Design, Deployment and Testing of a WSN and Weather Forecast based Irrigation Regulator System

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Abstract: Punjab is an agriculture oriented state. Over the last couple of years we have started adopting modern practices in agriculture, but still there is a great need to improve the conventional agriculture practice and tools. The major crops grown here are wheat and rice. The crop of rice mainly grown during June-July consumes a lot of water, due to which the underground water table is going down day by day. So there is a great challenge before us to save the underground water. The present work aims at designing a WSN based soil moisture content measuring system. It is also desired to use this information in association with weather forecast information to design an expert system for regulating the switching ON/OFF of the motor based on the soil moisture content and weather forecast. A "WSN and Weather Forecast based Irrigation Regulator System" has been developed. The Moisture Sensor Unit (MSU) has been designed to generate a signal whenever the soil goes dry. The Main Control Unit (MCU) of the system on receiving the dry signal from the Moisture Sensor Unit enquires about the weather forecast from the mobile service provider (IDEA) and accordingly makes a decision whether to switch ON the motor or not. The said system has been deployed over a period of about six months to regulate the irrigation process for two crops – wheat and onion. On the basis of the results obtained it can be concluded that the system can reliably be used to regulate the irrigation process.

Keywords: Wireless Sensors, Soil Moisture, Weather Forecast, Irrigation Regulator, GSM Modem.

I. INTRODUCTION

Punjab occupies only 1.57% geographical area of India, it contributes more than 50 % grain in the central grain pool. More than 83% of land in Punjab is under agriculture as compared to 40.38% of national average. The cropping pattern of wheat and paddy rotation has led to manifold increase in irrigation water demand. Injudicious surface water irrigation policies, indiscriminate / excessive ground water pump-age due to free electricity coupled with irrational irrigation and agricultural practices have led to situation wherein fresh ground water resources of the state have depleted at an alarming rate in most parts of the state. In major part of the state, ground water levels are in the range of 10 to 20 meters. However around major cities like Jalandhar, Ludhiana, Patiala, Amritsar and Sangrur, water levels are 20 to 40 meters deep. The long term water level fluctuation data indicates that water levels in major parts of the state have declined drastically. The fall in water table in Punjab has been a serious issue. One of the main reasons for it has been the early transplanting of rice (before mid-June), which means severe withdrawal of groundwater, as the monsoon is still far away, temperatures are very high and evapo-transpiration rate (ETR) is maximum. Several water management strategies have been

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suggested e.g. drip irrigation and on-farm management practices, change in cropping pattern, banning early plantation of paddy etc.

New technologies and practices based on WSNs are being developed and implemented in agriculture around the whole world, but their deployment in Punjab is still at the beginning stage. So there is a great challenge before us to implement these technologies practically in the fields. In this paper, we have taken a step towards the deployment of WSN and Weather Forecast based irrigation regulator system practically in the fields.

II. LITERATURE REVIEW

Xinjian Xiang [6] introduced an automatic control drip irrigation system based on ZigBee WSN and Fuzzy Control. This system uses (CC2430) ZigBee module for WSN node design, selecting soil moisture, temperature and light intensity information and sending the drip irrigation instructions by the wireless network.

In Punjab, rather India the prevalent method of irrigation is flood irrigation, so developing a drip irrigation system will practically be of no use. Economically the farmers are not rich enough to deploy drip irrigation in their fields. Since most of the people use flood irrigation, we thought of using technology to regulate an effective use of flood irrigation.

Izzat Din Abdul Aziz et al [3] developed a system that can remotely monitor and predict changes of temperature level in agricultural greenhouse. The objective of the research is to develop a remote temperature monitoring system using wireless sensor and Short Message Service (SMS) technology. The proposed system has a measurement which capable of detecting the level of temperature. This system also has a mechanism to alert farmers regarding the temperature changes in the greenhouse so that early precaution steps can be taken. In this research, several tests had been conducted in order to prove the viability of the system. Test results indicated that the reliability of the system in propagating information directly to the farmers could be gained excellently in various conditions. But it not happens in capacitance behavior as firmness change. The capacitances were decreased as firmness improved. In traditional method of farming, human labors were required to visit the greenhouse at specific time and need to check the humidity level and temperature level manually. This conventional method is considered time consuming and needs a lot of work and effort.

