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WIRELESS SENSOR NETWORK (WSN) TECHNOLOGY FOR PRECISION AGRICULTURE: A NEW CONCEPT IN MODERN AGRICULTURE

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Abstract: *Agriculture is the backbone of Indian economy and contributes around 21% role in GDP. With agriculture being the primary economic sector of India, it is essential to automate it to increase efficiency. Precision agriculture is an option to produce high quality food and raw material in sufficient amount for the consumers. WSN can show the path to the rural farming community to replace some of the traditional techniques. For supplying the food without restricting the demands of growing population, it is required to use modern machinery and farm equipments of high efficiencies to developed a fully automated mechanized farm without causing environmental pollution. The planning of this mechanized farm is only possible by application of Wireless Sensor technology to manage all activities and processes in integration to ensure food security. Wireless sensor technology has potential to analyze the sensed data. Today WSN is not only used in agriculture, widely used in interdisciplinary branch as nuclear reactor control, surveillance and security etc. This paper presents an overview on recent development of wireless sensor technologies in various agriculture sectors to produce best agriculture products through precisely management of irrigation, detection of essential plant micro-nutrients of an existing cropping pattern etc. by using modern technologies in low prices. Thus, wireless sensor technology is only the option to do all these activities in a planned and managed way by using agriculture remote sensors to achieve ultimately more profit from different interlinked agricultural activities.*
Keywords**:** *precision agriculture, WSNs, modern technology*.

Introduction: In India, 60-70% economy depends on agriculture hence there is a great need to modernize the conventional agricultural practices for the better productivity. Due to unplanned use of land and water resources, the crop productivity is decreasing day by day. Lack of advanced technology also results in decrement of crop production. In this situation, wireless sensor network is a major technology that drives the development of precision agriculture. Precision agriculture can be defined as the science of using latest technology to enhance crop production. In general, precision agriculture targets to increase the crop production in a sustainable manner. Precision agriculture is a method of adequately prediction of the various stages of crop growth in order to be able to determine irrigation and fertilizer requirements [1]. Precision agriculture is a comprehensive system designed to optimize agricultural production by soil and crop management [2]. It is a important practice in water- saving agriculture cropping system, which allows to maximize crop productivity and also save the water while the accurate irrigation amount is difficult to obtain [3]. Precision agriculture utilizes many technologies and infrastructures: data instrumentation and gathering systems, geographic information systems (GIS), global positioning systems (GPS), microelectronics, wireless technologies and so forth for observing, assessing and controlling the agricultural practices and make possible to increase efficiencies, productivity and profitability [4,5].

WST must be able to operate in a wide range of environments such as bare fields, vineyards, orchards, from flat to complex topography and over a range of weather conditions, all of which affect radio performance [6]. Wireless sensor networks (WSNs) is a system comprised of global positioning sensors (GPS), radio frequency (RF) transceivers, soil sensors, water sensors, power sources [7]. Wireless sensors have been designed and are undergoing field trials and have a wide range of applications, including wireless data acquisition, machine monitoring and maintenance, smart buildings and highways, environmental monitoring, site security, automated on-site tracking of expensive materials, safety management [8]. WSN applied in agriculture to detect the moisture, temperature, humidity and the proportion of pesticides and fertilizers in a given sample of soil for paddy, Banana and Turmeric fields [9]. Sensor networks are used for a variety of applications in agriculture including determination of the percentage of potassium, phosphorus, nitrogen with the help of fertility meter and ph. Meter are given in Table: 1 [9, 10]. Wireless sensor network (WSN) designed for a water irrigation control monitoring and is composed of a number of sensor nodes with a networking capability that can be deployed for an ad hoc and continuous monitoring purpose [11]. Sensor networks are very important and play a key role in precision agriculture for supporting the food requirement of any nation. Sketch diagram of Wireless Sensor Technology used in typical agriculture is shown in Figure: 1.

Table 1: Specifications of some wireless sensors used in agriculture

Sensors	**Specification**
Soil Temperature	*Sensor working temp. (-40* ºC *to 8*5ºC)[9]
Humidity Sensor	*working* RH (30% to 90%)[9]
Soil Moisture Sensor	*measures volumetric water content (VWC) or Gravimetric water content (GWC)* [9]
Biosensor	*detection of fertilizers, pesticides and herbicides* [9]
Rapides soil fertility meter	*indicates overall soil fertility* [10]
ph. meter	*provide ph.Value of soil solution* (7 or < 7)[10]

