International Journal of Emerging Trends & Technology in Computer Science (IJETTCS)
Web Site: www.ijettcs.org Email: editor@ijettcs.org
Volume 6, Issue 6, November- December 2017 ISSN 2278-6856

Information Dissemination using Computer and Communication Technologies for Improving Agriculture Productivity

Saurabh Sindhu[1] , Divya Sindhu[2]

[1]Assistant Professor, Deptt. of Computer Sciences, CRM Jat College, Hisar - 125001, Haryana

[2]Assistant Professor, Deptt. of Computer Sciences, CRM Jat College, Hisar - 125001, Haryana

Abstract

Agriculture is the backbone of India's economy and approximately 59% population derive their livelihood from the agricultural sector. However, yield of several crops in India is significantly low as compared to the yield in developed countries. Hence, it is necessary to find solutions that may improve the crop success and productivity. The enhancement of agricultural production and rural development through application of improved information and communication processes is termed as E-agriculture. This emerging field E-agriculture involves the conceptualization, design, development, evaluation and application of innovative ways to use information and communication technologies in the rural domain, with a primary focus on agriculture. Data mining of different crops information system, their production techniques and information inquiry system is necessary to help the farmers. Collection and distribution of crop growth stage information, detailed digital maps of the farmer's fields, geo-fencing, weather forecasting and pest information could be provided using global positioning system (GPS) vocational devices and sensors in the field. Geographic information systems (GIS) are also extensively used in agriculture, especially in precision farming and in decision making based on historical data and sampling. Use of mobile technologies and smartphone apps in rural areas has extended the information and communication services for agriculture, horticulture, animal husbandry and farm machinery. The mobile apps are designed in regional language to break the literacy barrier and deliver the information in most simple manner. Computer-controlled automatic milking systems are controlled by a robot using complex herd management software for milking of the dairy cattle. Moreover, electronic commerce (E-commerce) facilitates the farmers about the up-to-date market information on prices for commodities, inputs and consumer trends, and in trading of farm produce using computer networks such as the **internet** ***and online shopping web sites. In this paper, a cost-effective agricultural information dissemination system will be discussed to disseminate expert agricultural knowledge to the farming community in order to improve crop productivity based on the demand in the world market.***

Keywords: Agriculture productivity, Computer technology, E-agriculture, Electronic commerce

1. INTRODUCTION

Indian agriculture contributes to 18.6% of India's GDP and exports of agriculture commodities accounts for 8.56% of India's total exports. Approximately two-thirds of the population live in rural areas and depend (directly or indirectly) on agriculture for living. The main phases of agriculture crop production include crop cultivation, water management, fertilizer application, management of pests and weeds, harvesting of crops, post-harvest handling and transport of food products, packaging, food storage and preservation, food processing/value addition, quality management and food marketing. In spite of successful research on new agricultural practices concerning crop cultivation, majority of the farmers are not getting upper-bound yield due to several reasons [1]. Hence it is necessary to find solutions that may improve the chances of crop success and improve the crop yield. Moreover, a cost-effective agricultural information dissemination system is needed to disseminate expert agricultural knowledge to the farming community in order to improve crop productivity.

With the increasing human population globally, the demand of food is increasing and the farmers, agricultural scientists and governments are trying to put extra efforts by implementing innovative techniques and implements for more food production. But till today, farmers are performing agriculture-related tasks manually and a very few farmers are using the new methods, tools and techniques of farming for better agriculture production. Advanced information technology that can provide quick and cost-effective ways to identify spatial variability within crop fields is the basis of precision agriculture. Moreover, remote sensing technologies have advanced rapidly in recent years and have become effective tools for site-specific management in crop protection and production. Therefore, appropriate methods and techniques are required for managing and organizing the data related to agricultural information to increase the efficiency and agricultural productivity. Data mining can help to process and convert this crop production related data into useful information. There are many government, private and non-government organizations involved in agriculture sector and rural development. They all have to work together to give better service to farming community.

