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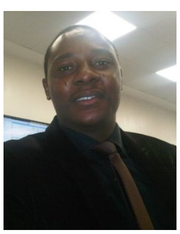
Author's Brief



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Remote Monitoring and Data Acquisition Model Of Agro-Climatological Parameter for Agriculture Using Wireless Sensor Network

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ABSTRACT

This paper X-rays the use of Wireless Sensor Network in Monitoring Agricultural and Environmental parameters using Wireless Sensor Network for the purpose of acquiring data and also and also feedback when any of the parameter goes below or beyond the threshold level, so has to optimise crop yield . The systems focuses on extreme monitoring and measurement of variables like temperature, humidity, and soil moisture content with a view to providing information with regards different stages of the plant growth in the farm. Wireless Sensor network was used to collect data for onward transmission via satellite Communication system. Object oriented analysis and design was used to development an efficient database by employing JAVA and ORACLE Software's which manages and queries the database. A faulty node localization and detection method was developed using artificial neural network The result of the parameter captured were viewed via the dynamic graph plotter from a C-Sharp software interface

Keywords : Wireless Sensor Network, Satellite Communication, Precision Farming, Agriculture.

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1. INTRODUCTION

Agriculture is one of the most ancient activities of man in which innovation and technology are usually accepted with difficulty, unless real and immediate solutions are found for specific problems or for improving production and quality. Nevertheless, a new approach of gathering information from the environment could represent an important step towards high quality and eco-sustainable agriculture. Nowadays, irrigation, fertilization and pesticides management are often left to the farmer's and agronomist's discretion: common criteria used to guarantee safe culture and plant growth are often giving a greater amount of chemicals and water than necessary. There is no direct feedback between the decision of treating or irrigating plants and the real effects in the field.

Plant conditions are usually committed to sporadic and faraway weather stations that cannot provide accurate and local measurements of the fundamental parameters in each zone of the field. Also, agronomic models, based on these monitored data, cannot provide reliable information. On the contrary, agriculture needs detailed monitoring in order to obtain real time feedback between plants, local climate conditions and man's decisions. to fulfill this requirement we need the environmental parameter sensors, such as Temperature sensor, humidity sensor, evapotranspiration etc. All these sensors can be connected to server or sink node without wire. Such a network is called Wireless Sensor Network. This network can help to monitor and control all the environmental parameter of Precision Agriculture and there after transmitted to any part of the world via Satellite link [1].

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There is need for more concern for farms and farmers, more advanced research in available recent agricultural technologies, more automation, and more testing and applying of new methods of study, analysis, and mechanization. This paper studies the application of Precision Farming, which is emerged as a management practice with the potential to increase profits by utilizing more precise information about agricultural resources through sensing and communication technology.

They also observed that, in early stage of WSN, farmers were reluctant to deploy it, because of high cost. Technological development has reduced the cost. In addition to MEMS technology for hardware, some other technologies like, satellite sensing, Remote Sensing, Global Positioning System and Geographical Information System are also contributing in overall progress [3]. Precision Agriculture model consist of Wireless sensors to assist for spatial data collection, irrigation control model, Arrangement for supplying information to farmers, Variable-rate technology model. In spatial data collection, a mobile field data acquisition system is available to collect useful data for crop management [7].

The system consist of a data collection instrument, a manager vehicle, data collection and control systems on farm machines. This system can handle local field survey and collects data of soil water availability, biomass yield, soil compaction, soil fertility, leaf area index, leaf temperature, leaf chlorophyll content, local climate data, insect-disease-weed infestation, plant water status, and yield of grain etc.The precision agriculture control system is develop by using wireless sensors and can be scheduled to work on-site as per remotely sensed data for a particular application.

The Variable-rate technology is available to determine the quantity of fertilizer to be used for tree crops. In this system, real-time sensor data acquisition console and GPS with input model are the integral part. This collected data can supply to farmers by using web server. This contains information on pesticide, disease infestation and climate forecasts which can download directly via Internet. Finally, the control can be achieved through WSN via Ethernet connected to the central PC of a remote network . Bluetooth technology can be different for some fields to collect environment data from a sensor network and transmit to a central control system. This type of remote control technology significantly improves productivity and reduces the labour cost.

2. ECOLOGY

Ecology is the study of living things and relationship with environment Interdepence:

(i) Non Living things and non living factors
(ii) Living and living
(iii) Non living and living

