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Pricision Agriculture

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Abstract:- Wireless Sensor Networks (WSNs) are nowadays widely usedin building decision support systems for better monitoring. Oneof the most interesting fields having an increasing need indecision support systems is agriculture. Inefficient and wastefulmethods of agricultural monitoring lead to extra time and costloss for farmers.

This paper presents the iFarm framework system, an easy-to-use and expandable agricultural monitoring solution to enhance land productivity by better managing water, improving the socio-economic factor of farmers and their awareness, predicting and planning the crop yields. The iFarm system proposes WSNs as a promising mechanism to agricultural resources optimization, decision making, and land monitoring. WSNs make it possible to know at any time information about the land and crop conditions, so that farmers can be assisted with various notifications and suggestions during their farming tasks. It addresses the advantage of the precision agriculture approach to help making valuable decisions which could not only improve the land productivity but also optimize the use of resources.

The paper gives a description of the precision agriculture monitoring approach that provides meaningful services to farmers.

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1. INTRODUCTION

lack of research on the field. All these challenges make it necessary to think of building decision The bad dealing with land by farmers can be the cause of critical problems which cost the agriculture a huge economical loss annually taking into account the income loss, productivity decrease, material cost etc. The increasing use of chemical fertilizers, irrigation and agricultural machinery in recent years has led to increased energy consumption, pollution of soil and groundwater and even the soil erosion in some areas.

In general, farmers have a small knowledge of their land and they are not necessary aware of how to improve their productivity. For instance, water availability is limited and must be monitored as it may cause deficiencies in water and salinity. The "pests" are poorly controlled (i.e. weeds, diseases, animal pests). Besides, agricultural practices are not optimized and remain traditional with scarcity of skilled labor, commitment to traditional knowledge, reluctance to innovation, few personal initiatives, and support systems for agriculture.

This paper presents an efficient approach to overcome some agricultural issues related to farming resources optimization and decision making. It considers the use of Wireless Sensor Networks (WSNs) as a way to help farmers optimize the use of natural and artificial resources in their agricultural tasks. I addresses the advantages of the precision agriculture approach to help not only improve the productivity but also optimize the use of resources.

2. Using WSN In precision Agriculture

2.1. Precision Agriculture: Throughout the world and especially in the developing countries, farmers lack the necessary information to increase their land productivity. For example, the majority of farmers are not aware of the efficient amount of water required for a better productivity. Thus, they use unnecessary amount which might have negative effects on the land fertility. In order to make food accessible to the increasing number of population, we have to find ways to maximize the land productivity.

In this context, using new technology in agriculture becomes inevitable. New systems should be created to assist farmers by giving them all the necessary up-to-date and credible information to increase their crop yield. This process of using techniques, technologies and management strategies that affect crop growth, called Precision Agriculture, helps farmers to be more efficient in minimizing loss of fertilizers, pesticides and water.

This is by measuring at different time and in many places the temperature, humidity, soil conditions, the fertilizers and pesticides, to deliver at each location the required amount, when and which action is appropriate. These measures can be performed by a network of hundreds or thousands of sensors in a field. Valuable information will be forwarded to the farmer, who can then act depending on the situation for saving water, fertilizer and pesticides, or putting them where it is necessary with just the necessary amount.

This will have a beneficial effect on the farmer's budget, but also on the quality of his/her land. Precision Agriculture is ensuring the optimization of agricultural production. It helps dealing with each

region based on its soil properties and its climate. Different technologies are used to provide the necessary data to better understand our environment and the farming needs.

2.2.WSN in Agriculture: A sensor network consists of nodes that can receive, process, communicate information to other nodes and to a base station. These nodes have sensors (temperature, motion, humidity, noise, etc.) that provide information to an electronic circuit that can process them, analyse changes, and decide whether to give an alarm or an action to take. The information is sent through other nodes to a base station, which can then make the necessary decisions.

The WSNs are widely used in many applications, for example, the monitoring of buildings, bridges, forests, farmlands, livestock, diagnosing vehicles, trains, airplanes, or even the monitoring of sick and elderly people.

