sensors which can be battery powered can be used in areas without electric connection.

Technology: Technology used to design sensor dictate the sensitivity, cost and durability of the sensors. Most low cost sensors have poor sensitivity, rust and corrode over time. Resistive or conductive sensors which are affected by soil (I-28) salinity thus have a short life.

Shape: Long and slender sensors can be used in many applications than bulky ones.

Durability: Soil moisture sensor which are not affected by soil salinity, corrode or rust should be selected. Soil moisture sensor probes that measure conductivity or resistance should be avoided, since they will wear out over time.

Accuracy and Linearity: A quality soil moisture sensor probe should give an output which is proportional to water content over the full output range. In addition, the soil moisture sensor probe should have a good output range to reduce sensitivity to noise.

Voltage Range: Choose a sensor that has a big supply voltage range. Powering a sensor with the wrong voltage will damage the sensor or give inaccurate results.

2.3.5 YL-69 MOISTURE SENSOR WITH LM393 PCB

The sensor has two electrodes inserted in the soil, as moisture content of soil between electrodes increase, drop in resistance is sensed by the sensor circuitry. The net resistance obtained is the measure of soil moisture present [46].

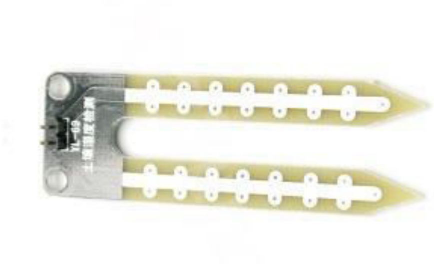


Figure 2.2: YL-69 Sensor

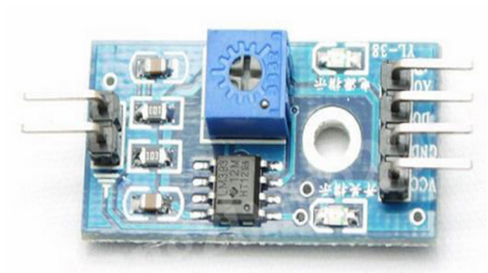


Figure 2.3: LM393 PCB

Table-2.1: Specification of YL-69 Sensor

Vcc power supply	3.3V or 5V
Current	35mA
Signal output voltage	0-4.2V
Digital Outputs	0 or 1
Analog	Resistance (Ω)
Panel Dimension	3.0cm by 1.6cm
Probe Dimension	6.0cm by 3.0cm
GND	Connected to ground

2.3.5.1 LM393 comparator

A compactor is an electronic device which determines the larger quantity between the two quantities being measured by producing a digital signal as output. The two quantities can be two different voltages or currents [46].

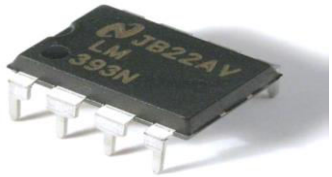


Fig 2.4: LM393 comparator IC

Table-2.2: Characteristics of LM393

Supply Voltage	(2.0 to 36.0) V
Supply	Single or dual (±1.0 to ±18.0) V
Current drain	0.4 mA
Biasing current	25 nA
Offset current	± 5 nA
Offset current	± 5 nA
Saturation Voltage	± 3 mV
Compatibility	TTL, DTL,ECL, MOS and CMOS logic systems
Differential input voltage range	Same as power supply voltage

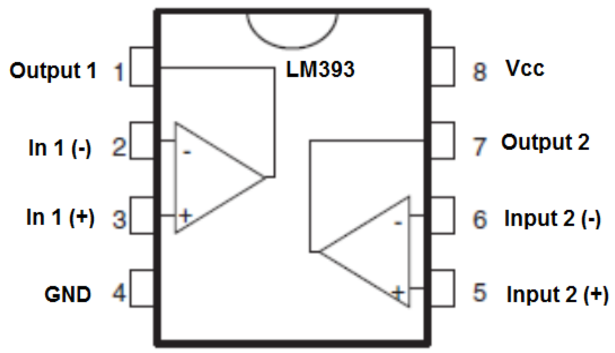


Figure 2.5: LM 393 Pin configuration

2.4 INTRODUCTION OF WSN (Wireless Sensor Network)

The power of wireless sensor networks [47] lies in the ability to deploy large numbers of tiny nodes that assemble and configure themselves. Usage scenarios for these devices range from real-time tracking, to monitoring of environmental conditions. The most straightforward application of wireless sensor network technology [48] is to monitor remote environments for low frequency data trends [49].

2.4.1 SENSOR NODE STRUCTURE

A sensor node normally consists of four basic components

1. A sensing unit
2. A processing unit
3. A communication unit
4. A power unit

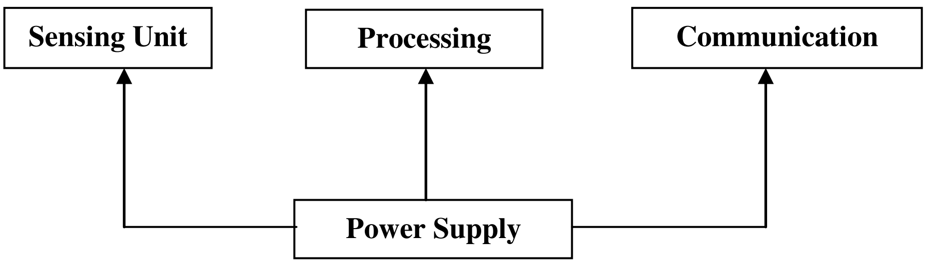


Figure 2.6: Sensor Node structure

2.4.2 CHARACTERISTICS OF SENSOR NODE

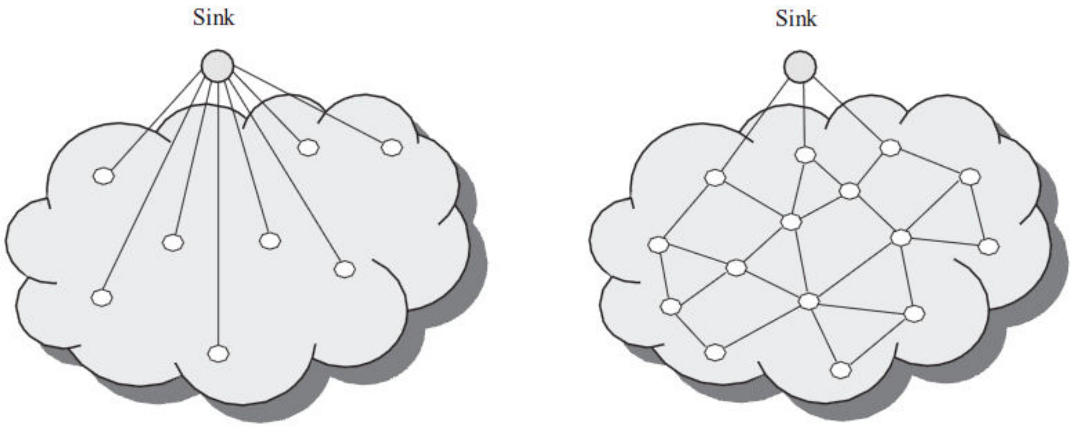
1. **Energy –efficiency-**Energy is scarcest resource that must be utilized properly because it is impossible to recharge each node so it must be energy efficient as possible as. **Low-cost-**WSN is a collection of hundred and thousands sensor nodes, so cost of each node should be node minimum.
2. **Distributed-Sensing-**As large numbers of node are distributed in sensor network so each node for collecting and storing data provides robustness to the system with distributed sensing.
3. **Multi-hop-**As large numbers of sensors are deployed in WSN, so it is not feasible for each node to reach the base station. It may be require intermediate node to reach the base station. Thus, the solution is multi-hop.
4. **Node Types -** In sensor network, there are two types of set or group of node that exist- **homogeneous group of node and heterogeneous group of node**.
5. **Application-oriented- Small Size node-** Sensor nodes are generally small in size where range of each node is restricted about 30m. Due to small size of node; energy is limited which makes processing capability low.
6. **Dynamic Network Topology-** Mostly sensor nodes are deployed in under-developed infrastructure area as a result the network topology always changes due to the addition of new nodes, failure of nodes, and mobility. Thus, the topology is responsible for affecting the sensor network characteristics such as latency, capacity, robustness, complexity and processing of data.

2.4.3. CLASSIFICATION OF WSN

From network architecture point of view WSN classified in two categories [50].

1. Flat Architecture –each node plays the same role in performing sensing task and all sensor nodes are peers.
2. Hierarchical Architecture –sensor nodes are organized clusters, where the cluster members send their data to the sink.

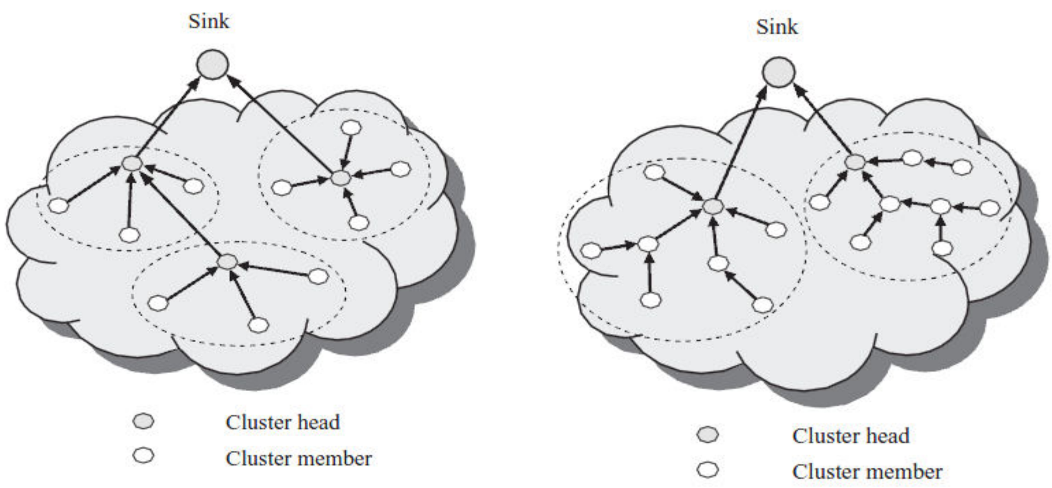
Example of Flat Architecture



Single-hop network Multi-hop network

Fig 2.7: Flat Architecture of WSN

Example of Hierarchical Architecture



Single-hop clustering architecture Multi-hop clustering architecture

Figure 2.8: Hierarchical Architecture of WSN

Figure 2.9: Possible deployment Sensors detect temperature, light levels and soil moisture at hundreds of points across a field and communicate their data over a multi-hop network for analysis.

Source: **System Architecture for Wireless Sensor Networks** By Jason Lester Hill, University of California, Berkeley

2.4.4 APPLICATIONS OF WIRELESS SENSOR NETWORK

Wireless Sensor Network applications are: Soil Moisture Monitoring, Environmental Monitoring, Habitat Monitoring, Air or Water Quality Monitoring, Hazard Monitoring, Disaster Monitoring etc.

Military Applications: Battlefield Monitoring, Object Protection**,** Intelligent Guiding**,** Remote sensing etc.

2.4.5 CHALLENGES OF WIRELESS SENSOR NETWORK

We point out some list of challenges of wireless sensor network. They are as follows [51]:

1. A general architecture that meets the strict efficiency and flexibility requirements of wireless sensor networks.

2. An implementation of the architecture using current microcontroller and low-power radio Technology.
2 An operating system that compliments the hardware capabilities and provides support for sensor network applications.
3 An integrated hardware platform for use in wireless sensor networks.

2.4.6 APPLICATION OF SENSOR NETWORK

We have selected four category of application of sensor network which are environmental data collection, data processing and uploading to web, security monitoring and sensor node tracking.

2.4.6.1 Data Collection

The environmental data collection application is one where collect several sensor readings from a set of points in an environment over some interval of time in order to detect soil moisture level of different location of the garden. We want to collect data from several points spread throughout the garden area and stored it through a database and then analyze the data at runtime and perform the specific operations. We need to collect data over several months or years in order to long-term and seasonal basis. For the data to be meaningful it would have to be collected at regular intervals and the node would remain at known locations. At the network level, the environmental data collection application is characterized by having a large number of nodes continuously sensing and transmitting data back to a set of base stations that store the data using database. These networks generally require very low data rates and extremely long lifetimes. In typical usage scenario, the nodes will be evenly distributed over an outdoor environment. This distance between adjacent nodes will be minimal yet the distance across the entire network will be significant.

After deployment, the nodes must first discover the topology of the network and estimate optimal routing strategies. The routing strategy can then be used to route data to a central collection points. In environmental monitoring applications, it is not essential that the nodes develop the optimal routing strategies on their own. Instead, it may be possible to calculate the optimal routing topology outside of the network and then communicate the necessary information to the nodes as required. This is possible because the physical topology of the network is relatively constant. While the time variant nature of RF communication may cause connectivity between two nodes to be intermittent, the overall topology of the network will be relatively stable.

Environmental data collection applications typically use tree-based routing topologies where each routing tree is rooted at high-capability nodes that sink data. Data is periodically transmitted from child node to parent node up the tree-structure until it reaches the sink. With tree-based data collection each node is responsible for forwarding the data of all its descendants. Nodes with a large number of descendants transmit significantly more data than leaf nodes. These nodes can quickly become energy bottlenecks.

Once the network is configured, each node periodically samples its sensors and transmits its data up the routing tree and back to the base station. For many scenarios, the interval between these transmissions can be on the order of minutes. Typical reporting periods are expected to be between 1 and 15 minutes; while it is possible for networks to have significantly higher reporting rates. The typical environment parameters being monitored, such as temperature, light intensity, and humidity, do not change quickly enough to require higher reporting rates. In addition to large sample intervals, environmental monitoring applications do not have strict latency requirements. Data samples can be delayed inside the network for moderate periods of time without significantly affecting application performance. In general the data is collected for future analysis, not for real-time operation. In order to meet lifetime requirements, each communication event must be precisely scheduled. The senor nodes will remain dormant a majority of the time; they will only wake to transmit or receive data. If the precise schedule is not met, the communication events will fail.

As the network ages, it is expected that nodes will fail over time. Periodically the network will have to reconfigure to handle node/link failure or to redistribute network load. Additionally, as the researchers learn more about the environment they study, they may want to go in and insert additional sensing points. In both cases, the reconfigurations are relatively infrequent and will not represent a significant amount of the overall system energy usage.

The most important characteristics of the environmental monitoring requirements are long lifetime, precise synchronization, low data rates and relatively static topologies. Additionally it is not essential that the data be transmitted in real-time back to the central collection point. The data transmissions can be delayed inside the network as necessary in order to improve network efficiency.

2.4.6.2 Security Monitoring

Our second class of sensor network application is security monitoring. Security monitoring networks are composed of nodes that are placed at fixed locations throughout an environment that continually monitor one or more sensors to detect an anomaly. A key difference between security monitoring and environmental monitoring is that security networks are not actually collecting any data. This has a significant impact on the optimal network architecture. Each node has to frequently check the status of its sensors but it only has to transmit a data report when there is a security violation. The immediate and reliable communication of alarm messages is the primary system requirement. These are “report by exception” networks. Additionally, it is essential that it is confirmed that each node is still present and functioning. If a node were to be disabled or fail, it would represent a security violation that should be reported. For security monitoring applications, the network must be configured so that nodes are responsible for confirming the status of each other.

One approach is to have each node be assigned to peer that will report if a node is not functioning. The optimal topology of a security monitoring network will look quite different from that of a data collection network. In a collection tree, each node must transmit the data of all of its decedents. Because of this, it is optimal to have a short, wide tree. In contrast, with a security network the optimal configuration would be to have a linear topology that forms a Hamiltonian cycle of the network. The power consumption of each node is only proportional to the number of children it has. In a linear network, each node would have only one child. This would evenly distribute the energy consumption of the network. The accepted norm for security systems today is that each sensor should be checked approximately once per hour. Combined with the ability to evenly distribute the load of checking nodes, the energy cost of performing this check becomes minimal. A majority of the energy consumption in a security network is spent on meeting the strict latency requirements associated with the signaling the alarm when a security violation occurs. Once detected, a security violation must be communicated to the base station immediately. The latency of the data communication across the network to the base station has a critical impact on application performance. Users demand that alarm situations be reported within seconds of detection. This means that network nodes must be able to respond quickly to requests from their neighbors to forward data. In security networks reducing the latency of an alarm transmission is significantly more important than reducing the energy cost of the transmissions. This is because alarm events are expected to be rare. In a fire security system alarms would almost never be signaled. In the event that one does occur a significant amount of energy could be dedicated to the transmission. Reducing the transmission latency leads to higher energy consumption because routing nodes must monitor the radio channel more frequently. In security networks, a vast majority of the energy will be spend on confirming the functionality of neighboring nodes and in being prepared to instantly forward alarm announcements. Actual data transmission will consume a small fraction of the network energy.

2.4.6.3. Node tracking Feature

A third usage scenario commonly discussed for sensor networks is the tracking of a tagged object through a region of space monitored by a sensor network. There are many situations where one would like to track the location of valuable assets or personnel. Current inventory control systems attempt to track objects by recording the last checkpoint that an object passed through. However, with these systems it is not possible to determine the current location of an object. For example, UPS tracks every shipment by scanning it with a barcode whenever it passes through a routing center. The system breaks down when objects do not flow from checkpoint to checkpoint. In typical work environments it is impractical to expect objects to be continually passed through checkpoints. With wireless sensor networks, objects can be tracked by simply tagging them with a small sensor node. The sensor node will be tracked as it moves through a field of sensor nodes that are deployed in the environment at known locations. Instead of sensing environmental data, these nodes will be deployed to sense the RF messages of the nodes attached to various objects. The nodes can be used as active tags that announce the presence of a device. A database can be used to record the location of tracked objects relative to the set of nodes at known locations. With this system, it becomes possible to ask where an object is currently, not simply where it was last scanned. Unlike sensing or security networks, node tracking applications will continually have topology changes as nodes move through the network. While the connectivity between the nodes at fixed locations will remain relatively stable, the connectivity to mobile nodes will be continually changing. Additionally the set of nodes being tracked will continually change as objects enter and leave the system. It is essential that the network be able to efficiently detect the presence of new nodes that enter the network.

2.5 INTRODUCTION OF IRRIGATION

2.5.1. DITCH IRRIGATION

In this system ditches on grounds are made in rows and crops are planted in those ditches

2.5.2. TERRACE IRRIGATION

This method is both time and labour intensive where crops are planted after creating a flat land surface.

