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Wireless Sensor Networks and Monitoring of Environmental Parameters in Precision Agriculture

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Abstract— The handiness and ease of use of tele-technology like mobile phones has surged the growth of ICT in developing countries like India than ever. Mobile phones are showing overwhelming responses and have helped farmers to do the work on timely basis and stay connected with the outer farming world. But mobile phones are of no use when it comes to the real-time farm monitoring or accessing the accurate information because of the little research and application of mobile phone in agricultural field for such uses. The current demand of use of WSN in agricultural fields has revolutionized the farming experiences. In Precision Agriculture, the contribution of WSN are numerous staring from monitoring soil health, plant health to the storage of crop yield. Due to pressure of population and economic inflation, a lot of pressure is on farmers to produce more out of their fields with fewer resources. This paper gives brief insight into the relation of plant disease prediction with the help of wireless sensor networks.

Keywords— Plant Disease Monitoring, Precision Agriculture, Environmental Parameters, Wireless Sensor Network (WSN)

I. INTRODUCTION

The climatic diversity of India makes the availability of different varieties and types of fresh fruits and vegetables available all-round the year. This uniqueness has ranked India second in the production of fruits and vegetables after China as reported by Horticultural Statics at a Glance 2015, Ministry of Agriculture, India [1]. According to the National Horticulture Database (NHB), India's production of fruit during 2012-13 was about 81.285 metric tons with 6.98 million hectares of land under cultivation [2]. Food security of India is totally dependent on the production of cereal crops as well as fruits and vegetables and milk to feed the growing population. India being a worldwide farming powerhouse still it will need productive, focused, competitive and differentiated agricultural sector to emerge at a quickened pace. Promotion and use of new science, technology and transforming agricultural research and expansion is amongst the critical requirement for the boost of India agrarian [3, 4].

But due to the attack of diseases on the apple crop state suffers too much big economic crush and the little education to tackle the attacks encourages the loss more. The location of the farms on hilly areas increases the problem of regular surveying to the orchards has made the farming management more critical. Thus, keeping the scenario in consideration, a forecasting system has been proposed to cater the problems. Terrestrial sensors will be used to input data or parameters like temperature, humidity and leaf wetness to the monitoring and forecasting system. Such system will be of much beneficial to the farmers for timely management of the diseases [5]. ICT's contribution has accelerated progressive growth in agricultural sector by introduction of right technologies, accessible to all population. But with the growing needs modern and young farmers are switching to technologies that access and analyse the real-time condition of a field or crop. To fill in the gap and needs of farmers wireless sensor devices were installed. The decisions like irrigation need or fertilizer need or disease or pest detection or chemical spray schedules or harvest or ripening time of a crop or storage management is almost all automatically maintained and looked after by sensor devices. This technology made the farmers life less burdened, less miserable and helped a farmer to spare time and look over his other livelihood activities.

II. WIRELESS SENSOR NETWORKS

A wireless sensor is a self-fueled and autonomous registering unit more often containing a processing unit, a transceiver, both analog and digital interfaces, to which different detecting units – regularly examining physical or environmental information, for example, temperature, wetness and so forth are connected to form a network (see Fig. 1 as an illustration). These sensors naturally sort out and adapt in the dynamic environment.

Fig.1 General layout of Wireless Sensor Network

A sensor system consists of
(a) a group of locally or distributed sensors;
(b) an interconnecting communication system (typically, yet not generally, remote based);
(c) a main point of data collection; and
(d) an arrangement of centrally processing elements to handle information relationship, location status, status of questioning, and information mining [6].

The sensor nodes speak with one another keeping in mind the end goal to trade and prepare the data gathered by their detecting units. Now and again, a sensor can also utilize multiple sensor nodes as transfers, in which case the system is said to be multi-hop. On the off chance when a sensor hub speaks just specifically with one another or with a base station, the system is single-hop. From research and technological advancements most analysts have predicted (using Moore's Law) a huge growth and only few U.S. dollar price for each unit in the next 5 to 10 years for light-weight applications utilizing sensors, like, structural monitoring, temperature sensors, humidity sensors, etc. [7].