The iFarm framework makes use of agricultural sensors that are self-organizing, with reasonable price, and can be easily deployed. Sensor nodes are deployed in the soil to get its temperature, humidity, and water content. Those data are not the only parameters that can be gathered but they are the most critical ones for any precision agriculture system. The proposed iFram system uses the eKo Pro series sensors that provide an outdoor wireless sensing solution for environmental research, microclimate studies, smart water management, conservation and precision agriculture.

2.3. Land Production Potential: The land productivity, as shown in the figure 1, depends mainly on three main factors: water, soil and socio-economic factors Considering the Radiation Potential Production (RPP) as the maximum production that can be achieved with respect to the crop physiological capacity and within the prevailing temperature and radiation regimes during the crop cycle, the Natural Production Potential (NPP) potential determines the maximum production of the crop that is allowed by the prevailing levels of biophysical land resources (climate, soil, and land form). The proportion of the NPP to RPP can be then considered as the efficiency of the biophysical factors in achieving the maximum crop production.

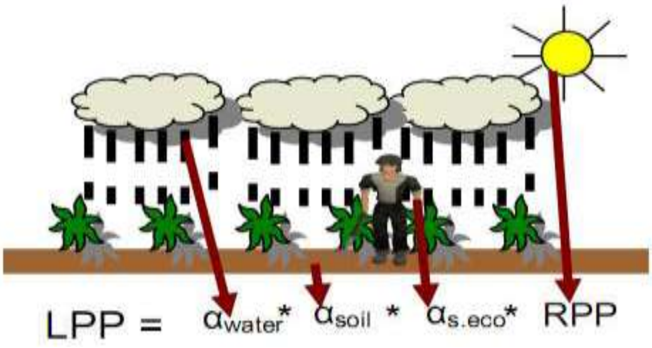

Figure 1: Land Production Potential

Considering any deficiency in the "water-soil-plant" system, the RPP can be reduced to a lower production potential level. The assessment of the NPP is determined by considering the water production efficiency (_water) and the soil resource production efficiency (_soil). Indeed, for its optimal production, a specified crop has a preference for a defined level of each relevant soil characteristic. Any deviation of the actual level of a soil characteristic from the crop requirement will reduce the crop productivity. The third factor that affects the Land Productivity Potential (LPP) is the way farmers deal with their land. It is defined as the socio-economic potential (_s.eco).

3. iFarm Architecture

3.1. The physical view: Figure 2 presents the physical view of the system. It mainly consists of a mesh network of wireless sensors, a GSM modem for sending SMS notifications and alerts to farmers. We use the ES1100 eKo Soil Moisture Potential Sensor, the ES1110 eKo Soil Water Content Sensor and the ES1201 eKo Ambient Temperature and Humidity Sensor, along with EN2100 node to form a wireless mesh network, EB2110 as a base radio to provide connection between eKo sensor nodes and eKo EG2120 gateway. The iFarm server is responsible for sending SMS messages and replying to farmers' requests from the website client side.