2.5.3. DRIP IRRIGATION

In this method water is supplied as close as possible to the roots of plants directly which saves significant amount of water wastage.

2.5.4 ROTARY SYSTEM IRRIGATION

In this method a individual sprinkler is allotted for specific part of land, when sprinkler is activated it sprays water for irrigation in 360 degrees fashion.

2.6 INTRODUCTION OF MICROCONTROLLER

A microcontroller is a single on chip computer which includes number of peripherals like RAM, EEPROM, clock Timers etc., required to perform some predefined task[35][52].

A microcontroller is a digital integrated circuit but used in some specific applications only. A microcontroller has processor core, memory elements and programmable input/output modules present in the single integrated circuit. It also has both combinational circuits and sequential circuits, combinational circuits perform logical operations and are designed with logic gates. The sequential circuits are interconnection of combinational circuits and memory or storage elements like counters, flip-flops, etc.. Microcontrollers are programmable device mostly used in embedded systems, engineering projects

[35]. They are designed for embedded applications and are heavily used in automatically controlled electronic devices such as cell phones, cameras, microwave ovens, washing machines, etc.

2.7 ABOUT ARDUINO

Arduino is an open-source electronics design platform. An Arduino is programmable to interact with physical world via sensors and can be used to generate control actions as a controlling unit [52].

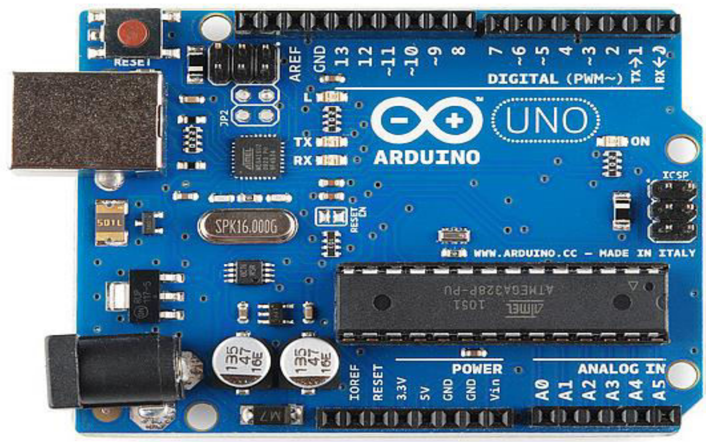


Figure 2.10: Arduino UNO Board

Technical Specification

Microcontroller: ATmega328

Operating Voltage: 5V

Input Voltage (recommended): 7-12V

Input Voltage (limits): 6-20V

Digital I/O Pins: 14 (of which 6 provide PWM output)

Analog Input Pins: 6

DC Current per I/O Pin: 40 mA

DC Current for 3.3V Pin 50 mA

Flash Memory 32 KB of which 0.5 KB used by boot loader

SRAM: 2 KB

EEPROM: 1 KB

Clock Speed: 16 MHz

2.7.1. Atmega328

It is a very popular microcontroller chip produced by Atmel. It is an 8-bit microcontroller that has 32K of flash memory, 1K of EEPROM, and 2K of internal SRAM [53].

The Atmega328 is one of the microcontroller chips that are used with the popular Arduino Duemilanove boards. The Arduino Duemilanove board comes with either Atmega168 or the Atmega328. The Atmega328 is more advanced has 32K of flash program memory and 2K of Internal SRAM unlike the Atmega168 which has 16K of flash program memory and 512 bytes of internal SRAM, the Atmega328[54].

The Atmega328 has 28 pins. It has 14 digital I/O pins, of which 6 can be used as PWM outputs and 6 analog input pins. These I/O pins account for 20 of the pins.

The pin out for the Atmega328 is shown below [54]

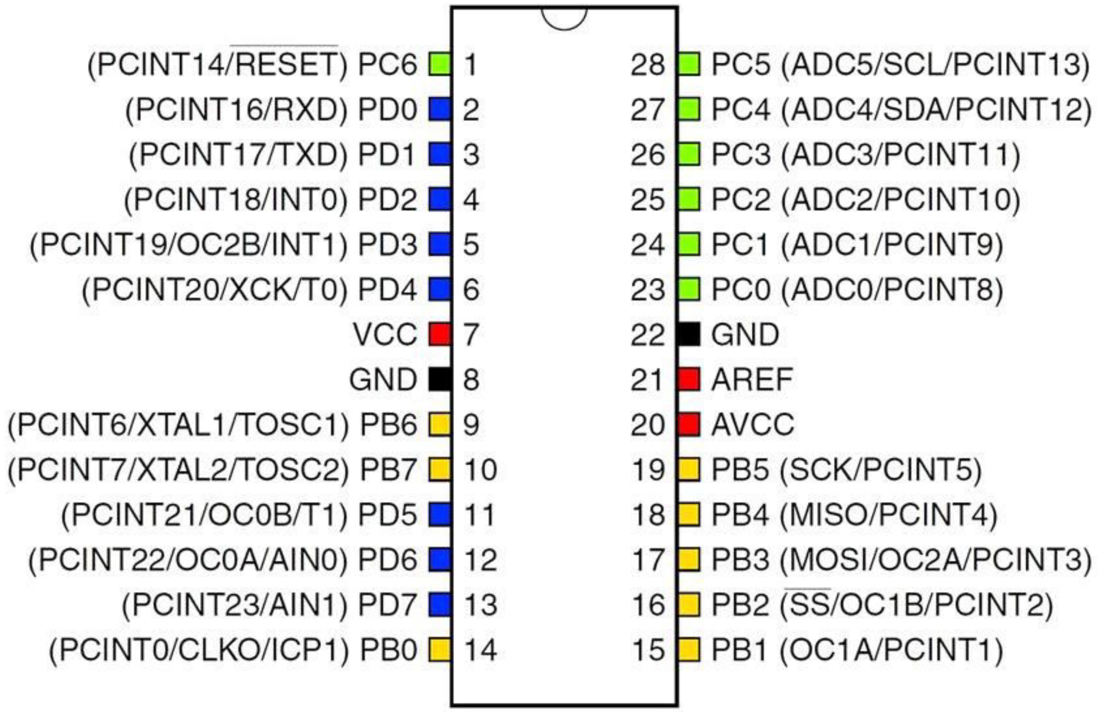


Figure 2.11: Pinout Diagram for Atmega328 Microcontroller

Table 2.3: Pin Description of Atmega328 Microcontroller

Pin Number	Description	Function
1	PC6	Reset
2	PD0	Digital Pin (RX)
3	PD1	Digital Pin (TX)
4	PD2	Digital Pin
5	PD3	Digital Pin (PWM)
6	PD4	Digital Pin
7	Vcc	Positive Voltage (Power)
8	GND	Ground

9	XTAL 1	Crystal Oscillator
10	XTAL 2	Crystal Oscillator
11	PD5	Digital Pin (PWM)
12	PD6	Digital Pin (PWM)
13	PD7	Digital Pin
14	PB0	Digital Pin
15	PB1	Digital Pin (PWM)
16	PB2	Digital Pin (PWM)
17	PB3	Digital Pin (PWM)
18	PB4	Digital Pin
19	PB5	Digital Pin
20	AVCC	Positive voltage for ADC (power)
21	AREF	Reference Voltage
22	GND	Ground
23	PC0	Analog Input
24	PC1	Analog Input
25	PC2	Analog Input
26	PC3	Analog Input
27	PC4	Analog Input
28	PC5	Analog Input

2.8 SOLENOID VALVE

A Solenoid valve is an electromechanical controlled valve. The valve features a solenoid, which is an electric coil with a movable ferromagnetic core, called the plunger, in its centre. In rest position, the plunger closes off a small orifice. But when electric current is sent through the coil, a magnetic field is generated that exerts a force on the plunger. As a result, the plunger is pulled toward the centre of the coil so that the orifice opens [55].

2.8.1. CIRCUIT FUNCTIONS OF SOLENOID VALVES

Solenoid valves are used to close, dose, distribute or mix the flow of gas or liquid in a pipe. There are types of solenoid valves based on their non energized condition where different type serves different perpose. A 2/2 way valve has two ports (inlet and outlet) and two positions (open or closed). A 2/2 way valve can be 'normally closed' (closed in de-energized state) or 'normally open' (open in de-energized state).

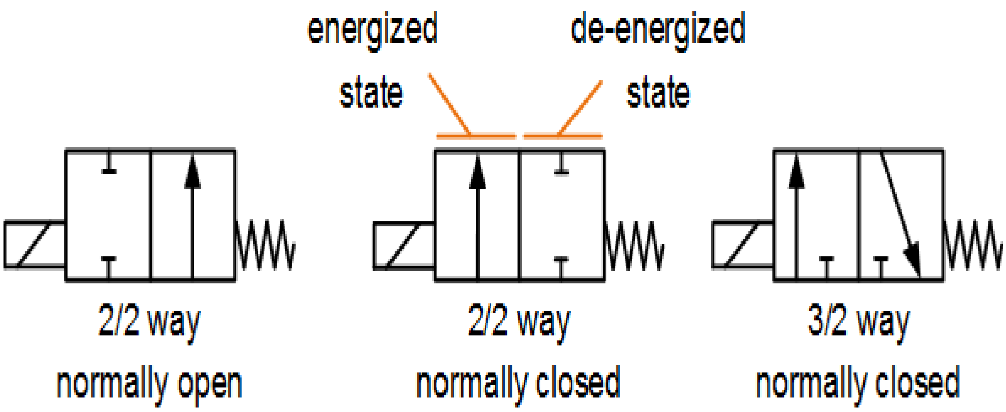


Figure 2.12: Open and Close Solenoid valve

Valve Symbols

For each state of the valve, a single square is drawn. A 2/2 valve has two states (open/close) and is therefore represented by two adjacent squares. In each square is shown how the medium can flow between the ports. This is done with arrows that indicate which ports are connected and what is the flow direction. Closed ports are indicated by a 'T'

To indicate which square is active when the solenoid is electrically energized, a little actuator symbol is used on both sides. On the left square a solenoid symbol is used to show that the left square is the energized state. On the right a spring symbol is used for the rest state.

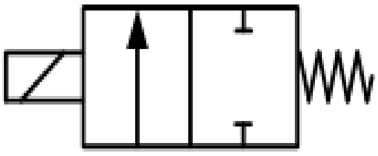
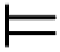
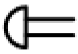
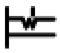
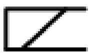


Figure 2.13: 2/2 Solenoid valve

Table 2.4: This table represents the different valve Symbols and its description

		Manual operation
		Push Button
Manual		Lever
		Foot operation
		Detent
		Spring
Mechanical		Pin
		Roller control
Pneumatical		Air operated
Electrical		Coil

2.9 INTRODUCTION TO ZIGBEE

ZigBee is a wireless networking standard applied for remote control and sensor applications which is ideal in harsh radio environments and in isolated locations[56].

The signal transmission from one station to the next extend up to about 70-100 meters, although by relaying data from one node to the next in a network very much greater distances may be reached[57].

The main applications for 802.15.4 ZigBee are focused at control and monitoring applications where one requires relatively low levels of data throughput. A key requirement is low power consumption that's allows for remote, battery-powered sensors application with it. Sensors, lighting controls, security and many more applications are all candidates for the new technology [58].

Data transfer

The applications in which 802.15.4 and ZigBee are likely to be used should not require very high data rates. The data is transferred in packets and have a maximum size of 128 bytes, allowing for a maximum payload of 104 bytes [57, 59].

Network

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. A ZigBee network is set up to make sure data messages are sent efficiently across the ZigBee network that may extend over considerable distances.

3

RESEARCH METHODOLOGY AND SYSTEM DESIGN

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3.1. INTRODUCTION

The system we designed is classified into three main categories or stages, namely, sensing stage, processing stage and last one is transmission stage. For controlling purpose of performance of each stage, there is one control unit. We made the system with the feature of data and information monitoring and recording facility to full fill the basic objective of the topic entitled as "Design and Development of Data Acquisition System for Recording, Controlling and Monitoring of Soil Moisture for Tea Garden".

3.2. DATABASE HANDLING

If we assume 100 wsn node plotted in the field then daily we have collect huge amount of data, so we create extra table for every month under the same database. So the large amount of data is handled properly.

3.3. SENSING STAGE

Moisture measurement methods are indirect in nature for e.g. relation of soil moisture and electrical conductivity (EC) or the dielectric permittivity can be utilized to measure water content in soil. Since EC is also considerably affected by the salinity of the material, mainly the dielectric methods promise good opportunities for accurate measurements. The demand for quality in sensing is high because obtained soil moisture value has immense application so any loss in quality of data is undesirable.

The selection of sensor type is governed by the operations to be carried on sensed signal in processing and control stage.

Electrical signals can be easily processed from analog to digital form using available tools like ADC ICs'. By using ICs we will be minimizing cost and converting to digital bits will make use of programming language and software technology. This support our objective of making data access an easy task through World Wide Web or GSM Technology [1].

The desired quality demands helping tools for sensors including power source viz. battery or solar panels.

3.4 PROCESSING STAGE

After sensing the parameter should be capable of conversion to detectable levels i.e. readable in useful form. For fulfillment of our goal the parameter has to be compatible with operations and algorithm for delivering performance of the efficient system.

Soil moisture is converted to corresponding analog voltage level using LM393 chip. Another chip, a microcontroller, holds algorithm to display voltage level into discrete value for user. Hence soil property is processed to a meaningful signal in order to have a soil moisture monitoring system.

Now after accepting all the data, system needs to process it and compare with set watering value.

3.5 TRANSMISSION STAGE

Acceptable standard of data transfer environment will be discussed here wired transmission (power loss over longer transmission) VS wireless transmission

Now since loss of signal data is undesirable and the medium has to support two way communications therefore standard of transmission required is high quality and long range. The data getting transmitted will hold address value of its plot/grids.

The standard ZigBee supports 64 bit IEEE addresses as well as 16 bit short addresses. The 64 bit addresses uniquely identify every device in the same way that devices have a unique IP address. Once a network is set up, the short addresses can be used and this enables over 65000 nodes to be supported [60].

There are three different network topologies that are supported by ZigBee, namely the mesh, star and cluster tree or hybrid networks. Each has its own advantages and can be used to advantage in different situations.

As the name suggests it is formed in a star configuration with outlying nodes communicating with a central node. The star network is commonly used, having the advantage of simplicity.

Mesh or peer to peer networks provides high degrees of reliability and nodes can be placed as needed, nodes within range communicate with each other to form a mesh. Using different stations as relays messages may be routed across the network. The advantage of choosing the routes makes the network very robust as any interference on one section of a network does not break the network as another can be used instead.

Lastly a cluster tree network is essentially a combination of star and mesh topologies.

The nodes with sensors of control mechanism i.e. broadcaster ZigBee towards the centre of a network are more likely to have mains power. But non broadcaster ZigBee have been optimized for low power consumption which enables battery life to be typically measured in years, enabling the network not to require constant maintenance. Because to achieve the full ZigBee network coverage messages must be able to be relayed[57].

3.6 BROADCASTER ZIGBEE

It will operate as Selector of Sensor and request to send instant soil moisture value to it and every router will have a unique id. It will broadcast moisture value request to router in sequence, only one at a time, to a router in a cycle i.e. after transmitting request to 1st router id it will wait until soil moisture value is received and then it transmits to second router id with same request code but with different sensor id. In a similar way, same message will be sent until the last router receives it and send back soil moisture value. In the event of any router not replying soil moisture value; GUI system will prompt an alert message about that particular sensor.

3.7 ROUTER ZIGBEE

It will operate as sender of sensed moisture value back to Broadcaster Zigbee.

Arduino board: It will operate as an interpreter as it will understand broadcaster message and convert soil moisture property to digital signal. It will also perform the execution of sprinkler.

3.8 CONTROLING STAGE

Depending on the appropriate requirement of moisture in garden soil the central control unit will start stop the sprinkler. The sprinkler Start/Stop value will be set by the operator, through Graphical User Interface developed with MS Visual Basic Studio software.

The control unit will collect all sensor values from router Zigbee's and corresponding decision to start or stop watering action will be decided by the Sprinkler Start/Stop value set by the user. The control unit will process the received value and compare it with set values, in case of lower moisture indication from received values, the control unit will identify sensor id and transmit sprinkler start command to respective id's. The coordinator Zigbee will transmit sprinkler start commands to router Zigbee's and Arduino boards receiving Sprinkler start commands from router Zigbee will start water sprinkler.

The coordinator Zigbee will again transmit moisture data acquisition signal to all router Zigbee once in a cycle. The router Zigbee will respond to request by sending current moisture value to coordinator Zigbee. The control unit will receive sensor's moisture value and identify sensor id to transmit start or stop command. In this way sensors with running sprinkler will receive their stop command and sensors with low moisture value will receive sprinkler start command.

The control unit will require sensor value for operation hence it will seek value from particular sensor. For this there will be selection of sensor by its unique sensor id.

3.9 BLOCK DIAGRAM OF THE SYSTEM

We segregated the block diagram of the system in three different parts Block-A, Block-B and Block-C. The system diagram and details of the Block is given below:-

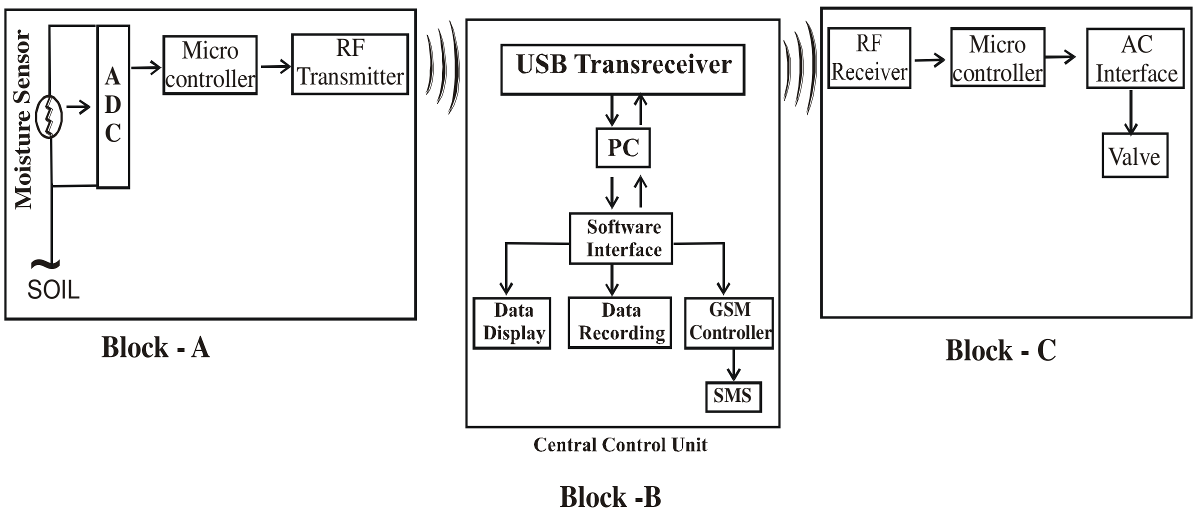

Figure 3.1: Block Diagram for acquisition of moisture data from the soil, analysis and execution.

