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Smart Farm Intelligence Model to Uplift Farmers in Rural Pakistan

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Abstract: Information and Communication Technology (ICT) is playing an important role for making decisions in many fields including agriculture and now the economists, researchers, and policymakers are focusing to improve agricultural development through ICT to innovate the existing information and monitoring system, to cut operating cost and increase farmer's profit. Smart farming also one of the innovative approaches it provides a broader picture of Information and Communication Technologies to enhance agricultural production, these technologies transfer important and timely information to make decisions for different farming activities by their own or combine with other models. In this research, we made an effort to develop a smart farming model to uplift farmers in Pakistan. In this model, we assimilated diverse modules related to Sensing, Communication, data analysis systems, and user control to check the farm environment remotely. For easy access, availability and affordability we designed a Smart farm model with low-cost devices so that low - Income farmers can also get benefits.

Keywords: ICT, Agriculture, Communication, Smart, Model

1. Introduction

Agriculture is an important sector of the economy and has many riots; it is a good source of providing food and labor force to the world population and raw-material to various industries but still, in most areas of the world particularly in developing countries, the farmers are planting the crops from centuries through traditional way and they are not getting benefits from modern-day technology, The growing use of information and communication technology (ICT) in diverse segments also bring revolution in agriculture. Self-governing, robotic, aerial vehicles are available for farming activities. [1] Lightweight powerful high megapixel snapshot cameras (shown in Figure 1) are also being used for farm management to find biomass and fertilization status [2]. Farmer is also getting benefits from different decision-tree models to differentiate between plant diseases based on optical information [3]. Computer-generated fence technologies are also here to use [4]. For livestock management by sensors attached to the livestock based on remote-sensing, with this technical innovation technical revolution has started in the field of agriculture and traditional practices have been innovated [5]. In the world where ICT is adopted in agriculture (use of internet, tablets and mobile phones) at a fast step will become the game-changers in upcoming days (such as weather forecasts, climate-smart agriculture) such types of changes in practice not only explore the opportunities but also bring challenges [6].

Figure 1. *Snapshot camera used for Farming.*

This is the need of time to highlight them out at an early stage of this revolution to avoid obstacles, supporters and those who don't believe in technology need to set together to discuss the upcoming innovation of farming in information age [7]. Features of technology, the variety of crops, cattle systems, and organizations should set together in the discussion, Should the agribusiness in the information age be called "smart farming." The Smart farming reduces the environmental footmark of farming and reduced the localized application of requirements, like use manures and insecticides, in the modern farming systems will ease filtering difficulties as well as the release of orangery gases [8]. Smart Agribusiness can be made more profitable through the use of smart farming technology, by decreasing inputs resources farmers' money and labor can be saved and profit will be increased. Reliable and clear information will cut risks. Finest, localized weather forecasts, crop plans, players involved and the possible misappropriation of information makes legal and moral challenges for regulation and monitoring bodies [9]. Apart from that ICT will strengthen the challenges of accountability of modern-day technologies [10]. Adoption of expensive technology for farmers and inadequate knowledge and skills can be an important obstacle to adopt technology particularly in developing countries [11]. Therefore the entrée to the newest knowledge might be limited to large and industrial farmers the advantages of ICT may be restricted to developed countries and they preferred the production of high value and broadly grown crops and farmers of developing countries may left far behind [12].

Pakistan government has taken many steps to improve farming by introducing innovative scientific research methods to improve production and livelihood [13]. The agriculture sector is connected with other sectors of the economy and playing a remarkable role in enhancing country socio-economic development. Share of Agriculture in GDP is 19.8% and labor employment share is 42.3 % this sector recorded negative growth of -0.19 % against the last year growth the decline in growth is due to the drop in production of cotton, maize, rice and other due to extreme weather condition and lack of advanced agriculture system [14]. Similar to numerous developing countries agriculture is seen as the vehicle for development also in Pakistan but due to the unavailability of suitable information and awareness system, its role is less effective [15]. The core causes the restrictive farmer to raise income and production is the lack of appropriate sources and systems [16].

