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Application of WSN in Rural Development, Agriculture Water Management

Rashid Hussain, J L Sahgal, Purvi Mishra, Babita Sharma

***Abstract* — India ranks second in agriculture activities. It supports the employment of several households. Being such a big industry it is important to increase the overall productivity.**

Today India faces several problems and one of the major problems is the shortage of water for irrigation purposes. Farmers depend heavily on the rains because they lack the access to irrigation facilities. Their crop yields are highly unreliable due to the variability in both rainfall amount and its distribution. Also these farmers depend heavily on the prediction values of various factors such as weather, water, soil, etc.

Here we describe the use of sensor networks for improved water management and for controlling other parameters. The target population is the resource poor farmers in the semi-arid areas of rural India. There is a major use of Information and Communication Technology (ITC).

Sensor network and other agricultural techniques might help them to store and utilize the rain water, increase their crop productivity, reduce the cost for cultivation and make use of real time values instead of depending just on prediction.

***Index Terms* — WSN, clustering, agriculture, water management.**

I. INTRODUCTION

Agriculture in India has a significant history. Today, India ranks second worldwide in farm output. The share of agriculture employment is about 67%. That is, nearly two-third of the population depends on the rural employment for a living. Agricultural practices are neither economically nor environmentally sustainable and India's yields for many agricultural commodities are low. Poorly maintained irrigation systems and almost universal lack of good extension services are among the factors responsible.

But the growing researches and experiments in this field has forced us to look at the brighter side of the technology in agriculture.

Today large mechanized farms in developed countries use a combination of technologies like in field sensor, Geographical Information System (GIS), remote sensing, crop simulation models, etc.

The major problems faced by Indian farmers:

Low amount of rainfall and its high variability is a cause of concern in the dry areas. Frequent occurrence of long dry spells in the states of Rajasthan, Madhya Pradesh, Andhra Pradesh, Karnataka, etc. is a major concern for the farmers of these states. Corp failure takes place in some parts of country due to lack of water at the same time in some parts due to floods. Poor seed quality often results into poor crop production, which leads into wastage of time, money, labor and other resources. Lack of cold storage leads to wastage of crops because they are often left in open where they are prone to insects, moisture, water, etc. The farmers have poor knowledge of new technologies which can help them to improve quality of seeds, irrigation methods and proper handling of their crops. The lack of good road connectivity between rural and urban India delays the delivery of crops on time in markets. The fields in low lying areas face a problem of acidity, salinity and see water entering their fields. Climatic condition may become unpredictable thus leading into wrong decisions by the farmers. In hilly and rocky areas, water for irrigation is too costly for the poor farmers. Drilling of bore wells is costly and it has high history of failure.

The sensor network technology can help the farmers in different ways:

Simulation models of crops, pests, diseases and farming operations are important tools for required information. It helps in calculating the water needs of the crops during growing period. The environment monitoring data provided over time and space by sensors can be used to validate and calibrate existing models. Farmers can monitor in real time the field conditions. This all can help them to take better decisions on crops, moisture conditions, climatic changes, water conditions, etc. The engineers and researchers can help the illiterate farmers by using maps and graphs drawn from the collected data which could help them in taking better decisions regarding their fields.

II. CROP MODELING

Many simulating models are available now to measure the growth of crops and to see the effect of various environment constraints, like moisture, water, different nutrients, etc, on their growth.

DSSAT (Decision Support System for Agro technology Transfer) basically simulates the growth, development and yield of a crop which is growing in a particular area under observation. But it rotates only around the crop development and does not undertake the issue of environment as a whole. And there is a difference that exists between the modeling system and its real time application when it comes to decision making at the farm level. But overall these modeling systems help in taking the right decisions at the small levels to help the farmers.

APSIM (Agricultural Production Systems Simulator): As the name suggests, this simulator is used to integrate the information that is derived from different researches. That is, research done by one system can be used by the other system if needed. Thus even the comparison of different models can be done by using ASPIM.