Although an intelligent system can be designed for weather prediction using temperature, humidity, wind speed etc., but it would be very complex and requires a lot of research. Our main concern was to develop a system using readily available resources which can work reliably. Therefore, we used available weather forecast information in order to save our time and resources.

In this paper, it is proposed to automate and regulate the irrigation process using a WSN and Weather Forecast based system. The proposed system shall be using wireless sensor nodes to check the moisture content close to the roots and recommend irrigation when it goes below a particular level. Further the system would use weather forecast information to forbid watering the fields if rainfall is expected in the next couple of days. In this way it would help to save ground water and electricity and at the same time also prevent crop damage. The aim is to develop a system using minimum resources, less cost and by making use of the readily available weather forecast information.

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III. SYSTEM DESCRIPTION

In this system we make use of wireless network and sensors to know whether to **ON/OFF** the irrigation system to water the field. Here in addition to the sensor network a GSM system is also used to send and receive the weather report as per requirement. A wireless sensor network is a system comprised of radio frequency (RF) transceivers, sensors, microcontrollers and power sources. Wireless sensor networks with self-organizing, self-configuring, self-diagnosing capabilities have been developed to solve problems or to enable applications that traditional technologies could not address.

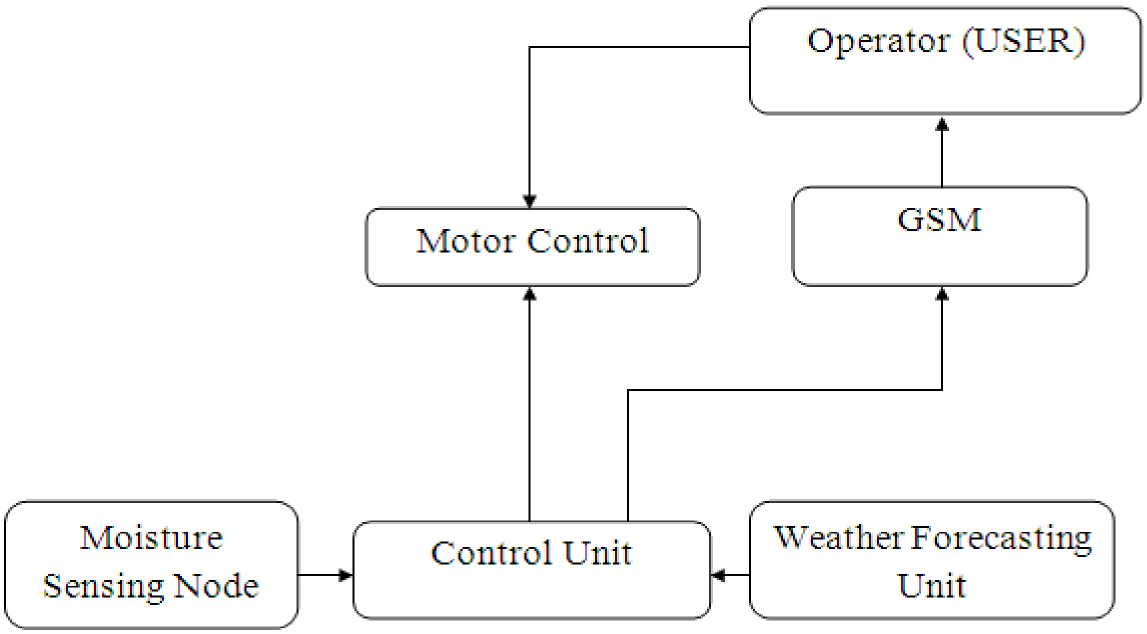

Fig.1 Block diagram of WSN and Weather Forecast Based Irrigation Regulator System

The block diagram consists of the four basic parts i.e. MSN (Moisture Sensing Node), WFU (Weather forecasting Unit), Control unit and GSM, etc.