Sensor units can be utilized almost in every aspect of a human being's day to day life. A sensor can be installed in any biological or physical environment or in science and technology or in public, private, Govt., or business elements either to sense or control purposes [6]. Sensors collaborated to work in a networked manner (WSN) and being watched and governed by a supervisor or admin will profusely expand their web of applications over the coming years. Some common applicable fields for sensors are healthcare, security, agriculture, business, defence etc [7].

III. SENSORS AND AGRICULTURE

Because of the unique characteristics of WSN like small size, cost, long battery and real-time nature use of sensors in agriculture has grown rapidly. Different type of sensor built for particular sensing job, centralized control, GUI, gateways and routers for communication, power supply are the important components of WSN to be implemented for P.A. [8]. Probes are also used in the field and are equipped to perform the computational work or act as transceiver for surrounding probes. All the sensors work in coordination to sense and monitor real time data of the crop or field. Sensed information is sent to the control unit or any decision or expert system by the self-organizing nodes of WSN. With the advancement in IC world, Micro Electro-Mechanical Systems (MEMS), low cost technology and low power consuming capacity, WSN have taken over other technologies. Terrestrial sensor networks (implanted on the ground) are more popular in agricultural sector. But with the research advancements hybrid WSN's (WSN along with Wireless Underground Sensor Network, WUSN) [9] are also now being used to get the underground information [19]. Several modifications and advancements were made in both the protocol stack, routing algorithms, software and hardware of WSN to suit the agricultural needs [10, 11, 12].

A. Sensor Network in an Agricultural Field

The working of a sensor network in agricultural field can be divided in following phases as shown in the Fig. 2:
Firstly, the sensors sense the physical phenomenon.
Then sensed data is sent to the sink node.
After that the received data is processed and,
Finally, the processed data is communicated to the user.

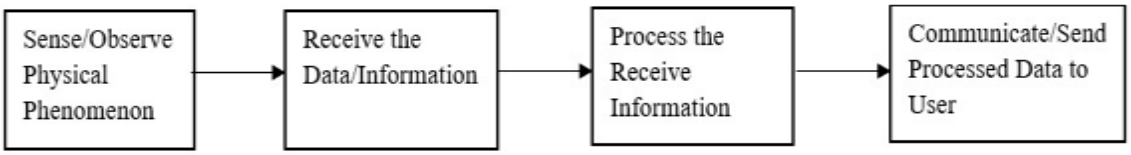

Fig. 2 Working of an Agricultural Sensor

The application of WSN in agriculture so far has been classified as Simulator based and implementation based. In simulator based simulators like TOSSIM, Matlab and QualNet were used to carry out implementation experiments where as in implementation based system were designed, deployed and implemented [12]. The studies [13,14,15] show the WSN is a promising technology to be included in farms to help a farmer. The features of WSN like the use of long range wireless protocols (WiMax, Wi-Fi etc.) for communication and transmission of data, ease of use, affordability etc. has encouraged the farmers in developing country like India to use the wireless sensor in their field for better farming decisions and support.

B. Precision Agriculture and WSN

State-of-the-art and cheap sensor have made the implantation of WSN in agro lands possible. All this had been possible by the efforts of ongoing research, hue and cry for the rise in food production and last but not least by the change of attitude of farmers toward the involvement of technology in their fields.

Modern agriculture replaced traditional agricultural ways by the introduction of new techniques, concepts, ways and technology. This new agricultural system is called as Precision Agriculture (PA). PA thus is the sustainable agricultural concept. It focuses on the initiatives to maximize the crop production from small land areas, low cost and less damage to the environment [16]. Thus, it is the system which utilizes information based tools and technologies for agro processes with each precise action taken to ensure more crop productivity. Mc Bratney et.al. stated that lack of decision support

tools and considering technological introduction into PA as a threat and are the most critical barriers that prevent adoption of PA by farmers. Draw backs of traditional monitoring system or agricultural practices, non-real nature of technologies like RS, GIS, GPS and high-tech instrument and labour charges [17] had made the employment of WSN possible in PA.

