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WIRELESS SENSOR BASED CROP MONITORING SYSTEM FOR AGRICULTURE USING WI-FI NETWORK DISSERTATION

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Abstract: **The advanced development in wireless sensor networks can be used in monitoring various parameters in agriculture. Due to uneven natural distribution of rain water it is very difficult for farmers to monitor and control the distribution of water to agriculture field in the whole farm or as per the requirement of the crop. There is no ideal irrigation method for all weather conditions, soil structure and variety of crops cultures. Farmers suffer large financial losses because of wrong prediction of weather and incorrect irrigation methods. In this context, with the evolution of miniaturized sensor devices coupled with wireless technologies, it is possible remotely monitor parameters such as moisture, temperature and humidity. It develop and implement a wireless sensor network connected to a central node using Wi-Fi, which in turn is connected to a Central Monitoring Station (CMS) through General Packet Radio Service (GPRS) or Global System for Mobile (GSM) technologies. The system also obtains Global Positioning System (GPS) parameters related to the field and sends them to a central monitoring station. The sensor motes have several external sensors namely leaf wetness, soil moisture, soil pH, atmospheric pressure sensors attached to it. Based on the value of soil moisture sensor the mote triggers the water sprinkler during the period of water scarcity. Once the field is sprinkled with adequate water, the water sprinkler is switched off. Hereby water can be conserved. Also the value of soil pH sensor is sent to the base station and in turn base station intimates the farmer about the soil pH via SMS using GSM modem This system is expected to help farmers in evaluating soil conditions and act accordingly.**

Keywords: **Wi-Fi, Wireless Sensor Network, GPS, Base Station, CMS, Packet transferring, Mobile Communication [10]**

1. INTRODCUTION

India being an agricultural country needs some innovation in the field of agriculture. This can be achieved through modern technologies which assist computing, communication and control within devices.WSN suit for this purpose. Wireless sensor networks (WSN) technologies have become a backbone for modern precision agriculture monitoring. WSN in agriculture helps in distributed data collection, monitoring in harsh environments, precise irrigation and fertilizer supply to produce profuse crop production while diminishing cost and assisting farmers in real time data gathering. This paper presents the preliminary design on the development of WSN for crop monitoring application. The proposed WSN system will be able to communicate each other with lower power consumption in order to deliver their real data collected to the farmer's mobile via GSM technology and to actuate the water sprinklers during the period of water scarcity.

A recent survey of the advances in wireless sensor network applications has reviewed a wide range of applications for these networks and identified agriculture as a potential area of deployment together with a review of the factors influencing the design of sensor networks for this application. The basic components of a sensor network consist of one or several sensors that are connected to a micro-controller and a radio module. When a large number of these tiny sensor nodes are deployed either randomly or in regular grid, they shall act collectively to perform sensing over a large area or in inaccessible terrains.

Within an agricultural environment, awareness has increased about implementing technology into the industry. Manual collection of data for desired factors can be sporadic, not continuous and produce variations from incorrect measurement taking. Wireless distinct sensor nodes can reduce time and effort required for monitoring an environment. Monitoring system can ensures quicker response times to adverse factors and conditions, better quality control of the produce and a lower labor const. The utilization of technology would allow for remote measurement of factors such as temperature, humidity, soil moisture and water level.

One particular reason is that the sensor location can often require being repositioned and a traditional wire layout could cost a substantial deal of time and energy in order to address such wiring problems. The system aims to reduce the cost and effort of incorporating wiring and to enhance the flexibility and mobility of the selected sensing points.