Agriculture has a direct influence on our daily life agriculture is moving towards transformation gradually. New developments are being made in the field of agriculture to improve production. When we compare the past and present agriculture practices we can easily understand how Information and Communication Technology (ICT) is playing an effective role in recent agriculture An increase in population agriculture demand has also been raised which can only be met by use of modern-day technologies like Wireless sensor networks and RFID tags are the most consistent advanced tools performing a dynamic role in the smart agriculture. In the world, many countries like China, India, Korea, Brazil, Australia, and many European countries while different American estates, are introducing agricultural technologies to strengthen their economy by using information and communication technologies for the growth in agricultural and rural development [17].

2. Related Work

Western countries like the United States of America, Japan, Canada, Europe, and Australia have established smart farms based Information and Communication Technologies (ICT) [2, 11]. Like Face farm and cloud-based smart farm technologies to improve agriculture. The smart farming system delivers services to farmers to manage their field related activities and crops pattern. Through these systems, farmers can prepare a plan to manage their workforce and check farm conditions to handle diseases and proper use of water and fertilizers. In the developed countries the smart farming systems are available on low-cost and farming is getting benefits from this system and in European countries, the different project such as CLARIS has been introduced to decrease production expenses and to increase profit, more research studies are being made to make innovation. The smartphone application is also available to check and control the farm Greenhouse automatic control systems have also been developed, Internet of thing (IoT) framework for smart farming is also available [18]. However, today they are focusing on the viability of using the RDF Stream Processing system, a self-growing agricultural knowledge cloud in smart agriculture has also been proposed by Kim et al, This system is based on knowledge only and not to address the problem of whole smart farm [19]. Without of the box thinking, Lin and Liu developed a remotely controlled farm system to check and control farm using smartphones or tablets without visiting, Lee and Yeo suggested a pig farm monitoring system to effectively manage the farm by monitoring the environment by using sensors, video [20]. Kaewmard et. al presented an automation system built on wireless sensor network systems to check the agriculture environs [21]. The irrigation system to collect environs data and control operation through mobile is also developed by Kaewmard et.al [22]. All became possible due to advances in ICT T like short-range wireless communication (ZigBee, Bluetooth, Wi-Fi), and cellular networks and extensive use of smartphones [23].

ZigBee Network with the help of XBee devices. There are three main parts in the ZigBee network as shown in (Figure 2) for more details. Sensing nodes or End devices are embedded with the various sensors like CO2, Temperature and Humidity. Sensor Nodes will percept the environmental values and forward to routers, Routers further collect values from various sensing nodes and forward to the coordinator. The coordinator is connected to a device that is Internet enabled. All the collected values from various sensing nodes will be dumped into a database for processing [25, 26]. In Figure 3 we can see the overview of Phenonet this system

link the producer to market to get real time prices and help to predict future prices [26]. Smart farming system can play much proficient role from sensing to acting to carry out optimal live control for performance or product quality through sensing technique as shown in Figure 4 [27].