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Rashid Hussain, Associate Professor, E&C, Suresh Gyan Vihar University, Jaipur, India.

J L Sahgal, Chairman Rajasthan, India, Institute of Engineers, India.

Purvi Mishra, M.Tech Scholar-DWCE, Suresh Gyan Vihar University, Jaipur, India.

Babita Sharma, M-Tech Scholar-DWCE, Suresh Gyan Vihar University, Jaipur, India.

It is an important tool for analyzing the whole farm system including the sequences and rotation of the crops and pastures.

III. WATER CONSERVATION MEASURES

Water is an important resource and due to its scarcity it becomes even important to take measures for its conservation. The different ways to conserve water are: building bunds, planting trees to stop water from flushing away, strip cropping, crop rotation, planting of grasses for stabilizing bunds, etc

Now how much these different water conservation methods are effective can be calculated by using the soil-moisture readings taken by the sensor.

Prediction of Crop Water Requirements:

The main requirement for increasing the crop productivity is water .There are three main sources of water available for farming, they are: soil water, rain water and irrigation water. In addition to this the other climate parameters are also needed they are: sun light hours, rain fall in a day, wind speed and humidity.

But a resource poor farmer in India does not have access to these facilities easily. Hence, the only option left with them is to depend on the predictions. They usually rely on the newspapers or the televisions for the predictions on the monsoon, humidity, the period of monsoon, the different temperatures, etc. They look at indicators in nature, such as flowering of mango and tamarind trees, wind directions, summer temperatures, etc.

These are highly unreliable techniques for production of crops. Thus, a system is needed where we can get the approximate values which are reliable for increasing both the quality and the quantity of the crop.

Through sensor networks the raw values directly from soil and environment can be converted into predictions which are almost approximate.

The input values for the sensors will be soil moisture, daily rainfall, sunlight hours, humidity and wind speed. For the values of rainfall, sunlight, humidity and wind speed less number of sensors will be needed as we can use these sensors at a distance from each other since there won't be a big change in their values from one place to another. But for the values of soil moisture, more sensors are needed as their values can change within a small distance.

The output from the sensors will be the real-time alerts, generated whenever the measured soil-moisture of a parcel reaches a threshold value. Once the alert is given, the farmer is able to look at weather forecast data and know, based on historical climatic data for the region, what is the probability of rain in the near future. Soil moisture predictions: which part of land contains how much moisture in it can be generated by the sensors. Thus, if there are two crops to be grown together and if one needs more moisture in the land than the other, these values can help the farmer to decide. Water Requirements: based on the above values the system generates the estimation of the minimum amount of water that will be required by the crop.

IV. PADDY CULTIVATION

India and China are the two major rice producing countries in the world with the total production of 49.1%. India is the largest rice growing country, while China is the largest rice producer.

Cropping Seasons:

There are three main growing seasons: Kharif, Rabi and summer. In the north and western Indian states, like J and K, Haryana, Himachal Pradesh, Uttaranchal, Utter Pradesh, Punjab, Rajasthan, Maharashtra and Gujarat, rice is grown mainly in kharif. While in southern and eastern India, it is grown round the year in three seasons with varying sowing time and periods.

Climate and Soil requirement:

Rice is grown in the tropical climate, humid to sub-humid and in almost all type of soils. It can also be grown under high temperature, high humidity with sufficient amount of water.

Field:

To improve the water holding capacity, field is ploughed for 1-2 times up to 20-25cm deep in the month of April-May. Now the field should be flooded with water for 15 days and bunds should be constructed around it. Different types of bullock and tractor drawn puddlers are used to make the soil surface even and bury the weeds.

There are two methods for rice cultivation: direct seed sowing or by seedling transplantation.

Direct Sowing:

Here the seeds are sown by either broadcasting or by line sowing.

Seeding Transplanting:

First the seeds are grown in the nursery and when they grow up to 15-20cm, they are ready for the transplantation. We have to maintain 5-10 cm water level for 2 days prior to uprooting. Seedlings should be transplanted at a depth of 2-3cm.