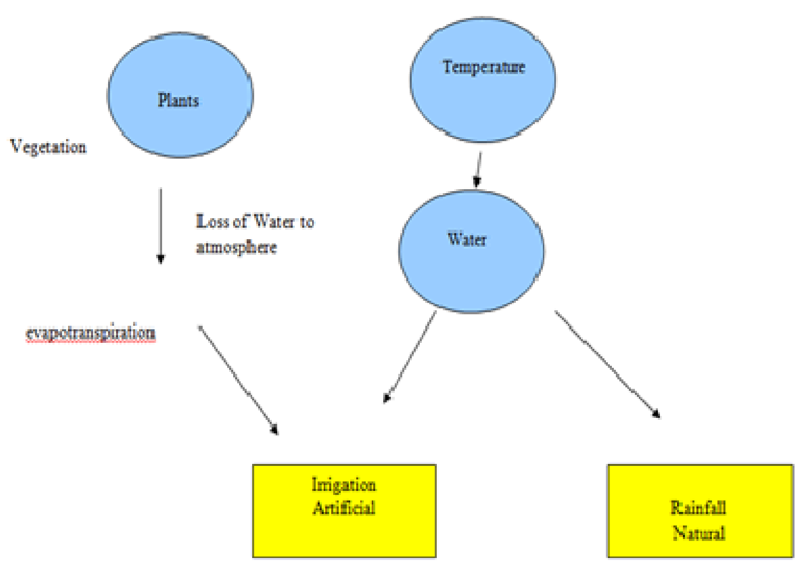

Figure 1 Temperature and water Cycle

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Vegetation Zones in Nigeria

1. Arid
2. Grassland
3. Forest
4. Marsh
5.

Table 1 Vegetation snd Climatic property

MARSH	FOREST	GRASSLAND	ARID
Formed from splash water bodies	Excess rainfall (Minimal temperature)	Temperature range slightly higher that forest	High temperature Little or no rainfall

3.1 Optimum Temperature Range For Maximum Yield In Plant

The following are the temperature requirement for some selected plant growth

21– 30 ^{0}C -------------------- Maize
25 – 30 ^{0}C -------------------- Rice
30^{0}C -------------------- Sorgum
20 -- 28^{0}C -------------------- Wheat
25 -- 30^{0}C -------------------- Yam
17^{0}C -------------------- Irish Potato

4. IRRIGATION

Irrigation is the application of water to the soil to supplement natural precipitation and provide an environment that is optimum for crop production. When moisture content goes below the threshold moisture value of 20mm , the Wireless sensor system senses and can transmit signal to the automated irrigation system and water will be supplied to the field, to get the soil moisture content level to required value of 40mm, however the process require evapotranspiration as shown in the equation below.

$$ET = I + P \pm \Delta S \pm \Delta R \pm \Delta D$$ … Water balance equation

I – Irrigation
P – Rainfall
ΔS – Soil moisture
ΔR – surface run off
ΔD – Percolation (Underground water)

The software output interface CROPWAT 8.1 in figure 2 is a result of data collection from a field via the Internet for monitoring of agricultural and climatic parameters.

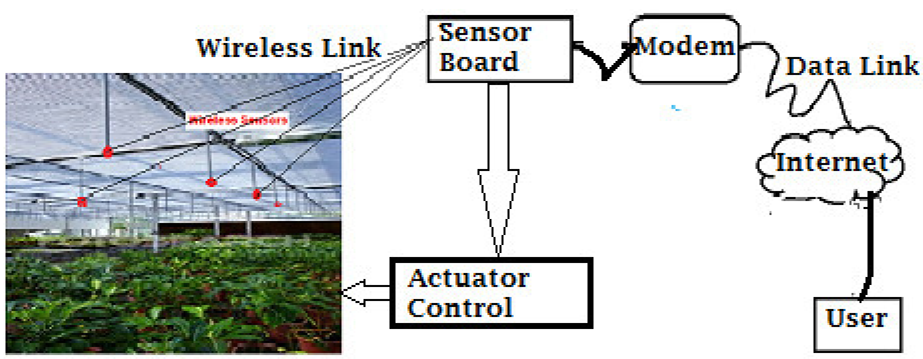

Figure 3 Wireless Sensor Gravity Fed Water Systems[1]

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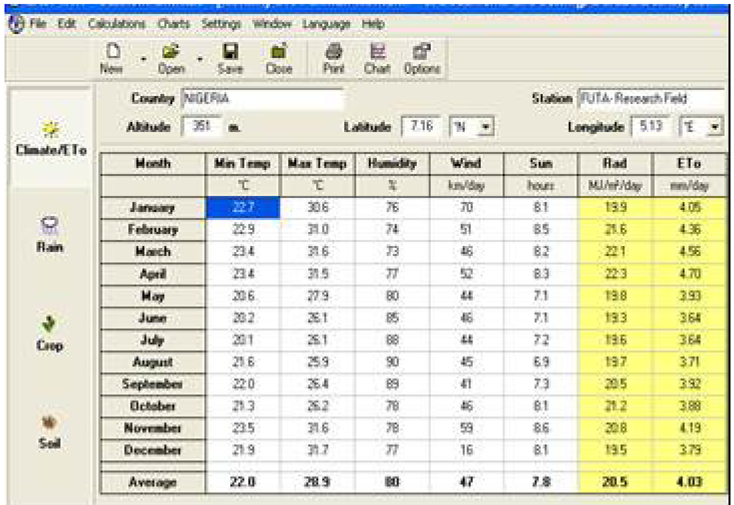

Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day
January	22.7	30.6	76	70	8.1	19.9	4.05
February	22.9	31.0	74	51	8.5	21.6	4.36
March	23.4	31.6	73	46	8.2	22.1	4.56
April	23.4	31.5	77	52	8.3	22.3	4.70
May	20.6	27.9	80	44	7.1	19.8	3.93
June	20.2	26.1	85	46	7.1	19.3	3.64
July	20.1	26.1	88	44	7.2	19.6	3.64
August	21.6	25.9	90	45	6.9	19.7	3.71
September	22.0	26.4	89	41	7.3	20.5	3.92
October	21.3	26.2	78	46	8.1	21.2	3.88
November	23.5	31.6	78	59	8.6	20.8	4.19
December	21.9	31.7	77	16	8.1	19.5	3.79
Average	22.0	28.9	80	47	7.8	20.5	4.03

Figure 2: Data collection Climatic Parameters CROPWAT 8.1 software Version

4. WSN APPLICATION TO IRRIGATION AGRICULTURE

Precision farming real implementations will arrest and come up with the development and associated attack of the crop depends strongly on the climatological conditions within the field; temperature, relative humidity, precipitation, wind strength and direction, and the height of the groundwater table are the environmental parameters sensed in this project; the WSN data and statistics are sent to a field gateway then to the gateway (a simple PC for data logging) via wireless connection, then through a wired connection .

The paper introduces a wireless sensor network. Data acquisition from sensors placed at different locations in crop field where the intended characteristics of the soil or atmosphere (temperature, soil moisture, electrical conductivity, soil temperature) need to be captured, the actuation is done based on the readings supplied by the sensors, upon exceeding a threshold, the system will generate automated alert messages on the console, upon which appropriate action can be taken.[4]. A preliminary design on the development of WSN for paddy rice cropping monitoring application in Irrua edo state is introduced, standard measurement parameters sensors such as ambient air temperature and humidity, soil pH and moisture are integrated in all nodes, there are two directions the data will go, which is first linked to server data based system to be recorded and revealed on an area Local Area Network or Wide Area Network.

A WSN based on Zigbee is proposed for monitoring a field-environment factors in an automatic manner and dynamic transmitting the measured data to the farmer or researchers; the main part of the network acquiring unit mainly includes the sensors of temperature and moisture in air and soil,

5. PRECISION AGRICULTURE

Figure 2 is a typical application of Satellite in monitoring agricultural environmental parameters **u**sing wireless sensor networks within the agricultural industry is increasingly common. Gravity fed water systems in figure 3 can be monitored using pressure transmitters to monitor water tank levels, pumps can be controlled using wireless I/O devices, and water use can be measured and wirelessly transmitted back to a central control centre.

Remote Data Acquisition (Da)
Data acquisition from the crops in the farms is collected and modeled based on the information collected from the plant bearing in mind the parameters like temperature and humidity control problems as it affects evapotranspiration.[6,11]. Precision farming (PF) is the ability to handle variations in productivity within a field and maximize financial return, reduce waste and minimize impact of the environment using automated data collection, documentation and utilization of such information for strategic farm management decisions through sensing and communication technology. Several technologies were used in the Precision Farming (PF) such as Remote Sensing (RS) Global Positioning System (GPS) ,and Geographic Information System (GIS) . The most important step in PF is the generation of maps of the soil with its characteristics. These included grid soil sampling, yield monitoring, and crop scouting. RS coupled with GPS coordinates produced acurate maps and models of the agricultural fields.

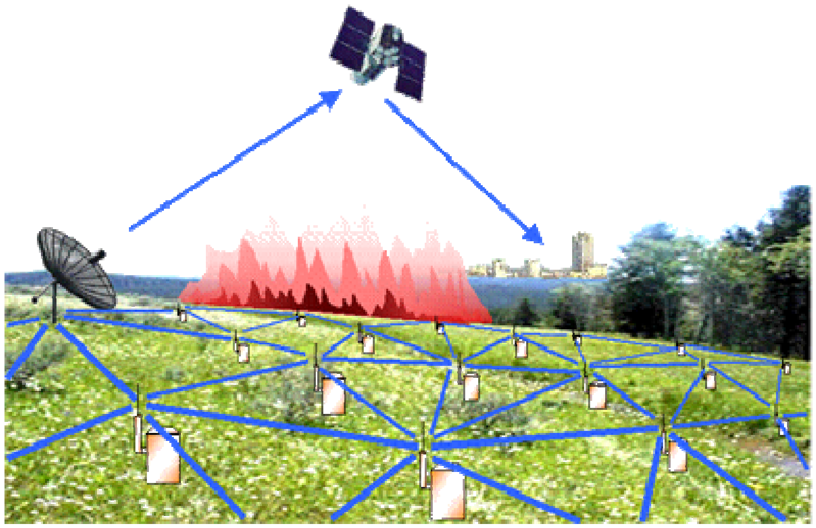

Figure 4: Node Block Structure[2]