1. MSU (Moisture Sensing Unit)

This is the most important unit. In this two stainless steel rods are inserted into the soil acting as electrodes. Depending upon the moisture level in the soil, its conductivity will change. This variation shall be measured and used to make a decision.

2. WFU (Weather Forecast Unit)

This is a challenging block here it is intended to access the available weather forecast information. Using GSM, the weather information is obtained through an SMS from a telecommunication company or data can be received from some specific weather forecast station.

3. Control unit

This unit will act as the brain of the complete hardware. The soil moisture sensed in the first unit plus the weather forecast information from the second unit is given to the control unit. Depending upon these two signals the control units makes a decision. The decision may be sent to the relay to switch the motor ON/OFF or it can be controlled manually by the user as it can cause chaos in the experimental setup.

4. GSM Module

This can be a mobile set or a special modem for sending an SMS to the user indicating the final decision of the control unit. This SMS would tell the user whether to switch the motor ON/OFF for irrigation process.

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3.1 Working

The working of the whole system can be divided into three parts or steps. As soon as the system is turned ON, all the three parts starts working. These three parts work in the following manner:

3.1.1. Moisture Sensing Unit (MSU)

The continuous monitoring signals from all the sensors are received by the receiver at the Base Station. The signal received here indicates the soil condition i.e. wet or dry. If the wet signal is received from all the sensors then MSU further performs no action and it waits until the signal gets DRY. As soon as the DRY signal is received, the MSU sends a signal to the second unit i.e. control unit that the soil is DRY. The whole working is shown in Fig.2.

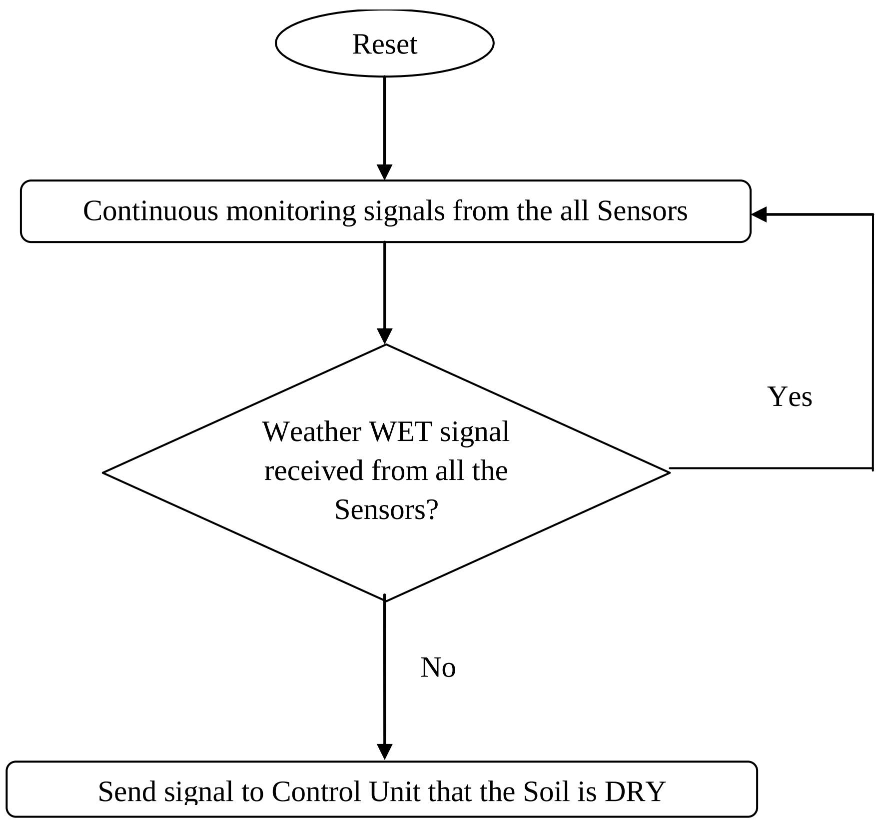

Fig.2 Working of Moisture Sensing Unit.