Nutrient management:

To maintain the productivity, vermicompost and biofertilizers are added in the soil at the time of pudding. We can also use neem compost and neem leaves because they work as pesticides and growth promoter.

Water management:

The main requirement of paddy is wet soil for its growth and sufficient water management according to need. Flooding is unnecessary if the weeds can be removed manually but if not then the fields are flooded to suppress weed growth and maintain nutrients such as phosphorus, potassium, silica and calcium iron. Water is needed only at three critical stages, at the initial seedling period (10 days), flowering and panicle initiation stage. After the transplantation till the seedlings grow it needs standing water at a depth of 2-5 cm. Then till the dough stage of the crop, 5cm of water should be maintained. Then at last, water should be drained out from the field 7-15 days before the harvest. The amount of water required for a given crop depends on state of development of soil, quantity and type of fertilizer given, quality of water used [6]. The paddy needs a lot of water. Another big concern here is that the water should not be in excess nor it should be less than the required amount. Both are very harmful for the cultivation of paddy. Therefore, we need a method by which the amount of water in the field can be monitored regularly and the water level can be controlled.

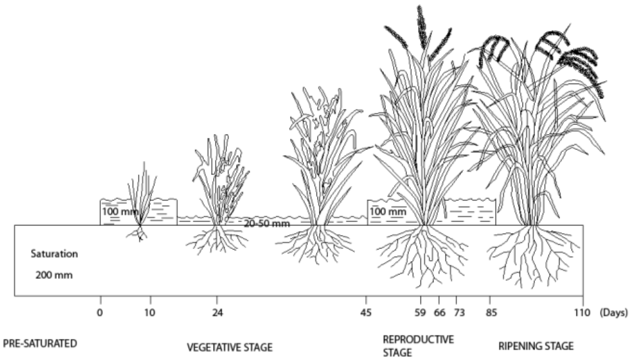

Fig:1 Different Water Levels in Paddy Cultivation

All the monitoring work is done manually only. Like monitoring of pests, weeds, the growth of the plant, water needs, etc. All these activities are time consuming and need a lot of attention by the farmer. Now the majority of the paddy field farmers are involved in some other activities. From plowing to harvesting there are different stages in the paddy cultivation and each stage needs different amount of water. Thus, it is required for a farmer to spend a lot of time in the fields since the pumping of water to and from the field at every stage needs a lot of time.

Thus, developing a system that could help the farmers to know the water requirements beforehand will help them to save their time.

Many automated systems are being used presently. Sensor network technology is one of them. It helps in knowing the soil moisture, soil type, water requirements, climatic changes, humidity, etc. which could help the farmer in advance and he can take right decisions at right time.

Sensor Technology:

Different sensors are employed for sensing various parameters like soil moisture, water levels, climate change, pest detection, humidity to various other things in the fields.

For sensing these parameters, the sensors are deployed in the field. They are spread in such a way that they cover the whole field. Now these sensors can be used in many different ways.

The basic technology employed in the sensors is the same. Only the way they are spread out differs. But this different arrangement plays an important role as when used efficiently these sensors save time, save the required power and also may decrease the channel congestion, thus increasing the overall efficiency of the whole network.

How the Sensor Network Technology works:

The sensor nodes are planted in the area which is under experiment. They sense the different parameters for which they are meant. These all individual nodes perform the minimal data processing and then send back the data via a base station to a single server where they are processed further. Data is transmitted between the individual nodes via a wireless sensor link. Then between the head nodes and the base station through some other link depending on the technology which suits most. At last there is the Data Access Subsystem in which a web-based interface is used for the display and upload of both raw and processed data. As most of the farmers do not have access to the web, those data are made available at a local village center in the form of graphs and spread-sheets.