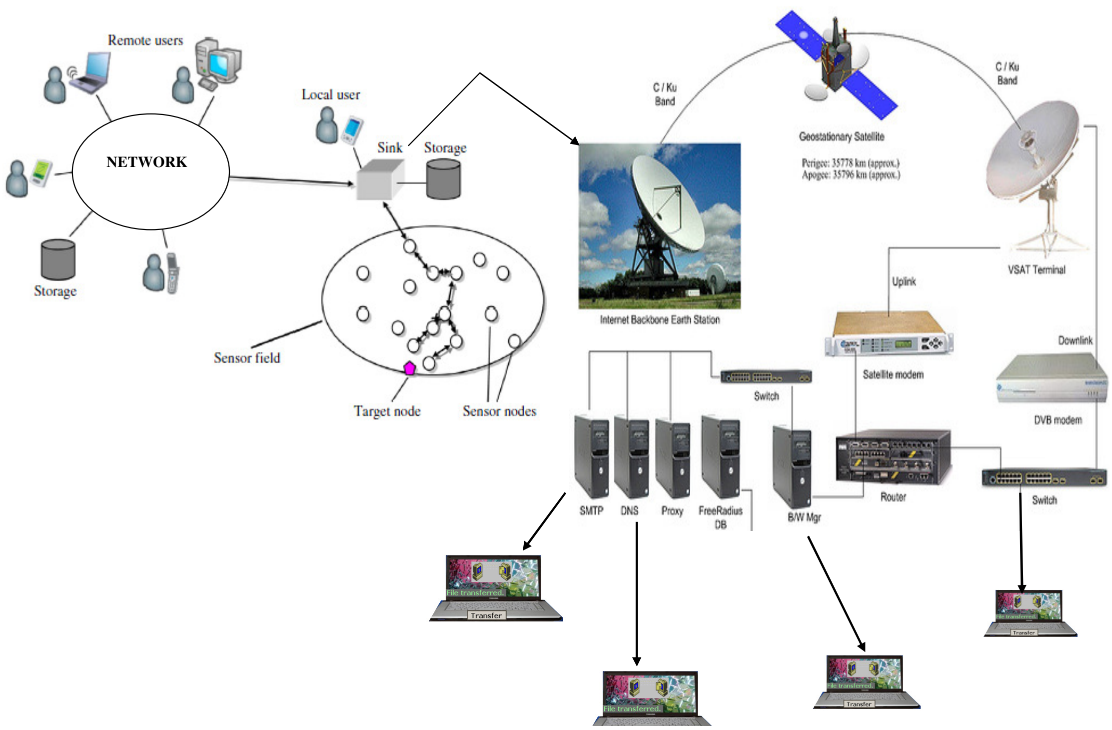

Figure 5: Data Acquisition Model

4.4 Mathematical Modeling of the New Data System

By analysis the Sensor data acquisition model of figure 5.0 could be represented thus:

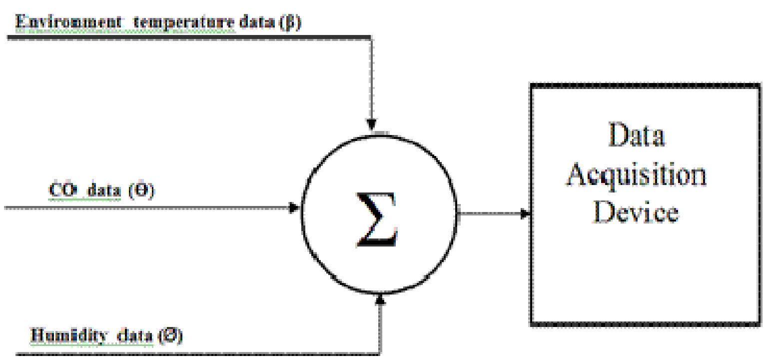

Figure 6: Mathematical Modeling of Data Acquisition

The acquired data (A_d) is a composite sum of the temperature β, Soil Moisture content Θ, and the Humidity Ø Hence the total acquired data is:

Ad = P + E + I ------------------------------ (1)

The effects of the unknown could be negligible in some cases but can be tremendous in others and can be found with regression analysis.

The Sensor O is a function of three main factors, Temperature *P*, its Humidity I, Moisture content *E*, such that:
$Ø = f(P, E, I)$ ---------------------------- - - - - (2)

P and *E* may be composed of different locations and conditions which are dependent on the type of environment in which the operation is carried out. And is a function of the following

That is,
$P = P_1 + P_2 + P_3 + - - + P_{n-1} + P_n$ - - - - (3)

And

$E = E_1 + E_2 + E_3 + - - - - + E_{r-1} + E_r$ - - - - (4)
Where,
$n = 1, 2, 3, 4, - - - - - -$
$r = 1, 2, 3, 4, - - - - - -$

The Sensor is to measure a number of operational points (*n*), the environmental readings (*r*) and the time of usage (*t*).
Therefore,

$$f(P) = \sum_{i=1}^{n} \sum_{j=1}^{t} P_{ij}$$ ---------------------------- (5)