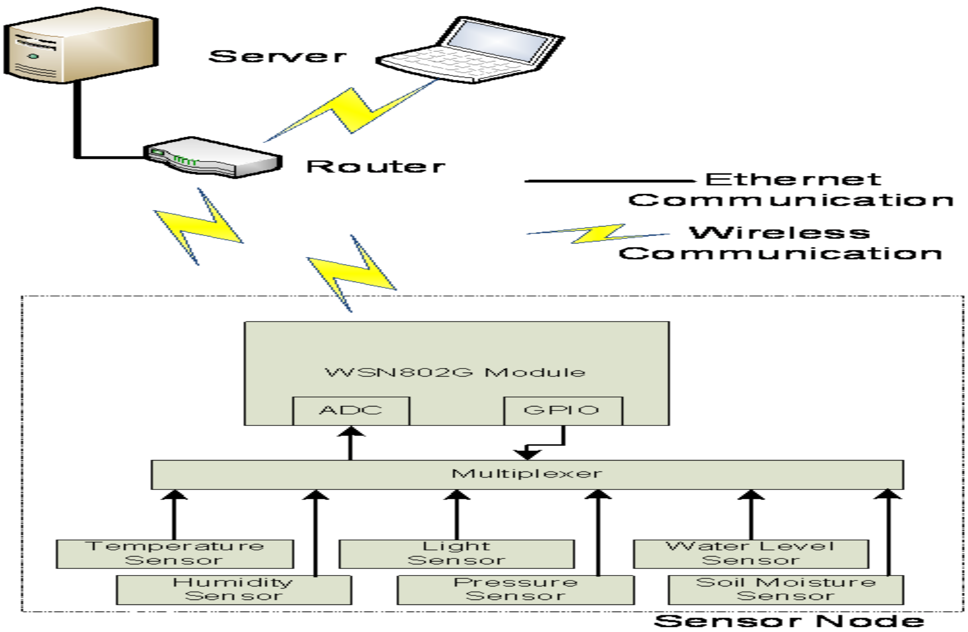

Figure 1 Diagram of system being developed

The system being developed is based on the WSN802G Wi-Fi / 802.11 module in order to communicate data to a selected server (Figure 2.1).The WSN802G module is connected to the various sensors with analogue outputs via a multiplexer used for signal gating. Where two particular signals can be selected based on the General Purpose Input/Output (GPIO) values from the WSN module. The signals are measured and converted to same values that are then transferred to a selected server connected to same network via a standard Wireless-G router. The server can be connected to the network either Wireless itself or through a wired Ethernet connection. The server stores the received data into a comma-separated values (CSV) file format which can be straightforwardly imported into a database, excel file or other software in order to perform analysis and displaying of data.

1.1 Researches on the use of wsn in agriculture is mainly focused on two major areas

(i) experimental or simulation work on various routing protocols and network topologies to increase data transfer rates whilst maintaining or reducing power consumption

(ii) Proof-of-concept applications to demonstrate the efficiency and efficacy of using sensor networks to monitor and control agriculture management strategies.

Wireless sensor network (WSNs) are being used in a wide variety of critical applications such as military and healthcare applications, agriculture and industrial process monitoring. WSN is an intelligent private network made by a large number of sensor nodes which do specific function. Wireless transmission allows deploy the sensors at remote, dangerous, and hazardous location. WSN has several advantages including easy installation, cost-effectiveness, small size and low power consumption. In recent years, Agriculture faces many challenges, while humanity depends on agriculture and water for survival, so precision agriculture monitoring is critical and the demand for environmental monitoring and remote controlling in agriculture is rapidly growing. However, there have been few researches on the applications of WSN for agriculture.

1.2 Motivation

In the past few years, new trends have appeared in the agricultural sector. Precision agriculture concentrates on providing the means for monitoring, determining and managing agricultural practices. It covers a wide range of agricultural involves from daily herd management through horticulture to field crop production. It relates as well pre- and post-production aspects of agricultural enterprises. Many topologies for WSNs have been developed but most of them do not take into consideration the limited power resources for sensor nodes. This is a main drawback in most topologies where they should choose the sensing place based on the supposition. More over the use of appropriate topology depending on the field conditions, water control, the optimum quantity of topology and spending less money on agriculture scientists and consulting firms are factors that WSN has a direct impact. Wireless sensors operate on limited power sources. Therefore, their main focus is on power conservation through appropriate optimization of communication and operation management.

2. THE PRECISION FARMING SYSTEM HAS THE FOLLOWING PARTS

- Sensing agricultural parameters.
- Identification of sensing location and data gathering.
- Transferring data from crop field to control station for decision making.
- Actuation and Control decision based on sensed data.