Data mining techniques will provide information about crops and enable agricultural enterprises to predict trends about customer's conditions or their behaviour. The computation of agriculture data and data mining techniques can be used as a tool for knowledge management in agriculture. Data warehouses can be prepared to hold agriculture data, which makes transaction management, information retrieval and data analysis much easier. The emerging field focusing on the enhancement of agricultural and rural development through improved information and communication processes is termed as E-agriculture. The information provided by the system must be in user-friendly form, easy to access, cost-effective and well protected from unauthorized accesses. Easier data extraction directly from electronic sources and its transfer to secure electronic system of documentation, will reduce the production cost, higher yield and higher market price.

Information and communication technology (ICT) is an umbrella that includes any communication device or application, encompassing radio, television, cellular phones, computer and network hardware and software, satellite systems etc, as well as the various services and applications associated with them, such as video-conferencing and distance learning. Over the last 10 - 15 years, ICT has changed the way the world works, communicates and shops. This paper describes the use of computer and communication technologies for dissemination of information in perspective of improving agriculture productivity. Furthermore, the application of ICT will also enhance the efficiency and inter-connectivity of the farmers, extension workers, coordinators and subject experts working in the agriculture sector/organizations.

2. TRADITIONAL LIVELIHOOD TECHNOLOGIES USED IN AGRICULTURE

Agriculture in the 21st century faces multiple challenges. It has to produce more food and fibre to feed a growing population, more feedstock for a potentially huge bioenergy market, contribute to overall development in the many agriculture-dependent developing countries and to adopt more sustainable food production which are viable even under changing climatic conditions. In order to feed a population which is anticipated to touch mark of 9 billion in the year 2050, the world will need a new vision for agriculture to deliver food security, environmental sustainability and economic opportunity through agriculture. This will require more food production with fewer resources while reinvigorating rural economies. It can only be achieved through collaboration, investment and innovation among all stakeholders. Many countries are now undertaking ambitious efforts to achieve the new vision through a transformation of their agriculture sectors, engaging in public-private collaboration and market-based approaches.

The farming community in India uses traditional agriculture technologies and implements to earn their livelihood (Fig. 1). Artisans and labourers help the farmers during the crop sowing and harvesting season. Besides apiculture and mushroom production, farmers also rear animals for getting milk, leather, wool and milk products. Excessive use of fertilizers and irrigation with saline water has deteriorated the soil health. In addition, climate change, drought conditions, improper rainfall and insect infestation severely affect the agricultural productivity. Plant diseases are a major threat to the crops throughout the world and affect the quality as well as quantity of farm produce. Though large information for plant disease management is available but the lack of proper diagnosis and management in real time is a serious constraint for farming community. Due to limited resources, education and medical facilities, and lack of renumerative prices for their farm produce, still there is unemployment, poverty and undernourishment in the farming community.