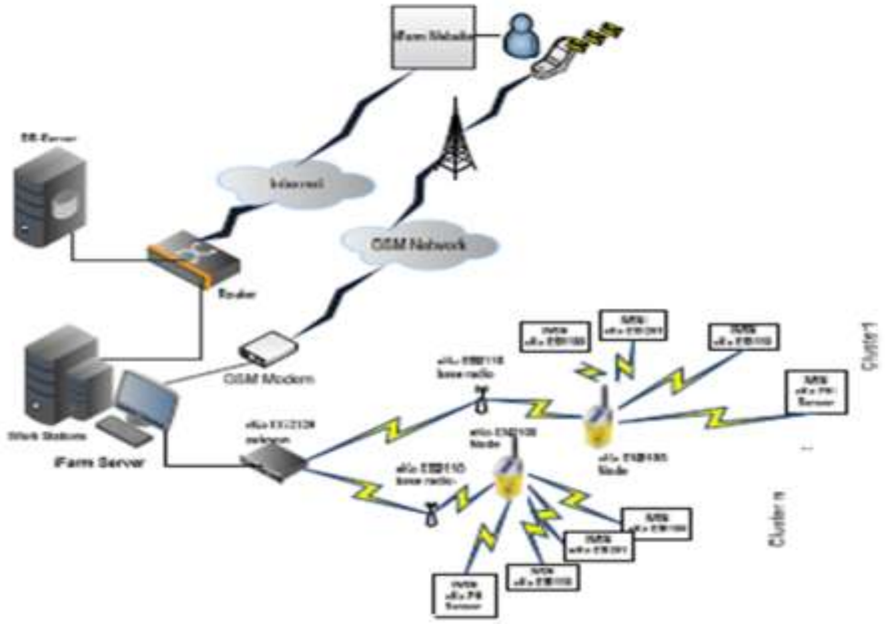

Figure 2: iFarm physical view

3.2. Layered component-based architecture: The iFarm System proposed in the present paper is represented by a layered component-based architecture that covers all the functional aspects of our WSN based approach. It consists of the composition of different components, layers of the system, the communication among those layers, and their interactions.Figure 3 shows the different components that intervene in the precision agriculture monitoring. The current system consists of Hardware and Software components. The Software component consists of three main layers: User Interface or Presentation Layer, the Application Layer, and the Data layer.

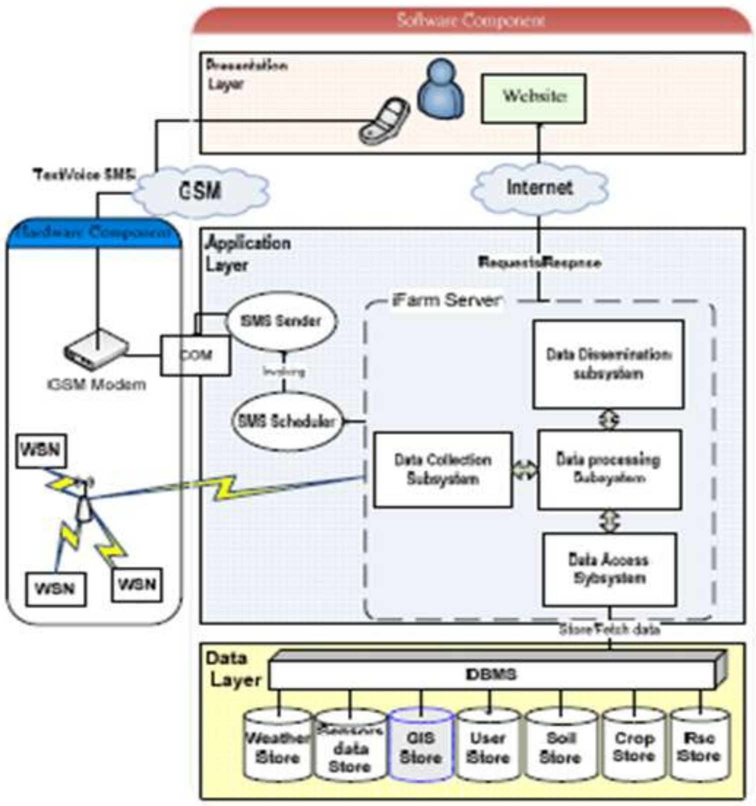

Figure 3: iFarm Overall Architecture

Software Component:

• **Presentation Layer**: The presentation layer provides the user access to the system's services. This layer is used to separate the business logic from the user interface. The presentation layer consists of a website that provides farmers and admin users to access the system services via Internet. As part of the presentation layer a farmer can get information as a text or voice SMS in his mobile phone via GSM network (figure 5). The interface provides different functionalities and features depending on the user profile.

• **Application Layer:** The application layer contains all the business logic of the application. It receives the user's request from the presentation layer and performs some operations based on the request. It also collects data and notifies farmers accordingly. This layer contains different components:

- **Data processing component**: this component contains algorithms to perform computational and sorting operations. It is responsible of analysing and processing data provided by the Data collection component to store only the valuable data in the corresponding data stores. Those data are user data, sensors data, weather data, or GIS data.

