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I-Cas: Intelligent Crop Advisory System for Farmers Based on Soil Chemical Components

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ABSTRACT

Over the past three to four decades, the growth of population in India has raised the requirement of food grains. Though modern technology is supporting agriculture, the area of agriculture is getting declined day-by-day due to several reasons such as lack of water resources, lack of man power, and insufficient mechanism to disseminate necessary information to farmers. In this case, the use of technology is inevitable. Now a days, most of the government organizations attempts to implement technology based solutions which give rise to E-Governance especially in rural India. Information and Communication Technology (ICT) plays a vital role in every domain but merely in Agriculture. Wireless Sensor Network (WSN) is a latest technology which is capable of acquiring data from any environment with the help of sensors. The objective of this work is to develop a system, which acquires farm-field data, analyses with the help of agro-expert systems, predicts the type of cultivation based on the soil quality and disseminates viable information to the farmers with the aid of ICT and WSN. In general, in and around Dindigul district three types of soils are available viz., Laterite Soil, Black Soil and Red Soil. The main challenges in Dindigul district are to choose the type of cultivation in order to improve yield and that achieves better quality based on the chemical components of soil. Moreover, the cultivation depends on the parameters such as soil erosion, application of proper fertilizers, liming and proper irrigation. The benefit of this technology will reach the farmers at their door steps through Mobile Communication as Short Message Service (SMS) in their native language.

Keywords
Information and Communication Technology, Wireless Sensor Networks, Sensors, expert system

Introduction

Agri in INDIA

The statistics shows that about 58% India's population in India relies on Agriculture. The Gross Value Added(GVA) by agriculture, fishing and forestry is calculated to be Rs.19.48 Lakh crore in the Financial Year 2020 (US$ 276.37 billion). The Indian Food Industry is contributing much to the world food trade every year. The Indian food grain production market size during 2019-2020 recorded 295.67 million tons (MT) and the same is expected to reach 298 MT by 2020-2021.

Agri exports from India are likely to reach US$ 60 billion by 2022. In FY20 (till January 2020) agriculture exports were US$ 28.93 billion. The Foreign Direct Investment (FDI) in Food Processing Industry has drastically increased to US$ 9.98 billion between 2000 and 2020. The expectation of INDIA is to double the farm income by 2022 [1].

Role of IoT in Agriculture at the Global Level

Internet of Things (IoT) has started its exceptional role of play in the field of agriculture in the modern arena. Till 2018, the global agriculture market stands at 1.8 billion US dollars and the change is continuous. It is expected to rise up to 4.3 billion US dollars by 2023 at a Compound Annual Growth Rate (CAGR) of 19.3%. The statistics taken recently reveals that world population will reach 9.6 billion by the year 2050.

The Agro-industry is constrained to cope up to the Internet of Things to feed this massive population. Among the barriers like extreme weather conditions, climatic changes, environmental impact, IoT is attempting to eliminate these challenges and helps the inhabitants to meet the claim for more food products [2].

Certainly, the joint venture of ICT and WSN will excel in the field of agriculture to meet the demands of the population.

Scope of WSN Deployment in Agriculture Field

Wireless Sensor Networks (WSNs) are widely functional in various applications of farming especially in agriculture.

The possible WSN applications, and the explicit issues and dispute associated with deployment of WSNs for improved farming is the talk of the day. In order to focus on the field oriented requirements, the devices, sensors and communication practices associated with WSNs in agricultural applications are analyzed comprehensively in the literature.

At present various case studies are carried out to completely survey the existing solutions proposed in the literature in various types according to their design and implementation related parameters. In regard to this, the WSN deployments for various Agro-applications in the Indian as well as global scenario are investigated [3].

The prime objective of the Intelligent - Crop Advisory System (i-CAS) is to (1) Acquire real time soil data from farm – field and retrieve data from repository, (2). Analyze the soil data using an Agro-Expert System and Human Experts, then creates a crop advisory, and (3) Disseminates Crop Advisories to Farmers and Records in Agro – Information System.

Literature Review

Tamoghna Ojha et al [3] focus on the new path of research in the agro and farming domains. Their work focuses on the soil nutrients, crop health, and production quality over time and irrigation arrangement. The working model contributes in irrigation administration, farming system monitoring, pest and disease control, fertilizer usage, cattle-movement tracing, greenhouse gas monitoring, quality tracking, control and diagnosis in remote.