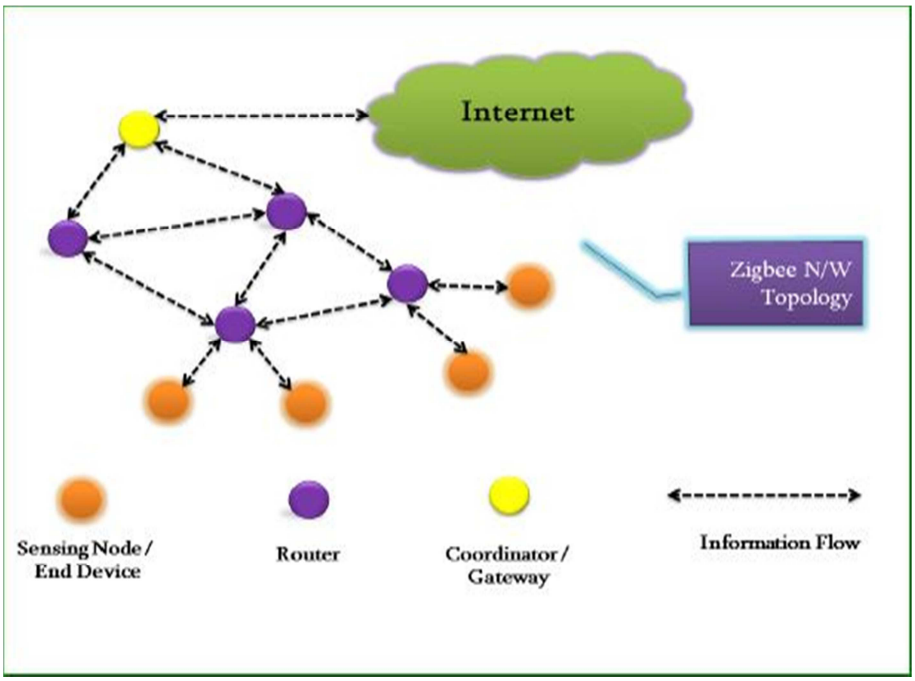

Figure 2. *Zigbee networl topology (Wsn).*

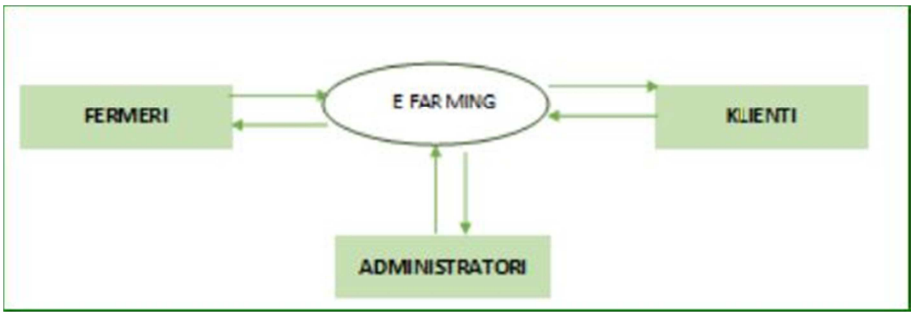

Figure 3. *Phononet system for farming.*

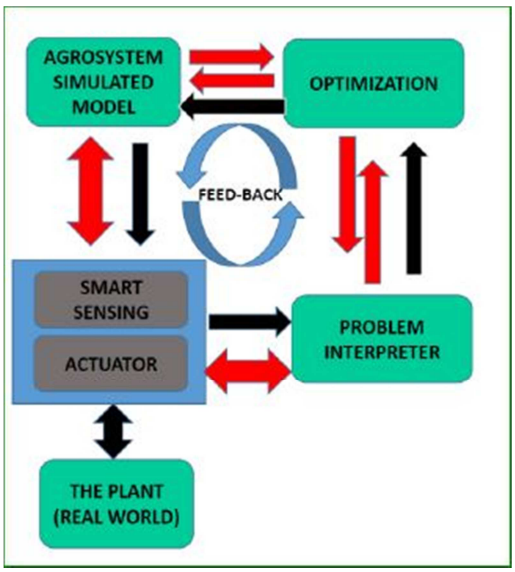

Figure 4. *Climate smart agriculture.*

3. Research Objectives

(1) To propose ICT based smart farm model which consists of sensing, Communication and data analysis systems that
(2) will support farmers to make decisions.
(3) To investigate problems and to propose solutions for module integration.
(4) To build an information base system for the plants to collect information for further use.
(5) To develop affordable mechanism which can be used for Commercial study?

