Food Science and Quality Management
ISSN 2224-6088 (Paper) ISSN 2225-0557 (Online)
Vol 5, 2012

How to Improve Food Security and Farming Systems by Using Wireless Sensor Networks (WSN)

Shrikrishan Yadav (Corresponding author)
Pacific College of Engineering, Pacific University
Udaipur-313001, India
E-mail: shrikrishanyadav77@gmail.com

Kuldeep Swarnkar
Pacific College of Engineering, Pacific University
Udaipur-313001, India
E-mail: kuldeep.996@gmail.com

Tanushree Chauhan
Pacific College of Engineering, Pacific University
Udaipur-313001, India
E-mail: tanushree82.chauhan@gmail.com

Abstract

According to a survey approximate 925 million people do not have enough food to eat. So it is a challenge to secure food as well as produce enough to fulfil all needs. A person can live without other necessities but cannot live without food. The food security refers to the ability of food systems to ensure that everyone has enough food to live a healthy life. A household is considered food-secure when its occupants do not live in hunger or fear of starvation. There are many reasons behind this, due to poor farming system, export restrictions, panic buying, increased farming for use in bio-fuels, global population growth, climate change, loss of agricultural land to residential and industrial development, and growing consumer demand in largest populated country such as China and India are claimed to have pushed up the price of grain. Some other factors which also cause food shortage, the agricultural productivity; soil health, water security, and food quality in storage and distribution are identified as the primary determinants of food security. So in this paper we have discussed how to secure food and enhance farming system by using Wireless Sensors Networks (WSN).

Keywords: WSN, Food Security, Developing Countries, Agriculture, Farming System, Management, ICT

1. Introduction

Food crisis and hunger have weighed down mankind throughout history and remain critical problems. Most recently, attention has been focused on the problem of food security, which has become one of the main issues on the global agenda. Concerns over food security have been prompted by the impact of climate change; sharp raises in food prices in many developing countries like India, and energy policies, in particular the issue of bio fuels. The food security refers to the availability of food and one's access to it.

To prevent food insecurity, we require reliable food systems at each stage of the food cycle: from food production and harvesting, during transport and distribution, at the shops we buy at and in the social settings wherever we consume food, and in the management of the resulting bio-waste outputs. The impact of climate change on food security has drawn great attention. Extreme weather events can have an immediate, adverse impact on food availability, while shifts in weather patterns can increase crop vulnerability to infection, pest infestations, and choking weeds. The increased use of agricultural lands to produce bio fuels instead of food, global population growth, loss of agricultural land to residential and industrial development and growing consumer demand in developing

countries have also been cited as reasons for rising prices and shortages.

The magnitude of the problem of hunger and food security is alarming. Every six seconds, a child dies from hunger and related diseases. The Food and Agriculture Organization (FAO), a specialized agency of the United Nations, estimates that more than 860 million people in the world today suffers from hunger. Of those, about 830 million live in developing countries, the very countries expected to be most affected by climate change.

Sharp recent increases in the price of food have raised special concern and calls for global action. In India food prices rose by nearly 60 per cent in 2011 and further large increases took place in the first part of year 2012. For the poor, higher food prices mean a reduced ability to purchase staples such as rice, maize, wheat, and dairy products. Lack of affordable food can cause long-term, irreversible consequences for health, productivity, and well-being. There are many factors which to be considered when addressing food security, but in all of them information and communication technologies (ICTs) such as wireless sensor network can act as catalysts. Some of them are policy, legal framework, technology, knowledge, markets, research, etc.

2. Wireless Sensor Networks (WSN)

All Sensor Networks have been signed as one of 21 most important technologies for 21st century by Business Week. Recent advances in sensing, computing and communication technologies coupled with the need to continuously monitor physical phenomena have led to the development of Wireless Sensor Networks (WSNs) . WSN consist of four main components: A radio, a processor, sensors and battery.