3.1.2. Control Unit

This unit acts as the brain of the complete hardware. It will check the signal from MSU. If the signal indicates the soil to be DRY, then it sends the signal to Weather Forecasting Unit (WFU) to update weather conditions. Along with this it will also send an alert message to the user regarding the weather enquiry made. In the mean time WFU will send weather information to the control unit. The control unit will interpret this message and carry out the decision making process. If the weather remains conducive for irrigation it will send a message to the user to turn

ON the motor otherwise it will send a message "No Need". The working of the control unit is shown in Fig.3.

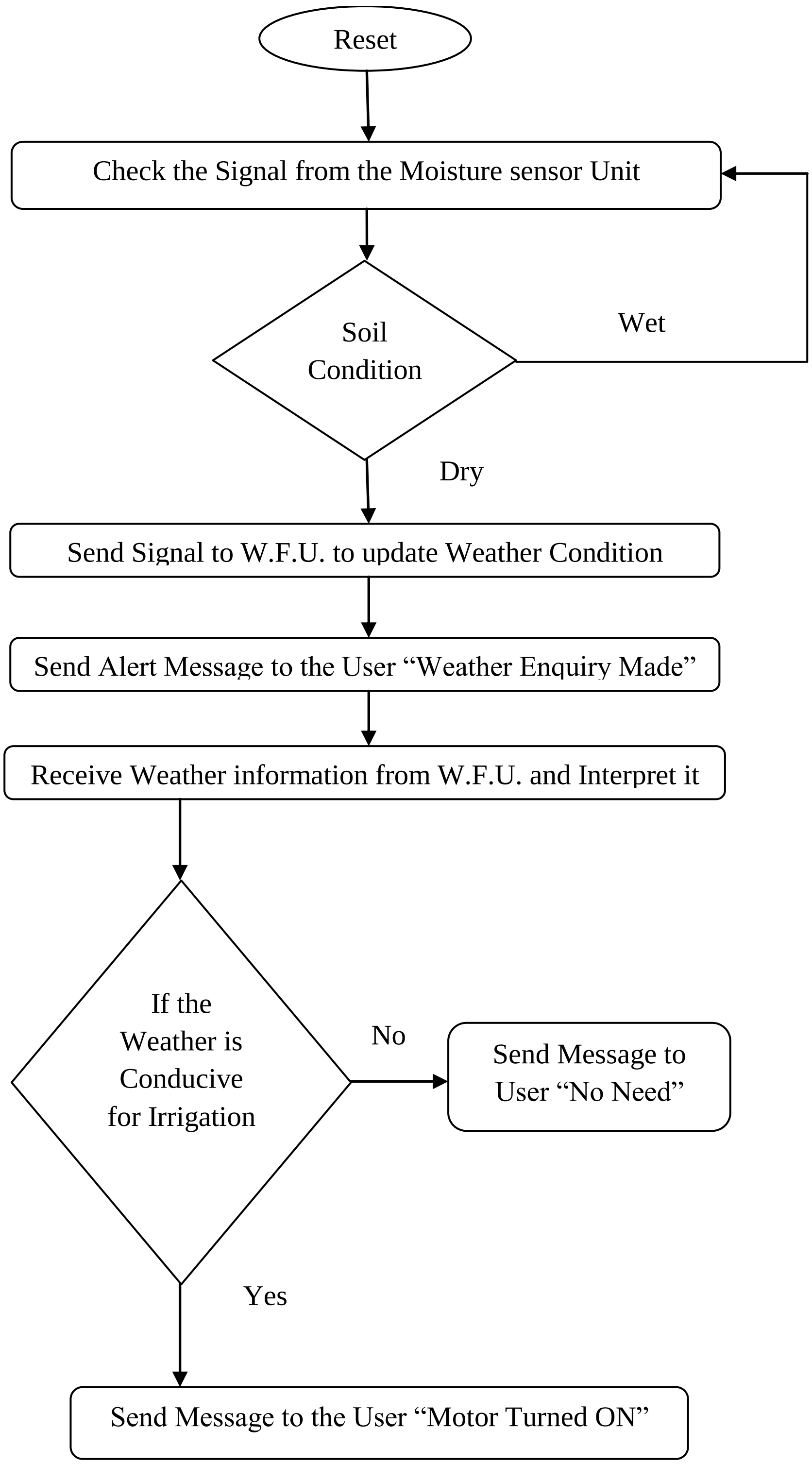

Fig.3 Working of Control Unit

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3.1.3 Weather Forecasting Unit (WFU)

The WFU will wait for the command signal from the control unit to update the weather condition. On receiving the command from the control unit for updating the weather, the WFU will send a SMS “Weather” to the Idea service centre for weather information. On receiving information, it will forward this information to the control unit otherwise it will wait for the SMS from the Idea service centre. The complete working of WFU is shown in Fig.4.