3.9.1 BLOCK A

The analog signal through moisture sensor probe, which is measure of water content in the soil, will be converted to digital form and each signal will be made unique with help of Arduino Board. The desired accuracy and reproducibility standards will be attained through laboratory work calibration to cope-up with real-life situation. The information signal thus generated by

Arduino Board will be propagated to central controlling unit and received with wireless Zigbee.

3.9.2 BLOCK B

The information received will be fed to software interface designed on Microsoft platform on PC with Windows OS. This PC will have a GUI interface for data display, data recording and generating command signals for later stage. This PC will be connected to GSM based hardware for SMS based communication to user.

3.9.3 BLOCK C

The final operation task of watering the soil will be governed by moisture values fed by the operator to control unit. The value obtained from moisture sensor will be compared with operator set value, received value will be either higher or lower than set value. The Arduino board will generate command to start solenoid water if received value is lower than set value. Conversely it will generate command to stop solenoid water valve if received value is found higher than set values. The Arduino board does not directly control AC interface but is responsible to control AC drivers from its DC control signal.

3.10 BLOCK DIAGRAM FOR SOIL MOISTURE SENSOR

This block diagram is for single module of the sensor unit. This block diagram shows the connectivity of required different parts of the sensor unit. The block wise description of the sensor unit is given below.

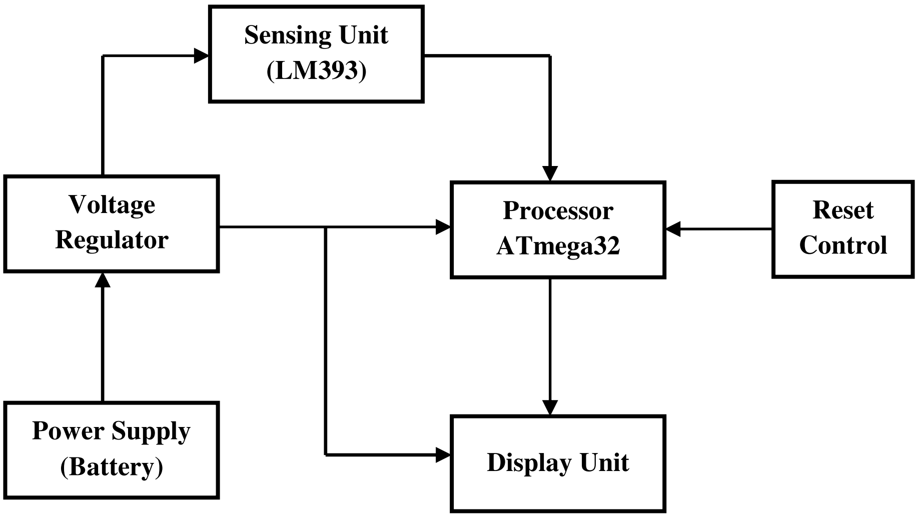

Figure 3.2: Simplified Block Diagram of Soil Moisture Sensor

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 9V 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 LM780 to avoid possible deficiency 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.

Display Unit

For display of moisture level of soil, a 16X2 LCD (Liquid Crystal Display) in interfaced with microcontroller to give reading as percentage values. A “16X2” display indicates two lines of display with 16 characters support for each line.

Reset Control

Reset control is used to reset the whole system.

3.11 FLOW CHART OF THE WHOLE SYSTEM

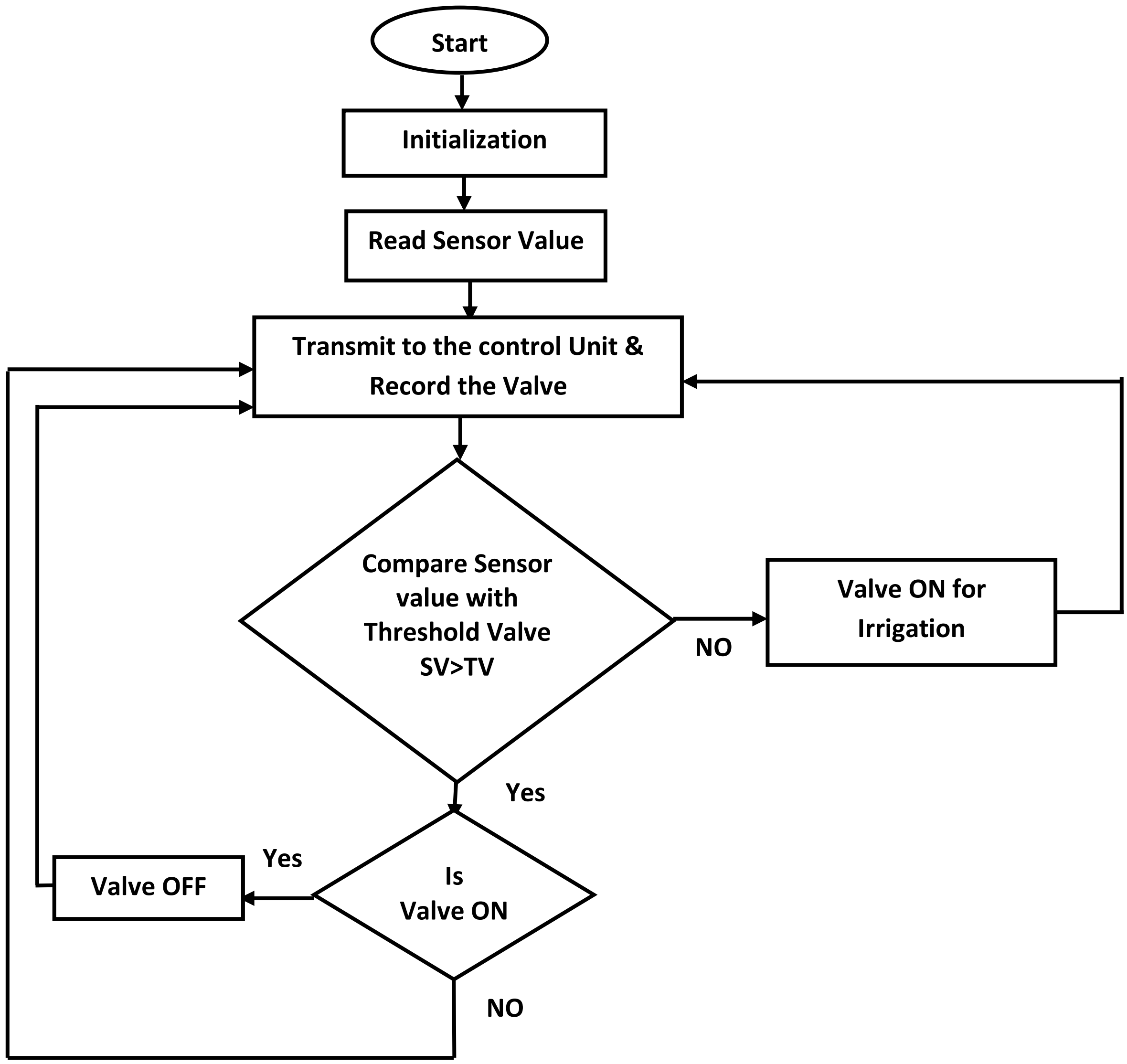

Figure 3.3: Flowchart of the System

Circuit diagram for moisture sensor

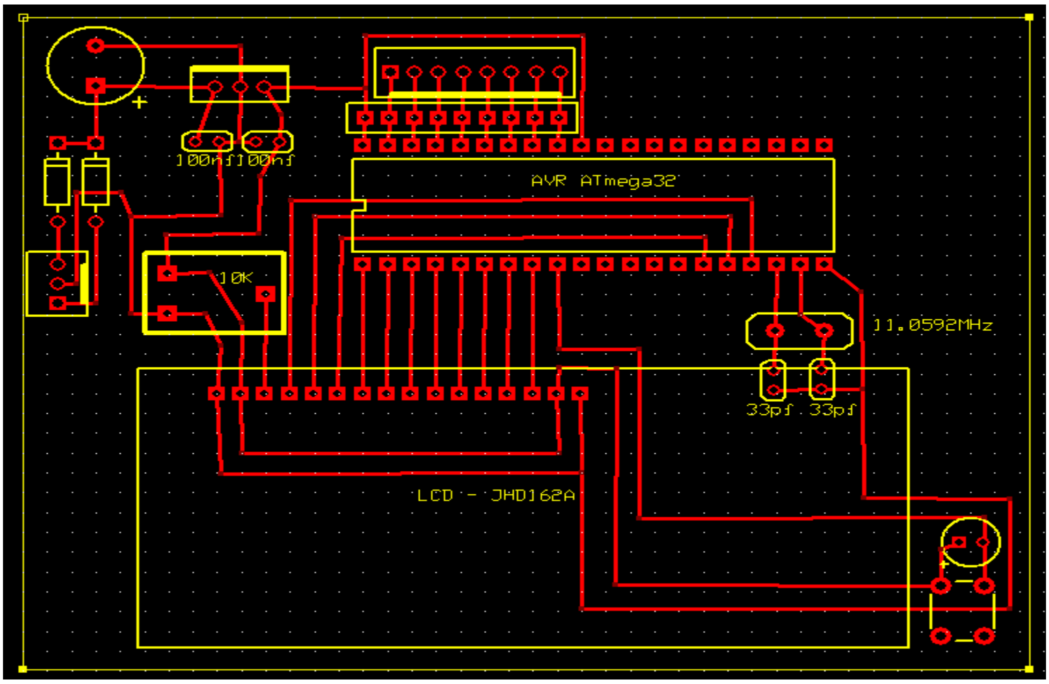

Figure 3.4: PCB Diagram for Moisture Sensor

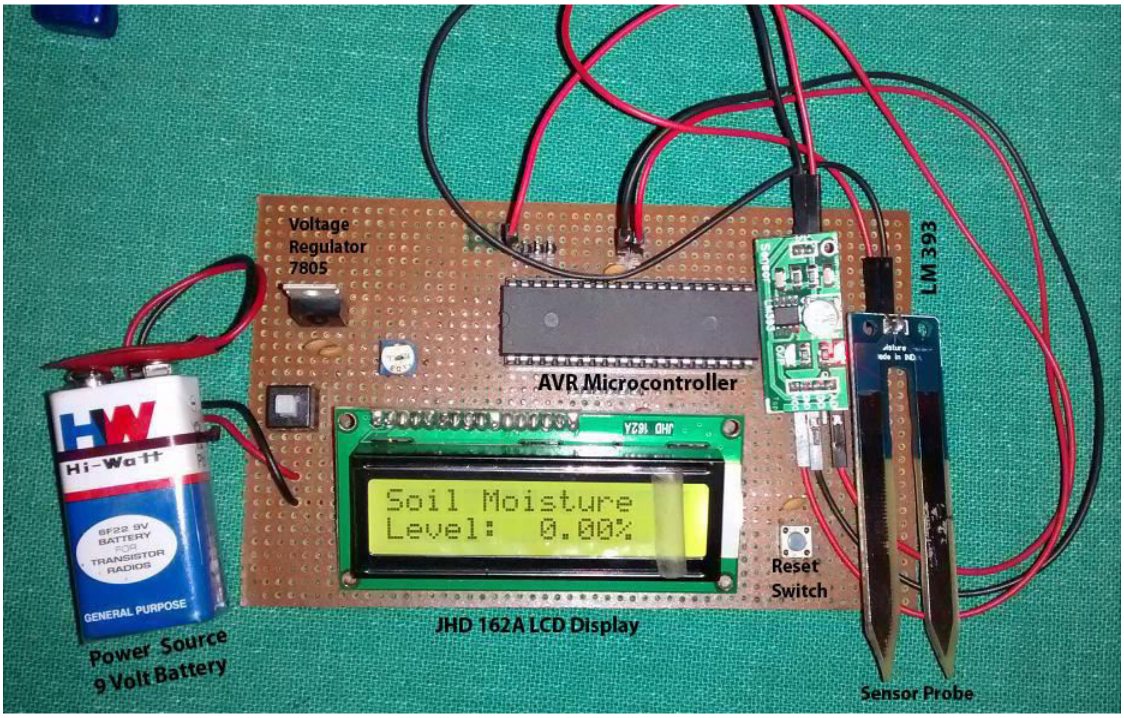

Figure3.5: Image of Soil Moisture Sensor

Circuit Diagram for Moisture Sensor with wireless Transmission Facility

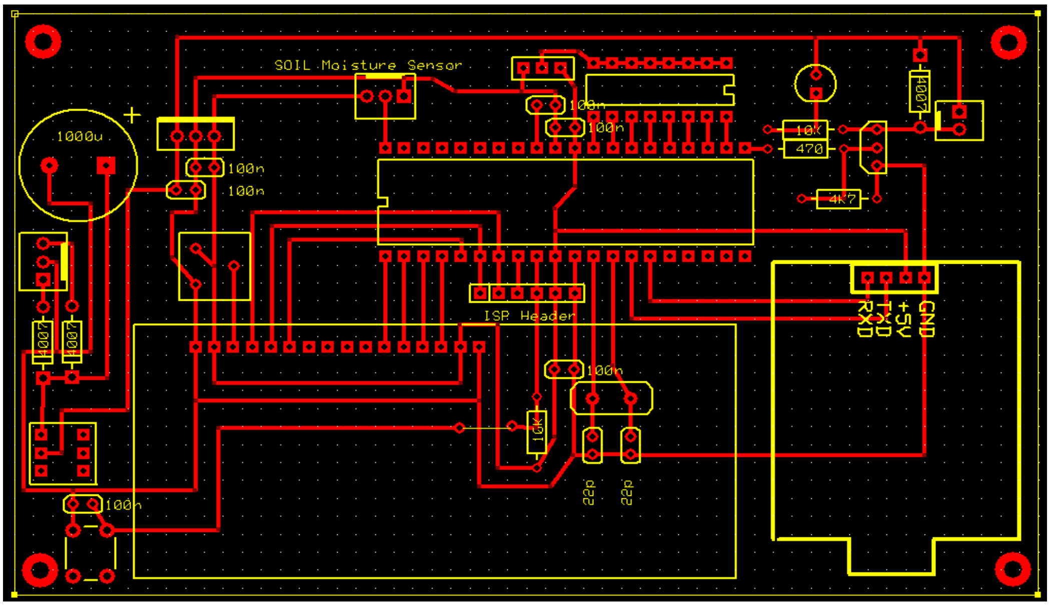

Figure 3.6: PCB Diagram for Moisture Sensor with wireless Transmission Facility

After design and development of the sensor unit, next most challenging task was the design of blueprint for the deployment of the sensor units in the tea garden. Because the methodology to be used has to provide low maintenance and robust communication between the sensor units. After a brief study and deep analysis on Wireless Sensor Network for deployment in tea garden conclusion was made to use XBee module because XBee is a communication wireless personal area networks (WPANs) specially built for control and sensor networks on IEEE 802.15.4 standard for. As XBee has low-cost and low-powered mesh network for controlling and monitoring applications where it covers 40-100 meters within the range.

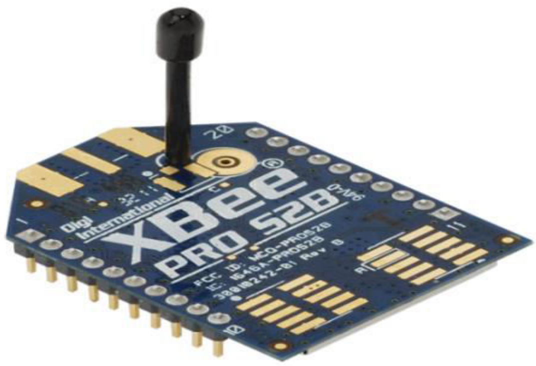

Fig 3.7: XBee Module

After implementing the moisture sensor using AVR microcontroller [61] we have design the moisture sensor module using Ardiuno microcontroller along with the Xbee module.

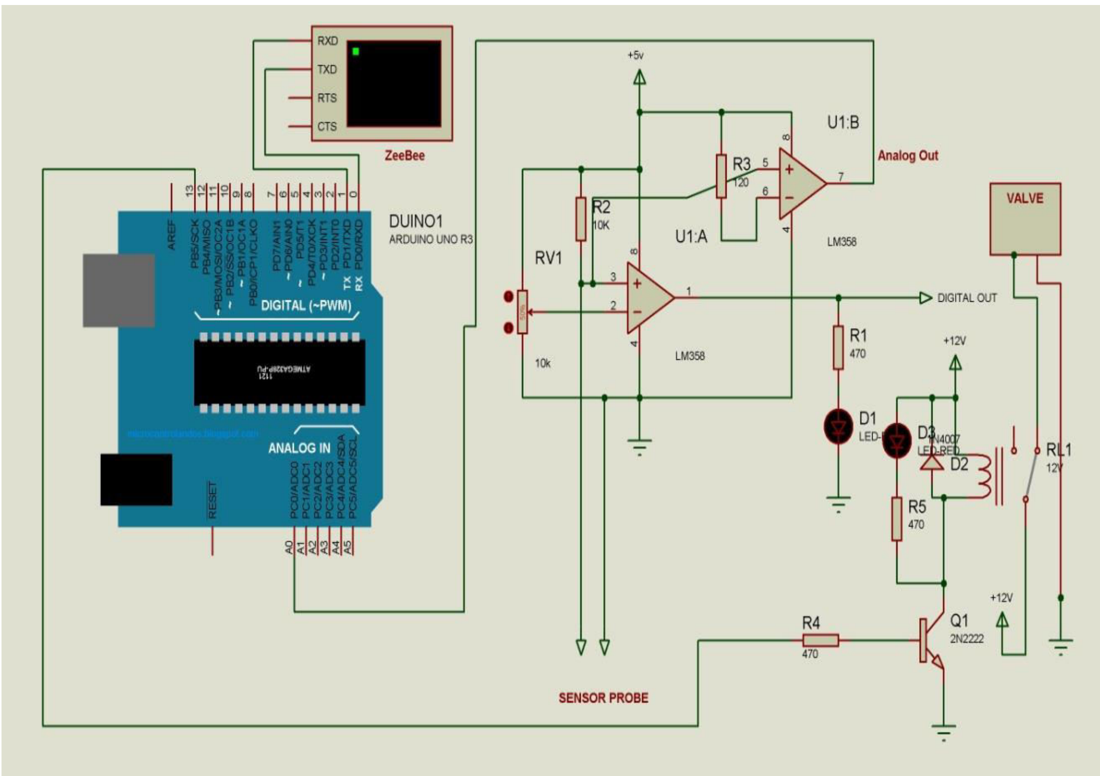

Figure 3.8: Circuit Diagram for whole System Module

Extraction of the raw data of moisture present in soil is done by the soil moisture sensor. The data about the soil moisture from the sensor is analogue in nature which is converted into digital signal using an ADC. The digital signal is transmitted to the system's control unit using Xbee module. For monitoring purpose we need a GUI, that GUI is developed by Visual Basic platform. We can monitor the data and activity of the valve in structure ways through the GUI. Now the monitored data are to be recorded for future reference. For recording purpose we use SQL Database Management System. The monitored data in Visual Basic platform will be saved in SQL by the coding developed in Visual Basic itself. So for recording purpose Visual Basic is the frontend and SQL is the Backend. That means it reflects that all the monitoring data will recorded in SQL database. So there is a scope of shortage of space regarding the recorded data. So to overcome of shortage of space for recorded data we need technical process for updating the recorded data. Here we can use a external backup system for old data. Our system runs on threshold value for controlling purpose if the transmitted data from the router is below the threshold value then the system will send a signal to open the valve to supply the water to the garden. And after getting water the soil moisture of the garden will definitely increase and where we get a value transmitted by the sensor greater than the threshold value, the system will send a signal to stop the supply of water by closing the valve. For valve ON/OFF controlling purpose, XBee transreceiver attached with system act as transmitter i.e. router and the XBee transreceiver associated with the sensor board will be acted as receiver coordinator.