- **Data collection component:** contains modules that gather dynamic data. It collects crop data from the sensors and weather data from web-services, and then provides it to the data processing component to perform calculations and analysis.

- **Data access component**: contains modules that access, store, and manage data. It is the application layer component that is responsible of interacting with the data layer to get or store data.

- **Data dissemination component:** it is an interface between the presentation layer and the data processing subsystem. It manages the use of the system by different users, gets requests from users, and delivers response in appropriate manner.

- **SMS Scheduler and SMS Sender**: it is responsible of determining which SMS has the priority to be sent first depending on data provided by the decision made by the data processing component which relies on the user profile and the type of information. The SMS sender sends the information setup by the SMS scheduler.

•**Data Layer:** The data layer contains a set of stores in which the necessary data for the system are stored. This layer contains different stores including the User store for user information, the Geographic Information store containing static data about lands, maps properties and locations. The Weather store to store changing weather information in different regions and history of weather data per region to build weather models and statistics. The sensors data store to store data provided by sensors about the dynamic soil and crop conditions and characteristics, mainly the humidity, temperature, soil moisture and soil/ crop pH. The crop store is used as a database of different crops, their characteristics and properties. The diseases store is used to store information about the different diseases types, their favourable conditions, and how they can be avoided or removed. The resources store contains information about agricultural equipment's, pesticides and tools that a farmer may use.

Hardware Component

The hardware layer consists of a mesh network of wireless sensors with all its necessary components, and a GSM modem for sending SMS notifications and alerts to users. As mentioned before, in iFarm system, we chose to use ES1100 the eKo Soil Moisture Potential Sensor, ES1110 the eKo Soil Water Content Sensor and ES1201 the eKo Ambient Temperature and Humidity Sensor, along with EN2100 node to form wireless mesh network, EB2110 a base radio to provides connection between eKo sensor nodes and eKo EG2120 gateway.

4. iFarm System Services

To facilitate the control and monitoring of agricultural practices, iFarm system offers a set of services to farmers. Four main services are described in the following sub-sections:

4.1.1. Irrigation Management: As we know, agriculture is the largest user of water throughout the world. This fact will push researchers to find solution for water conservation in agriculture. This management of water should be done in an efficient way without affecting the production. iFarm provides farmers with précis information about the amount of water needed for irrigation depending on the land, weather, crops type, and soil properties. Most farmers know that crop yield is linked to water usage and that shortage of water may result in yield damage, but the yieldloss may also be caused by the over-irrigation. Farmers then need to know when and which amount of water is needed for specific crops.

4.1.2. Pest and Disease Control: Helping farmers to optimize resources used during their farming life cycle is another service that is offered to framers. We mean by resources fertilizers, pesticides and human resources used to prevent the crop from several pests and diseases. Observing the correlation of different environmental parameters with the study of pests and diseases could lead to the definition of statistical models of pest or disease prediction. The use of such models allows issuing various warnings to farmers. This service, through collected data from sensor nodes, enables farmers to better know the state of their crop in order to know whether to use pesticides or no, when and where they must be used. The up-to-date crop conditions help reducing unnecessary or inadequate pesticide usage and consequently maintain healthier crops.

4.1.3. Crop yield prediction and planning: The farmers need to be assisted to know the appropriateness of crop choices they can make. Several crop models should be available for simulating the growth of various crops and crop mixes taking into consideration different environmental constraints (soil moisture, nutrient stress and water supply). Giving farmers the valuable information to control their crop production and ensure the land quality and fertility will lead to improve the farmer awareness and his knowledge about which crop to grow in which season and in which part of his/her land.

4.1.4. Resources optimization: One of the challenges facing farmers today is the use of agricultural equipment and human resources. Knowing the amount of water and pesticides, what crop, when to cultivate or to harvest will help the farmer knowing what equipment to be used and how many people should be involved. This decision will improve production without wasting time, money or resources.

4.2. Services delivery depending on the user profile

There are two main types of user for our system: Farmers and Specialists.