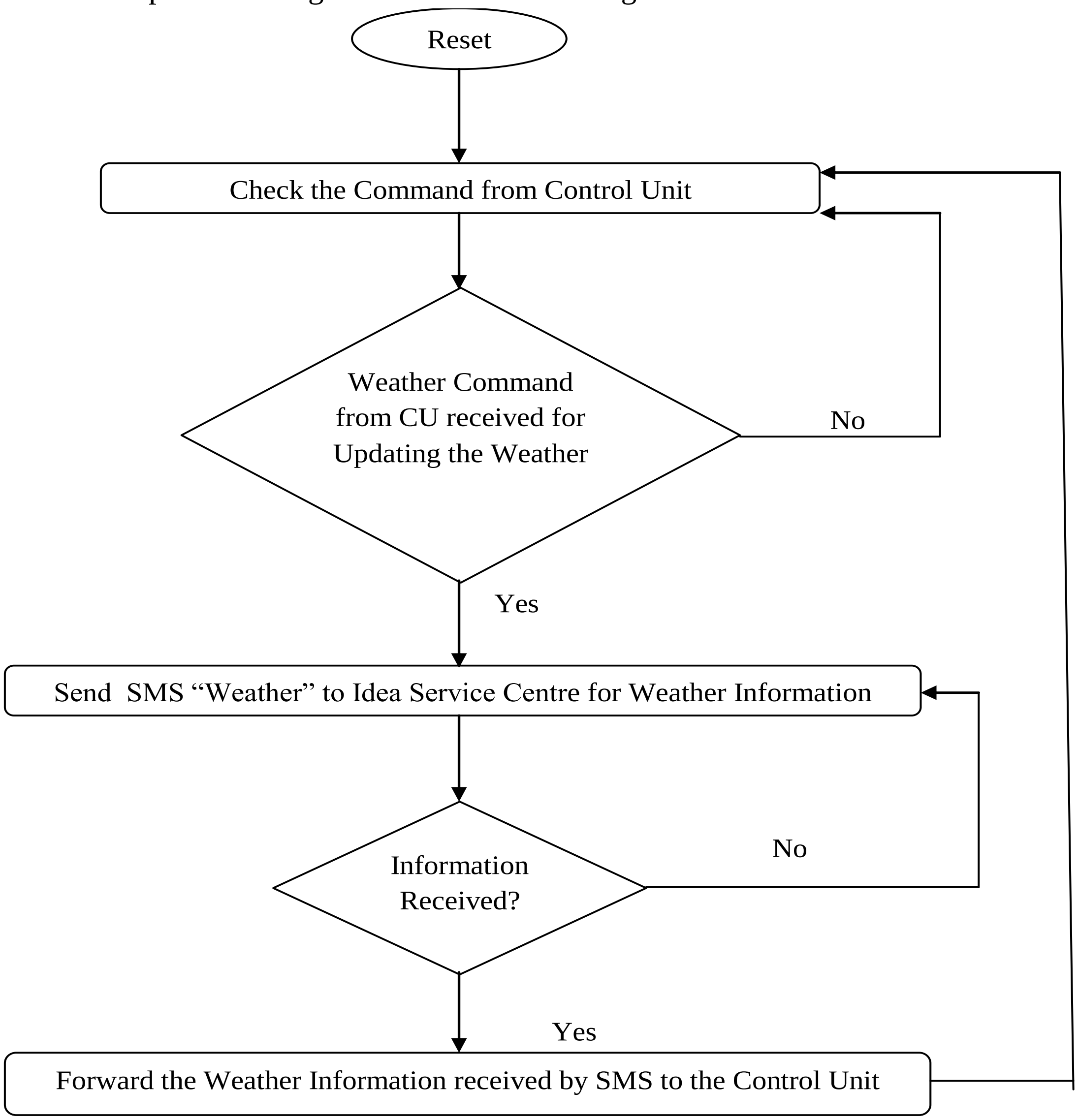

Fig.4 Working of Weather Forecasting Unit

3.2. Hardware

3.2.1. Moisture Sensing Unit (MSU)

It consists of light weight circuit comprising of two stainless steel rods inserted into the soil acting as electrodes. A comparator circuit is used for checking the moisture level in the soil as shown in

Fig. 3.9. The TWS-434 and TWS-330 are used for transmitting the moisture level to the base station.

3.2.2. Base station (Control Unit and Weather Forecast Unit (WFU))

It is the unit where whole processing takes place. The signal from the sensors is received by the receivers (RWS-434 & RWS-330) working at different frequencies. The receiver forwards the signal to the controller. The controller AVR Mega series, is interfaced with GSM module (SIM300AT) and LCD LMB162A. The GSM modem is used for sending and receiving the weather updates. Along with the weather information it also sends alert messages to the user. The LCD indicates the status of all the sensor units and final decision made by the control unit.

IV. RESULT AND DISCUSSION

4.1. Deployment for Monitoring of the Wheat Crop (Dec-2013 to April-2014)