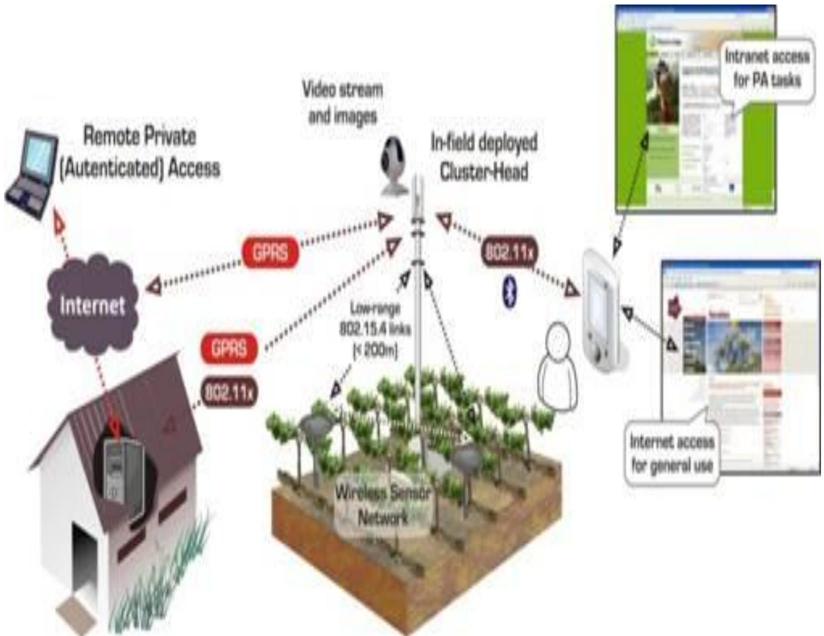

Figure 2 Wireless Sensor network Using Crop Monitoring

2.1 Wireless Agriculture

Key technology used in the above example of the wireless home is the wireless sensor. Research in this area of wireless networking is also quite popular. Wireless sensor networks have applications from monitoring volcanoes and forest fires to climate change in the oceans. Wireless sensors could also be used in other climate sensitive applications such as farming and agriculture.

Many times they have to call in their staff in the middle of the night in the winter (because that is when the ideal temperature is usually reached) but find out that the temperature is actually not quite cold enough yet. So all the workers are sent home and paid for three hours of work. If wireless sensors were used instead perhaps some money and time could be saved. Additionally, many of the wineries have technology which circulates air around the fields to control the temperatures from become too extreme for the grapes to grow how they want. These devices could be controlled via wireless sensors spread across the vineyard as well. Similarly, in other areas of agriculture the same ideas could be applied.

While soil moisture data provides information about the root zone, the measured application of water can be used concurrently with the soil moisture values to provide a more complete suite of tools for the irrigator. The measured application of water (D) is the amount of water applied to the crops with sprinklers, plus the amount of natural precipitation measured in inches/day. It is the total depth of water received by the crop.

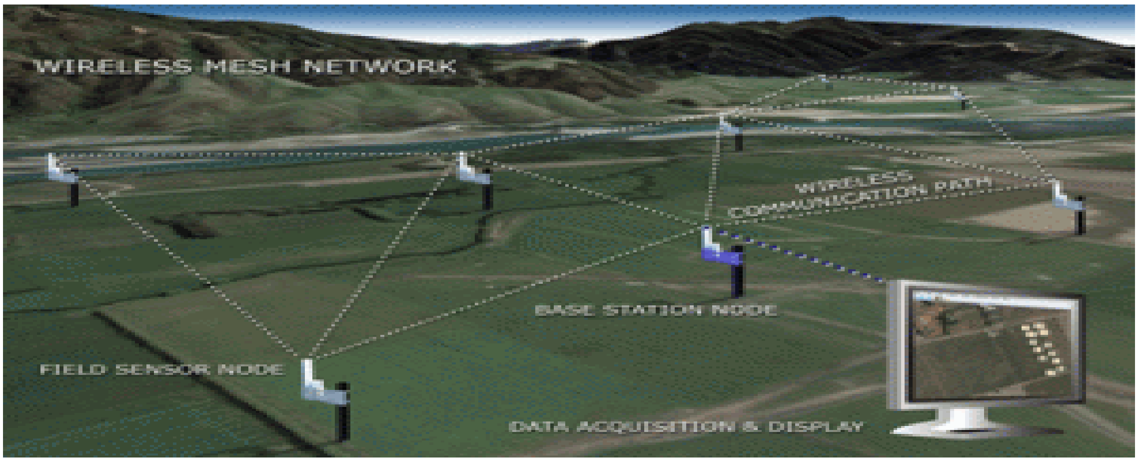

Figure 3 Wireless Agriculture

Wireless Sensor Networks (WSN) is the enabling technology for efficient and inexpensive Precision Agriculture (PA). Prior to PA, farmers had to rely on satellite and aircraft imagery or other map based systems to accurately target their growing areas. Precision Agriculture has the benefit of providing real time feed-back on a number of different crop and site variables. As its name implies, Precision Agriculture is precise in both the size of the crop area it monitors as well as in the delivery amounts of water, fertilizer, etc. The data collection, monitoring and materials application to the crops allows for higher yields and lower cost, with less impact to the environment. Each area receives only what is required for its particular space, and at the appropriate time and duration.

A wireless sensor network for Agriculture is similar to those used in other industries such as Industrial Controls, Building Automation and Security Systems. The WSN system requires a centralized control unit with user interface, communication gateways and routers, power elements and most important – the sensors. Unlike other systems, Precision Agriculture requires a unique software model for each geographical area, the intrinsic soil type and the particular crop or plants. For example, each location will receive its own optimum amount of water, fertilizer and pesticide.