And

$$f(E) = \sum_{i=1}^{n} \sum_{j=1}^{t} E_{ij}$$ --------------------------- (6)

Recall that,

Ø = *f*(*P*,*E*,*I*)

Ø = *f*(*P*) + *f*(*E*) + (*I*) ------------------- ----- (7)

Thus,

$$Ø = \sum_{i=1}^{n} \sum_{j=1}^{t} P_{ij} + \sum_{i=1}^{n} \sum_{j=1}^{t} E_{ij} + f(I)$$ ---- *(8)*

Again, the environmental condition β is affected by sensor M and E. The environmental could therefore be represented thus, M is a sum function of all the sensors releases and E is as defined in equations (4) and (6).

Hence,
$M = M_1 + M_2 + M_3 + \text{--} + M_{2-1} + M_2$ ---- *(9)*

Where,
j= 1, 2, 3, 4,– – – – – – – 10

The higher the number (l) of the data is releases to the environment the higher the number of data released over time.
Thus,

$$f(M) = \sum_{i=1}^{1} \sum_{j=1}^{t} M_{ij}$$ ---------------------------- (11)

From equation (9)
$\beta = f(M) + f(E)$ ----------------------------- *(12)*

Combining equations 12, 11, and 6, therefore,

$$\beta = \sum_{i=1}^{1} \sum_{j=1}^{t} M_{ij} + \sum_{i=1}^{r} \sum_{j=1}^{t} E_{ij}$$ ....*(13)*

Equation 13 clearly shows that data should be acquired from the internal Processes of operation, the external environment to the whole parameter been monitored.

$\beta = f(M, E)$ ------------------------------------ *(13.1)*

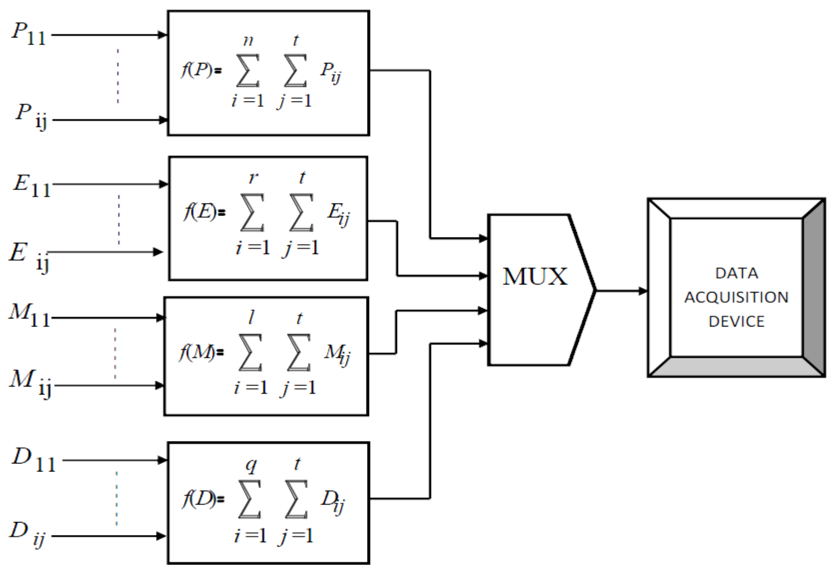

Figure 7: Distributed Mathematical Model

Thus,

$$Ad = \sum_{i=1}^{n}\sum_{j=1}^{t}P_{ij} + \sum_{i=1}^{r}\sum_{j=1}^{t}E_{ij} + \sum_{i=1}^{1}\sum_{j=1}^{t}M_{ij} + \sum_{i=1}^{q}\sum_{j=1}^{t}D_{ij}$$

$$Ad = \sum_{i=1}^{t}\ \sum_{i=1}^{n}P_{ij}\ \sum_{i=1}^{1}\sum_{j=1}^{t}M_{ij} + \sum_{i=1}^{q}\sum_{j=1}^{t}D_{ij}$$

Note *P,E,M,D* all represent sensor acquiring different data from the field. While Ad stand for aquired data . The idea is sum of all data collected from different sensors.

Figure 7 represent is a diagram representing all data acquired through the multiplexer.

Mathematical model were evolved from the data obtain and the correlation were calculated as seen in figure 9, the model in equation 14, 15 and 16.

P = 1909.02t + 1022 ……..14
E = 4.08t + 1022.7 ……… 15
I = 25.08t + 1023.7 ……... 16

Figure 7 shows a more detailed representation of acquisition process initially depicted in figure 6.

It could be seen from this representation that the acquisition process is a sum collection and processing of all data form for storage and analysis in order to effect probable changes. This therefore forms the hardware platform for the model on which any desired DA can be built.