A Wireless Sensor Unit is comprised of Moisture sensor, a micro-controller, XBee and power sources. Several Wireless Sensor Units can be deployed in-field to configure a distributed sensor network for the automated irrigation system. Each unit is based on the micro-controller that controls the radio modem XBee and processes information from the soil-moisture sensor.

Figure 3.9: Wireless sensor Unit A

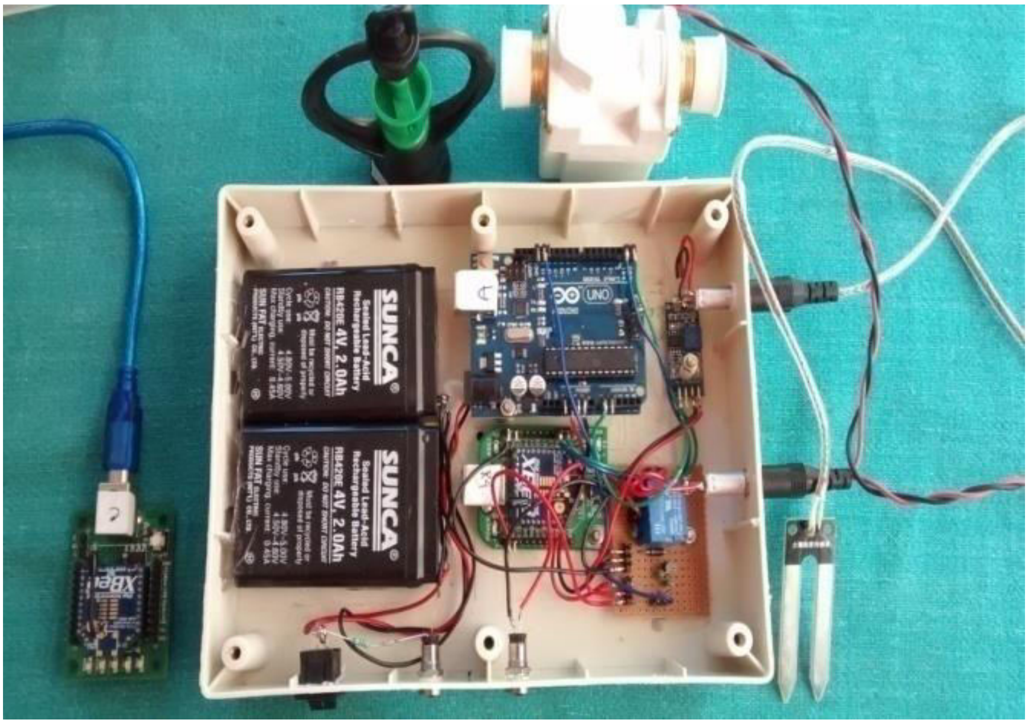

Figure 3.10: Wireless sensor Unit B

4

ANALYSIS OF ROUTING PROTOCOL

CONTENTS

4.1	**INTRODUCTION**	**56**
4.2	**MANET (Mobile Ad Hoc Network) ROUTING PROTOCOL**	**56**
4.3	**SIMULATION AND ANALYSIS METHOD**	**57**

4.1 INTRODUCTION

In this research we have used wireless sensor network to transmitting the data from different nodes in this case we need a routing protocol to routes the data from source to destination consuming minimum energy and better Packet Delivery Ratio (PDR). So during this phase we analyze the different routing protocols which are used in wireless transmission [62].

4.2 MANET (Mobile Ad Hoc Network) ROUTING PROTOCOL

We analyze two main MANET protocols, AODV Protocol (Ad hoc On-Demand Distance Vector) as reactive protocols and DSDV Protocol (Destination Sequenced Distance Vector) as proactive protocol.

a) Ad-hoc On-demand Distance Vector (AODV)

AODV is a combination of on-demand and distance vector i.e. hop-to-hop routing methodology. When a node needs to know a route to a specific destination it creates a ROUTE REQUEST. Next the route request is forwarded by intermediate nodes which also create a reverse route for itself for destination. When the request reaches a node with route to destination it creates again a REPLY which contains the number of hops that are require to reach the destination. All nodes that participate in forwarding this reply to the source node create a forward route to destination. This route created from each node from source to destination is a hop-by-hop state and not the entire route as in source routing [63].

b) Destination Sequenced Distance Vector (DSDV)

DSDV is a hop-by-hop distance vector routing protocol requiring each node to periodically broadcast routing updates based on the idea of classical Bellman-Ford Routing algorithm. Each node maintains a routing table listing the “next hop” for each reachable destination, number of hops to reach destination and the sequence number assigned by destination node. The sequence number is used to distinguish stale routes from new ones and thus avoid loop formation. The stations periodically transmit their routing tables to their immediate neighbors. A station also transmits its routing table if a significant change has occurred in its table from the last update sent. So, the update is both time-driven and event-driven. The routing table updates can be sent in two ways: a “full dump” or an “incremental” update [63, 64].

4.3 SIMULATION AND ANALYSIS METHOD

The simulations were performed using Network Simulator (Ns-2), which is popularly used for ad hoc networking community. The routing protocols were compared based on the following 3 performance metrics: -

1. **End-to-End Delay (EED):** It is the time taken for an entire message to completely arrive from the source to destination.
   End-to-End delay depends on the following components i.e.
   Propagation time (PT), transmission time (TT), queuing time (QT) and processing delay (PD). Therefore, EED is evaluated as:
   EED = PT + TT + QT + PD.
2. **Throughput:** It is the measure of how fast a node can actually sent the data through a network. So throughput is the average rate of successful message delivery over a communication channel.
3. **Packet Delivery Ratio (PDR):** It is the ratio of the total data bits received to total data bits sent from source to destination.

By using the awk scripts, the performance metrics of 50 nodes for AODV and DSDV routing protocol is been calculated and shown below.

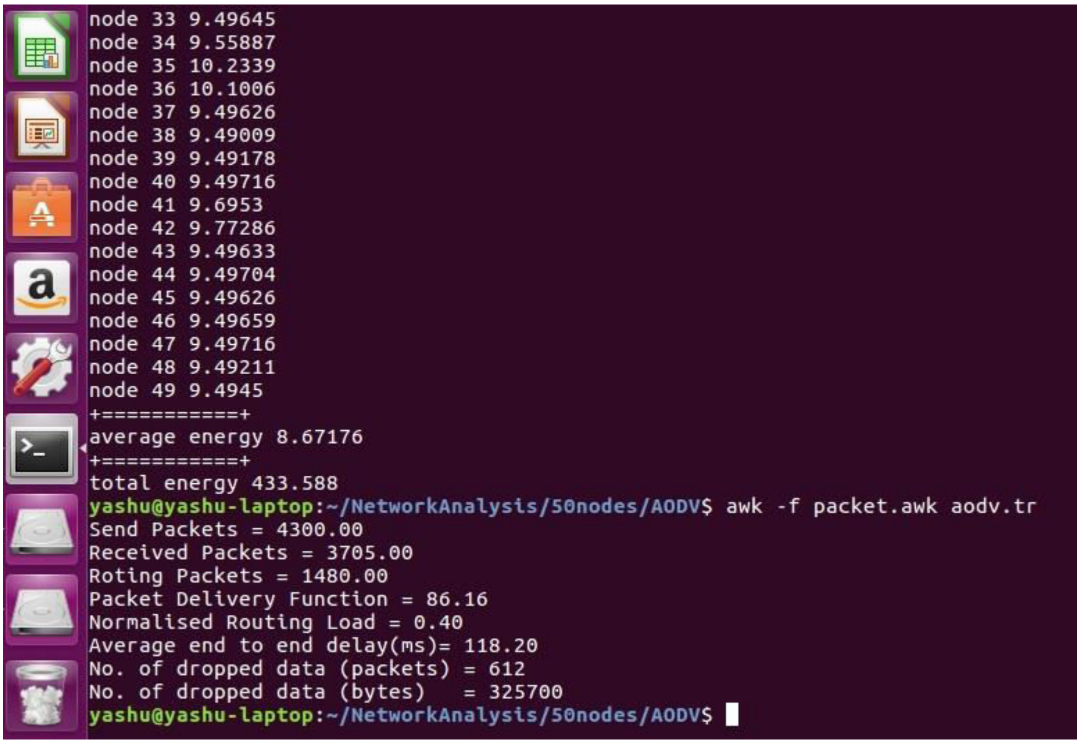

Figure 4.1: Performance metrics of AODV Protocol

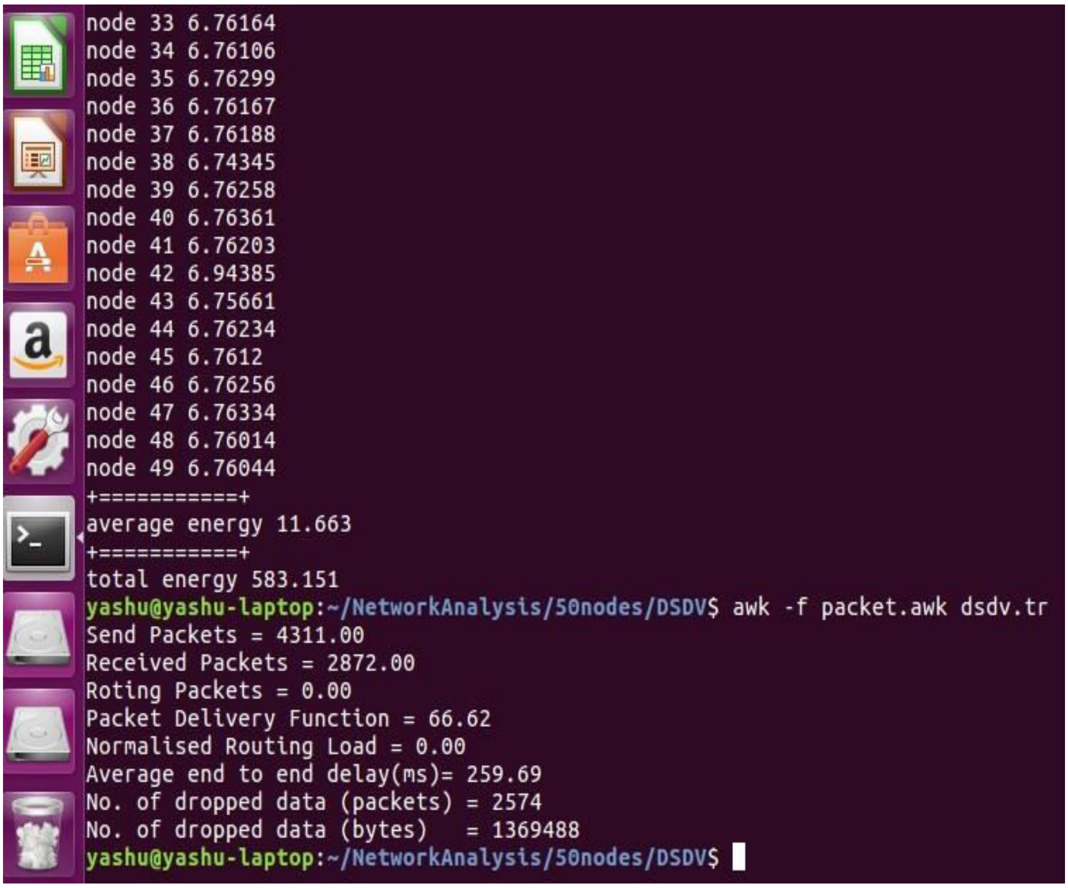

Figure 4.2: Performance metrics of DSDV Protocol

Following are the results of xgraph for the different performance metrics such as throughput, delay and packet loss of 50 nodes for AODV and DSDV routing protocols