The nodes can be spread out in the fields using different topologies or different methods:

Tree topology:

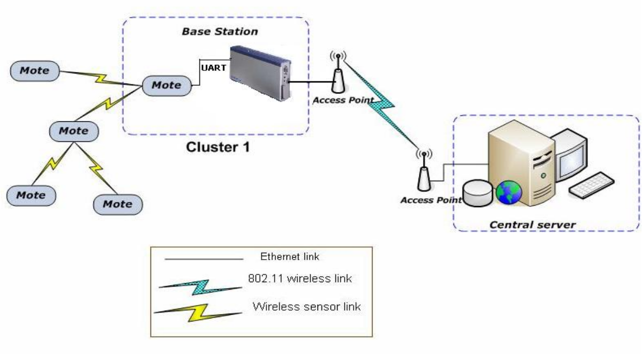

Fig:2 Tree Topology used in a Cluster

It the tree topology, the nodes are linked to a secondary hub that in turn is connected to a central hub that controls the traffic in the network. It allows more devices to be attached to a single central hub and can increase the distance that the signals can travel between the devices. But as the number of devices increase, the load on the central hub also increases.

Mesh topology:

Routing: This is the routing method used by nodes in the mesh technology. Every node when has to communicate to the head node has to follow a particular path. Now in this case it is important to find and maintain the routes all the times because the energy restrictions and the sudden changes in node status may cause unpredictable changes and may lead to failure, jamming or temporary obstructions. If we resort to automatic routing, then it needs powerful node processors, large amount of memory, dedicated routers, etc.

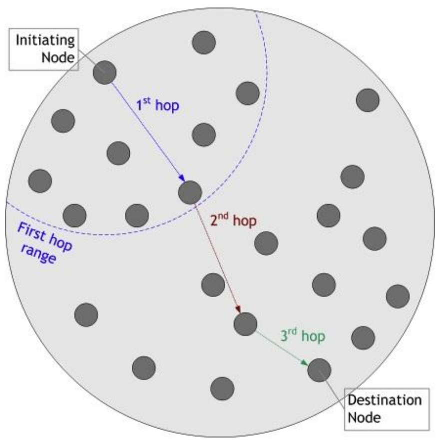

Fig:3 Routing

Flooding: To overcome the problems faced in the routing method another method was developed known as flooding. Instead of using one particular route here, the message is sent from one node to all the other nodes in the network, including those to whom it was not intended. Thus, there arises a major problem of traffic.

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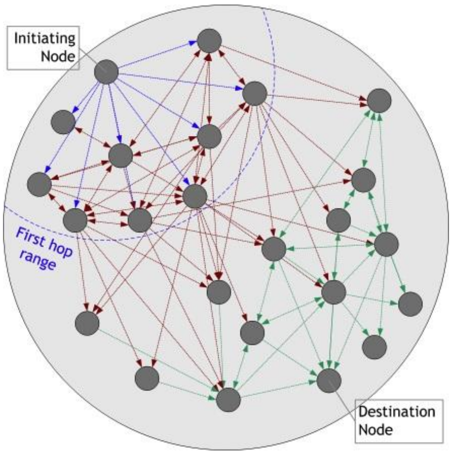

Fig:4 Flooding

Thus, the two major considerations here are: traffic and efficient power management.

Clustering:

After the sensors are deployed in a field, they are formed into a group. These groups are known as clusters. A cluster can have either same types of sensors or different types of sensors depending on the requirements. Every cluster has a head node. That is, all the nodes of a particular cluster report to the same head node. Communication in a cluster can be done by two types; intercluster or intracluster [7].

Proposed Method:

(A) In this method, we use a number of sensors performing various tasks like water monitoring, keeping a track of soil moisture, pests/diseases and climate change effect.

All the sensors employed in the field are divided into clusters such that each cluster contains all the four sensors. The sensors of one cluster do not communicate with the sensors of other cluster. Instead they communicate to their head node. All the head nodes of each cluster communicate with the root node.

There are four types of sensors used to four parameters, they are: water level, soil moisture, pest and disease and chemical measurements.