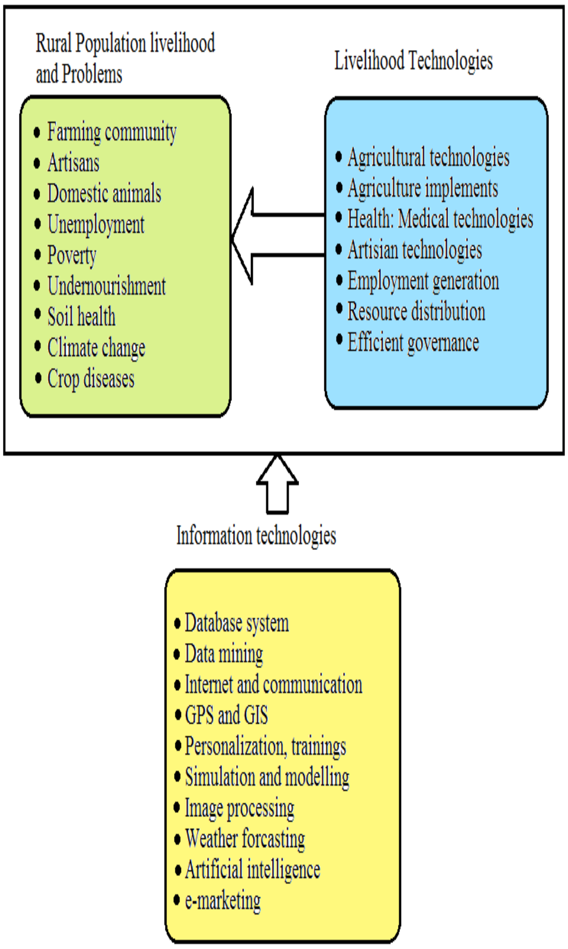

Fig. 1. Rural population depends on agriculture for their livelihood and adopts different livelihood technologies. The use of recent information technologies could further enhance their skills for better crop productivity and profitability.

Recently, use of different information and communication technologies such as data mining, internet, artificial intelligence and image processing (Fig. 1) are providing adequate knowledge for nutrient deficiency in soil, sowing of the crops, prediction of diseases and control measures for prevention of diseases. Application of GPS, GIS and weather forecasting is useful for timely cultivation and sowing of different crops using agronomic practices. Recent advances in technology for electronic communication of data and information have opened up new avenues to communicate agro-meteorological information in a timely and effective manner. The mass dissemination of agro-advisory bulletins is done through Radio/TV and local/regional newspapers. Still, there is need to increase effective outreach of the weather based services to the farmers through mobile SMS, mobile apps and Information Kiosks in the state so that farmers can minimize farm losses due abnormal weather and increase their farm productivity with efficient use of available resources. E-marketting will further help the farmers to sell their farm produce at remunerative prices.

3. METHODS AND TECHNIQUES USED

For the creation of agricultural information system, collection and storage of agriculture-related data in the form of database is required. Different data mining techniques can be used as tools for knowledge management in agriculture to provide information about soil fertility status, prediction of climatic conditions, pest's infestation and to predict trends related to farm produce. Different methods and techniques used for improving agriculture productivity are described in this section.

3.1. Disease diagnosis through image processing and use of mobile phones

Different phytopathogenic microorganisms including bacteria, fungi and viruses cause various diseases on crop plants and reduce the yield of crops. The observation of plant pathologists or experts is the main approach adopted in practice for diagnosis of plant diseases. The continuous monitoring by experts or visit to the infected fields is expensive. Further, many times farmers may have to travel long distances to obtain farm advisory services from officials/subject experts of State Agricultural Universities, Krishi Vigyan Kendras and Agriculture departments etc. By the time, the expert opinion is received; the disease takes severe form and becomes difficult and uneconomical to manage. For example, late blight of potato and yellow rust of wheat if not diagnosed at an early stage, will cause heavy losses and may take an epidemic form. Therefore, to provide a real time and economical method for diagnosis of plant diseases is of great significance for farming community.

Nikos [2] reported that an image processing technique capable of recognizing the plant lesions can allow its implementation on mobile phones and higher than 90% accuracy was achieved. Mobile phones were used for real time monitoring of plant diseases for proper diagnosis and treatment [3]. The part of the processing is carried out on mobile device that included leaf image segmentation, and spotting of disease patch using improved k-means clustering. Xie et al. [4] developed a fast, accurate and robust diagnosis system of wheat leaf diseases based on android smart phone, which comprised of two parts – the client and the server. The functions of the client include image acquisition, GPS positioning, corresponding and knowledge base of disease prevention and control. The server includes image processing, feature extraction and selection, and classifier establishing. The results showed that the average recognition rate and predicted speed of Relevance Vector Machine (RVM) model were 5.56% and 7.41 times higher than that of support vector machines (SVM). The application needs about one minute to get the result of disease identification.