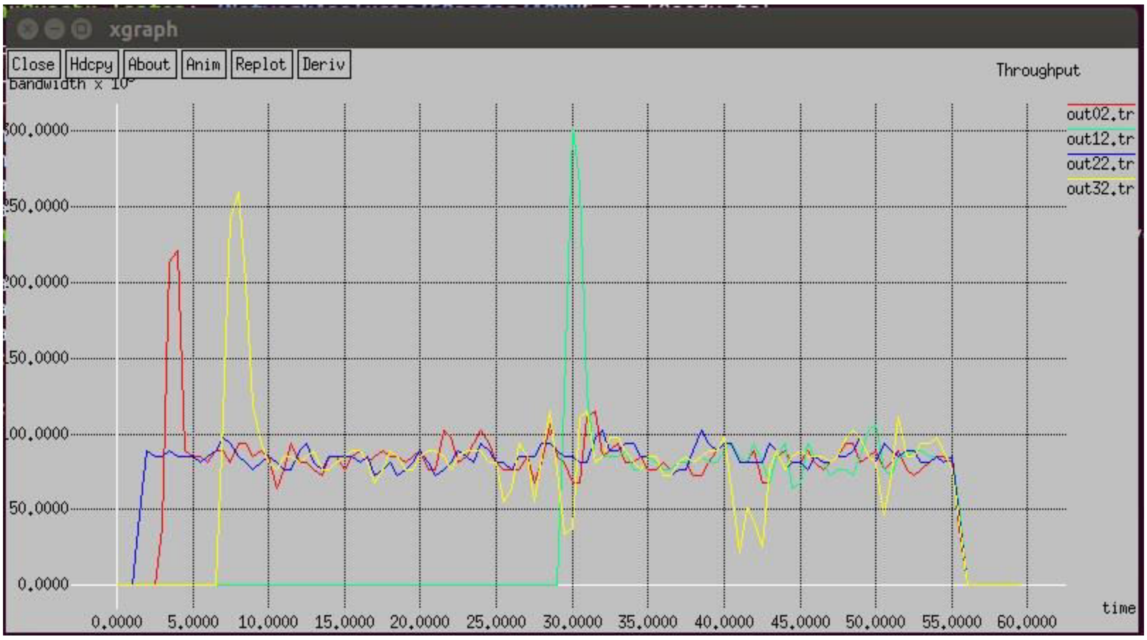

Figure 4.3: Throughout for AODV Routing Protocol

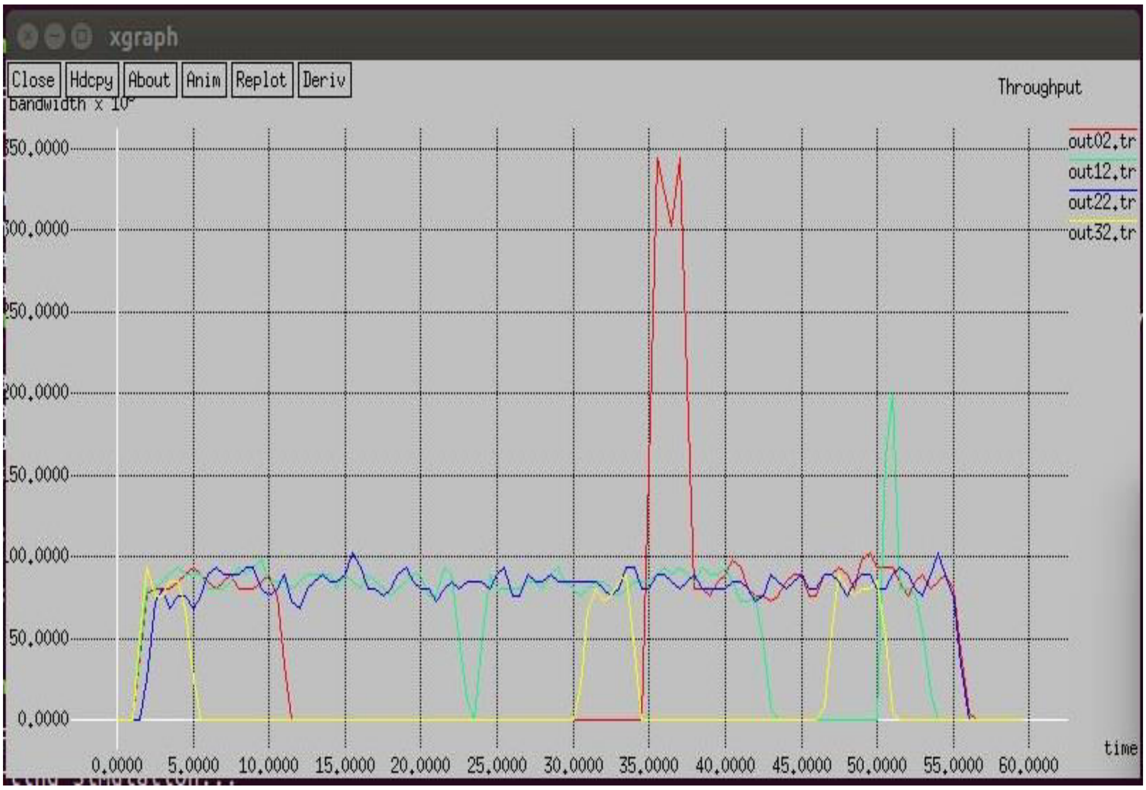

Figure 4.4: Throughout for DSDV Routing Protocol

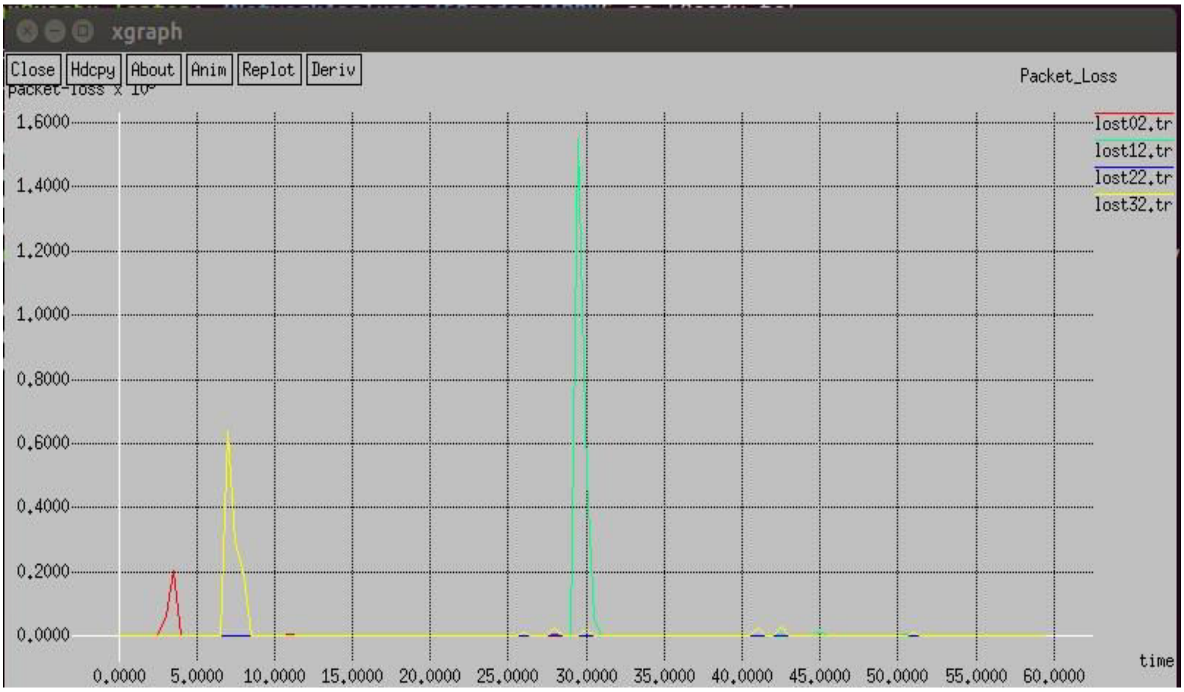

Figure 4.5: Packet loss for AODV Routing Protocol

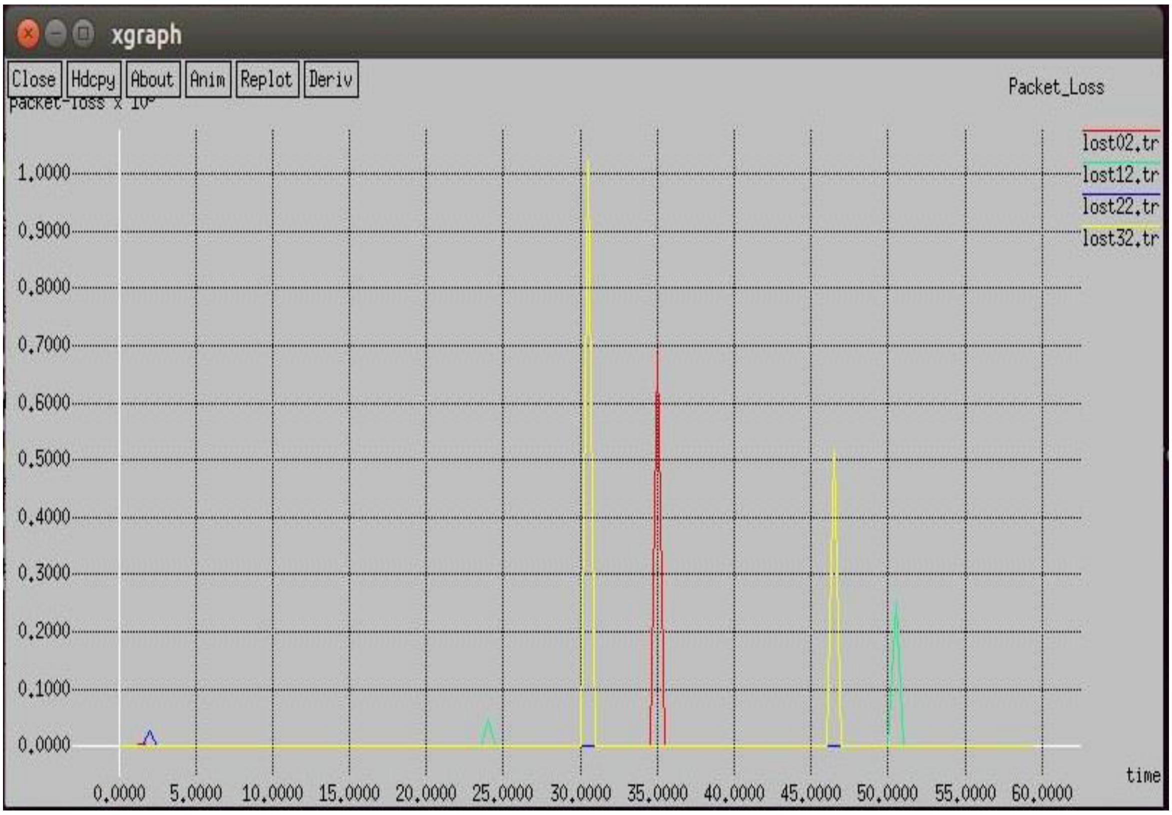

Figure 4.6: Packet loss for DSDV Routing Protocol

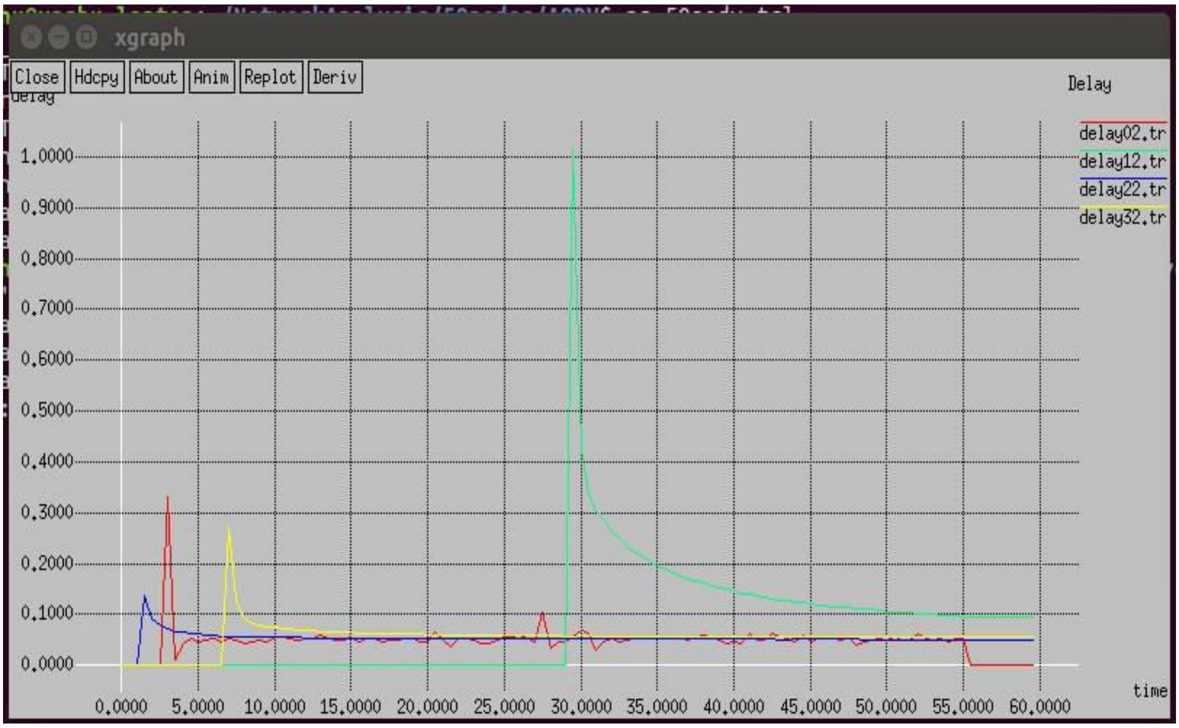

Figure 4.7: Delay for AODV Routing Protocol

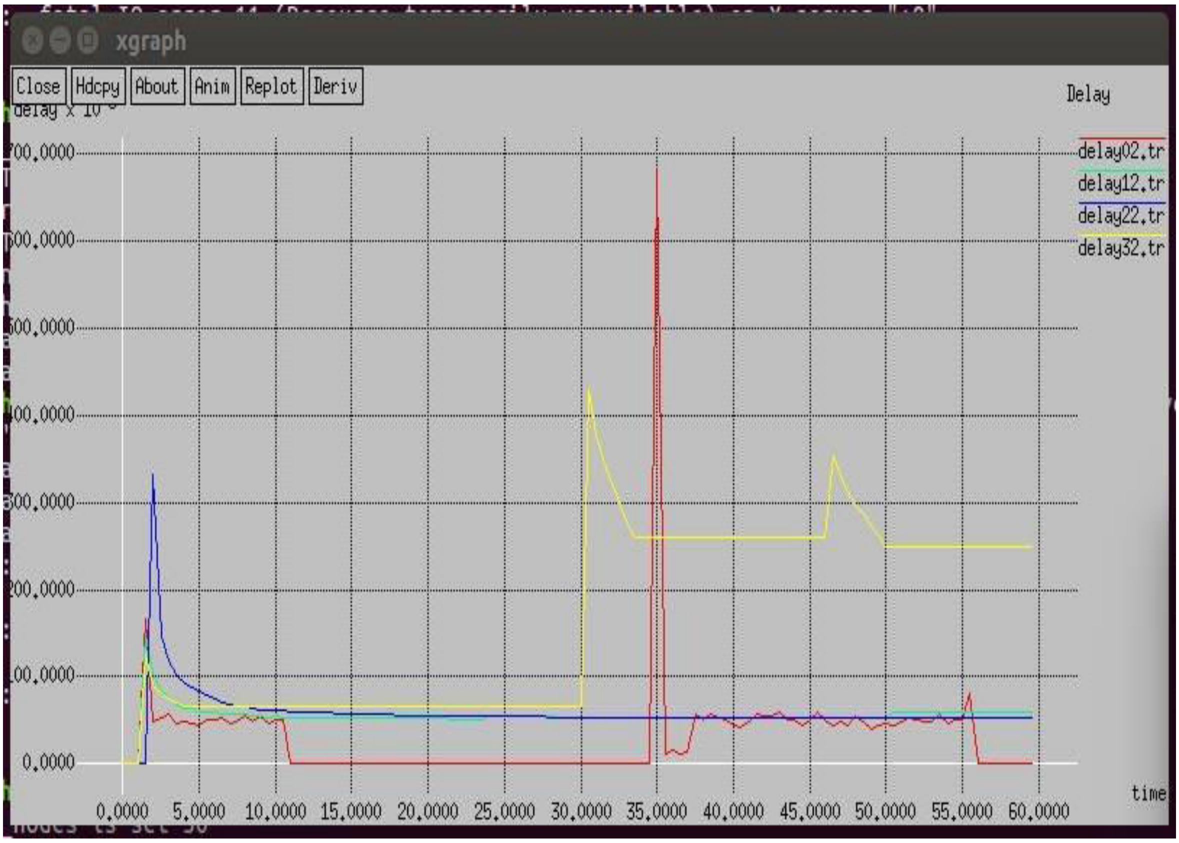

Figure 4.8: Delay for DSDV Routing Protocol

Table 4.1: Table for Analyzing Data of 50 nodes for AODV and DSDV routing protocol

Legend \ Protocols	**AODV Protocol** (Ad-hoc On-demand Distance Vector)	**DSDV Protocol** (Destination Sequenced Distance Vector)
Average Energy	8.67176	11.663
Total Energy	433.588	583.151
Packet Delivery Ratio (PDR)	86.16	66.62
Avg. End to End Delay (ms)	118.20	259.69
Throughput (KBps)	1.7360	1.5840

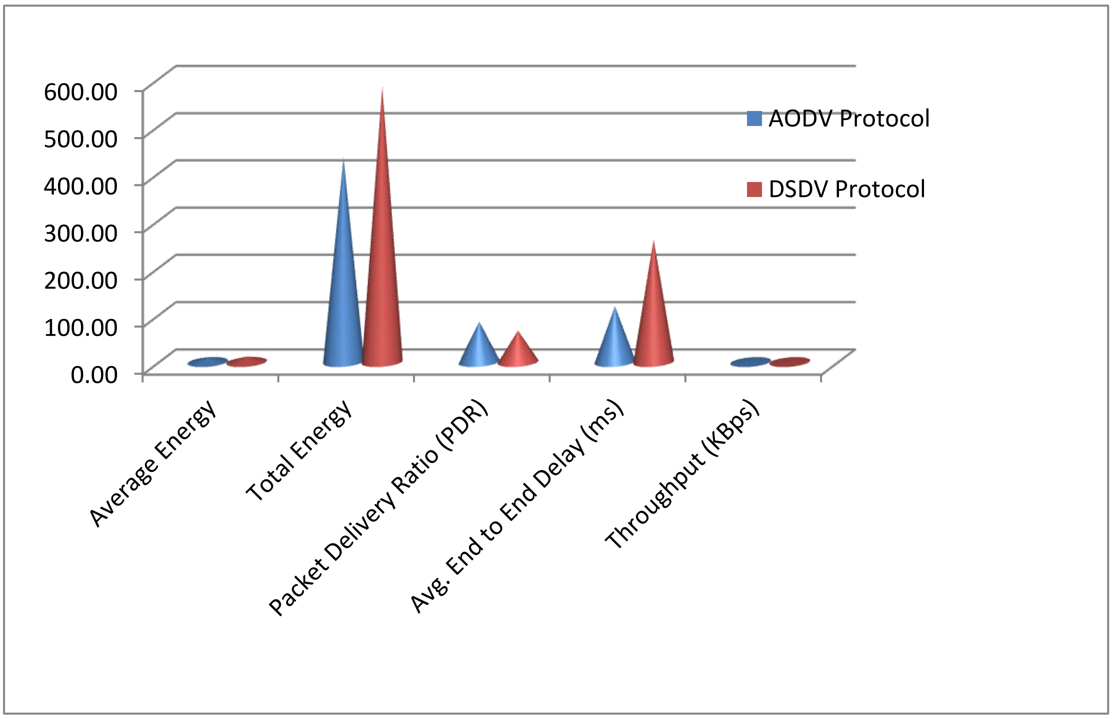

Figure 4.9: Graph for comparison of AODV and DSDV in different parameters.

We compared the two MANET (Mobile Ad Hoc Network) Routing Protocol AODV and DSD. Simulation results show that DSDV (Destination Sequenced Distance Vector) has a higher End to End Delay as compared to AODV (Ad-hoc On-demand Distance Vector). DSDV (Destination Sequenced Distance Vector) has a less PDR (Packet Delivery Ratio) than AODV. From the above analysis AODV (Ad-hoc On-demand Distance Vector) is better in terms of packet delivery ratio and energy consumption. We are using zigbee module for data transmission in this research and zigbee module use AODV protocol. So we have analyzed this protocol along with other MANET (Mobile Ad Hoc Network) Routing Protocol. After analysis we got zigbee module fulfill our requirement for this research.

5

RESULT AND DISCUSSION

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5.1 DATA ACCESS ABOUT GUI AND WEBSITE

Tools for applying control logic in real life will be discussed here.

Lastly the PC based GUI and website will be discussed with their advantages and applications the human and data interaction will provide the necessary control required for efficient water monitoring system. The purpose of human is to regulate water demands as per current seasons in tea estate. Hence the operator will read data and plan for the operation of soil moisture monitoring system. The more convenient path to access data the more efficient will be our soil moisture monitoring system. Therefore integrating World Wide Web/ Internet with soil moisture monitoring system will be a promising pillar of efficient soil moisture monitoring system.

The operator needs a GUI to check the status of the sensor, to monitor the moisture level and status of the water sprinkler etc. this graphical user interface (GUI) developed using visual studio software and for database we are using MySql.

LOGIN WINDOW

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

Figure 5.1: Login window of the sensor application

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.

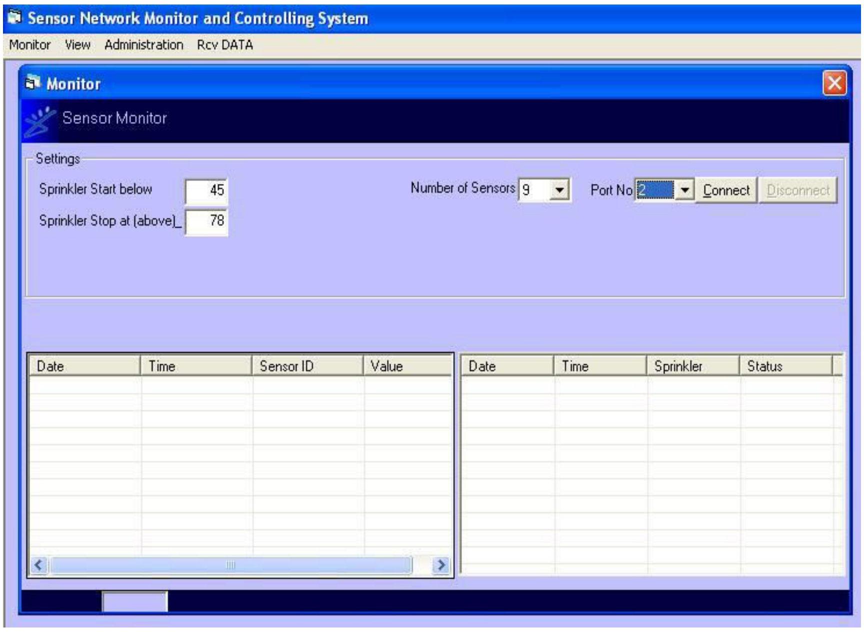


Figure 5.2: Sensor Data Monitoring Window

SENSOR DATA LOG

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

From prevailing tools available we have opted for solenoid valve operating water sprinkler for irrigation. For ease in sensor data evaluation and easy access we have host a website **www.wsndatalogger.in**. From this website we can easily monitor the acquire data from the field at anywhere in the world.