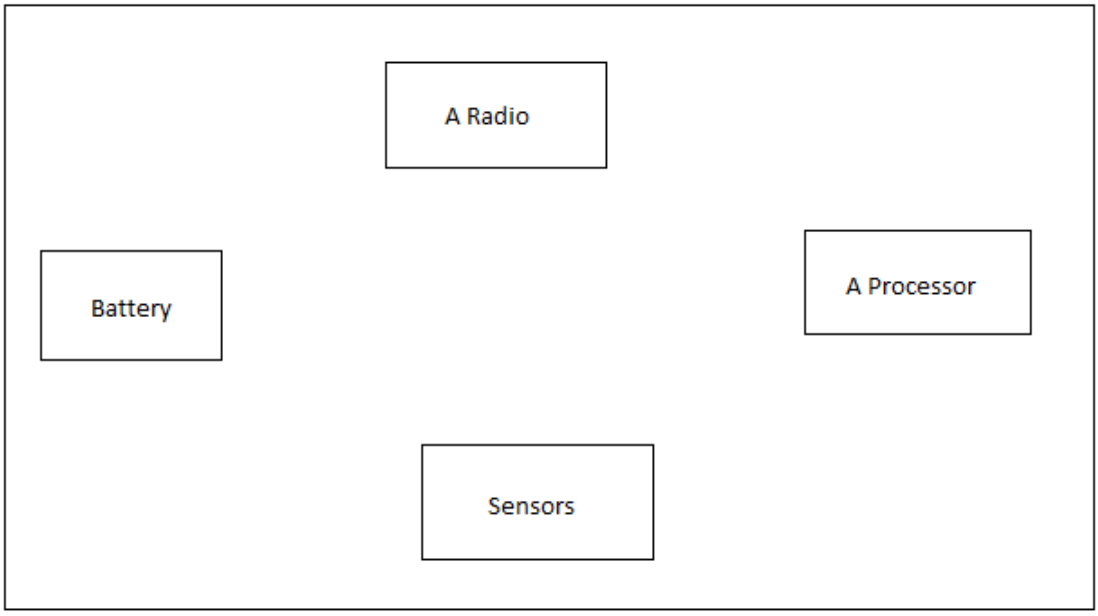


Figure 1. Four Main Components of a Wireless Sensor Network (WSN)

A WSN is formed by densely deployed sensor nodes in an application area. In most deployments, the sensor nodes have self-organizing capabilities, to form an appropriate structure in order to collaboratively perform a particular task. The Sensor Node, which is a basic element of Wireless Sensor Network, is composed of Sensing, Computation and wireless Communication unit. These sensor nodes are hence capable of observing physical phenomenon, process the observed and received information and communicate the observed or processed information to the nearby sensor nodes to form a network of sensor nodes.

A sensor network is a computer network Composed of a large number of sensor nodes. Usually these devices are

small and inexpensive, so that they can be produced and deployed in large numbers, and so their resources in terms of energy, memory, computational speed and bandwidth are severely controlled. There are different Sensors such as pressure, accelerometer, camera, thermal, microphone, etc. They monitor conditions at different locations, such as temperature, humidity, vehicular movement, lightning condition, pressure, soil makeup, noise levels, the presence or absence of certain kinds of objects, mechanical stress levels on attached objects, the current characteristics such as speed, direction and size of an object. Normally these Sensor nodes perform mainly three types of task: sensing, processing and communicating.