8. MONITOR VIA DYNAMIC PLOTTER

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Figure 8 displays the variable as shown by the graph in the monitor. The graph shows a dynamic graph plotter for sensor 1, sensor 2, and sensor 3 as deploy to various farm location, with the aid of the sensors. Other means of monitoring via the graph were also used with the aid of Graphical Crystal Display GLCD in figure 9. The database software interface shown in figure 10 and 12 is a process for data collection, while graph shows the data as generated from the field, is a result of event in different farm locations.

9. DATABASE MANAGEMENT SYSTEM
4.5 DATABASE ALGORITHM

Start
Count(i) = 1
Read temperature sensor node
Read CO Sensor node
T = 1
J = 1
Read Time
Get Data
T = T+1
J = J + 1
T >= M
J >= M
Print and store to Database Data transmitted by temperature/CO Sensor node
Cout(i) = I + 1
I >= n
Return to origin

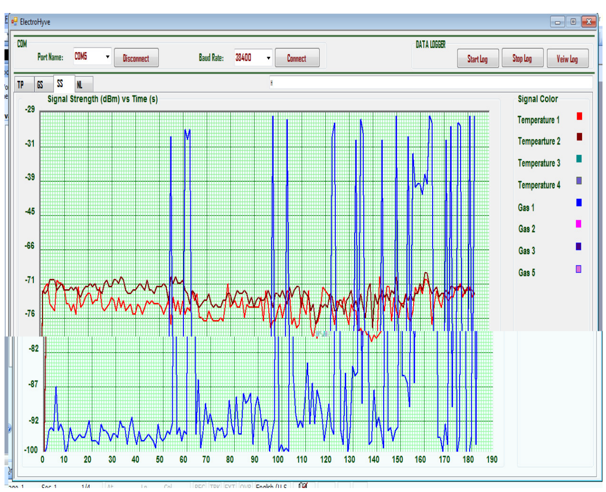

Figure 8: GUI display of Dynamic Graph Plotter

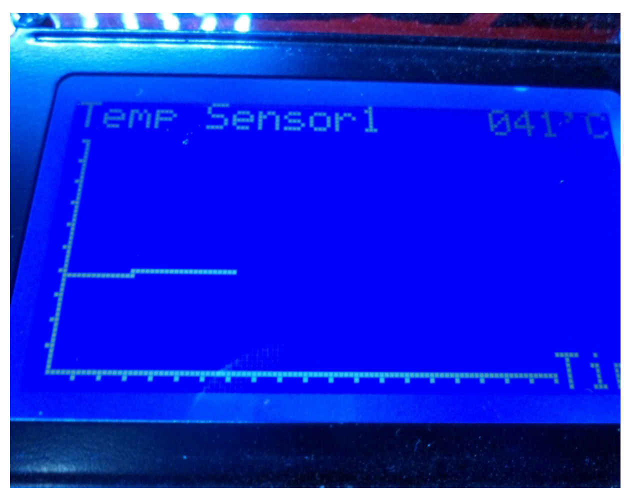

Figure 9 Graphical Crytal display of Dynamic Graph Plotter

DATABASE SYSTEM IMPLEMENTATION
The paper accomplished the concept for Distributed remote monitoring parameter analysis. These sensor motes are to extract data from sensors, used to monitor Environmental condition. All the motes have unique Address id to identify the mote. The mote can handle different data related to the Variable humidity or temperature. The data is being stored in database and the required information can be retrieved in the Software monitoring system. In order to simplify the system we have divided the whole data into categories. The data are those types of data which can be monitored continuously with sensor motes, for example, temperature, and so on.

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Information from the field will be store in the data base, the variable to be measured is stored with respect to time and quantity . A table will be establish to capture all the data been measured in the field. A database is an organized collection of data for one or more purposes, usually in digital form to show relevant aspects of reality, in a way that supports processes requiring this information (for example, getting information from a node in the field). This definition is very general, and is independent of the technology used.

Java is a general-purpose, concurrent, class-based, was used in designing the database by linking up with ORACLE in figure 12, and JAVA in figure 10 an object-oriented language that is specifically designed to have as few implementation dependencies as possible.

Table 2: DAY 1 (FEBRUARY 2ND. 2012)

Temperature

SN	SENSOR 1	SENSOR 2	SENSOR 3
06.00	0.1222901142387+02	0.1223048880450+01	0.1477380630341D-03
07.00	0.1507980352553+02	0.1508497647121+01	0.5172945686114D-03
08.00	0.1894251391813+02	0.1895765122854+01	0.1513731041409D-02
09.00	0.2460382773866+02	0.2464962756723+01	0.4579982856682D-02
10.00	0.3391873333485+02	0.3408223442336+01	0.1635010885070D-01
11.00	0.5248451742415+02	0.5331855223459+01	0.8340348104371D-01
12.00	0.1069156363364+02	0.1168137380031+02	0.9898101666695D+00
12.00	0.5993762963300+02	-.6847966834558+02	-.1284172979786D+03
13.00	0.3675614567764+02	-.8687629546482+01	-.3675701444059D+06
14.00	0.1371434973316+02	-.4588037824984+01	-.1371434973316D+36