Any more frequently doesn't provide additional useful information for the software model and becomes a burden to the Wireless Sensor Network in terms of power consumption and data transmission. Less frequent monitoring may be acceptable for certain slow growth crops and areas that have very stable, uniform climate conditions.

2.2 A General Agricultural Application Can Be Employed For

- Large crop area monitoring
- Forest / Vegetation monitoring
- Forest fire prevention
- Biomass studies
- Tracking Animals
- Crop Yield Improvement

While Agriculture is typically thought of to be land-based, the concepts presented here are also applicable to water and under-water eco-systems. For example, a WSN is used to monitor kelp beds and algae growths. Air temperature for farms is often as critical as water temperature for marine plants. A similar correlation can be made for the amount of sunlight and pH levels.

2.3 The Sensors Are Used To Monitor The Following Parameters

- Temperature
- Humidity
- Barometric Pressure
- Carbon Dioxide(CO) Gasses
- Soil Moisture
- Soil Acidity / PH

The modeling software incorporates the data from the sensors in a feedback loop which activates the Control Network. This provides the optimal amounts of agricultural inputs to the individual locations and varying times.

2.4 The Control Network Is Responsible For

- Water Pressure
- Valve / Irrigation Operation
- Animal Control (e.g., open and close gates)
- Fertilizer Dispersal
- Pesticide Dispersal
- Heating / Cooling
- Sunlight / Shading (typically in a greenhouse or enclosed growing area)

As the cost for sensors and communications infrastructure trend downward, more growers are implementing Wireless Sensor Networks for their crops. This is becoming more prevalent with smaller farms, micro-farms and urban farms.

In each of these situations, the crop yields are critical as growers may only have a very small area and unique space requirements to contend with. In some cases, farm areas are being constructed on vertical trellises which are only 4 to 8 feet high, and placed on high-rise roof-tops, or alongside residential housing.

WSN technology makes it possible to monitor and specifically target each crop, making it practical and cost effect to implement Precision Agriculture regardless of the growing area. This approach is also easily scalable by adding additional communication hubs and sensors.

2.5 System Architecture and Service Process

The agricultural environment monitoring server system proposed in this paper collects environmental information such as luminance, temperature, humidity, wind direction, wind speed, EC, pH, CO_2 *etc.*

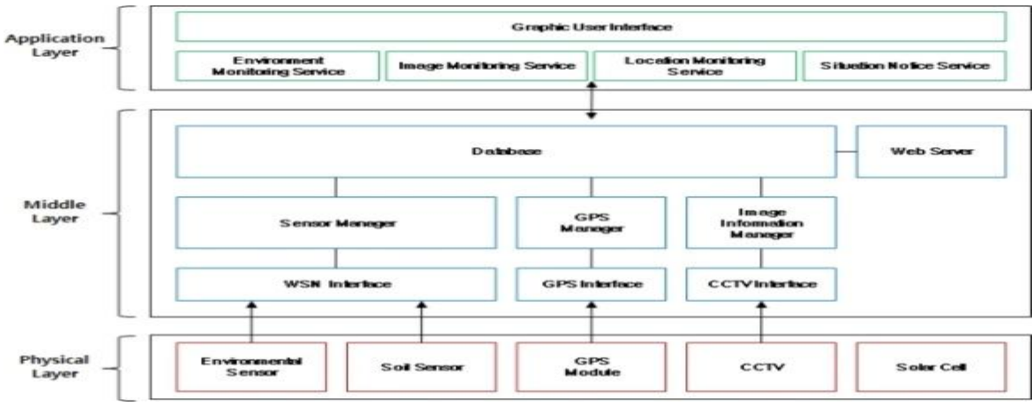

Figure.5 System Architecture and Service Process

The above section describes the structure and components of the proposed system and services provided by the system. The WSN sensors are composed of environmental sensors to collect environmental information including luminance, humidity, temperature *etc.* .

The CCTV system collects image information on the outdoors in real time to provide outdoor images to user, and the GPS module collects location information on the installed server system and the collected outdoors information.

The solar cell supplies power for the server system installed outdoors, and the system is therefore applicable in an agricultural environment with insufficient power infrastructure because can operate even if no external power is supplied to the server system.

The sensor manager manages data acquisition from the soil and environmental sensors, extracts the soil and environmental data by processing the collected data packets into a format which could be stored in the database, and stores it in the database or sends it to other server systems for processing by converting the processed data into the format suitable for the measurement elements.