The project was installed to monitor the irrigation of wheat in the current season. The crop was sowed in the month of November in 2013. The irrigation monitoring system was ready and installed by the beginning of December 2014. The system checked the moisture level of the soil, whenever the soil was found to be dry, it went on to check the weather forecast. If the weather was found to be sunny for the day and also for the next couple of days, it recommended switching ON of the motor. Otherwise it is suggested not to switch ON the motor as rains were expected. The data thus obtained is presented in the table below. The decision made by the system was also verified by manual enquiring about the weather (using IDEA message services) whenever there was a need to water the crop. The manual verification was needed because the project was in the evaluation phase. The data thus obtained is presented in the last column.

Table 1 Analysis of System Performance

S.No.	Date	Soil Condition	Alert Message Received	Decision made by the System	Manual Verification
1.	01-Dec-2013	Wet	No	No Need	
2.	08-Dec-2013	Dry	Yes	Motor turned ON	Sunny
3.	15-Dec-2013	Wet	No	Motor turned OFF	
4.	22-Dec-2013	Wet	No	Motor turned OFF	
5.	29-Dec-2013	Wet	No	Motor turned OFF	
6.	02-Jan-2014	Dry	Yes	No Need	Rain
7.	12-Jan-2014	Wet	No	Motor turned OFF	
8.	19-Jan-2014	Wet	No	Motor turned OFF	
9.	26-Jan-2014	Wet	No	Motor turned OFF	
10.	02-Feb-2014	Wet	No	Motor turned OFF	
11.	03-Feb-2014	Wet	No	Motor turned	