DAY 2 (FEBRUARY 3RD. 2012)

Moisture content

SN	SENSOR 1	SENSOR 2	SENSOR 3
15.00	0.1223048913837D+01	0.1223048880450+01	0.3338691878518-07
16.00	0.1508496167191D+01	0.1508497647121+01	0.1479930124670-05
17.00	0.1895754160233D+01	0.1895765122854+01	0.1096262057532-04
18.00	0.2464899686958D+01	0.2464962756723+01	0.6306976472326-04
19.00	0.3407820425152D+01	0.3408223442336+01	0.4030171840324-03
20.00	0.5327896816591D+01	0.5331855223459+01	0.3958406868224-02
21.00	0.1155393207572D+02	0.1168137380031+02	0.1274417245901+00
22.00	0.1921699249630D+03	0..6847966834558+02	0..260649593308503
23.00	0.3119852767022D+18	-0.8687629546482+01	0.3119852767022+04
00.00	0.3278192015012+261	0.4588037824984 +01	0.3278192015012+03

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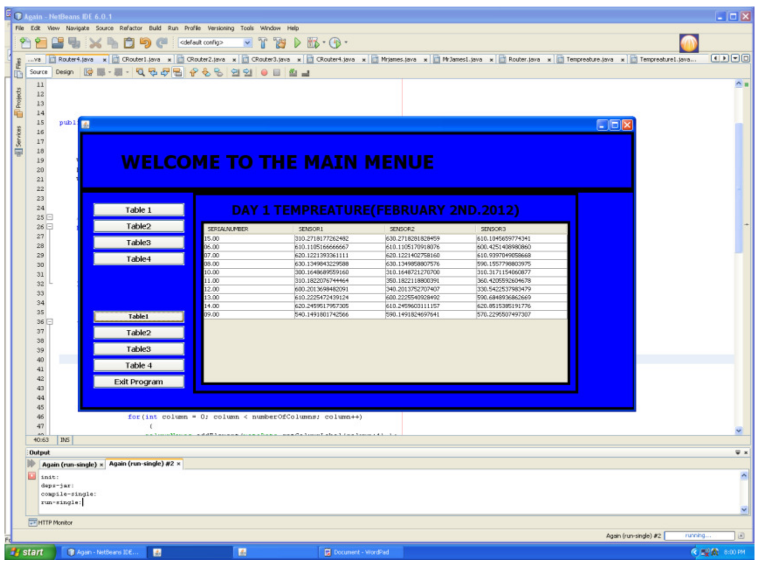

Figure 10 Java Database Temperature

SENSOR NODE QUERY IMPLEMENTATION

We implement sensor node query technique in figure 6 the arrows represent Filtering information from Database for a particular sensor node. With there different location also noted.

We develop a formula for implementing the query for the sensors, the following terms were used to develop the formulas

ST_1 = Sensor node one monitoring Temperature

$\sum_{i=1}^{n} ST_i$ = All Sensor monitoring temperature.

DB = Database

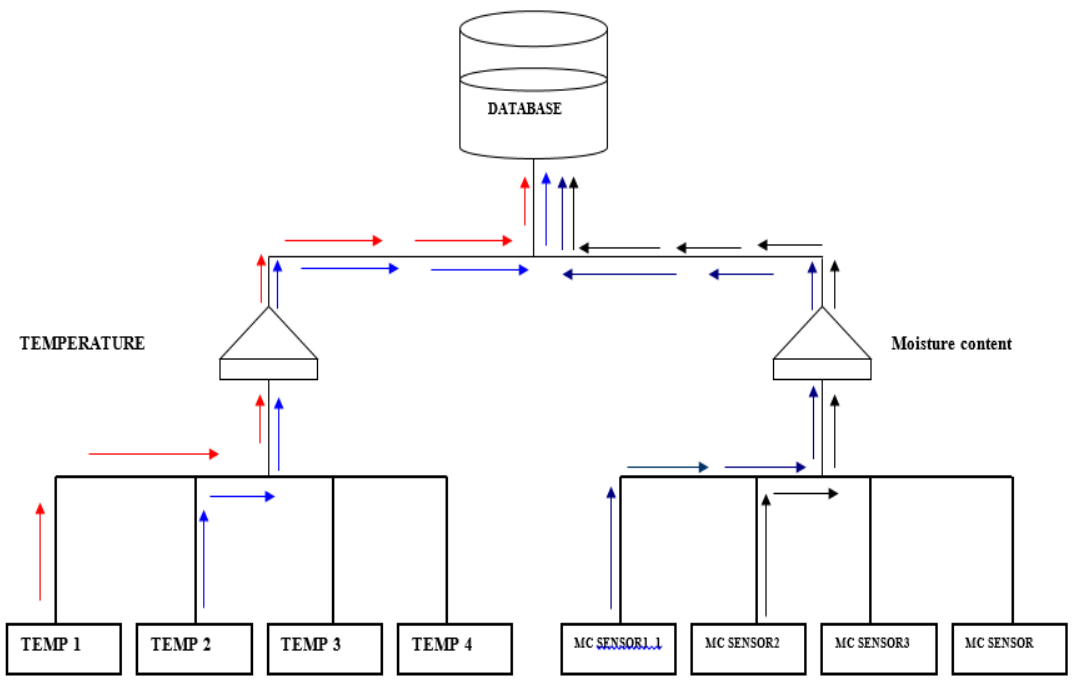

Fig 11: Querying Sensor Node Database[12]