Devi Kala Rathinam et al [4] comes out with the application of WSN in modern agriculture and the authors strongly express that application of ICT and automation of certain processes in the farming will certainly improve the productivity and others there by.

Kansiime et al [5] overwhelm on the effectiveness of agri-advisory service with the mobile technology. It is evident that the farmers would definitely gets benefit through the model developed by them in the Direct 2 Home Program in India.

Sandeep shiravale et al [6] discusses the implementation feasibility of WSN based working models in the Agriculture domain. Precision agriculture is found to be the area of focus in the model developed by the authors. The authors focus on the technical internals of the WSN implementation.

Anilkumar et al [7] developed a system that helps in increasing the agricultural production by analysis of nutrients like pH, moisture, humidity, temperature and NPK with the WSN technology. Their implementation result suggests the type of crop possible for cultivation based on the soil properties in the field.

Anandkumar et al [8] surveyed the impact of WSN in precision agriculture for the increase in production cum quality of crops and remote monitoring. The authors discuss about the importance and implementation feasibility of WSN in precision agriculture.

From the literature, it is learned that the application of working WSN models in agriculture will definitely increase the productivity and economical position of the Farming community and there by the social-economic status of the Nation.

Table 1. Sample Soil Data

SAMPLE SOIL DATA - REDDIYAR CHATRAM VILLAGE, DINDIGUL DISTRICT, TAMILNADU			
TYPES	**LATERITE SOIL**	**BLACK SOIL**	**RED SANDY SOIL**
SUB-TYPES	1.Compact 2. Reddish 3. Yellowish-red	1. Shallow black - soil. 2. Medium black - soil. 3. Deep black - soil.	1. Red loam soil. 2. Red gravelly soil. 3. Mixed red and black soil.
CHEMICAL COMPONENTS AVAILABILE	1. Rich in bauxite or Ferric oxides. 2. Poor in lime, Potash & Nitrogen. 3. Has Iron Phosphate.	1. Alumina 2. Iron-oxide 3. Lime 4. Magnesium Carbonates 5. Phosphates 6. Nitrogen.	1. Alkali 2. Rich in potash and Potassium. 3. Poor in lime, 4. Magnesia, Phosphates, 5. Nitrogen.
CROP CULTIVATION FEASIBILITY	1. Paddy 2. Rice 3. Sugarcane 4. Green gram 5. Gram.	1. Best for cotton 2. Wheat 3. Millet 4. Sugarcane 5. Linseed 6. Gram 7. Pulses	1. Wheat 2. Rice 3. Millet 4. Gram 5. Sugarcane. 6. Groundnut 7. Coconut 8. Ragi
HEALTH STATUS	➢ Varies from farm to farm based on Biological, Physical and Chemical Properties. ➢ Health benchmark is fixed based on the above parameters.		

Intelligent - Crop Advisory System (I-CAS)

The Intelligent - Crop Advisory System is designed and developed to perform distinct and hierarchical tasks.
The i-CAS system (Figure 1) is composed of three Sub systems that are:

(i) SOIL DATA ACQUISITION AND RETRIEVAL SUB-SYSTEM (SDARS).
(ii) AGRO-EXPERT SYSTEM (AES).
(iii) ADVISORY DISSEMINATION SYSTEM (ADS).

The SDARS sub-system is used for the soil data aggregation from both the Farm-Field in Real Time and soil history from the database as well. The role of AES sub-system is very vital and in arriving at Decisions based on soil data supplied by SDARS and generates Crop Advisory. The ADS Sub-System is instrumental in the dissemination of Crop Advisories to the Farmers and updating relevant information in the Agro-Server Database.

Soil Data Acquisition and Retrieval Sub-System (SDARS)

The organization of Soil Data Acquisition and Retrieval Sub-System (SDARS) is shown in Figure 2. The main responsibility of this sub-system is to collect or aggregate data related to the Soil Chemical Components (SCC) from the farm field in real time and the soil history of that area from the Soil Database.