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				OFF	
12.	09-Feb-2014	Dry	Yes	No Need	Showers
13.	16-Feb-2014	Wet	No	Motor turned OFF	
14.	23-Feb-2014	Wet	No	Motor turned OFF	
15.	02-Mar-2014	Wet	No	Motor turned OFF	
16.	14-Mar-2014	Dry	Yes	No Need	Rain
17.	16-Mar-2014	Wet	No	Motor turned OFF	
18.	23-Mar-2014	Wet	No	Motor turned OFF	
19.	30-Mar-2014	Wet	No	Motor turned OFF	
20.	06-Apr-2014	Wet	No	Motor turned OFF	

As can be observed from the table, the fields were found to be dry on four occasions. We will discuss each situation in the reverse order i.e. we will start from the recent period when the soil was found dry.

[i] 14 March 2014: The Moisture Sensor Unit of the system checks the soil to be dry. On detecting the soil to be dry, the system follows the following procedure:

- It sends a message "Weather" to the Idea service centre for weather enquiry. In the meantime the system sends another alert message to the user that the weather enquiry message has been sent.
- On receiving this alert message a manual verification was carried out by the user in the same way by sending a message "Weather" to the Idea service number 51115. In response to this message user receives a reply message from Idea describing the weather condition for almost a week. The message received by the user.
- The manual verification was needed because the project was in the evaluation phase. The same message was received by the system also. On receiving the message, the system interpreted it and made the following final decision. This decision was sent to the user through an SMS service. The decision made as per the weather conditions of 14 March 2014, 15 March 2014 & 16 March 2014 was sent to the user.
- It means it was decided by the system to keep the motor OFF during this period as rain was expected.
- *And the rain was experienced on 15 March 2014, evening.*

[ii] 9 Feb 2014: The soil was found to be dry. Hence the following steps were carried out by the system

- Alert message sent to the user.
- On receiving the alert message initiated manual verification process. Sent a message to 51115 as "weather". Weather enquiry message received during verification process.
- Decision made by the system as per the weather conditions on 9 Feb 2014, 10 Feb 2014 & 11 Feb 2014.
- It means that the weather condition was again not suitable for turning the motor ON.

- *Showers were experienced on 10 Feb 2014, morning.*

[iii] 2 Jan 2014: Third occasion when the system checks the soil to be dry.

- Alert message send to the user.
- On receiving the alert message initiated manual verification process. Sent a message to 51115 as "weather". Weather enquiry message received during verification process.
- Decision made by the system as per the weather conditions on 2 Jan 2014, 3 Jan 2014 & 4 Jan 2014.
- It means few showers or rain was felt on these days, so there was no need to turn the motor ON.
- *The rain was experienced on 2 Jan 2014, evening.*

[iv] 8 Dec 2013: Last occasion when the system checks the soil to be dry.

- Alert message sent to the user.
- On receiving the alert message initiated manual verification process. Sent a message to 51115 as "weather". Weather enquiry message received during verification process.
- Decision making process was carried out by the system as per the weather conditions on 2 Jan 2014, 3 Jan 2014 & 4 Jan 2014.
- So here the decision was made to water the crop manually because the weather was conducive for irrigation process.
- *Weather was sunny for these days.*
- As the motor was turned ON at the same time user received a message.

V. CONCLUSION

The WSN and Weather Forecast based irrigation regulator system was used over a period of about six months to regulate the irrigation process for two crops – wheat and onion. The results thus obtained help us to conclude that the system can reliably be used to regulate the irrigation process. This automation has many advantages as listed below:-

A. It reduces human burden

During conventional agricultural practices one needs to visit the fields regularly. But by using this system there is no need to visit the fields on regular basis to check whether there is need to irrigate the crop or not.