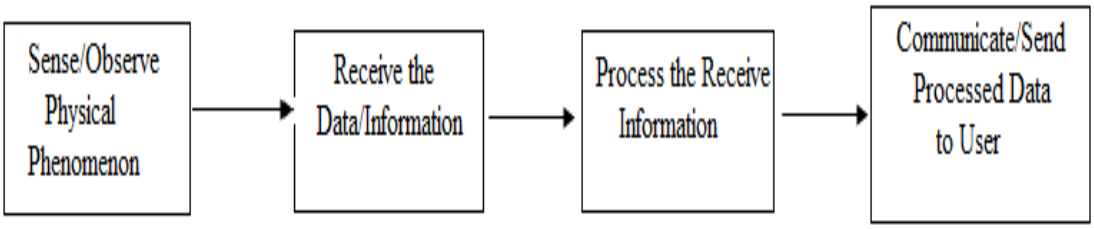


Figure 2. Basic Concept of a Sensor Node

Wireless Sensor Networks are found suitable for different applications such as in its early stages, its impact is envisaged to be far reaching, from daily life, to remote area, some applications are: Surveillance and Tracking, Monitoring of environment, Smart homes, Habitat monitoring , Automation, Precision agriculture, Health care, Automobiles, Hazardous zones, Disaster prone zones or detection, Vehicular Traffic Management, Supply Chain Management, Defence applications to probing of planets, Underwater monitoring, Military applications such as Monitoring Friendly Forces, Equipment and Ammunition , Security management etc. Sensor networks are also widely used in health care area. In some modern hospital sensor networks are constructed to monitor patient physiological data, to control the drug administration track and monitor patients and doctors and inside a hospital. Wireless Sensor Networks (WSN) has emerged as an important area for research and development. Moreover they can be used for monitoring as well as control. In fact, they form the basic constituent of ubiquitous sensing, communication, computing, and control.

3. WSN for Food Security and Agriculture

The food security refers to the ability of food systems to ensure that everyone has enough food to live a healthy life. To prevent food insecurity, we require reliable food systems at each stage of the food cycle: from food production and harvesting, during transport and distribution, at the shops we buy at and in the social settings wherever we consume food, and in the management of the resulting bio-waste outputs.

The wireless sensor networks can be deployed or implemented locally as well as globally to secure food in a food cycle from production stage to a consumer stage. The proper monitoring and management of food at every stage of food cycle can solve out the problem of food crises easily. It can be done by following techniques:

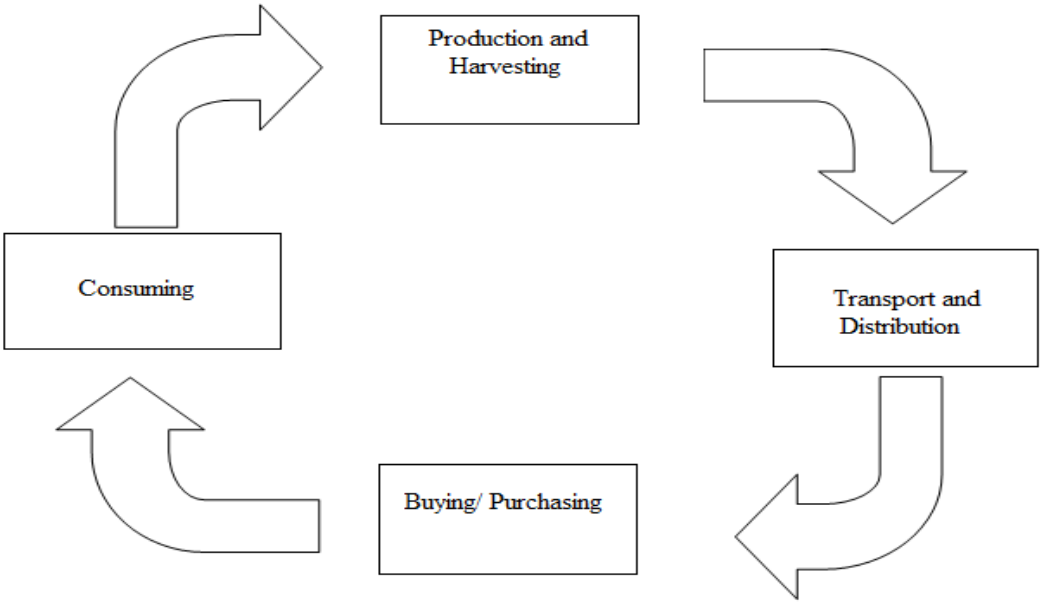


Figure. 3. Food Cycle

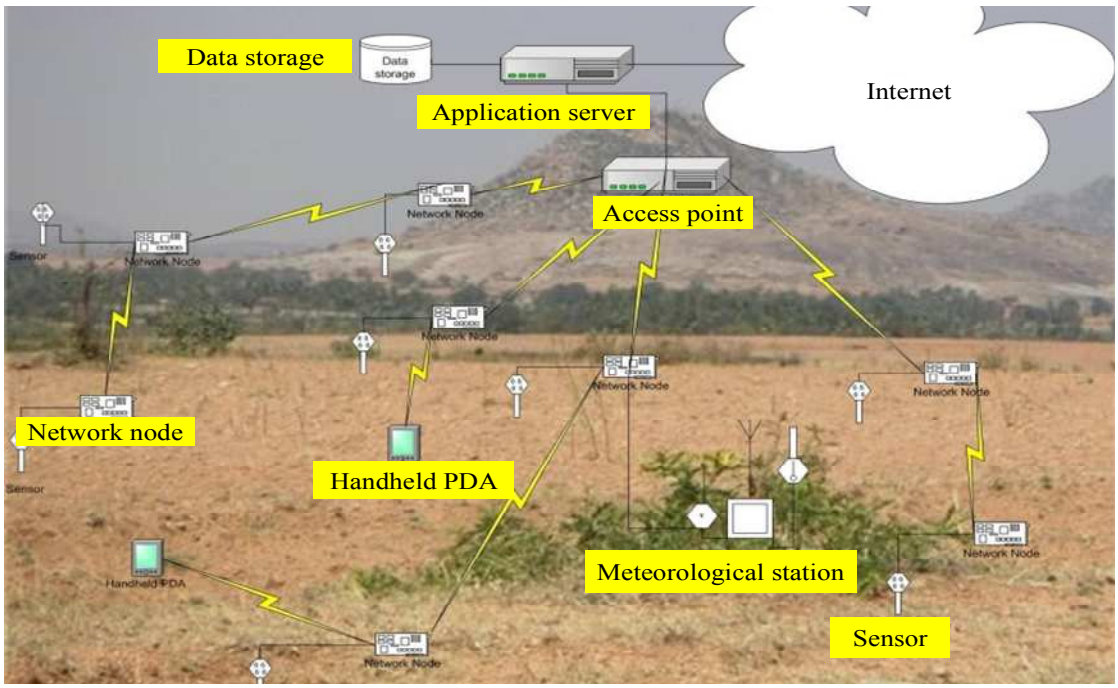
3.1 Monitoring and Early Warning

The systematic monitoring of food supplies is a first and necessary step to address food security. This includes mapping agricultural production and food shortages and establishing comprehensive data bases. Monitoring can be greatly facilitated by more effective use of WSNs, including:

Remote Sensing Infrastructure: by monitoring of agriculture and water resources by the use of high resolution radiometers and moderate-resolution imaging spectrometers, general placed aboard aircraft and satellites.

Other Equipment: PCs, PDAs, servers, mainframes, network databases and software are used for food security analysis, including statistics, modelling and mapping. In particular geographic information systems (GIS) [3] can help to establish cross-sectoral communication - by providing powerful tools for storage and analysis of statistical data, and integrating databases of different sources in the same format, structure and map projection.

Communication Infrastructure: The relevant information can be distributed via the Internet and other communication channels to farmers and consumers, and can be presented on web portals, interactive maps, etc. The mapping and monitoring of vegetation productivity, yield forecasts and global weather patterns are also used by organizations to issue early warnings to alert those concerned of potential problems of food security.



Source: COMMON Sense net, http://commonsense.epfl.ch/

Figure 4. Monitoring and Analysis of Agriculture Field

They can make it possible for governments to take preventive actions in areas at risk of a food crisis and arrange the possible outcomes as soon as possible especially in the case of natural disasters e.g. flood, earthquake, tsunami, etc.