Equation 5.1and 5.22 will help trace the sensor node amongst other sensors node in the network, the equation will help in extracting information on Sensor node ST_1 from Amongst Sensor nodes covering temperature which is further extracted from the Database DB.

$$\frac{ST_1 \sum_{i=1}^{n} ST_i}{\sum_{i=1}^{n} ST_1 + ST_2 + ST_3 + \ldots\ldots\ldots ST_{n-2,} ST_{n-1,} ST_n}$$

DB........................ [12]

The equation 12 represent the querying implementation of two temperature Sensor nodes one and two, again the Sensor node will query and extract data from database for node one and two respectively. The Diagram in figure 11 implements queries for two nodes for both temperature and gas. The equation in equation 18 and 19 is a general representation for the implementation of the queries.

With the data successfully sent to the MySQL database, any user with appropriate credentials can access the sensor network data through our user interface. This does not require Internet access if both the user interface and the MySQL server are running on the same computer. The user interface first retrieves all database rows, placing the data in tree data structures sorted by timestamp and Tmote id number. This storage scheme allows quick access to all information. Following the initial data retrieval, the user interface requests only new data from the database on a regular basis. This keeps the interface current while not requesting superfluous data. A screen capture of the user interface is shown Figure 10.

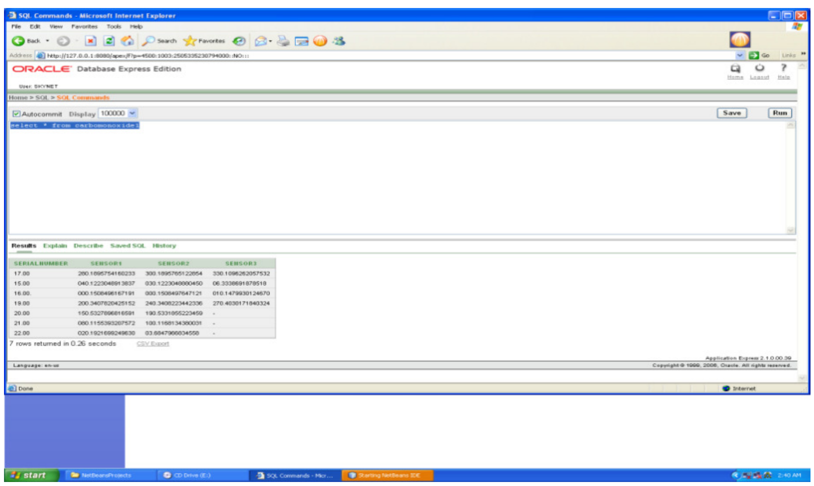

Figure 12 Query Temperature Database Interface

DISCUSSION OF RESULT

In figure 7 a Mathematical model for distributed wireless system was evolved , which is a collection of the parameter to be measured , the diagram in figure 2 is a cropwatt 8.1 software , which displays maximum and minimum temperature , humidity wind, evapotranspiration with respect to time ,equations and data collected 14,15 and 16 are mathematical models representing historic data collected which can can be queried as shown in figure 12 . The data is being stored in database and the required information can be retrieved in the Software monitoring system. In order to simplify the system we have divided the whole data into category i.e. The data are those types of data which can be monitored continuously with sensor motes, for example, temperature, and Carbon monoxide.

CONCLUSION

The paper accomplished the concept for Distributed remote monitoring parameter analysis. These sensor motes are to extract data from sensors, used to monitor Agro-Climatological condition. All the motes have unique Address id to identify the mote. The mote can handle different data related to the Variable humidity , temperature and so on. Information from the field will be store in the data base, the variable to be measured is stored with respect to time and quantity . A table will be establish to capture all the data been measured in the field. A database is an organized collection of data for one or more purposes, usually in digital form.

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The data are typically organized to model relevant aspects of reality, in a way that supports processes requiring this information (for example, getting information from a node in the field). This definition is very general, and is independent of the technology used. Java is a general-purpose, concurrent, class-based, was used in designing the database by linking up with ORACLE, JAVA an object-oriented language that is specifically designed to have as few implementation dependencies as possible.

This work came up with ways of achieving remote monitoring of Agro-Climatological parameters by spatially monitoring Agro-Climatological Parameter via distributed wireless sensor system. The work develop a model for carrying out multiple monitoring at a time, the output of the monitored parameter were viewed via a dynamic graph plotter from a GUI interface and Graphical liquid crystal display.

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