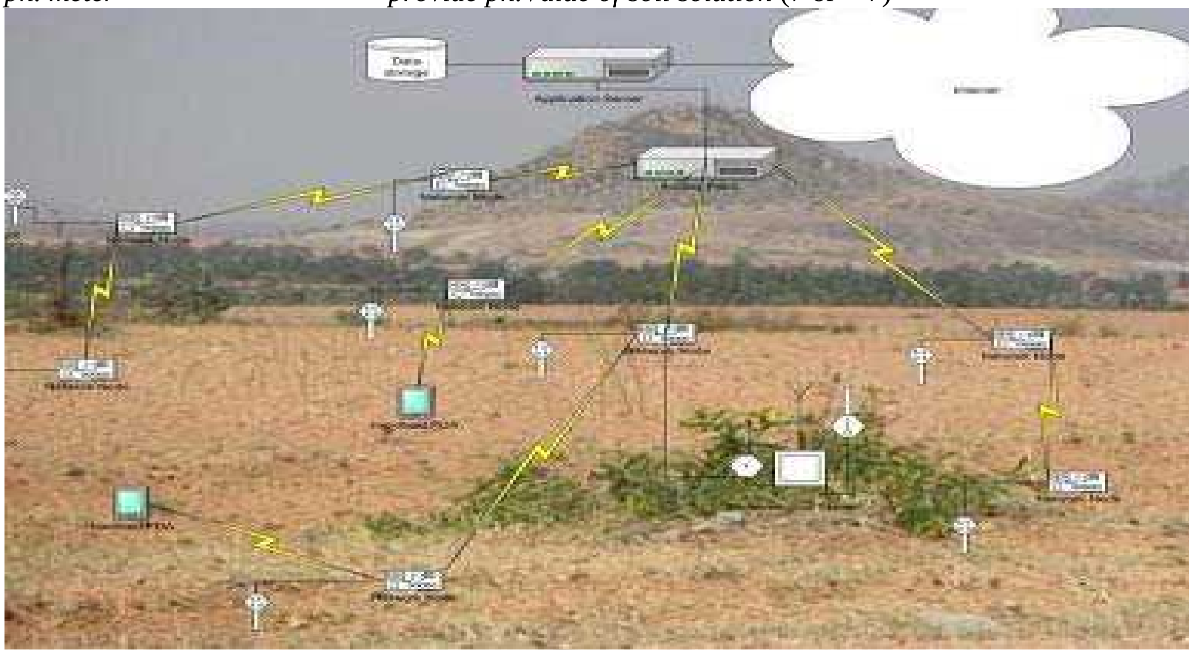

Figure 1: Sketch diagram of Wireless Sensor Network (WSN)

Challenges to 'Agriculture Sector' in India: In India, spatial and temporal variation of rainfall is high especially 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 [11]. In some parts of country crop failure takes place due to uneven distribution of water throughout the year and results in drought and flood situation. Poor seed quality often results into poor crop production leads to wastage of labor, money, time 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 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.

Need of Wireless Sensor Technology (WST) in India

1. To provide capability of developing large scale systems for monitoring of real-time data.
2. To reduce the risk of crop failure by adopting suitable technology by getting crop related information accordingly.
3. To facilitate the monitoring of environmental data provided over time and space can be used to validate and calibrate the models.
4. To help in calculating the crop water requirements during crop growth stages by use various types of simulation models related to crops, pests and diseases etc.
5. Empowering farmers to take timely decisions about the climate changes, water conditions, moisture conditions etc.

Merits of WST: In agriculture, wireless technology helped in a significant reduction and simplification in wiring system and results in reduction of high cost involved. Wireless sensor networks enables new precision practices in agricultural ultimately for increasing the productivity. Recently two standard technologies *ZigBee* and *Bluetooth* are used for Wireless Sensor Network and details of both technologies are given in Table: 2.

Table: 2 Details of Bluetooth and zigbee technology used in WSN[12]

	Bluetooth	**ZigBee**
Frequencies	2.4 GHz	2.4 GHz
No. of nodes	8	65,000
Range	8 m to 100 m	1-100 m
Data type	Audio, graphics, pictures, files	Small data packet
Battery life	1 week	> 1 year
Extendibility	No	Yes
Data rate	1 Mb/sec	20-250 kb/sec

Examples of Wireless Sensors in Agriculture and Food Production:

Environmental monitoring [13]
- Weather monitoring [14, 15]
- Geo-referenced environmental monitoring [13, 16]

Precision agriculture
- Spatial data collection [17, 18, 19]
- Precision irrigation [20, 21]
- Variable rate technology [22]
- Supplying data to farmers [23, 24]

Advanced precision agriculture components [25] -
- Combine harvester
- Sprayer
- Fertilizer spreader

Machine and process control
- Vehicle guidance [26-30]
- Machinery management [31-34]
- Robotic control [35]
- Process control [36]

Automation of facility [37]
- Green house control [38-42]
- Animal feeding facilities [43, 44]

Traceability systems [45, 46, 47]
- Animal identification and health monitoring [48-50]
- Food packaging [51, 52]
- Transportation [53, 54]
- Food inspection [55-57]

Some Application of Commonly Used WST in Agriculture: Today, WSN used in very broad sense in agriculture sector for the purpose of providing accurate information to the farmers for taking the decisions regarding to water application like when to irrigate, how to irrigate and how much irrigate during non monsoon season and drainage of surface water in monsoon periods because of high rainfall occurance.WSN is applied to solve the problems of security of grain-storing keeping temperature and humidity in optimal range for creating adverse situation in the granary to maintain their quality by adopting appropriate management strategy at a instant.