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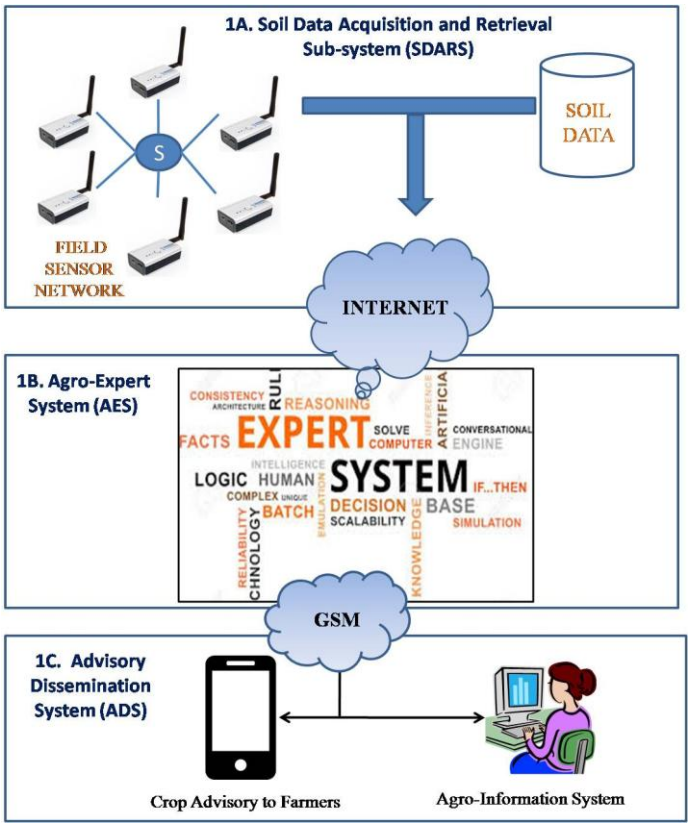

Figure 1. i-CAS Architecture.

In SDARS sub-system, the Field Sensor Network incorporates an assortment of sensors for finding Temperature, Moisture, pH, Electrical Conductivity (EC), Rain and other parameters in the Farm-Field in a real-time manner.

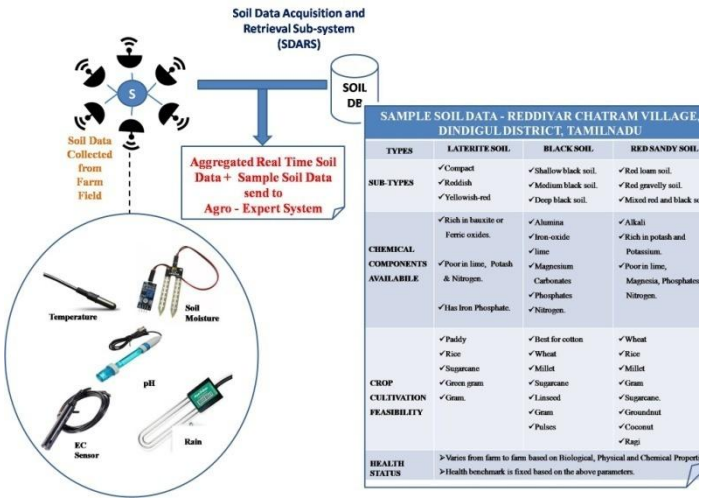

Figure 2. SDARS Sub-System

Further, these information is aggregated by a Sink (S) node. In addition to this, the Farm-Field Soil History is retrieved from Data Base and collectively fed to Agro-Expert System (AES) to strengthen the process.

Agro-Expert System

Once the soil data is supplied by the SDARS sub-system, the AES sub-system (Figure 3) initiates its task by analyzing the soil data using an Agro-Expert System and Human Experts and then the crop advisory is generated by the AES system.