Figure 5.3: Website for online monitoring the system.

After acquiring month wise data we store the data into database as date wise. For comparing purpose we also collect the moisture data of the soil manually (Lab Tested). In laboratory we using dry oven method to collect the data. At same date and same time we simultaneously collect the data from sensor as well as manual sample for lab.

Table - 5.1: Date wise sensor and manually collected soil moisture data

Days	Sensor Data Soil Moisture (%)	Manually Collected Data (Soil Moisture) (%)
03/01/2016	11.00	10.07
10/01/2016	12.02	11.00
17/01/2016	10.78	10.90
24/01/2016	10.24	11.00
07/02/2016	12.34	14.00
14/02/2016	10.21	9.21
21/02/2016	11.19	11.19

28/02/2016	9.23	10.04
06/03/2016	10.44	11.33
13/03/2016	8.16	9.44
20/03/2016	10.00	11.00
27/03/2016	13.00	12.04
03/04/2016	15.00	15.08
10/04/2016	11.45	10.00
17/04/2016	12.23	12.69
24/04/2016	16.01	14.12
01/05/2016	18.33	18.50
08/05/2016	20.21	18.44
15/05/2016	22.33	23.33
22/05/2016	19.00	21.78
29/05/2016	25.00	26.54
05/06/2016	30.70	33.12
12/06/2016	32.23	30.49
19/06/2016	31.60	33.23
26/06/2016	35.00	33.89
03/07/2016	38.00	37.69
10/07/2016	35.34	34.03
17/07/2016	34.34	35.23
24/07/2016	33.55	32.90
31/07/2016	35.76	34.78
07/08/2016	38.84	39.67
14/08/2016	36.22	36.89
21/08/2016	37.44	38.66
28/08/2016	38.33	37.02

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.

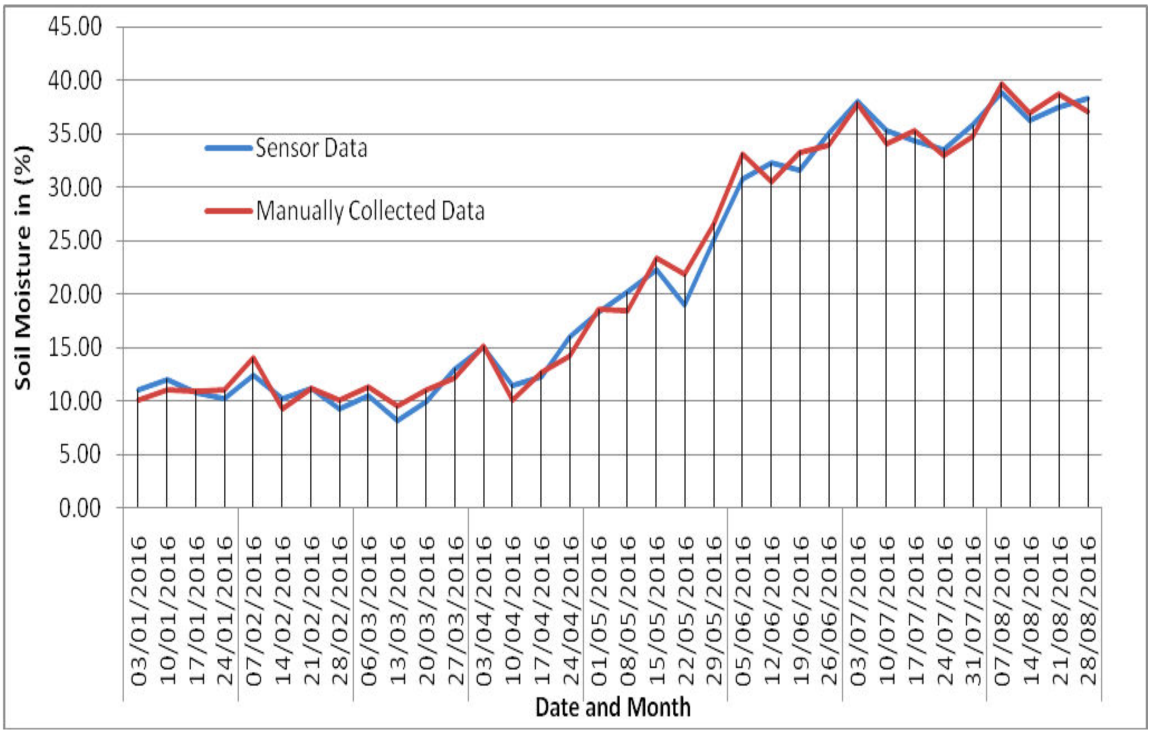


Figure 5.4: Graph to comparing accurate sensor collected data to the traditionally collected data.

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.

5.2. FACTORS AFFECTED ON TEA PRODUCTIVITY

We have collected the four main factors which will affect the productivity of the tea leaves. These factors are rainfall, temperature, moisture of soil and pH value of the soil. Firstly we have selected three different small gardens for experiment and the experimented area of each garden is 14,400 sq ft.

Each garden is equally dived into two parts, both are equipped with Data Acquisition system but only one half is equipped with facilities to maintain soil moisture using irrigation. Other half soil moisture is governed by natural condition and no changes to soil moisture have been delivered from our end.

The list of the collected data are given below

After setting up the Data acquisition system to different gardens the following data are:

Table - 5.2: Table for productivity and different parameters are affected in Tea productivity in the year of 2015 (Garden –A)

Month	Rainfall (MM)	Temperature (c)	Soil Moisture		pH		Productivity	
			Before use of data acquisition System	After use of Data Acquisition System	Before use of Data Acquisition System	After use of Data Acquisition System	Before use of Data Acquisition System	After use of Data Acquisition System
January	0	20.96	9.45	37.23	4.5	4.7	0	0
February	53.8	22	13.63	38.13	4.3	4.4	0	0
March	21.4	27.41	12.33	34.55	5	5.4	55	94
April	27.2	33.17	12.78	40.19	4.5	4.5	70	104
May	509.4	31.48	40.35	40.35	4.7	4.8	135	149
June	826.8	32.27	58.9	58.9	4.5	4.3	150	160
July	446	33.62	44.63	44.63	5.5	5.5	152	163
August	879	31.36	63.41	63.41	5.9	5.7	164	170
September	572	31.55	40.82	40.82	4.5	5.1	170	159
October	12.2	30.7	16.32	36.13	5.8	5.5	100	145
November	0	27.1	9.13	33.51	4	4.4	65	140
December	0.8	22.24	8.1	34.17	4.8	4.7	0	0

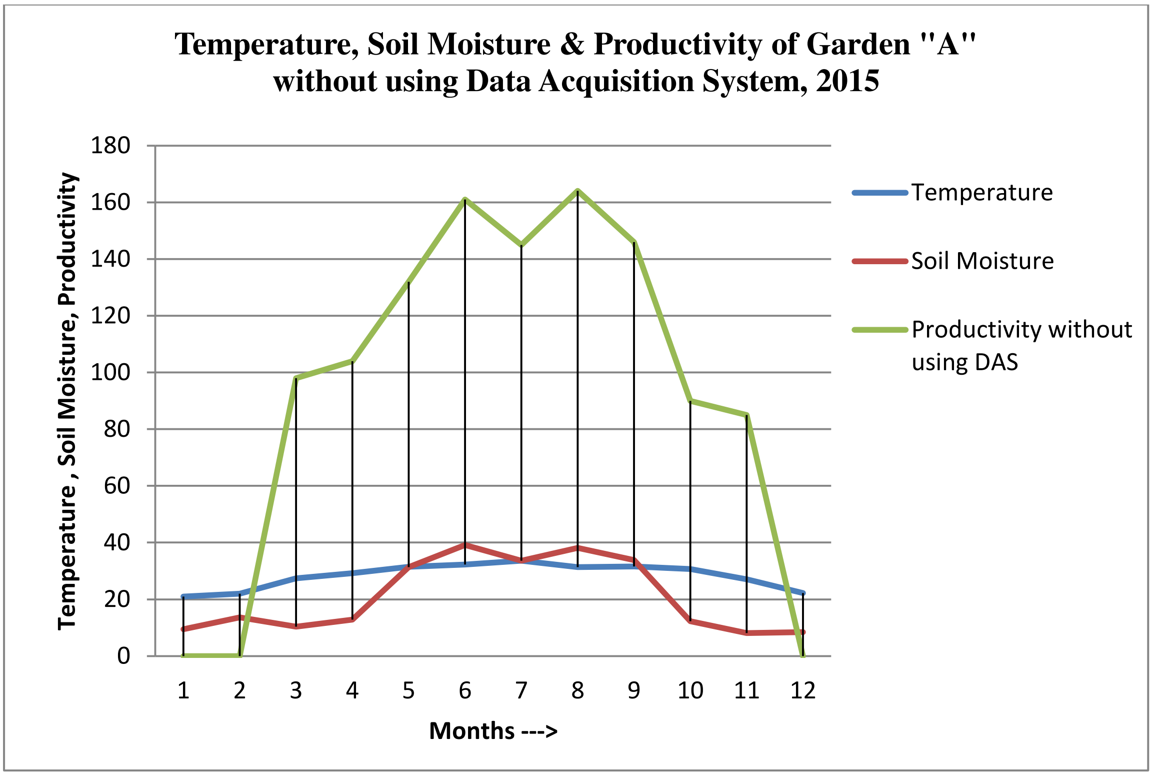


Figure 5.5: Graph for Temperature, Soil Moisture & Productivity of Garden "A" without using Data Acquisition System, 2015

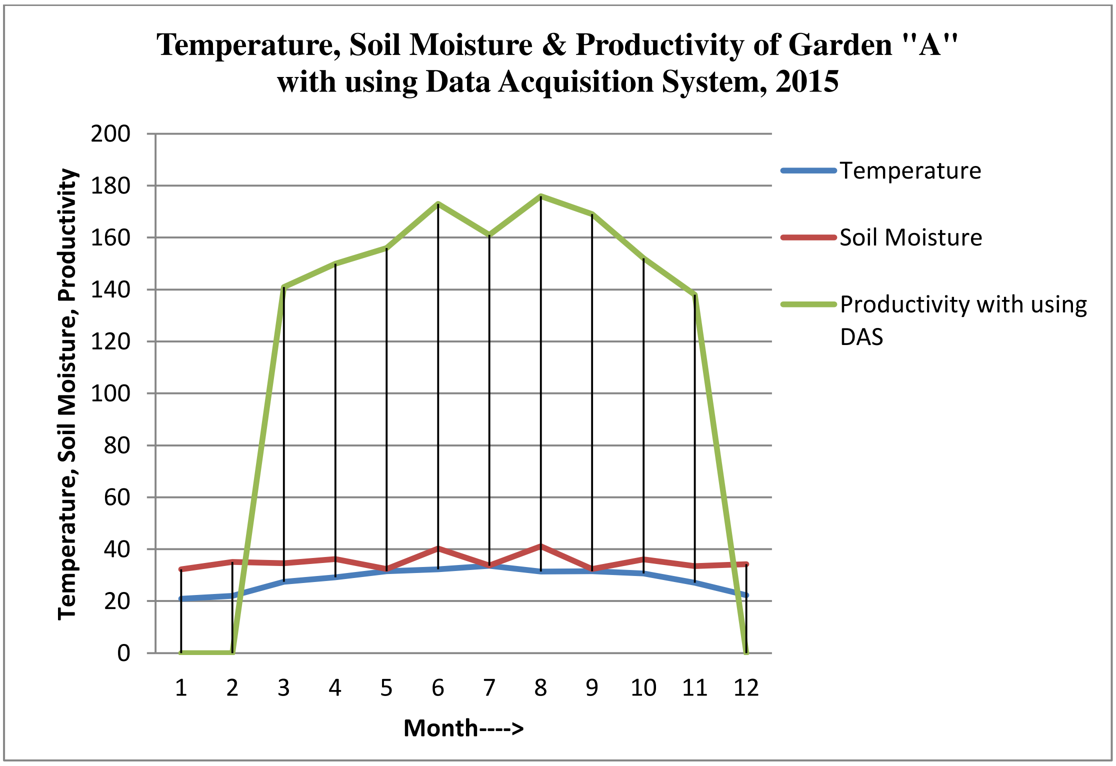


Figure 5.6: Graph for Temperature, Soil Moisture & Productivity of Garden "A" with using Data Acquisition System, 2015

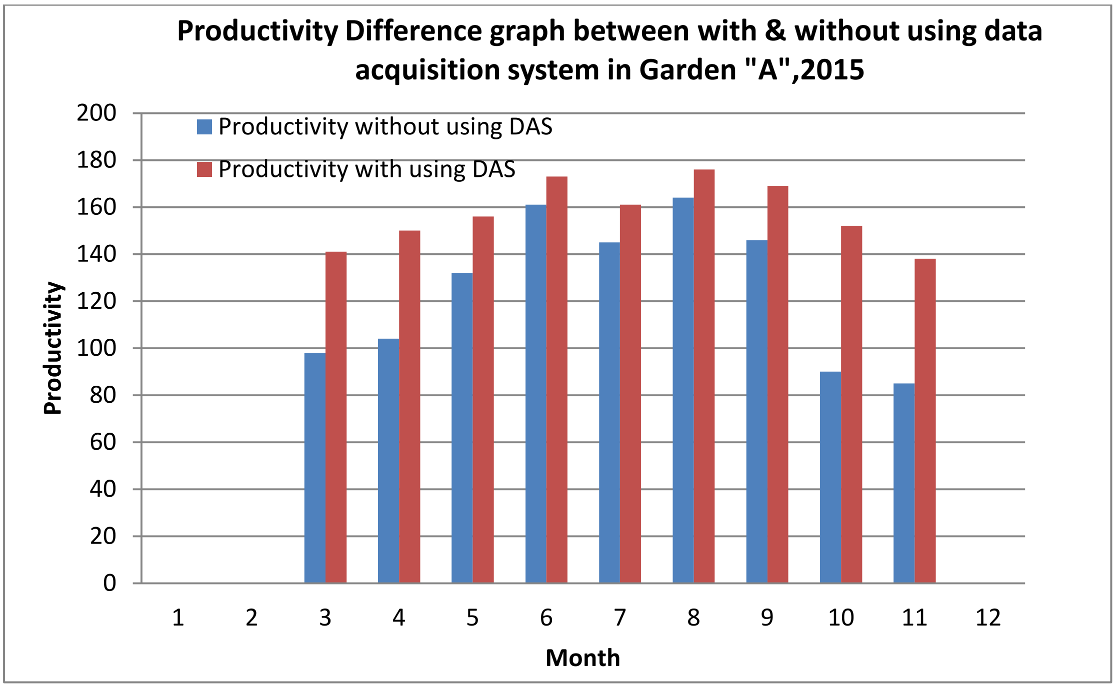


Figure 5.7: Graph for Productivity Difference graph between with & without using data acquisition system in Garden "A", 2015

Table 5.3: Table for productivity and different parameters are affected in Tea productivity in the year of 2016 (Garden –B)

Month	Rainfall (MM)	Temperature (c)	Soil Moisture		pH		Productivity	
			Before use of data acquisition System	After use of Data Acquisition System	Before use of data acquisition System	After use of Data Acquisition System	Before use of Data Acquisition System	After use of Data Acquisition System
January	9.8	21.37	9.08	38.08	4.6	4.3	0	0
February	1.2	23.75	8.23	33.23	4.8	4.9	0	0
March	43	28.94	11.56	33.11	4.2	4.4	61	140
April	188.8	29.62	20.79	35.15	4.5	4.5	82	153
May	576.6	31.51	31.77	34.77	5.5	5.3	150	152
June	1146.2	30.56	45.36	45.36	4.5	4.3	165	175
July	532.8	33.34	38.65	38.65	5	4.9	163	173
August	1155.2	32.06	46.37	46.37	4.9	4.6	166	176
September	310	31.81	29.49	36.49	5.2	5.4	143	162
October	2.4	31.63	12.86	34.54	5	5.6	82	159
November	7.4	26.36	9.84	33.13	5.5	5.5	70	138
December	16.8	21.81	10.22	34.22	5.6	5.3	0	0