3.2 Locally and Globally: Emergency Communications

To be able to coordinate and to rapidly provide food supplies in emergency situations and crises affecting basic food access, for example the UN World Food Programme (WFP) is making use of emergency telecommunications services, including radio networks and satellite phone services.

Its main tasks include:

- Providing inter-agency telecommunications infrastructure and services, for both data and security communications;
- Providing standard, interoperable ICT platforms and procedures to avoid duplication and ensure cost effective services;
- Ensuring a smooth transition to the post-emergency reconstruction.

Technical standards are vital to safeguard interoperability of different systems for monitoring, early warning and emergency communications.

3.3 Locally: Monitoring Agricultural Conditions

The monitoring environmental and soil conditions can make farming more profitable and sustainable, for instance, through better water management and pest and disease control (It is estimated that the overall efficiency of water use for agriculture is less than 30 per cent). Improved operation and management of

Sources: www.techgadgets.in and www.e-agriculture.org

Figure 5. Mobile and Radio services to Farmers

Water for irrigation can lead to significant savings and to a more sustainable use of water resources, as well as enhanced soil productivity.

The some following tools can be used in agricultural and soil monitoring to enhance the farming system and increase the production, which includes:

Stand-Alone Sensors: These sensors measure air temperature, atmospheric pressure and humidity.

Ubiquitous Sensor Networks (USN): In this network the sensor nodes are deployed on the field and transmitting data to a base station. This data can also be uploaded to global systems and can use or analysed for different purpose and this makes the farming conditions much better.

Telemetry Units: These units are used to transmit air temperature, humidity, leaf wetness data, solar radiation, wind speed, and soil moisture, using cellular networks.

The deployment of WSN in the field can help to improve food yields and enable farmers to better forecast crop yields and production. By combining sensors such as humidity, temperature, and light, the risk of coolness can be detected. Monitoring can ensure prevention of possible plant diseases or manage watering requirements based on soil humidity. This helps to control conditions in nurseries and to closely monitor high performance or delicate crops, such as vineyards or tropical fruit, where the slightest change in climate can affect the final outcome. All of this information can also help us to determine the optimum conditions for each crop, by comparing the figures obtained during the best harvests. Given their ease of use and scalability, wireless sensor networks can also be used to monitor isolated areas of difficult access, where mushrooms, truffles and other sensitive crops are grown which are very sensitive with climate changes.

The use of WSN to share data increases the number of farmers profiting from the information. One example is provided by the COMMON Sense Net project (Community-Oriented Management and Monitoring of Natural

Resources through sensor network). COMMON Sense Net is used for agricultural management in the rural semi-arid areas in Karnataka, Southern India. The project consists of a wireless network of ground-sensors that periodically record the state of the soil (measuring salinity and humidity), the air temperature, the volume of precipitation and other parameters. A second network of subterranean sensors is used to monitor the level and quality of ground-water.

A number of limitations and challenges in the technology still need to be resolved, e.g., the limited lifetime of sensor nodes and the reliability of multi-hop communication. Different approaches and protocols have been proposed to increase the lifetime of sensor nodes. These include synchronized communication protocols, and efficient sleep/wakeup cycles. However, the deployment of sensors and networks is costly and requires technical knowledge and trained personnel. Today's installations mostly serve research purposes in the developed world, rather than being used to safeguard food security. More effort must be made so that the technical design is appropriate to the geographical, cultural and socioeconomic situation of the end-users. Finding technology appropriate solutions is a critical need in developing countries.

3.4 Locally: WSN to Enhance Sustainable Agricultural Development

At the local level, WSN can provide farmers with useful and beneficial information, such as new farming techniques, weather reports, and crop prices. This is also referred to as e-agriculture and the following are some practical examples of this use of WSN:

Rural Radio: Information and knowledge play a key role in improving farming method and addressing food security. The radio has a fairly wide coverage and is a relatively inexpensive communication medium that can provide farmers with information about farming conditions.

