



# A review of wireless sensors and networks' applications in agriculture

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## ABSTRACT

Due to advancement in technologies and reduction in size, sensors are becoming involved in almost every field of life. Agriculture is one of such domains where sensors and their networks are successfully used to get numerous benefits. Selection of sensors and their effective utilization to solve agricultural domain problems has been an arduous task for novice users due to unavailability of conglomerated information in literature. The aim of this paper is to review the need of wireless sensors in Agriculture, WSN technology and their applications in different aspects of agriculture and to report existing system frameworks in agriculture domain.

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## 1. Introduction

Agriculture has played a key role in the development of human civilization. Due to the increased demand of food, people are trying to put extra efforts and special techniques to multiply the food production. Use of different technologies towards agriculture is one of such efforts. Apart from use of scientific technologies in agriculture, information technology is now being heavily exercised in this area. Technologies like satellite navigation, sensor network, grid computing, ubiquitous computing and the context-aware computing are supporting the said domain for improved monitoring and decision making capabilities [1].

Use of sensors and their networks is supporting agriculture practices in a very positive direction [2,3]. For sensor based agriculture, varieties of terminologies are now in use like Precision Agriculture (PA), Smart Agriculture, Variable Rate Technology (VRT), Precision Farming, Global Positioning System (GPS) Agriculture, Farming by Inch, Information-Intensive Agriculture, Site Specific Crop Management etc. [4] but the underlying concept in all of them is same.

Advancements of technologies reduced the size of sensors to such extent that enabled them to be utilized in variety of the domains of human life. Due to the significance of sensor technology, several issues related to sensors and their networks are in research. Energy constraint, limited computing power, small memory and data security are some of the substantial issues of sensor networks for which researchers proposed several solutions [5–7].

The aim of this paper is to review the need of wireless sensors in different aspects of agriculture. The remainder of this paper is organized as follows: In next section, we will present the importance

of sensors in agriculture. In Section 3, sensor technology and their networks will be introduced. Wireless sensor and actuator networks application in agriculture will be discussed in Section 4. Section 5 will discuss the available system framework proposed for agriculture domain followed by conclusions in the last section.

## 2. Why sensors in agriculture?

Sensors are used for collecting information about physical and environmental attributes whereas actuators are employed to react on the feedback to have control over the situations. The sensors' accumulated information that characterizes the object or environment and used to identify people, location, objects and their states is known as context [8,9]. The context acquisition provides a valuable contribution in modeling situations of domains that have variety of time variant attributes. Agriculture is one such domain.

Agriculture domain poses several requirements that are following:

- 1- Collection of weather, crop and soil information
- 2- Monitoring of distributed land
- 3- Multiple crops on single piece of land
- 4- Different fertilizer and water requirement to different pieces of uneven land
- 5- Diverse requirements of crops for different weather and soil conditions
- 6- Proactive solutions rather than reactive solutions.

Above requirements entail parallel and distributed application and processing. In addition, wireless sensors and actuators are required to collect the requisite information and to react on different situations. Decision support imposes the requirement to have processed information rather than raw sensor data.

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To cope-up with such requirements, wireless sensors, actuators and their networks present themselves as a strong candidate for development of system for context acquisition, presenting acquired data to remote decision support systems and thus providing a controlled environment based on decision. Several sensors that are used for agricultural related attributes' acquisition are presented in Table 1.

### 3. Wireless sensor technology and networks

Utilization of sensors is becoming possible in almost every field of life due to the advancement of technology and size reduction. Sensor is a device that has capabilities to measure physical attributes and convert them into signals for the observer. Sensors are the part of