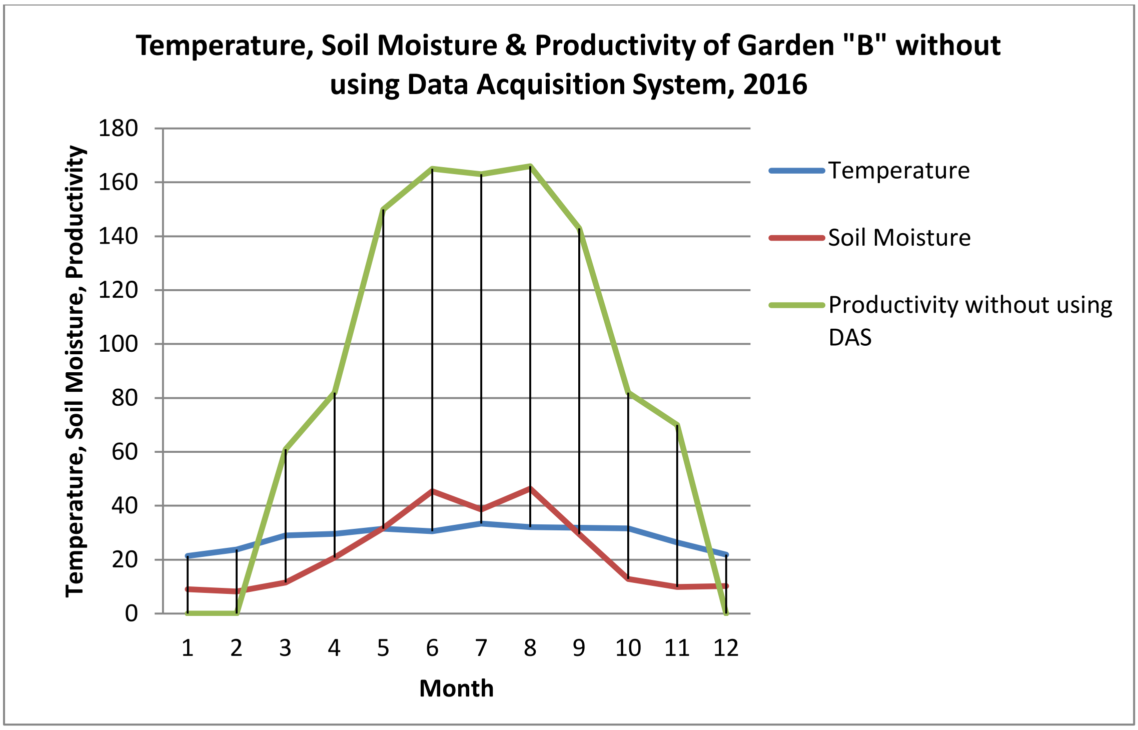
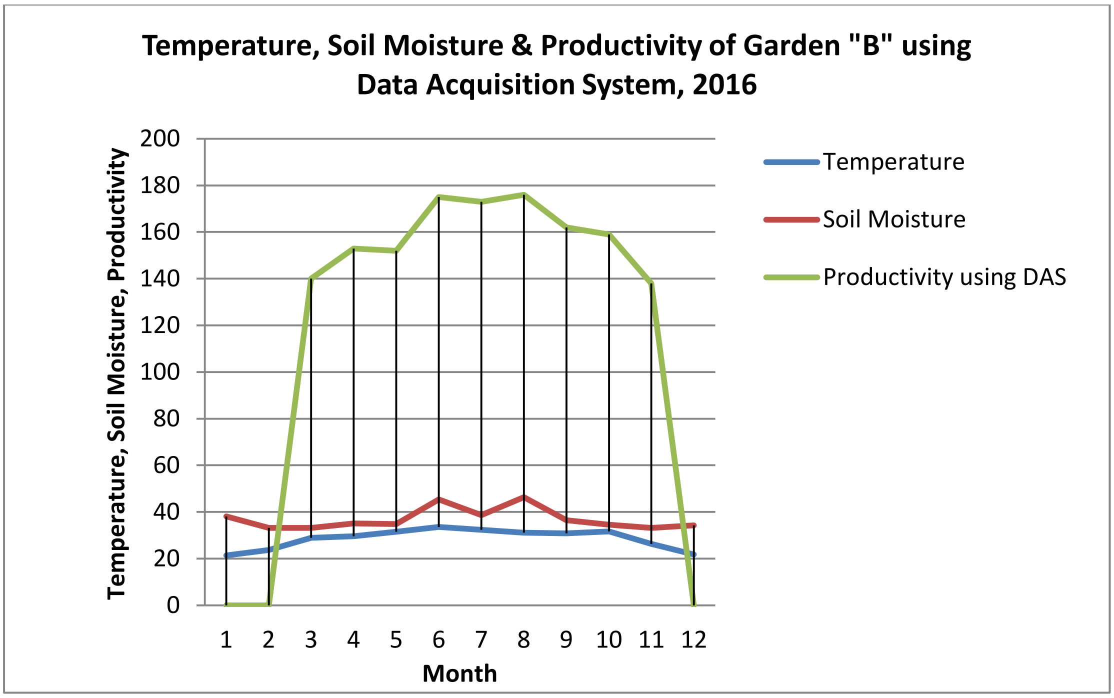


Figure 5.8: Graph for Temperature, Soil Moisture & Productivity of Garden "B" without using Data Acquisition System, 2016



Graph 5.9: Graph for Temperature, Soil Moisture & Productivity of Garden "B" using Data Acquisition System, 2016

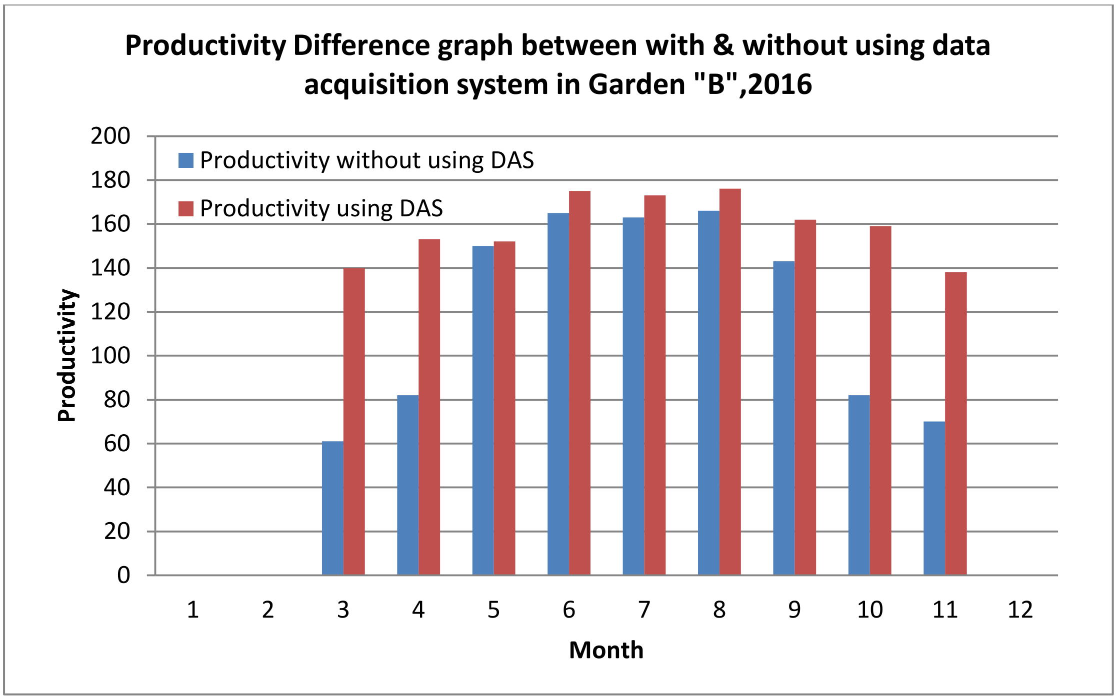


Figure 5.10: Graph for Productivity difference graph between with & without using data acquisition system in Garden "B", 2016

Table 5.4: Table for productivity and different parameters are affected in Tea productivity in the year of 2017 (Garden –C)

Month	Rainfall (MM)	Temperature (c)	Soil Moisture		pH		Productivity	
			Before use of data acquisition System	After use of Data Acquisition System	Before use of data acquisition System	After use of Data Acquisition System	Before use of Data Acquisition System	After use of Data Acquisition System
January	4.6	20.29	21.37	38	4.3	4.3	0	0
February	0	24.81	23.75	34.12	4	4	0	0
March	132.6	29.74	28.94	33.7	5.3	5.3	73	98
April	348.6	30.79	29.62	40.14	4.5	4.5	90	120
May	447.8	30.55	31.51	42.66	4.8	4.8	143	155
June	658	32.58	30.56	48.19	4.9	4.9	160	165
July	583.4	31.27	33.34	47.11	4.8	4.8	163	169
August	114.6	34.79	32.06	38.25	5.9	5.9	140	168
September	318.4	31.48	31.81	35.46	5.6	5.6	145	165
October	191.4	30.51	31.63	39.37	5	5.2	120	168
November	0	27.39	26.36	35.14	5.4	5.2	86	105
December	0	23.41	21.81	38.11	4.6	4.8	0	0

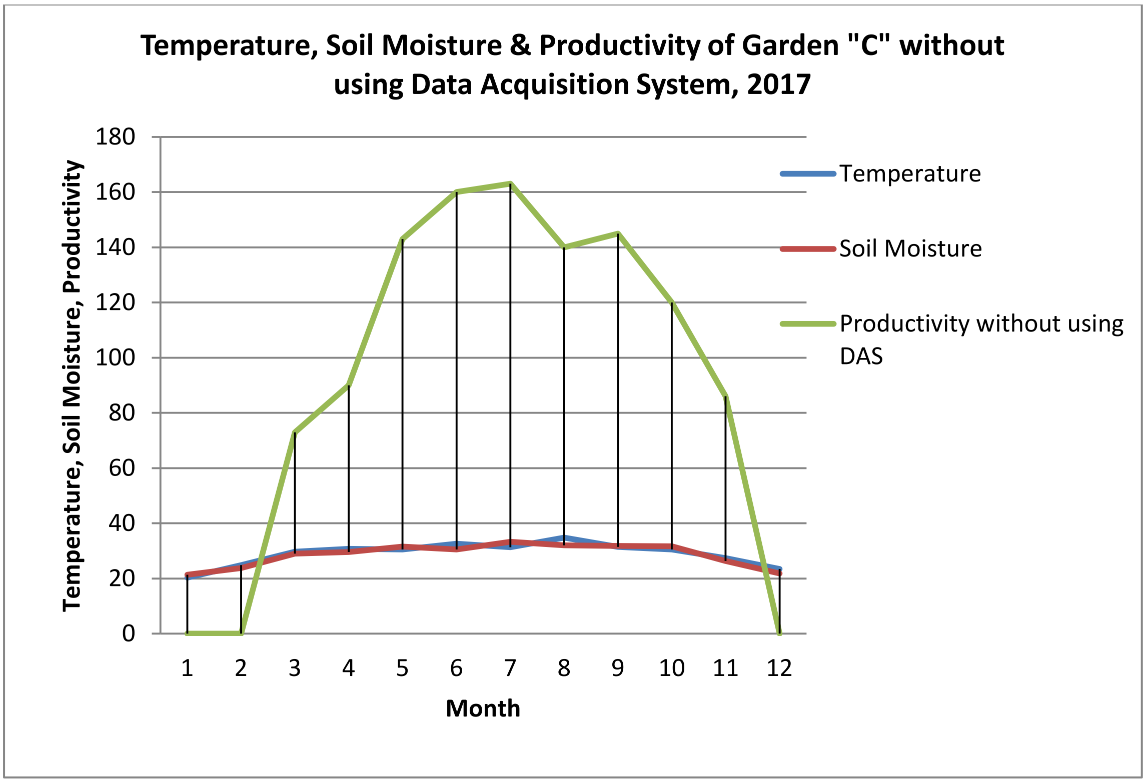


Figure 5.11: Graph for Temperature, Soil Moisture & Productivity of Garden 'C' without using Data acquisition System, 2017

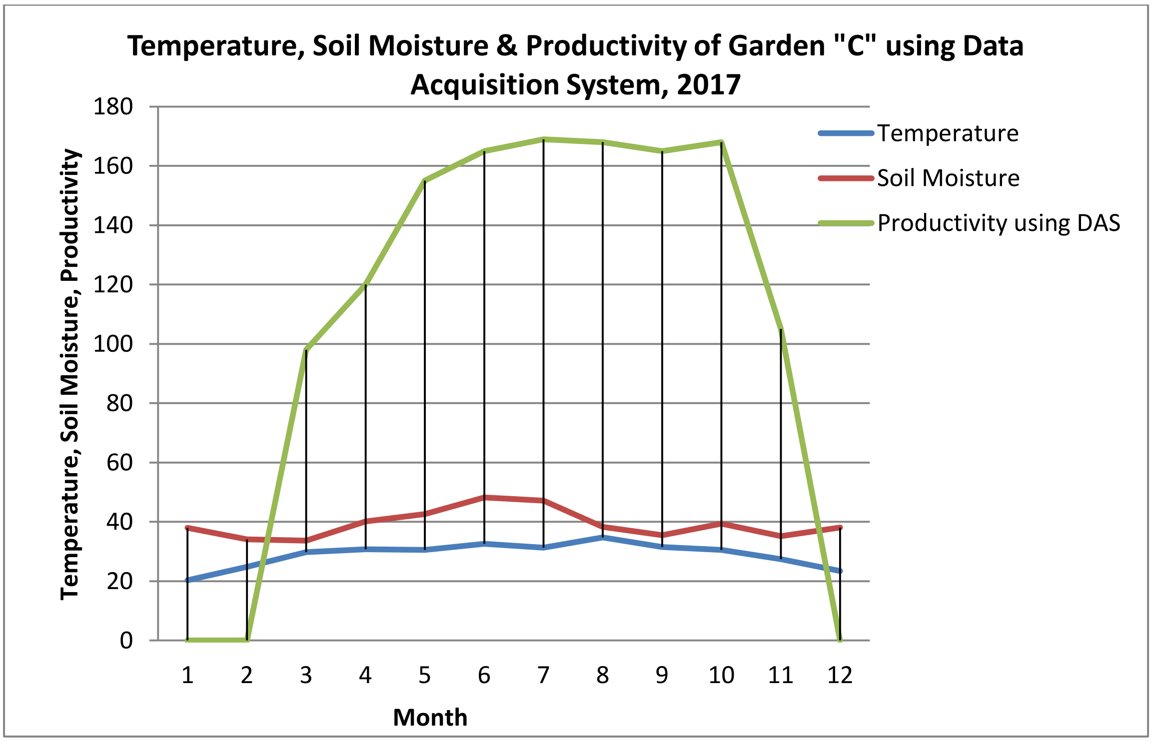
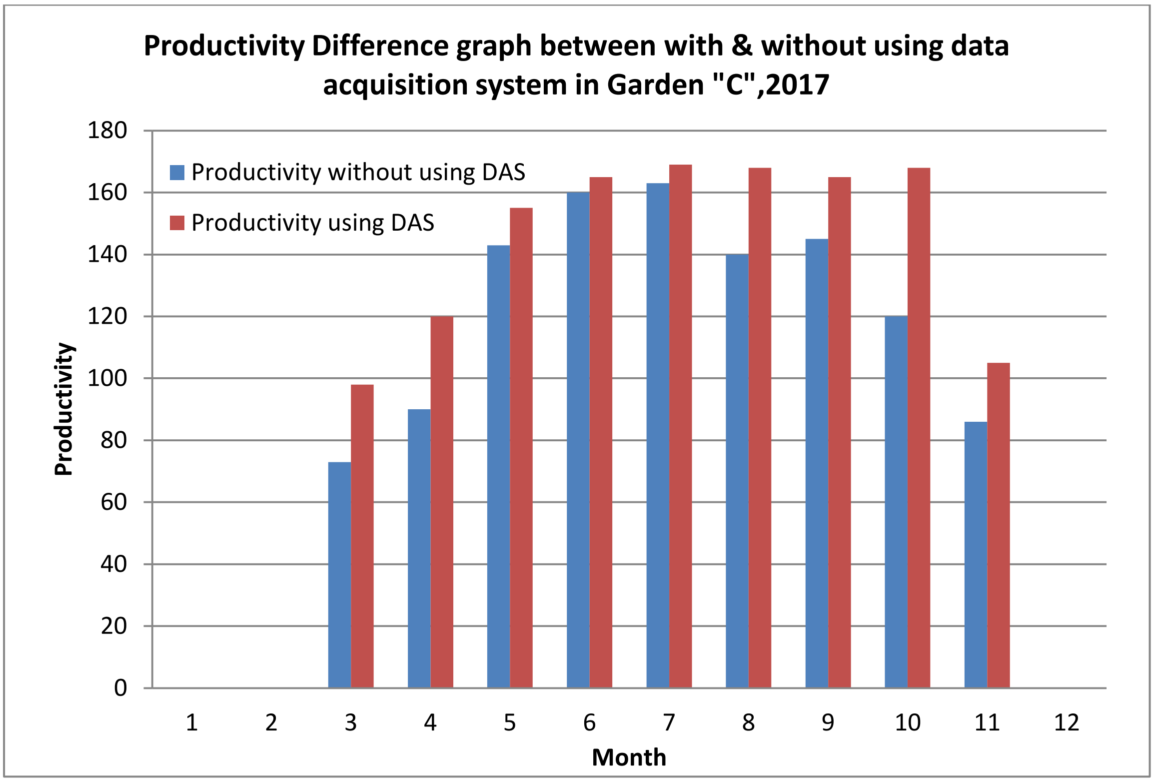


Figure 5.12: Graph for Temperature, Soil Moisture & Productivity of Garden 'C' using Data Acquisition System, 2017.



Graph 5.13: Productivity difference graph between with & without using data acquisition system in Garden 'C', 2017

5.3. ANALYSIS OF WITHOUT USING DATA ACQUISITION SYSTEM IN TEA GARDEN

In absence of adequate rainfall, moisture level drops and optimum productivity cannot be achieved due to lack of sufficient level of soil moisture. The solution would be a data acquisition system which help to sense soil moisture from soil and perform operations to raise level of moisture in soil sufficient for nourishment of plant. Without any data acquisition system real time monitoring and control operation of soil moisture cannot be achieved.

January February is considered non productive period proved to be true as there was no noticeable productivity. With start of March productivity starts to increase From March to April both moisture and surrounding temperature increases so increase in productivity is observed. April to May temp increases but drop in moisture is observed which resulted in production increase of 4-6% of last month. May to June temp and moisture both increases which result in maximum productivity of the year. June to July temperature increases but moisture falls, production drops although it's highest temperature of year highlighting that only temperature increase does not guarantee productivity. July to August moisture is at highest with second highest temperature gives highest productivity of year. August to Sept temperature is almost same but drop in moisture reduced productivity. Sept to October temperature drops moisture increased but productivity dropped suggesting only moisture without temperature cannot provide maximum productivity. October to November temperature moisture both dropped to lowest productivity of the month. November to December moisture increased but temperature further decreased resulting in un-noticeable productivity.

5.4 ANALYSIS OF USING DATA ACQUISITION SYSTEM IN TEA GARDEN

Jan Feb considered non productive period proved to be true as there was no noticeable productivity. Feb has more rainfall than Mar but due to nourishment from Feb rainfall productivity starts to increase. From March to April more rainfall increased moisture level thereby increasing productivity. April to May temp increases but tremendous rainfall increases moisture which resulted in production increase. May to June temp and moisture both increases which resulted in maximum productivity of the year. June to July temperature increases but moisture falls, production drops. July to August in fact highest rainfall of the month moisture is at highest with second highest temperature gives highest productivity of the year. August to Sept temperature is almost same but drop in moisture reduced productivity. Sept to October temperature drops moisture drastically dropped so productivity also dropped. October to November temperature moisture both dropped to lowest productivity of the month. November to December moisture and temperature further decreased resulting in un-noticeable productivity.

5.5 SUMMARY OF USING AND WITHOUT USING DATA ACQUISITION SYSTEM IN TEA GARDENS

The productivity has started to increase after the month of February. In the month of June, July and August the rate of production increase per month is in the range of 7-12% which is less compared to months of Feb March. Also these three months have highest productivity for the entire year. It highlights the optimum level of production has been achieved and hence expected productivity similar to February-March and September-November could not achieved, still 7-12% increase in productivity was observed every month because plant has optimum level of production.