The database stores environmental and soil data, image data, location information data and environmental reference values for notifying conditions into each table, and creates average statistical information by using the collected information. The web server provides an environment that users could monitor data processed

3. PRECISION FARMING THROUGH WIRELESS SENSOR NETWORK

Consistent advances in micro sensing, smaller devices, and wireless communication have resulted in new comprehensive technologies that offer even more consistent and reliable systems for smallholders and policy makers alike. Wireless sensor networks (WSNs), which combine many kinds of sensory data in one location, are some of the most innovative technologies available for farming and agricultural planning.

A WSN is a group of small sensing devices, or nodes, that capture data in a given location. These nodes then send the raw data to a base station in the network, which transmits the data to a central computer that performs analysis and extracts meaningful information. The base station acts as a door to the Internet (typically a local area network), providing operators with remote access to the WSN's data. Because the networks can have multiple sensory devices, the data can contain information on soil, climate, chemicals, and other relevant subjects.

The wide application of WSNs allows them to be used not only in managing agriculture but in testing water quality, managing disasters, detecting volcanic activity, and conducting environmental Evaluations.

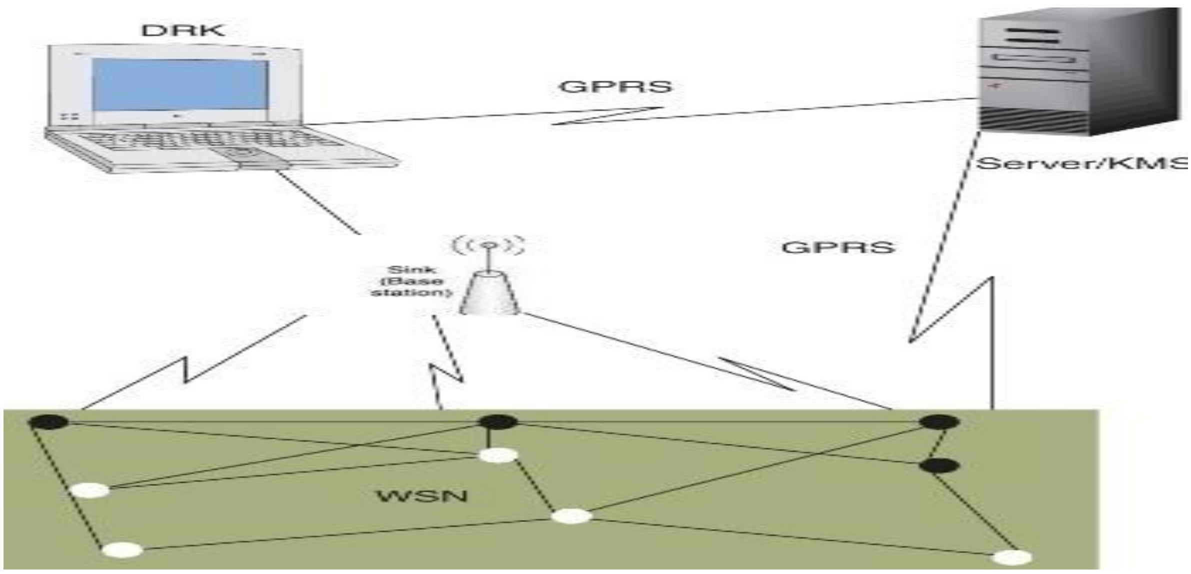

Figure 6 Precision Farming through Wireless Sensor Networks
DRK = Distributed Resource Kits GPRS = General packet radio service; KMS = Knowledge Management System

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These networks have several key features. First, WSNs have both active and passive sensors. Active sensors release a signal to detect a physical phenomenon like seismic activity and radar. Passive sensors, which transform a physical phenomenon into electrical energy, can detect a vast array of phenomena, including temperature, humidity, light, oxygen, and chemicals. Once sensors (for example, temperature and soil moisture) are selected, node locations are needed.

In addition, because low-income countries often experience poor network and telecommunications connectivity, nodes will often require a "buffer," where data can be rerouted or stored in another node if connection to the base station fails.

The design and implementation of WSNs requires a number of important features. The nodes should monitor the field(s) continuously and for a significant period—it is best if maintenance is not required for at least one cropping season (or 4–6 months).

The nodes should cover a wide area, be small to prevent animal and human interference (like stealing), and tolerate harsh environmental conditions like monsoons and extreme heat. Self-organization is also important: The network should automatically detect removed or newly arrived nodes and adapt the messaging route.

3.1 Basic Components of The Suggested Framework

To develop an integrated framework of dynamic cartographic visualization and modeling tools for agricultural applications based on wireless sensor networks information. The terms "dynamic visualization" describes mainly the possibility to select required scale, interactive creative communication of users and map authors over the Internet, and also presence of simple modeling tools for spatial as well as temporal analysis.