**Table 1**  
Sensors used in Agriculture Domain.

		Soil							
S. no.	Sensors	Temperature	Moisture	Dielectric permittivity	Rain/ water flow	Water level	Conductivity	Salinity	References
1	Hydra probe II soil sensor	✓	✓	✓	✓	✓	✓	✓	<a href="http://www.stevenswater.com">www.stevenswater.com</a>
2	Pogo portable soil sensor	✓	✓	✓	✓	–	✓	–	<a href="http://www.stevenswater.com">www.stevenswater.com</a>
3	MP406 Soil moisture sensor	✓	✓	✓	–	–	–	–	<a href="http://www.ictinternational.com.au">www.ictinternational.com.au</a>
4	ECH2O soil moisture sensor	✓	✓	✓	–	✓	✓	–	<a href="http://www.ictinternational.com.au">www.ictinternational.com.au</a>
5	EC sensor (EC250)	✓	✓	–	✓	–	✓	✓	<a href="http://www.stevenswater.com/catalog/products/water_quality_sensors/manual">www.stevenswater.com/catalog/products/water_quality_sensors/manual</a>
6	ECRN-50 low-REC rain gauge	–	–	–	✓	–	–	–	<a href="http://www.decagon.com">http://www.decagon.com</a>
7	ECRN-100 high-REC rain gauge	–	–	–	✓	–	–	–	<a href="http://www.decagon.com">http://www.decagon.com</a>
8	Tipping bucket rain gage	–	–	–	✓	–	–	–	<a href="http://www.stevenswater.com">www.stevenswater.com</a>
9	107-L temperature Sensor (BetaTherm 100K6A1B Thermistor)	✓	–	–	–	–	–	–	<a href="http://www.campbellsci.com/107-l">http://www.campbellsci.com/107-l</a>
		Leave/plant							
S. no.	Sensors	Photosynthesis	Moisture	Hydrogen	Wetness	CO <sub>2</sub>	Temperature	References	
1	237 leaf wetness sensor	–	✓	–	✓	–	✓	<a href="http://www.campbellsci.com">http://www.campbellsci.com</a>	
2	LW100, leaf wetness sensor	–	✓	–	✓	–	✓	<a href="http://www.globalw.com">http://www.globalw.com</a>	
3	SenseH2™ hydrogen sensor	–	–	✓	✓	✓	✓	<a href="http://www.NTMSENSORS.com">http://www.NTMSENSORS.com</a>	
4	Leaf wetness sensor	–	✓	–	–	–	–	<a href="http://www.decagon.com">http://www.decagon.com</a>	
5	YSI 6025 chlorophyll sensor	✓	–	–	–	–	–	<a href="http://www.ysi.com">http://www.ysi.com</a>	
6	Field scout CM1000TM	✓	–	–	–	–	–	<a href="http://www.specmeters.com/pdf/2950FS.pdf">http://www.specmeters.com/pdf/2950FS.pdf</a>	
7	TT4 multi-sensor thermocouple	–	✓	–	–	–	✓	<a href="http://www.ictinternational.com.au/thermocouple.htm">www.ictinternational.com.au/thermocouple.htm</a>	
8	LT-2 M (leaf temperature sensor)	–	–	–	–	–	✓	<a href="http://www.solfranc.com">http://www.solfranc.com</a>	
9	TPS-2 portable photosynthesis	✓	✓	–	✓	✓	✓	<a href="http://www.ppsystems.com/Literature/EDSTPS2_System.pdf">www.ppsystems.com/Literature/EDSTPS2_System.pdf</a>	
10	PTM-48A photosynthesis monitor	✓	✓	–	✓	✓	✓	<a href="http://phyto-sensor.com/PTM-48A">http://phyto-sensor.com/PTM-48A</a>	
11	CI-340 hand-held photosynthesis	✓	✓	✓	✓	✓	✓	<a href="http://www.solfranc.com">http://www.solfranc.com</a>	
12	107-L temperature Sensor (BetaTherm 100K6A1B thermistor)	✓	–	–	–	–	–	<a href="http://www.campbellsci.com/107-l">http://www.campbellsci.com/107-l</a>	
		Weather							
S. no.	Sensors	Temperature	Humidity	Atmospheric pressure	Wind speed	Wind direction	References		
1	CM-100 compact Weather sensor	✓	✓	✓	✓	✓	<a href="http://www.stevenswater.com">www.stevenswater.com</a>		
2	Met station one (MSO)	✓	✓	✓	✓	✓	<a href="http://www.stevenswater.com">www.stevenswater.com</a>		
3	XFAM-115KPASR	✓	✓	✓	–	–	<a href="http://www.pewatron.com">http://www.pewatron.com</a>		
4	HMP45C (Vaisala's HUMICAP® H-chip)	✓	✓	✓	–	–	<a href="http://www.campbellsci.com">http://www.campbellsci.com</a>		
5	SHT71 (Humidity and temperature sensor)	✓	✓	✓	–	–	<a href="http://www.sensirion.com/humidity">HMP45C Temperature and Relative Humidity Probe</a> <a href="http://www.sensirion.com/humidity">http://www.sensirion.com/humidity</a>		
6	SHT75 (Humidity and temperature sensor)	✓	✓	✓	–	–	<a href="http://www.sensirion.com/humidity">http://www.sensirion.com/humidity</a>		
7	CI-340 hand-held photosynthesis	✓	✓	–	–	–	<a href="http://www.solfranc.com">http://www.solfranc.com</a>		
8	107-L temperature Sensor (BetaTherm 100K6A1B thermistor)	✓	–	–	–	–	<a href="http://www.campbellsci.com/107-l">CI-340_hand-held_photosynthesis_solfranc_ENG.pdf</a> <a href="http://www.campbellsci.com/107-l">http://www.campbellsci.com/107-l</a>		

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