4. Model Overview

ICT has enabled farmers to increase production and improve livelihood Smart farming is also an emerging trend in modern farming our smart farm model consists of Sensors, Communication systems and data analytics shown as Figure

5. To monitor the farm environment such as humidity, temperature, luminosity sensors are used while for plant culture agitators like water pumps, fans and lights are used. For communication wireless links are used. This model is comprised of a web server, database, and management information base (MIB). The database is used to store data and MIB is managing the information for further use. Furthermore, Farmers and other stakeholders can access the application from the server through the public network. The main objective of the smart-farming model is facilitating farmers to resolve their problems to improve plant health and increase production.

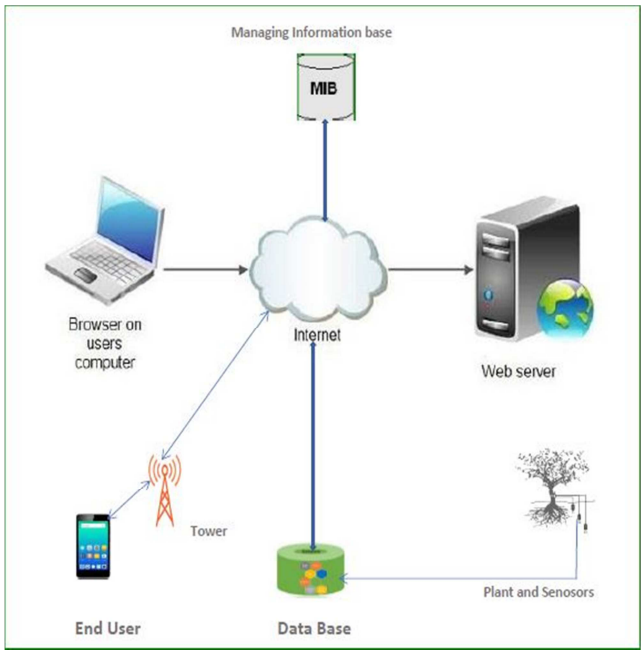

Figure 5. *Smart farm Model (SFM).*

5. Sensor System for Smart Farm Model

Smart farm system needs sensors for the automatic operation because to describe the plant's condition and farm environment data is to be measured by sensors and to make the smart farm system able to act in specific situation therefore different kind of sensors are used for the measurement of objects. In our proposed model we used Sensor EE181 for measurement of air moisture and temperature while for measurement of humidity we used HS10 and for measurement of Luminosity, Sensor BH1750 is used. We have chosen these sensors on the basis of easy use and, cheap cost despite that, for data collection there is flexibility in the frequency to adopt for sensitive plants due to their growing period, To rush added values to the model other kinds of sensors are also used. For example, we used GPS sensors for farm management and local supervision. In case of any issue, the sensor will rapidly since the corresponding location and the farmer can also observe the farm environment to manage the farm. Independently sensor cannot send information to another party in the smart farming system it always needs help from the integrated circuit which gathers information from sensors. Our smart farm model consists of a sensor circuit, gateway circuit, and relay circuits. Additionally, we deployed Atmega328P to collect data locally from different sensors, to play the role of gateway we used the Raspberry Pi circuit in the model. Raspberry Pi accomplishes a set of sensors and attaches to other nodes in the farm system. To control the water pump, lights and fan Relay circuits are designed.

6. Communication System

Communication is an important part of the smart-farming model and consists of two types of movement in the model one is data flow and other is control flow, In data follow movement data travel from one node to another web server collect data from sensors while in control flow signals and agitator are controlled in the network for example, when we want to activate or deactivate the activity such as to switch on a light bulb or water injector. In this case-control flow from the web server to the agitators based on Hypertext Transfer Protocol (HTTP). HTTP is an appropriate way for data collection from sensors to the web server. To exchange data between two nodes in a system usually, the Hypertext Transfer Protocol Secure (HTTP) is used. In the smart farming context we noticed that HTTP is only appropriate for data collection from sensors to the web- server through the internet; the web- server has public IP address through which other nodes contact it to exchange data mutually this means that the web server cannot access the systems having any IP addresses so there is an issue to perform control flows from the web server to an agitator to fix this issue we used Advanced Message Queuing Protocol (AMQP) it is open standard layer protocol designed to professionally support wide range of messaging application and communication patterns. Another feature of this protocol is UBIQUITY clear and unmistakable core functionality to route messages and distribution within the internet set up. The communication framework is shown as (Figure 5) and further descriptions are as under.