Usability of the proposed solution will be evaluated in a scope of information systems acting in the agricultural domain. The pilot area has been selected as a possible extension of the environmental European INSPIRE initiative.

The target of the project is a framework developed for agile accessing heterogeneous sensor data and services, which are necessary for effective decision making in the area of agricultural management. The suggested framework is based on following components

1) Heterogeneous distributed network of hierarchical agricultural sensors

2) Communication infrastructure and standardized interfaces between sensors and the Internet.

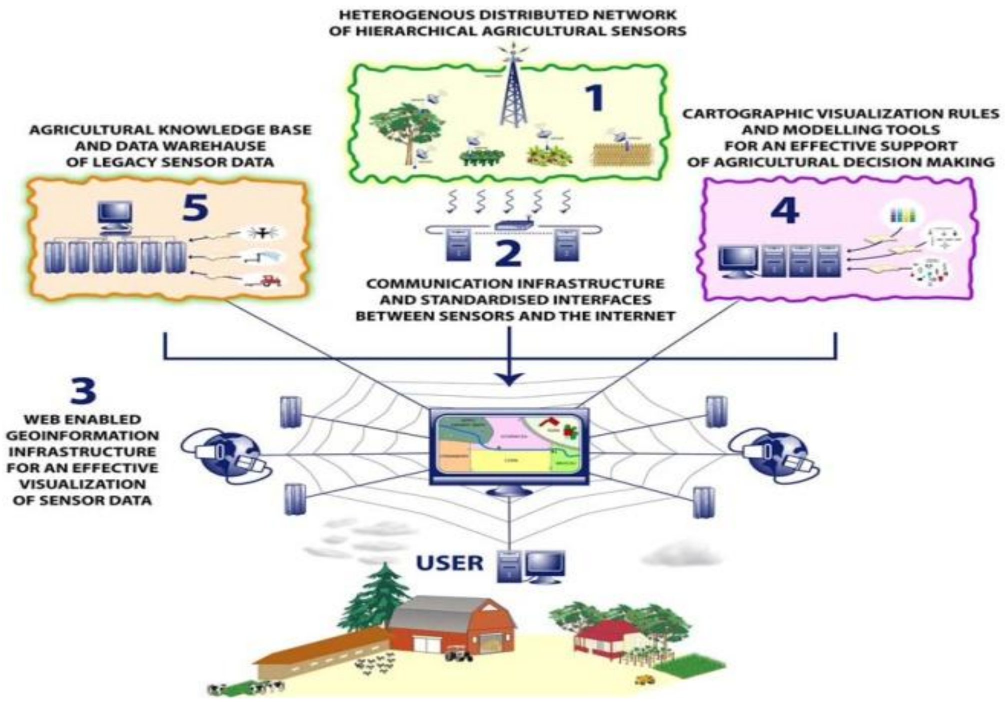

Figure 7 Basic components of the suggested framework

4. WATER MANAGEMENT

Water management is crucial to improving conditions in agriculture. India currently has around 5,000 large dams that are able to store more than 220 teralitres, which ranks seventh in the world in terms of capacity. While dams in other parts of the world are built for flood mitigation, power generation and water supply, the primary purpose of India's dams is irrigation. Around 40 per cent of crop areas are now irrigated, and these areas produce 70 per cent of India's crop output.

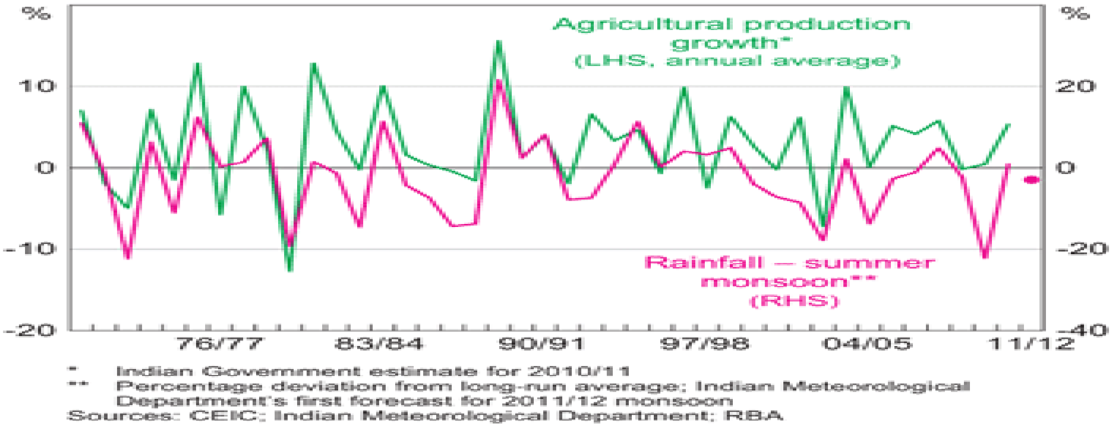

Figure 8 India – Rainfall and Agriculture Production

5. THE FOOD PROCUREMENT AND DISTRIBUTION SYSTEM

In addition to policies on land distribution, the Government has significant influence on the agricultural sector through other policy instruments, including subsidies for inputs, minimum price support arrangements and government procurement of food. One-third of input subsidies are paid in the form of fertilizer subsidies, which are equivalent to 1 per cent of GDP.