WSNs formed of mobile or immobile sensor nodes can be distributed over a wide range and can do the job of collecting the desired information required for the monitoring, control and decisions [18, 19, 20]. The capability of sensor nodes that sense and combine sensed physical environmental values of temperature, humidity, soil ph., moisture content, change in position or change in parameters in an agricultural field with processing and transmitting functions are going to end up ubiquitous and almost universal in future [21]. Design and development of small sized, less power utilizing, cheap sensors are now being promoted by research agencies like National Science Foundation and are gaining popularity in Indian farms [22].

Specific functions of sensors are determined by its use in agriculture, besides the following unique features: [23, 24, 25].

1. To detect, compute and communicate values of the parameters like intensity of sunlight, ph. Value, rainfall etc.
2. To sense the emergence of an event of interest and measure the values of arguments that may have changed.
3. Classification of changes and differentiation of sensed activities.
4. Keeping track of detected events.

C. Plant Disease Monitoring

In order to manage and control the diseases and pests on time monitoring, chemical sprays, regular visits to fields and analysing every tree for visual symptoms keeping in view the biotic and abiotic factors in consideration and then identifying the disease and choosing the appropriate chemical spray. Root sampling, fruit sampling and soil sampling are the main tasks and then taking these samples to labs for tests delays the disease detection process and makes it late for the farmer to recover his crop.

Bhat et al. stated that technology is one of the important need for the control and management of crop disease and pest. With proper resource management, technology may be sound, feasible, relevant and quite useful to measure factors like climatic changes undefined rainfall and high temperature and humidity. It was listed that bad orchard management practices, absence of resistant varieties and absence of disease forecasting system in the valley lead to more havocs at the outbreak of a disease [26]. According to Miller and O'Brien (1952), "Forecasting involves all the activities in ascertaining and notifying the growers of community that conditions are sufficiently favourable for certain diseases" [27]. Forecasting and monitoring the emergence of plant disease should not only consider the disease but also the microclimatic like farm location, canopy size etc., and macroclimatic factors like temperature, humidity etc., in consideration which are difficult to be viewed by naked eye. These features make a monitoring and forecasting system more accurate, reliable and useful. These systems can be of importance to both the farmers and plant pathologists if and only if:

- They give accurate information about the level of infection or possibilities of the emergence of the disease.
- Inform about when and where the management practices are to be needed.
- Suggests appropriate decisions to be taken or a prevention measure.
- Conveys information on time.
- Reliable means of communication with farmer.
- Should be cost effective.

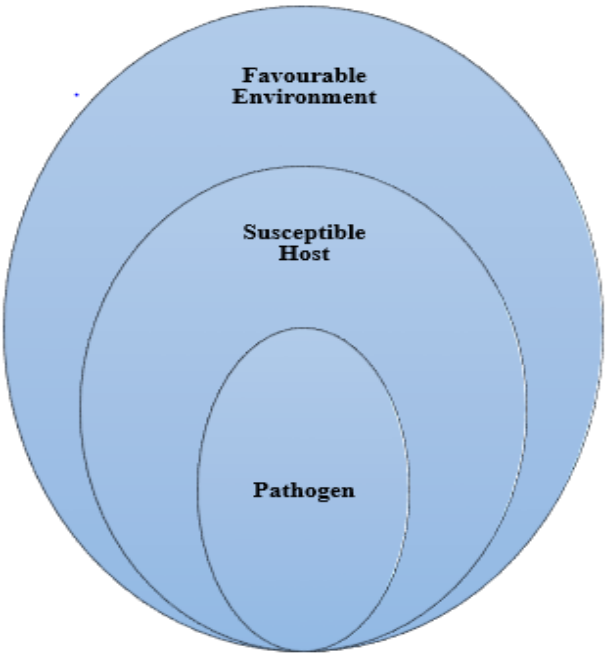

Fig. 3 Represents the factors necessary for disease to occur

According to R.S. Mehrotra following types of plant disease prediction models are used [28].