App: App or application is computer software specially designed for group interconnected functions to perform tasks to facilitate users it can be computer application or Smart Phone App.

Server: The server is used to access centralized resources in a network.

Farm: It consists of the Smart Farm Model and other devices.

7. Managing Information Base (MIB)

We used an info base for our smart farm model to facilitate cultivation and guarantee good shape of plants over the cropping cycle. For wide and simple use expert feature is integrated into the system in order that less practiced farmers may additionally get advantages. Info base covers the automated manner management just in case of failure of one parameter of the farm this technique takes necessary action

for instance if brightness lacking system is capable to activate the light to enhance the ecosystem. A plant has different growing periods and in each time period, the plant has varying development factors like soil humidness, air humidness, luminosity, temperature etc, therefore, the database is proposed to hold these data. Information follows shown in (Figures 6 & 7).

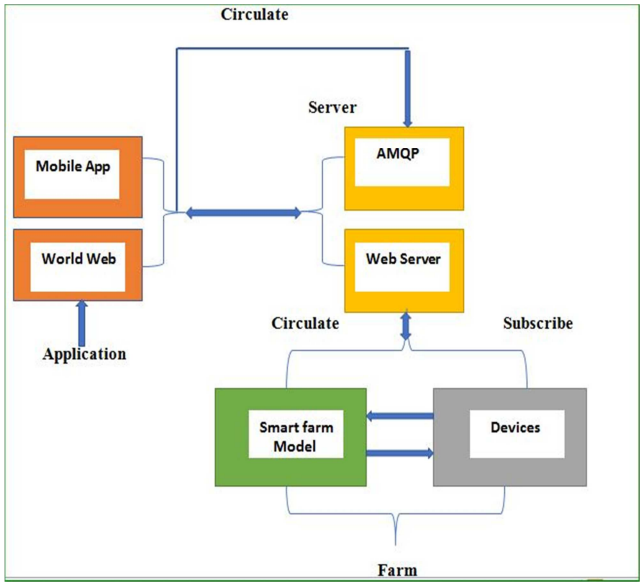

Figure 6. *Communication framework.*

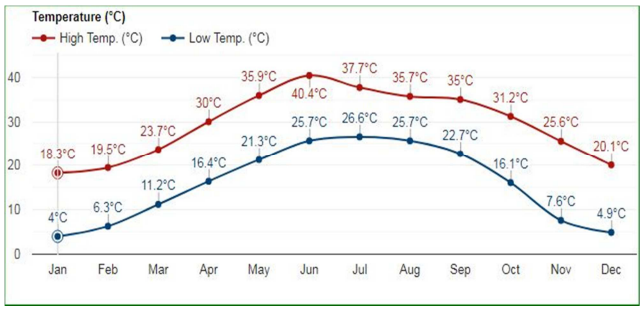

Figure 7. *Month wise status of pakistan climate.*

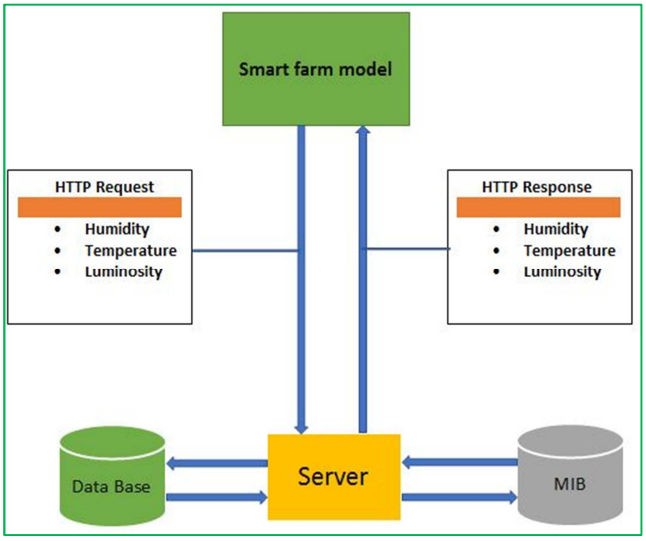

Figure 8. *Inforamtion flow with managing information base (MIB).*

8. System Design

We described here the incorporation of the defined modules cited in the smart farm system. Smart farm systems at the farm level collect information from different sensors and Raspberry Pi connect sets of sensors and relay components for the agitator. The Raspberry Pi also communicates with the Web server and AMQP. Moreover, on Microsoft SQL Server we deployed an info base and system database. For User access, we developed a web-based and smartphone mobile app to manage the farm. To make the model more intelligent we developed the prototype