This extra increase in productivity was observed in plot where Data acquisition system was maintaining water moisture in soil since January. We concluded some points using data acquisition system and without using data acquisition system during this study which is given below:

- With three years data captured on monthly basis, prepared by capturing average value every month for soil moisture, surrounding temperature, productivity and rainfall is applied to understand its effects on tea productivity. The careful observation helps to understand how productivity changes when plants surrounding change. With our main focus on change in soil moisture and surrounding temperature.
- When smart watering system is facilitated to plants even during non productive season, annual production found to be improved 25-30%.
- The practice of focusing on yearly productivity plan was found effective compare to monthly productivity plan.

- The monthly productivity after use of Data Acquisition was higher than monthly productivity before use of Data Acquisition system.
- The productivity data for three years show January February December months as non profitable productivity.
- The relation between soil moisture and productivity is directly proportional in the range of 25-40% because it was found that, at same temperature, month with high productivity has more soil moisture level compared to month with low productivity with low moisture level.
- Also beyond 40% of soil moisture productivity starts to saturate and no further increase of productivity is observed. However during this saturation phase productivity increase was directly proportional to surrounding temperature but magnitude of change is very small.
- In case of rainfall during a month, soil moisture naturally rises from its last level. In addition if in succeeding month there happens to be rainfall soil moisture further increases but if there is no rainfall in succeeding month soil moisture level drops from its last level. Also if for consecutive months same level of rainfall occurs then moisture level of two months in consideration remains almost same.
- It is also found that higher rainfall in previous month increases the soil moisture for next month.

From the statistical study on factors affecting production, the following points have to be discussed

- With usage of Data acquisition system the overall productivity of tea garden has achieved 20-25% increase in productivity
- In the month of December January February considered as off season is proved to be true as there was no noticeable productivity but this period is used for maintaining moisture level between 25-40% for the soil by the system for better productivity.

- Although maintain soil moisture between 25-40% is continued for Jan Feb March but there was no profitable productivity but with approach of March we observed rise in temperature which gave 25% increase in productivity
- Productivity is observed above temperature of 27 degrees
- April had higher temperature and moisture content so productivity jump of 14.2% is observed

5.6 SIGNIFICANCE OF DATA USING REGRESSION METHOD

To show statically the significance between soil moisture and productivity we are using tools of regression in MS-Excel. We test the data before use of Data acquisition system in garden and after use of data acquisition system in garden .

Table 5.5: Regressing Table for Soil Moisture in the year of 2015

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.908141101
R Square	0.82472026
Adjusted R Square	0.799680297
Standard Error	20.1333674
Observations	9

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	13350.75484	13350.75484	32.93616152	0.000706357
Residual	7	2837.467379	405.3524827		
Total	8	16188.22222			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	53.67974231	13.12975917	4.08840266	0.004640287	22.63279537
X Variable 1	1.919459674	0.334458702	5.73900353	0.000706357	1.128590515

Table 5.6: Regressing Table for Soil Moisture in the year of 2016

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.88519951
R Square	0.783578173
Adjusted R Square	0.752660769
Standard Error	21.78884838
Observations	9

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	12032.28	12032.28	25.34424	0.001506
Residual	7	3323.277	474.7539		
Total	8	15355.56			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	64.31676879	13.86557	4.638596	0.002374	31.52991
X Variable 1	1.658297174	0.329399	5.034307	0.001506	0.879392

Table 5.7: Regressing Table for Soil Moisture in the year of 2017

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.794971409
R Square	0.631979541
Adjusted R Square	0.57940519
Standard Error	21.86121077
Observations	9

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	5744.834	5744.834	12.02068	0.010447
Residual	7	3345.388	477.9125		
Total	8	9090.222			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-270.0854333	114.026	-2.36863	0.049706	-539.714	-0.45671
X Variable 1	12.87303375	3.712927	3.467085	0.010447	4.093358	21.65271

In the above regression summary table we observed that the value of P<=0.95 which indicates the significance between soil moisture and productivity.

HYPOTHESIS -1

Working Hypothesis: Data Acquisition System (Soil moisture) has influences the tea productivity in tea garden.

H_N: Data Acquisition System (Soil moisture) doesn't have any significance in Tea productivity in tea Garden.

H_A: Data Acquisition System (Soil moisture) has significance in Tea productivity in tea Garden.

After using the regression we got the value of P>=0.95 which indicates the significance between soil moisture and productivity. Therefore, there is overwhelming evidence at the confidence label 0.95. So the Null hypothesis (H_N is rejected and Alternate Hypothesis (H_A) is accepted. Hence Hypothesis1 is statically proved.

6

CONCLUSION & FUTURE SCOPE

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6.1. CONCLUSION

Tea gardens are spread over very vast area; this makes the task of monitoring and caring for plants a challenging one. Therefore the mandatory task of watering tea plants demands large amount of water, electric power and manpower. Moreover, water requirement of soil for different areas in tea garden are different. The inaccurate information about amount of water required for different plots results in insufficient and excess distribution of water in different plots; which in both cases is harmful for plants. It is evidently wastage of water and electrical power in tea gardens, happening in areas as vast as tea gardens, results in huge wastage of natural resource and energy. Moreover, till date, there has been no tool developed that monitors the health of garden soil; no attention has been paid in soil condition of tea garden which directly affect the quality and productivity of tea estate. Therefore an intelligent platform with facilities for statistical analysis; of soil condition in the past will positively drive the decision making process, in long term planning, in favor of tea industry.

In this proposed study, the technique is designed to operate automatic irrigation system for tea plants on the basis of the soil moisture. Depending upon the soil moisture of the tea garden the system will decide to supply proper amount of water to tea plants. This is for proper utilization of the water which is one of the natural resource. This study also 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 value, 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 this system can also provide a platform with multiple functions like data logging, GSM based and web based monitoring system.

6.2 FUTURE SCOPE OF THE STUDY

A data acquisition system is designed and developed through this study to use in tea gardens to fulfill some tasks smartly instead of manual and conventional ways. This thesis will cover three major parts of that data acquisition system to be used in tea gardens. These three major parts are responsible to perform three major tasks, namely recording, monitoring, and controlling of soil moisture present in the tea garden. The distinct scopes to be extracted from this study are drawn below:

1. The constant monitoring facilities of the system will give scope to preventive the role from future draught situation hence may be used in draught control.
2. The ability of recording data of the system leads towards some other research fields with reference to level of soil moisture and its effects on the tea plants.
3. Using the system gives growers more control over their irrigation by delivering accurate data on field and crop conditions, thereby lowering their costs and raising their yields (and in theory, earning a higher profit from their operations). The access to real-time data on the state of the plants and the levels of moisture in the soil, right from a Smartphone or browser, allows users to control and monitor their system for optimal irrigation scheduling.
4. A GSM unit that sends whole day summary of data acquired to the concerned person in-charge of tea estate through an SMS and its also notifying the indication of not working node of the system.
5. The Data Acquisition system may be applied to other plant species to understand various relations with productivity.
6. The Data Acquisition system can be used to monitor and control soil parameters other than soil moisture using appropriate sensor as per requirement

7. Soil parameter like NPK detection in soil may also be achieved with Data Acquisition system.
8. Pest control system may be achieved because DAS is capable in sensing, storage and data processing with Web based program.
9. Production forecast may be developed using the productivity-soil moisture and temperature relation obtained from this research with yearly data, precision will be as high as amount of data increases.
10. Using AI, the system can be trained more precisely using collected data from data acquisition system.

6.3. MAJOR CONTRIBUTION OF THE THESIS

1. Design a model of WSN
2. Design a database which handled the sensor collected data from the field.
3. Design a GUI for user, from which user can communicate easily with the hardware and software.
4. Design a World Wide Web based monitoring and controlling system.
5. Analysis of protocol available for low energy power consuming protocols and fast transferring in the scope of wireless sensor network.
6. Analysis about the correlation between productivity of tea and different parameters of tea production.

6.4 RECOMMENDATIONS

Based on the findings of the study, the following recommendations are made for future research

- This study has demonstrated the importance of monitoring and control of parameters used to utilize the optimum level of production with tea plants.

- Further green house environment experiments are required to study about effects of temperature on productivity for different species of tea plant.
- The analysis performed so far, the conclusion and solutions associated with this research need to be communicated to growers, manager and owners of tea state so they can reap the benefits.
- Efficient watering techniques should be explored and adopted if applicable as old techniques used for tea gardening water has not utilized the maximum productivity.

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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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Available online at: www.ijcseonline.org

***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-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

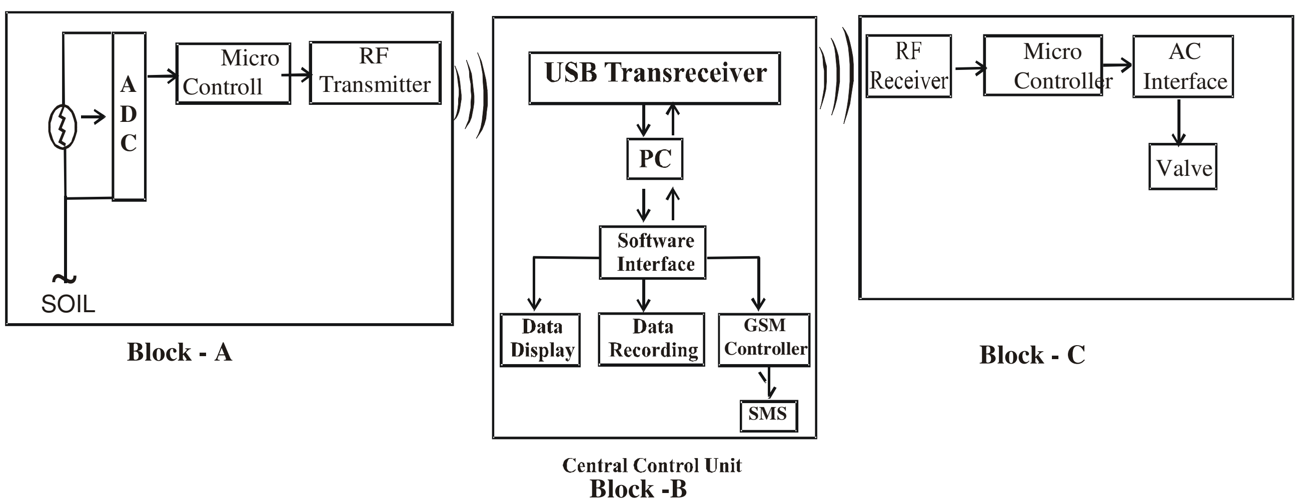

Figure1: Block diagram for Automatic watering system

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

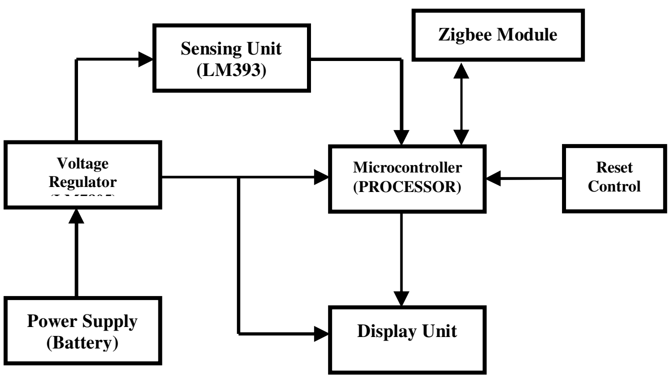

Figure2 : Block diagram for soil moisture sensor

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.

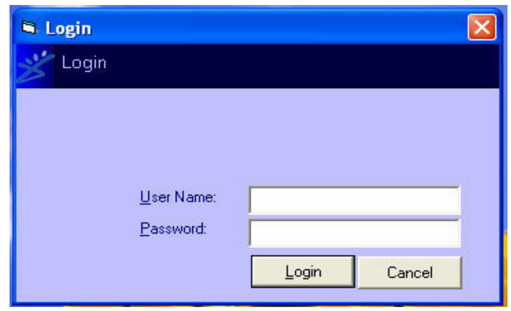

Figure3 : Login Window

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.

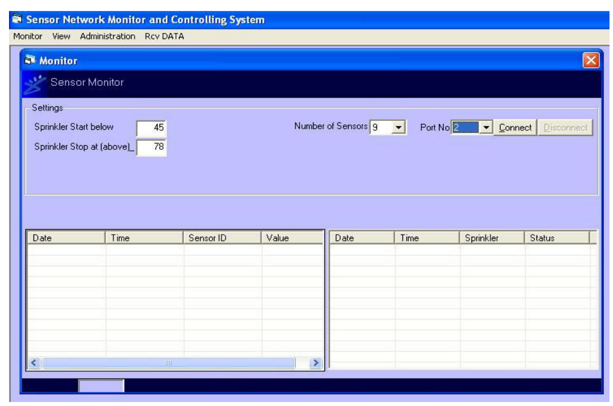

Figure4: Sensor data monitoring window

Sensor Data Log

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

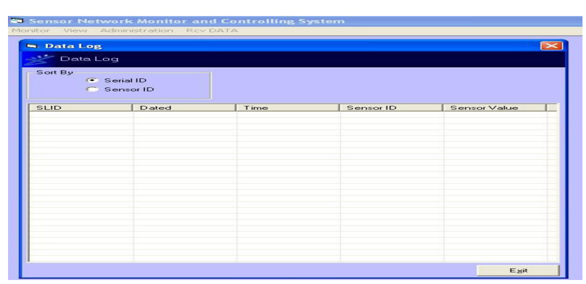

Figure5 : Sensor data log

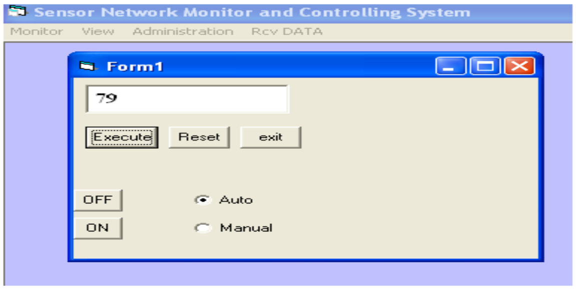

Figure6: *Sprinkler controlling window*

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.

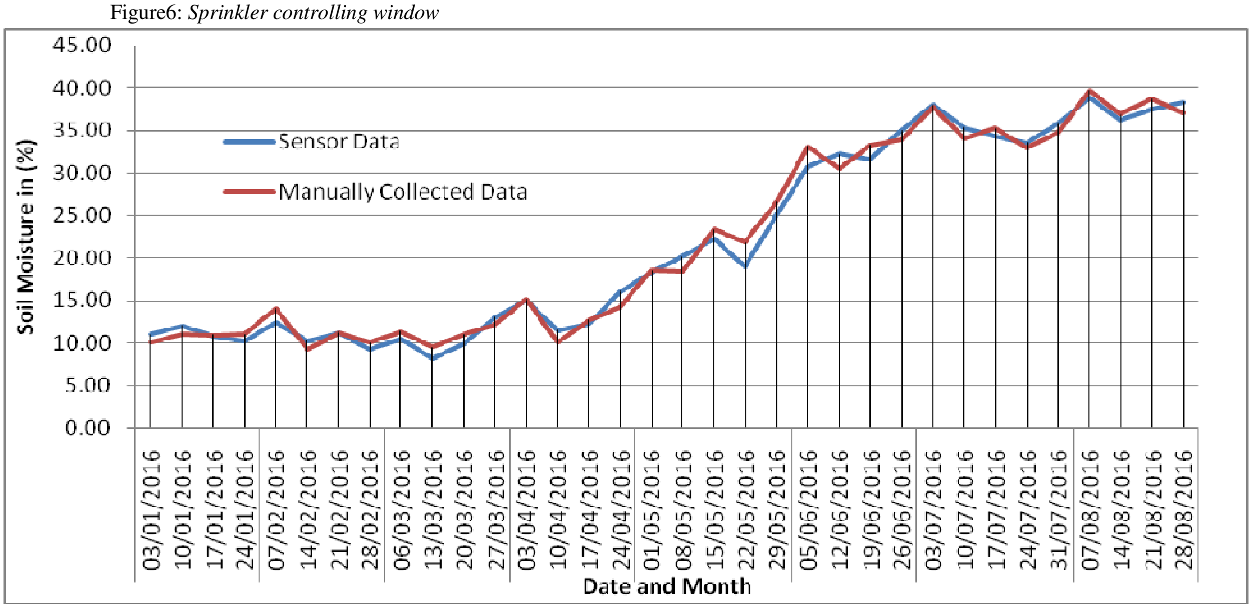

Figure7 : Comparison of sensor generated and manually collected soil moisture data in tea garden

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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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.

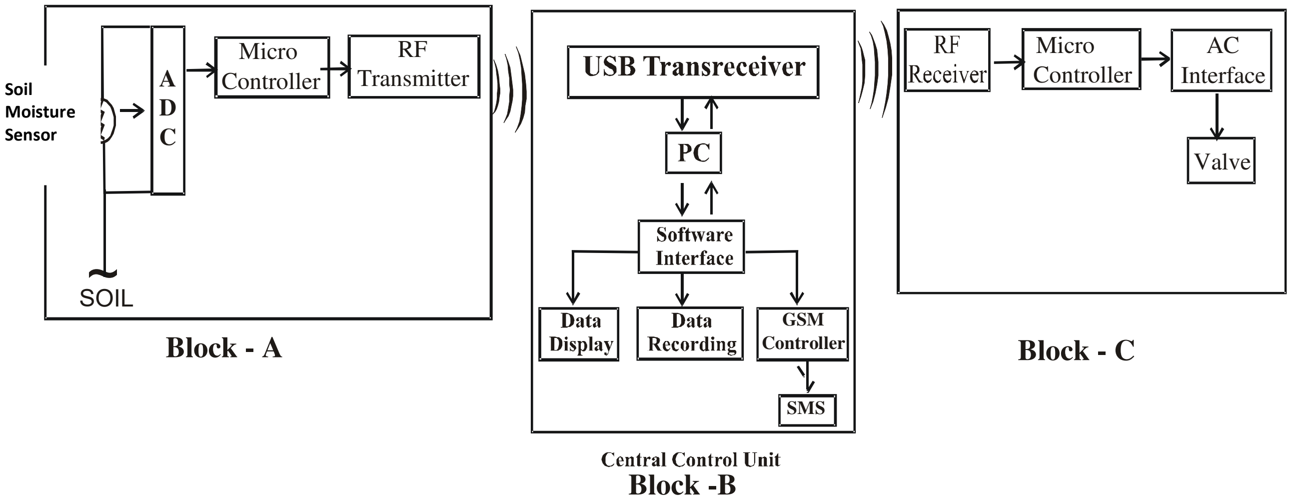

Fig 1: ***Block Diagram of Smart Watering System***

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