B. Avoids misinterpretation

Sometimes by usually interpreting the top layer of the soil we take it as dry, but if we penetrate deep (about an inch) into the soil, we find it to be wet. In fact, it is the moisture content at the root level that matters. But by using the sensor electrodes that goes deep into soil up-to the root level, we come to know the exact moisture content. So there is no chance of wrong interpretation in this case. But there is moisture in the soil near to the roots of the crop.

C. Helps in saving Energy and Groundwater

In normal conventional practices we water the crop by making interpretation from the soil upper layer. And we don't have any knowledge about the weather forecast. If it rains within the next couple of days it may lead to loss of energy and groundwater. But by using this system we will have weather forecast information for next three days and proper soil moisture. The system won't water the crop unless the weather conditions are conducive. Therefore, it minimizes the energy and underground water loss.

D. Prevent Crop Damage

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In conventional practices we water the crop without any weather information. If the weather gets turbulent within a couple of days from watering the crop, it may lead to the crop damage. As the system has weather forecast information therefore, the system saves the crop from being damaged.

E. Improves Crop Yield

Using this system the irrigation process is carried out only when it is required by the crop and along with that it also checks the weather forecast information for few couples of days. Therefore, it irrigates the crop with the exact amount of water required by the crop and also prevents irrigation when it may harm the crop. Hence the crop overall yield is improved.

VI. FUTURE SCOPE

A WSN and internet based irrigation regulator system has been developed. Although a lot of efforts have been made for the development of the system; still it can be further improved with some small modification. Following points may be considered for the improvement of the system in future.

A. Sensor node can be made to work on solar energy.

B. Number of sensor nodes can increase to make the system more efficient.

C. High range RF module can be used to cover a larger area.

REFERENCES

[1] D.L. Corwin, Apparent soil electrical conductivity measurements in agriculture. Computers and Electronics in Agriculture 46 (2005) 11-43.

[2] Ning Wang, Wireless sensors in agriculture and food industry. Computers and Electronics in Agriculture 50 (2006) 1-14.

[3] Izzat Din Abdul Aziz et al, Remote monitoring in Agriculture Greenhouse Using wireless sensor and SMS. International Journal of Engineering & technology IJET-IJENS Vol:09 No:09.

[4] Nannan Wen, A wireless intelligent valve controller for agriculture Integrated Irrigation System. IFIP International Federation for Information Processing 2011.

[5] Bei Wang et al, Application of wireless sensor network in farmland data acquisition system. Springer-Verlag Berlin Heidelberg 2011.

[6] Xinjian Xiang, Design of fuzzy drip irrigation control system based on ZigBee WSN. IFIP International Federation for Information Processing 2011.

[7] Max Billib betal, A Methodology to identify representative conFig.urations of sensors for monitoring soil moisture. Springer Science B.V. 2011

[8] Robert Coates et al, Wireless sensors networks with irrigation valve control. Computers and Electronics in Agriculture 96 (2013) 13-22.

[9] Adamchuk, V.I., and P.J. Jasa. On-the-go Vehicle-Based Soil Sensor. University of Nebraska, Cooperative Extension, EC-02-178.

[10] Doerge, T., N.R. Kitchen, and E.D. Lund. Soil Electrical Conductivity Mapping. SSMG-30. Site-Specific Management Guidelines series is published by the Potash & Phosphate Institute (PPI).

[11] Eshani, R., and M. Sullivan. Soil Electrical Conductivity (EC) Sensors. Ohio State University Extension, AEX-565-02.

[12] Anderson-Cook, C.M., M.M. Alley, J.K. Roygard, R. Khosla, R.B. Noble, and J.A. Doolittle. Differentiating soil types using electromagnetic conductivity and crop yield maps. Soil Science Society of America Journal 66.

[13] Geonics Limited at: *http://www.geonics.com/*

[14] Geophex at *http://www.geophex.com/*

[15] Veris Technologies at: *http://www.veristech.com/*

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