Under this subsidy scheme, the Government quotes a maximum retail price for various types of fertilizers and reimburses the seller the difference between the retail price and the 'market' price. The market price for domestically produced fertilisers takes into account transportation, storage, labour and energy costs.

The subsidy for imported fertilizer is the difference between the import price and the maximum retail price. Urea fertilisers are a major input into agricultural production and its price has been fixed since 2003 despite large fluctuations in the cost of inputs.

While India is able to produce enough urea fertilizer to meet domestic needs, it relies on imports to satisfy its demand for compound fertilisers, so that the increase in global fertilizer prices during 2007 and 2008 saw a large outlay in the subsidies paid for compound fertilisers (Figure 8.5)

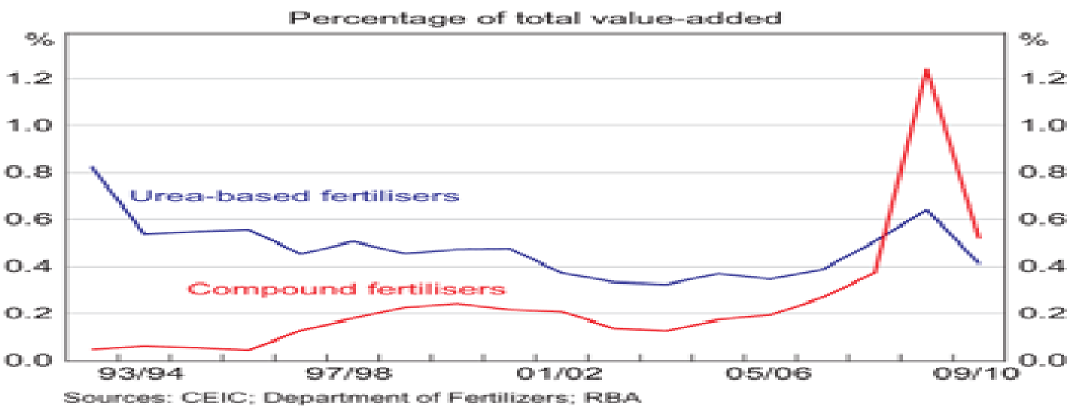

Figure 9 India – Fertilizer Subsidies

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To help alleviate poverty and to shield Indian consumers from global food price fluctuations, the Government subsidies food purchases for many consumers. The Government procures agricultural goods from producers, who must sell a share of their output to the Government at minimum support prices (MSPs), which are typically below market prices. Procured food is sold through the Targeted Public Distribution System (TPDS), which consists of about half a million 'fair price shops'. In order to purchase food through this system, households apply for ration cards, which indicate whether they are assessed to be Above Poverty Line (APL) or Below Poverty Line (BPL). In 2005, 81 per cent of rural households and 67 per cent of urban households held ration cards.

6. EXPERIMENTAL SYSTEM

In order to effectively use the application of water in a water budget model, high sprinkler efficiency (E*f*) is required. Sprinkler efficiency (E*f*) is the measure of uniformity of water application. Ponding of irrigation water, and uneven application of water over the field is the result of poor sprinkler efficiency. Soil moisture data and rain gauge data are less meaningful if the monitoring site receives more or less water than the rest of the irrigation regime. Sprinkler efficiency is determined by placing catch cans or a set of uniform containers in the field.

The catch cans can be placed in grid or uniformly distributed amongst the crops. After running the sprinklers for a length of time, the amount of water in the catch cans is measured. The sprinkler efficiency is expressed as a fraction and an E*f* value of 1 is perfect uniformity. There are a number of methods for calculating E*f*. The most common method for determining E*f* involves averaging the lower 25% of the measured catchment of catch cans divided by the mean. An E*f* value greater than 0.8 is preferred. Table 3 shows typical E*f* values for several different types of sprinkler systems.