and used the Management information base (MIB). The prototype perform two main functions first is to monitor the farm network and visualize the farm environment parameters for end users through the use of web or smartphone application second is to control devices remotely like lights, water pump, and fans as shown in (Figure 8).

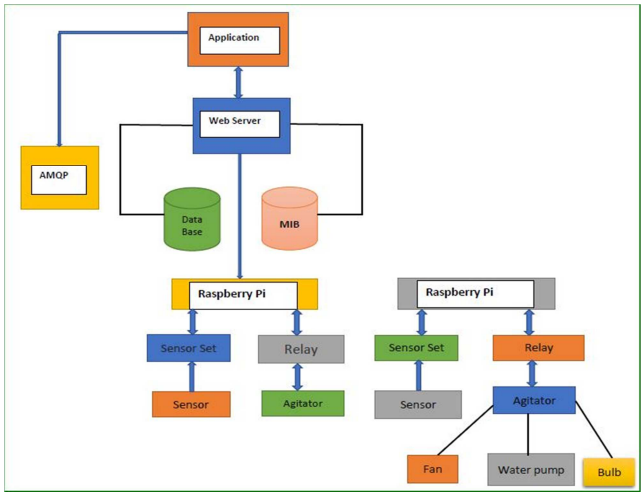

Figure 9. *Smart farm model system design.*

9. Cost Analysis

Our Smart farming model consists of nine devices EE181 to check humidity of the air and Temperature, to check soil humidity we used HS10, and to measure luminosity BH1750 is used. For agitator relay module is utilized, Raspberry Pi and 16 GB memory for the gateway and the Power Module to run LM2596 to run the system. Table 1 denotes the cost of each device used in our Smart Farm model. Furthermore, we used a Wi-Fi connection which is easily and economically available in Pakistan.

Table 1. *Cost break down.*

SNO	Name of devices	Per Unit Cost	Quantity	Total Cost (in Pak Rupee)
1	Sensor HS10	4500	1	4500
2	Sensor EE181	5500	1	5500
3	Sensor BH1750	4100	1	4100
4	Relay Module	4999	1	4999
5	Raspberry Pi	4850	1	4850
6	Memory	3500	1	3500
7	Atmega 32P	3850	1	3850
8	Wifi device	3500	1	3500

SNO	Name of devices	Per Unit Cost	Quantity	Total Cost (in Pak Rupee)
9	Power Module	5100	1	5100
				39899

10. Conclusions

In this research work, we proposed a low-cost smart farming model including a communication system, Sensor system Management information base (MIB) system. Moreover, we discussed and resolved the different issues in all modules and assimilate all into one system for smooth functioning. Furthermore, we made our smart farming model more intelligent by arming it with an Information base to supervise the farm environs and control the devices remotely. Finally, this assistance will help farmers to reduce expenses and increase profit as well as manage farm activities with innovative ways.

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