Farmers: Farmers are the main users of the system. The objective is to provide them with the necessary up-to-date information whenever needed. More feedback and more opportunities for closure are required. Farmers are either literate or illiterate. The system will act accordingly to each group.

• **Literate farmers**: For this group of users, information and notifications are provided in the main website and/or SMS. All system messages should be clear, precise, and in the preferred language of the user. Help and guidance should be continuously given, and the main functionalities should be simple enough to make it easier to the user to make decisions based on the provided notifications. Those notifications are delivered based on the user request or automatically triggered. If a user for instance, wants to know about the possibility of growing a specific crop in his land, he will use the crop prediction service and click. on the wanted crop to test its conformity within his land characteristics. Besides, depending on the user possibility to access the website, iFarm system can deliver information to farmers using text SMSs.

• **Illiterate farmer**s: Concerning the illiterate farmers, the initiative should come from the system because the user may not know what should be done. As those users cannot read text SMSs, the system provides information and notifications as voice messages. The message should beshort, precise, and in the farmer's language.

Specialists / Experts: These users need consistent structures, good help facilities, and good documentation. They can use the system to have larger and professional view of data and statistics. The system provides information in text, tables, and charts. It also allows them to contribute extending the system's knowledge by adding valuable information and advice in the system. Those users can be experts from agricultural agencies

5: Future Work

India has the second largest arable land area (157,350,000 hectares as of 2011) of any country, after the U.S., due to its large network of rivers and good soil fertility. The agriculture sector alone accounts for 60% employment in the India and has a share of 18% in the country's GDP. The diverse climate of India also ensures production and availability of all varieties of fruits in the Indian subcontinent. India thus ranks second in the production of fruits globally, after China. As per the National Horticulture Database 2012, India produced 76.424 million metric tons of fruits and exported fruits worth Rs. 2467.40 crores during 2011-2012.

Apple is the most important temperate fruit and is fourth most widely grown fruit in the world. India ranks 5th among apple-producing nations, in terms of volume. It grows mostly in dry temperate areas, which is why Jammu and Kashmir (JK) and Himachal Pradesh (HP) account for 94% of total apple production in India. The apple industry in HP itself is worth over Rs 2,500 crore. Although the overall numbers are impressive, the yield is not proportional to the arable area of the country or the yields of other developed nations. For instance, the average per acre yield of apples in India, as per studies in 2012, is 11 tons compared to 30- 70 tons in the U.S., New Zealand, Israel, China and European countries. This is due to paucity as well as inadequate use of technology, lack of awareness and education amongst the farmers, vagaries of monsoon in mountainous terrains and the use of certain obsolete practices. Numerous pests and diseases also affect the crops leading to reduced proceeds.

Apple Scab, for instance, is an epidemic disease that spoils the apple produce to a large extent. Studies have claimed that with the escalating population, we are advancing towards a food doomsday by 2050 and that the food producing capacity will collapse, as the population rises to

10 billion, unless we innovate and introduce smart technology and better management of resources. Thus, there is an imperative need to design and develop affordable technology for the Indian farmers that can be deployed and sustained on a rough, hilly terrain, and which can help them in predicting the pest attacks and diseases that affect their crop cultivation for timely prevention and cure. Precision agriculture is the science of using advanced technology to improve the crop yield and ensure growth in a sustainable manner.

Currently, remote sensing techniques are being applied to provide appropriate information to the farmers with the help of images collected by satellites. However, for more accurate data analysis and cost effectiveness, there is a need to collect real time field data. WSNs can play an important role in this context because of their ability of providing real time data on environmental parameters, collected by spatially distributed sensors.

6:CONCLUSION

In this paper, the use of wireless sensor networks in the precision agriculture has been introduced by presenting the design and architecture of a precision agriculture monitoring system. The iFarm system has been discussed from the perspective of agricultural productivity, architecture, features, and main functionalities. The iFarm offers a set of services to farmers including the irrigation and water management, the pest and diseases control, the crop yield prediction and planning, and the resources optimization.

7: Refernces

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