1) Weather Based: Weather conditions like temperature, relative humidity, rainfall, light, wind velocity etc., during the crop season and during the inter crop season are measured. Weather conditions above the crop and at the soil surface are also recorded.

2) Inoculum Based: Presence of primary inoculum, its density and viability are determined in the air, soil or planting material. The extent of survival of such virus and fungi is dependent on the severity of the weather which affects the size of vector population in the growing season.

3) Host Physiology Based: Weather data of several years are collected and correlated with the intensity of the diseases. The data are compared and then the forecasting of the disease is done.

In all the three models the monitoring of weather data is plays an important role mainly in fungal and bacterial disease and needs to be monitored accurately and on time because both biotic and abiotic environmental factors control whether disease develops or not and also determine presence and capability of the pathogen [29]. Thus if these biotic and abiotic factors are read and understood by the sensors the whole agricultural process can be made dynamic and intelligent.

As long as the biology of the pathogen and the cycle of the crop are well known to a user, sensors can be deployed to get the physical environmental parameters like humidity, temperature, soil ph., leaf wetness and soil moisture that affect the crop and the pathogen, thus making it possible to forecast the infection caused by the pathogen [30]. Therefore, all forecasting system are based on the fact that pathogen interacts with the host and environment as shown by the relationship in fig. 4 below. Predicting the occurrence of disease or a pest on time can save the damages done to the crop and thus help a farmer.

Image based sensors can be deployed to read the visual symptoms of the affected parts of a crop. These symptoms can be verified with the computerised expert opinion database and the collected sensor parameter database to make the prediction more accurate [31].

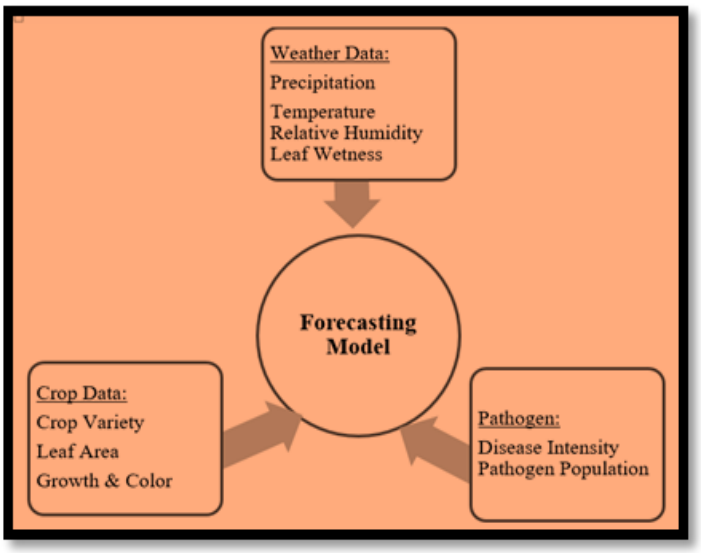

Fig. 4 Weather-Crop-Pathogen Relationship

IV. CONCLUSIONS

Disease forecasts are predictions of probable outbreaks or increase in intensity of disease. It involves well organized team work and expenditure of time, energy and money. It is used as an aid to the timely application of chemicals. With the real-time nature of the sensors, their low cost and their accuracy the disease forecasting can be more dynamic and revolutionized. The time and the hard work of the farmer can be saved and the disease management can be also done in more effective manner. There is still a great work to be done to make the Indian farmers aware and friendly with the adaption of sensor devices technology in their farms. Village level workshops or trainings are needed to be held to create more awareness. The study shows that WSN is a promising technology to be included in farms to help a farmer. The features of WSN like the use of long range wireless protocols (WiMax, Wi-Fi etc.) for communication and transmission of data, ease of use, affordability etc. has encouraged the farmers in developing country like India to use the wireless sensor in their field for better farming decisions and support.

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