The arrangement that we propose contains sensors which are spread out in the whole field in alternate manner. That is if there is a water sensor employed at a particular place, then it won't have another water sensor anywhere near by it. Each sensor is surrounded by 8 other sensors, which are different from the sensor used in the middle.

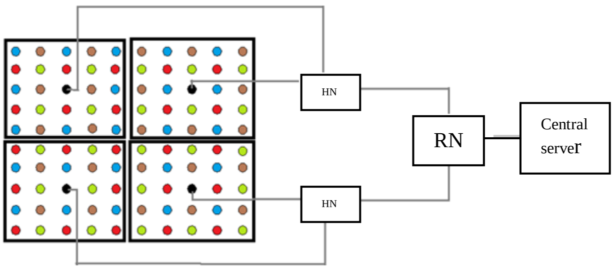

Fig:4 1st method

The black boundary covers one cluster.

Soil moisture

Climatic change

Water level

Pest/diseases

The nodes with different color work on different frequencies. Whenever these nodes have to send any data, they pass it to the head node. From there the data moves to root node which is connected to a server. This server and the root node are collectively known as the base station. From this base station all the data will be transmitted to central server. All the data storage will be done at this central server. Here all the processing and the interpretation of the data are done. According to this data result is drawn out which is usually in precision form.

Since all the nodes of one color in a cluster work at different frequencies, they do not interfere with the transmission of the other data. Every cluster works independently. And the problem of congestion is reduced.

All the nodes, head nodes and the root nodes are connected through the wireless links. Which link suits the best in the network depends on the work site.

Thus, this is the proposed model, with a different arrangement of the nodes by which we try to reduce the congestion, try to increase the data reliability and reduce try to reduce the time taken by the data to travel to its destination.

(B) There is one another method proposed for the fields which are comparatively small or for those big fields which are not too much prone to diseases or changes but still require automation due to their large size. Here, the sensors are placed in alternate rows around the head nodes.

All the head nodes are placed in the centre of the field. The 1st and the 3rd row transmit their data to the to the 1st head node. In the same way the 2nd and the 4th row transmit their data to the 2nd head node. Since the number of sensors are less the congestion is highly reduced.

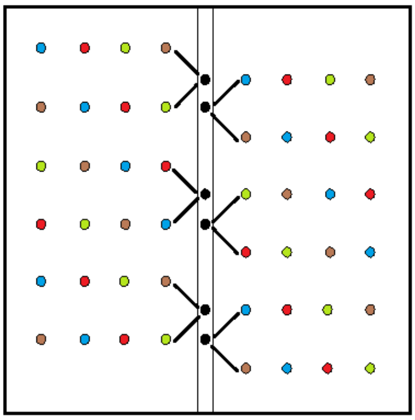

Fig:5 2nd method

The receiver which will be used at the head node is powerful enough to receive the data from the last node. Then the data from the head node travels to the root node in the same manner.

V.CONCLUSION

The sensor network technology will help the farmers to know the exact values of the requirements that they need to improve the crop productivity.

It will help them in taking better decisions at the right time. This will save their time and labor also. The basic aim here is to transport the Indian farmer from prediction to the exact values which are beneficial for their farms.

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AUTHORS PROFILE

Mr. Rashid Hussain, Rashid Hussain,M Tech,MBA pursuing PhD on topic "Application of WSN in Ryral Development.Area of research is WSN application from rural as well as urban area.Paper published on 1.WSN application in Health monitoring.2.WSN application in Intelligent traffic monitoring 3.WSN application in agriculture as well as water management etc.Member of Institute of Engineer, Memebers of extended Board of management.

- Executive committee member of Institute of Engineer Rajasthan chapter
- Founder &Coordinator for national level Techfest Aayam.
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Dr.J.L.Sehgal, Chairman Rajasthan, India Institute of Engineers

Purvi Mishra, M.Tech Scholar-DWCE, Suresh Gyan Vihar University, Jaipur, India.

Babita Sharma, M-Tech Scholar-DWCE, Suresh Gyan Vihar University, Jaipur, India.

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