Table 1 Sprinkler types

Irrigation System	Sprinkler Efficiency (E_f)	Sprinkler Efficiency (sprinkler spacing over 40 X 40 feet)
Solid Set	0.70	0.63
Hand Move or Side Roll	0.80	0.74
Pivot or Linear Move	0.90	0.81
Offset Managed Hand Move	0.90	0.81

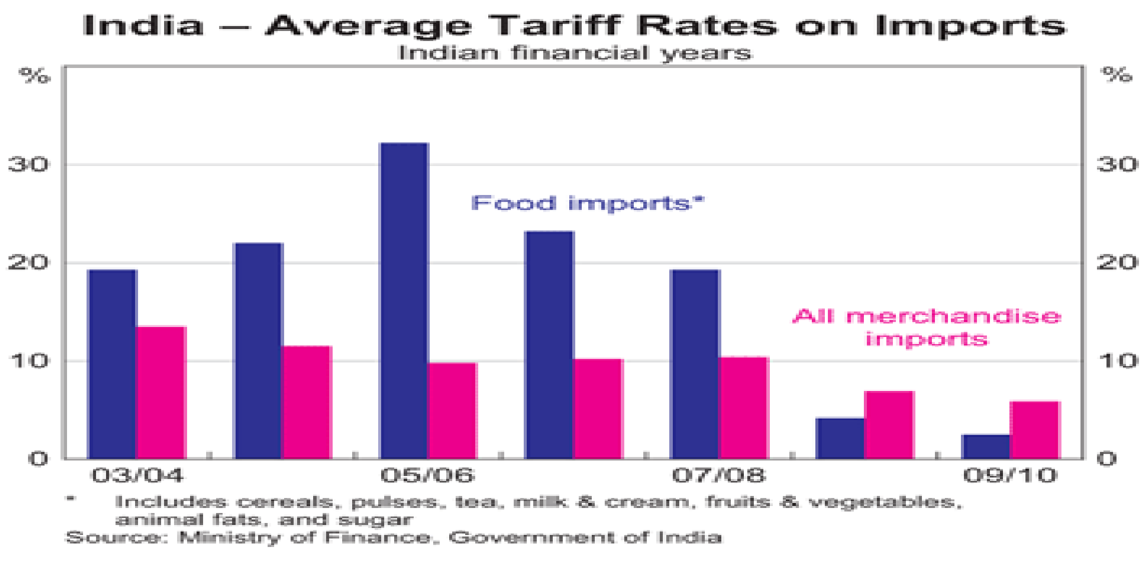

Figure 10 India – Average tariff rates.

7. CONCLUSION

India's agricultural sector is still very important to the Indian economy, although its share of the economy has decreased over the past 50 years. India has made significant advances in agricultural production in recent decades, including the introduction of high-yield seed varieties, increased use of fertilizers and improved water management systems. Reforms to land distribution, water management and food distribution systems will further enhance productivity and help India meet its growing demand for food.

We proposed real-deployment of WSN based crop monitoring which is designed and implemented to realize modern precision agriculture. End Users can tailor the mote operation to a variety of experimental setups, which will allow farmers to reliably collect data from locations previously inaccessible on a micro-measurement scale. Such a system can be easily installed and maintained.

The report presents research on an application of a Wi-Fi based wireless sensor network (WSN) for agricultural monitoring. The proposed system consists of three stations: a Sensor Station, Access Point and Central Server Station.

The sensor station acts as a data acquisition unit capable of measuring six different climate parameters, such as temperature, relative humidity, soil moisture and water level. The access point is a commercially available wireless router. It is responsible for controlling the flow of data and instructions between the sensor station and the central server station. The central server station is the main controller of WSN system. It carries out various tasks such as data collection, data storage, and configuration of sensor nodes deployed. Data is sent by the server to configure WSN802G modules wirelessly.

The WSN802G modules capabilities and function were thoroughly investigated. Analysis was done on the communication of information within the WSN with logs and wireless protocol analyzers such as Wireshark. This showed one of the strengths of Wi-Fi and IP technology systems, was readily available tools which can be used to monitor and control the Wi-Fi system. It was seen that the WSN802G modules allows for relatively easy connection to nodes and communication. The system can be operated with standard commercial products that are commonly implemented.

Finally, agricultural environment monitoring systems are an attractive opportunity, particularly wireless sensor systems which use Wi-Fi such as the WSN802G module. This thesis can therefore be used as a good reference source for further integrating/developing similar work using the Wi-Fi WSN802G modules. The thesis investigates and explains in depth the use of wi-Fi WSN802G modules and its abilities. The current system performs well for transferring and logging of values from the various sensor nodes using standard commercial products and works in conjunction with equipment already in use. It allows for relatively easy connection to nodes and communication.

This thesis has provided a comprehensive report on the design process and implementation of a Wi-Fi based wireless agricultural monitoring system.

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