SMS: Farmers can use mobile phones to receive text messages with market information on commodities such as market price, supply, demand and traffic jam problems. In some countries, these types of services reach millions of farmers every week and making their lifestyle better.

Telecenters: In rural areas, information can also be made available to farmers through community telecenters. These centers provide the rural population with access to the Internet, to telephone and fax services connection. Farmers can use these services to enhance communication with potential buyers and to access information on improved farming techniques.

E-learning/Training: Rural education is a key resource in the fight against poverty and hunger. In addition, where access is available, the Internet can help farmers to reach new markets and better allocate resources. Several partnership initiatives offer online toolkits to train individuals and support institutions and networks world-wide in the effective management of agricultural information.

For example, **e-Choupal in India** and **Tradenet in Ghana** offer mobile phone and web based services that help farmers achieve better yields and secure better prices by allowing them to receive accurate weather forecasts and local price information direct to their mobile phones, and in their local language.

Similar services are used by coffee producers and fishermen to quickly respond to market demand and to avoid waste. A study in Kerala, India, showed that fishing profits grew by 8 per cent while fish prices decreased by 4 per cent, after mobile phone services were introduced in the market. This improvement was equivalent to an increase of 2 per cent in per-capita GDP.

Mobile phones are rapidly becoming widespread in developing countries (more than 70 per cent of the world's mobile subscribers were in developing countries at the beginning of 2008). The use of mobile phones to distribute food market information offers great advantages for consumers and food producers.

4. Some other Ways to Secure and Control Wastage of Food

4.1 Locally and Globally: Proper Storage and Management

Due to the improper storage and management the problem of hunger and food insecurity remains as such after a good production of food materials. For example In India some time before farmers strikes because they don't have enough containers (i.e. Boris) to store their food products. A survey said that approximate 20 percent food materials destroy by the rats in store houses in India also government don't have enough warehouses (Godowns) to store food materials. So with good production the security of food is must and it can be done by proper management and

storage. The government and NGOs can control or stop the deaths due to hunger at local as well as global level.

4.2 Locally and Globally: Proper Transport and Monitoring

The accuracy of monitoring our food supply during the transport and distribution increases consumer confidence and protects community health and the food industry's integrity. To prevent food insecurity, we require reliable food systems at each stage of the food cycle: from food production and harvesting, during transport and distribution, at the shops we buy at and in the social settings wherever we consume food, and in the management of the resulting bio-waste outputs. Using the GPS and GPRS/3G modules the food being transported can be located at all times, providing detailed information on its condition. This helps to improve product traceability, and to determine liability where applicable if it becomes spoiled during the logistics phase.

WSN can detect and store environmental samples during the product's transport and know therefore whether it has been exposed to high temperatures, damp, or whether it has been contaminated during the journey, or whether the container was opened in an unauthorised fashion or even whether it has been dropped or suffered an impact. We can discover a wide range of things such as whether a frozen product's cold chain has been broken.

4.3 Locally: Control Wastage of Food in Marriages and Parties

In India large amount of food is wastage in marriages, religious festivals as well as parties. According to a survey which is done by Food Corporation of India (FCI) approximate 58 thousand million rupees food wastage in marriages and parties in India every year The vast decoration, different types of food dishes, thousands of guests becomes the tradition as well as showcase in marriages and parties. These are the main factors which causes the wastage of food materials. These causes of food wastage can be control by people at their own level and by government by making rule and regulations.

5. Conclusion and Future Scope

In the past few years, sharply rising prices and shortages of food and agricultural commodities, particularly in many developing countries, have led to global concern about food security. This problem is linked in large part to the impact of climate change on agriculture. There are several ways in which information and communication technologies can address this problem at the local and global level. Information Communication Technologies (ICTs) such as wireless sensor network, cognitive radios are used by many international organizations for mapping and monitoring world food supplies, early warning systems, and to respond when disasters strike. In this area, some organizations work on telecommunication and radio communication standards is essential to the functioning of the humanitarian community.