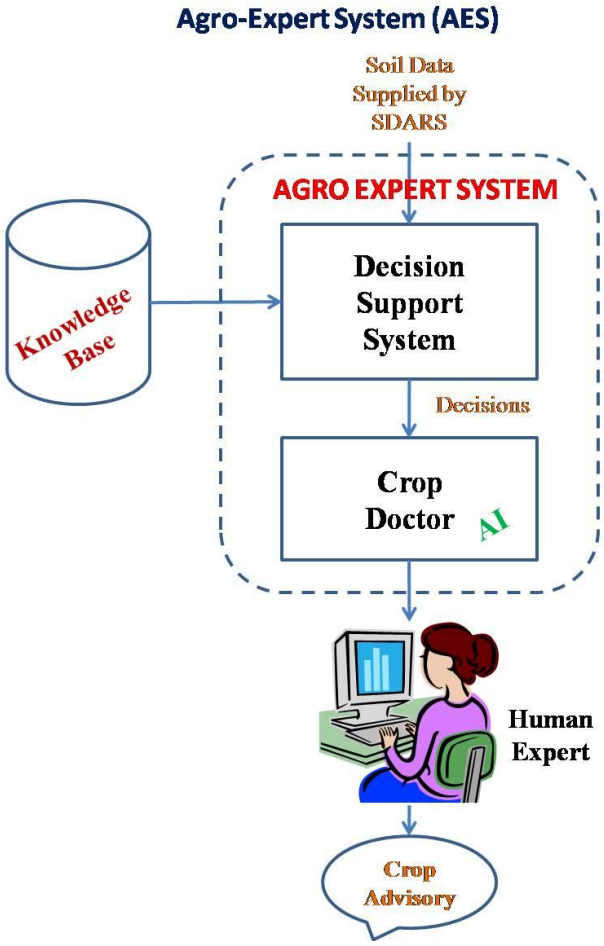

Figure 3. Agro-Expert System.

With reference to the Knowledge Base and real-time soil data, the Decision Support System generates Decisions. These Decisions are then fine tuned by an Artificial Intelligence component called Crop Doctor. Then the decision is supplied to an Agriculture Engineer say a Human Expert. Then the Human Expert generates a Crop Advisory based of the fine tuned decisions. This Crop Advisory is then fed as input to the Advisory Dissemination Sub-system for further process.

Advisory Dissemination System

The role of ADS sub-system is vital in dissemination of Crop Advisories to the Farmers

in their native Language and records the same in Agro Information System database for future use.

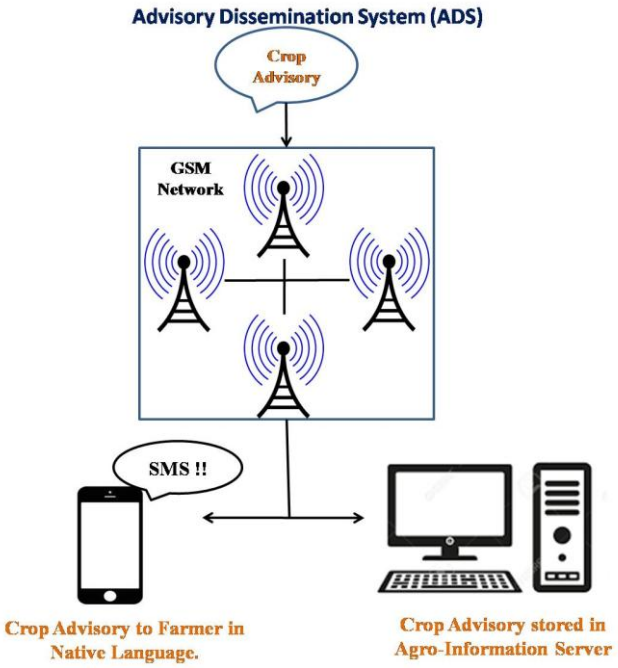

Figure 4. Advisory Dissemination System

The ADS sub system uses a GSM Network to disseminate Crop Advisory to Farmers in the form of Short Message Service (SMS) in their Native Language. Further the Crop Advisory is stored in Agro-Information System for future reference.

Implementation feasibility and discussion

It is planned for a pilot implementation of this system in Reddiar-Chatram village of Dindigul District, Tamilnadu with due permission from the Agriculture Department, Government of Tamilnadu. As an initial move, it is planned for the system that to be designed with mixed methods of both quantitative and qualitative data with an Analytical Framework and Pilot Implementation as well. The sample soil data taken from the proposed pilot implementation site is listed in Table 1.

Further, it is evident that farmers are very much willing to adopt new methods and act based on the information that they receive through mobile communication. In the other side, the Government of Tamilnadu is also keen in implementation of Information and Communication Technology in the Agriculture Domain for the improvement. It is strongly expected that the Pilot implementation of i-CAS will definitely lend a hand to the community in a better way for their development in all respects.

Conclusion

In the modern arena, area of farming is being decreased where as the population of the Nation gets increased drastically. Global warming, insufficient rainfall, water scarcity, inorganic farming, urbanization are becoming severe threats for agriculture. Somehow, we need to increase the cultivation and production of food grains to meet out the demand. Application of Information and Communication Technology (ICT) as well as Wireless Sensor Networks (WSN) will play a vital role in Modern Agro - Industry. Days are not too far, ICT and WSN will become viable technologies for applications like Crop Advisory System for Farmers to select crops for cultivation with respect to soil health, water resources and other parameters. The scope and purpose of i-CAS system is to increase the productivity and improve the economical status of the Farmers, the back-bone of the Nation.

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