Agricultural Management

Greenhouse Control System (GCS): Greenhouse Technology is the technique of providing favourable environment condition to the plants. In a typical green house control system, wireless sensor-actor is a collection of sensor and actor nodes linked by a medium of wireless to perform distributed sensing and acting tasks [58]. The sensor nodes collect typical information about the physical world (e.g., humidity and temperature) and communicate over a network environment to a computer system, called, a *base station*. Based on the information collected, the base station takes the decisions or sometimes the actors themselves take decisions and then the actors perform appropriate actions upon the environment. This action allows users to sense and control the environment from anywhere, at any time. After that, the networked sensor provides information. By application of wireless technology, such sensors and actors can be connected over a wireless network system (e.g., Bluetooth, WiFi Wide). Sensor based green house system has been designed to control environmental parameters, temperature and humidity into greenhouses for flower growing [59, 60].

Advantages of GCS: *Solve climate control problems*-for controlling two independent systems, climate parameters and fertirrigation because water and nutrient requirement of plant species are different and known and this problem is reduced to the control of crop growth as a function of climate environmental conditions [61, 62]. *Air Temperature control*–under two different set points, diurnal conditions and nocturnal conditions. Diurnal temperature is necessary to maintain high temperature level required for photosynthesis process whereas under nocturnal condition. Plants are not active and not able to grow [63].

Humidity control–to keep the humidity within a particular range, which is required for disease control, maintain transpiration rate, reduce hydro stress, stomata opening and regulate the photosynthesis process etc. the temperature set point can be changed by humidity controller by selecting maximum allowable changes for a particular crop species based on the inside relative humidity value [62].

Raised Bed Planting: Sensor Network Technology used to improve wheat crop production in raised bed farming and analyzed that farmers can identify the demands of the fertilizers, irrigation and other requirements of crop grown [64]. Main advantage of raised bed farming is particularly in areas where groundwater levels are falling and weeds are becoming a problem. This method of planting is also facilitates crop diversification and intercropping of crops like wheat, chickpea and maize with potato, rice with soybean, and pigeon pea with sorghum or green gram.

Irrigation Water Management: In recent times, intelligent irrigation systems is very essential and prime requirement of any nation for ensuring food security of increasing population without making any stress in natural resources and also reduces the strength of labor requirement ultimately to fulfill the demands by using the concept "*less drop more crop*". Wireless technology is known for easy installation, maintenance and used to develop automatic irrigation network. The application of wireless sensor network (WSN) for a water irrigation control monitoring is composed of a number of sensor nodes with a networking capability that can be used for continuous monitoring purpose [65].

Drip Irrigation Automation: A low-cost wireless controlled irrigation for real time monitoring of water content of soil has been monitored with the help of wireless sensors [10]**.** The data is recorded by using solar energy for the wireless station for the purpose of control of valves to do irrigation. Diagram showing the automated drip irrigation system is depicted in Figure: 2.

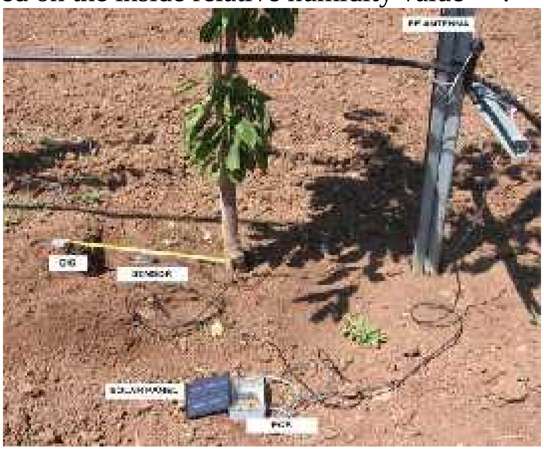

Figure 2: Application of WSNs in drip irrigation

Figure 3: WSNs to improve wheat crop production in bed farming

Grain Storage Management: The food price has been rising constantly, so it is immediate urgent to solve the problems of security of grain-storing with the application of agriculture science and technology. The conventional manual method of the granary storage could no longer meet the requirements of the agricultural development. With the development of sensor network technology, it is an inevitable trend to adopt the suitable techniques to control the temperature and humidity in the granary. Many researchers have developed wireless sensors in order to control the microclimate in grain storage. In this way, WST used to test and control the temperature and humidity by using *Zigbee* and *XBee* module [66, 67].

Conclusion: The wireless sensor networks described here a real chance for monitoring soil and environment condition for a cropping system, successfully monitor the crop during its all growing stages and food industry provides new features that have the potential to be an economically viable replacement to wired networks. The farmers are now able to collecting more accurate data in both space and time. The WST can be best realized when integrated with agronomic facts, using the information gathered in the improvement of decision support systems. Thus, the agriculture production system have benefited from incorporation of new advanced technology. Despite the great potentials of this technology some obstacles have been detected (lack of experienced staff for troubleshooting, high cost for the sensors, power supply as a great concern, etc.).

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