In developing countries such as India, the use of information communication technologies or systems like wireless sensor network or cognitive radio network by farmers can increase the production as well gives the opportunity to watch the food in the food cycle for proper management and supply of the food items. Then the rural population to overcome hunger and food security can be improving in early stages. The mobile phone revolution, especially the growth of mobile penetration in developing countries, offers new opportunities to benefit farmers and agricultural production. Better access to weather, market and price information can have an impact on the incomes of farmers and fishermen. However, the full potential of ICTs to address food security and for farming system has yet to be realized, and can be implemented in future for better results.

References

Trade Reforms and Food Security, UN Food and Agriculture Organization (FAO) FAO, 2003, http://www.fao.org/docrep/005/y4671e/y4671e00.HTM

“Wireless Sensor Networks for marginal farming in India” by Jacques Panchard, École Polytechnique Fédérale de Lausanne, Switzerland. http://commonsense.epfl.ch/Resources/thesis.pdf.

Geographic Information Systems (GIS) en.wikipedia.org/wiki/Geographic_information_system

UN World Food Programme (WFP) http://www.wfp.org

COMMON Sense net, http://commonsense.epfl.ch/

www.techgadgets.in and www.e-agriculture.org

Prabal Dutta, Jay Taneja, Jaein Jeong, Xiaofan Jiang, and David Culler, "A Building Block Approach to Sensornet Systems", In *Proceedings of the Sixth ACM Conference on Embedded Networked Sensor Systems (SenSys'08)*, Nov. 5-7, 2008. © ACM, 2008

Sukun Kim , Shamim Pakzad , David Culler , James Demmel , Gregory Fenves , Steven Glaser , Martin Turon, "Health Monitoring of Civil Infrastructures Using Wireless Sensor Networks" In IPSN '07: Proceedings of the 6th international conference on Informationprocessing in sensor networks.

Arun K. Pande, Bhushan G. Jagyasi, Sanjay Kimbahune, Pankaj Doke, Ajay Mittal, Dineshkumar Singh, Ramesh Jain, "Mobile phone based Agro-Advisory System for Agricultural Challenges in Rural India," IEEE Conference on Technology for Humanitarian Challenges, August 2009, Bangalore, India.

S. Neelamegam, C.P.R.G. Naveen, M. Padmawar, U.B. Desai, S.N. Merchant, N.G.Shah, and V. Kulkarni ; AgriSens: Wireless Sensor Networks for Agriculture - A Sula Vineyard Case Study, 1st International Workshop on Wireless Sensor Network Deployments in conjunction with International Conference on Distributed Computing in Sensor Systems (DCOSS 2007), Santa Fe, New Mexico, U.S.A. June, 18 - 20, 2007.

Prekshep Mehta, Deepthi Chander, M. Shahim, Kalyana Tejaswi, S. N. Merchant and U. B. Desai, "Distributed Detection for Landslide Prediction using Wireless Sensor Network", First International Global Information Infrastructure Symposium, 2007. GIIS 2007, 2-6 July 2007 pp 195 – 198.

Bhushan Jagyasi, "Distributed Detection in Wireless Sensor Networks", Ph.D. Thesis, IIT Bombay, 2008.

"21 ideas for the 21st century," Business Week, pp. 78-167, Aug.39, 1999

http://en.wikipedia.org/wiki/Sensor_Networks

Akyildiz, I.F.,W. Su, Y. Sankarasubramaniam, E. Cayirci, "A Survey on Sensor Networks", IEEE Communications Magazine, August, 102-114(2002).

Chee-Yee Chong; Kumar, S.P., "Sensor networks: Evolution, opportunities, and challenges,"Proc IEEE, August 2003

Food Coorporation of India (FCI) Report June 2012.