3.2. Data mining techniques: k-means approach and Fuzzy clustering

The k-means is a data mining technique for clustering [5, 6]. The aim is to find a partition of the set in which similar data are grouped in the same cluster given a set of data with unknown classification. Samples that are close to each other are considered similar and the measure of similarities between data samples is calculated using a suitable distance. The parameter k in the k-means algorithm plays an important role as it specifies the number of clusters in which the data must be partitioned. Bashir and Sharma [7] reported disease detection in *Malus domestica* through an effective method like k-means clustering, texture and colour analysis.

Studies were conducted by using fuzzy clustering in detection of leaf spots in cucumber crop [8]. Spots on leaves gave an indication of plant diseases, which were examined manually and were then subjected to expert advice. Experts from Plant Pathology declared the disease after proper investigation. Scientists proposed a segmentation technique for identifying leaf batches in cucumber crop using fuzzy clustering algorithm. The first step of image analysis and pattern recognition is the segmentation of image [9].

3.2.1. Support vector machines (SVMs)

These machines are binary classifiers that are able to classify data samples in two disjoint classes [10]. In this technique, two considered classes are linearly separable. In such a case, there exists a hyperplane which is able to separate all samples in two classes. Actually, in most of the cases, more than one hyperplane satisfying this condition exists and one of them is chosen as classifier on the basis of the margin it creates between the two classes. Arivazhagan and Newlin [11] used the SVM for detection of feature extraction and it is supervised by machine learning algorithm, and a set of related features is extracted. In this application, SVM improved the accuracy of detection.

3.2.2. Decision trees and Bayesian network

Classification and prediction are two forms of data analysis that can be used to extract models describing important data classes or to predict future data trends. It is a process in which a model learns to predict a class label from a set of training data which can then be used to predict discrete class labels on new samples. A decision tree is a flowchart-like structure with two types of components: (i) Leaf nodes that assign class labels to observations, (ii) Internal nodes that specify tests on individual attributes and each branch represents an outcome of the test [12]. The tree classifies observations in a top-down manner, starting from the root and it moves down according to the outcomes of the tests at the internal nodes until a leaf node has been reached and a class label has been assigned. Decision tree approach technique is also used in the prediction of soil fertility [13].

Bayesian network is a graphical model that encodes probabilistic relationships among variables of interest. This model has several advantages for data analysis when used in conjunction with statistical techniques [14]. It is an ideal representation for combining prior knowledge and data because the model has both a causal and probabilistic semantics. Moreover, Bayesian statistical methods in conjunction with Bayesian networks offer a feasible and efficient approach for avoiding the over fitting of data. It is a powerful tool for dealing the uncertainties, which widely occur in agriculture data sets. Naive Bayesian classification technique is used to classify soils that analyze large soil profile experimental datasets [15].

3.2.3. Artificial neural networks and Association rule mining

Artificial neural networks (ANNs) are systems inspired by the research on human brain [16]. The ability of a neural network to perform a given task depends on the structure of the network. The most commonly used ANNs is the multilayer perceptron, in which neurons are organized in layers. The input layer contains neurons that receive the input signal which is then fed to the network. The neurons on the output layer are active and the result provided by them is considered as the output generated by the network. There are also hidden layers between the input and the output layers. The organization of neurons in layers and their interconnections define the structure of the multilayer perceptron. The neural network is used in prediction of flowering and maturity dates of soybean [17] and in forecasting of water resources variables [18]. Landge et al. [19] used the applications of colour transformation and neural networks for classification of diseases that affect the plant leaves. They tested the proposed algorithm on various diseases viz., brown stripe, downy mildew etc.

Association rule mining is the technique of discovering association rules used to search unseen or desired pattern among the vast amount of agricultural data [20]. In this method, the focus is on finding relationships between the different items in a transactional database. Association rules are used to find out elements that co-occur repeatedly within a dataset consisting of many independent selections of elements (such as purchasing transactions) and to discover rules. An application of the association rule mining is the market basket analysis, customer segmentation, catalog design, store layout and telecommunication alarm prediction [21].

3.3. Interaction between farmer and extension worker/coordinators

The farmers get registered in database system and provide the information related to soil health and the crops grown in their field. Using the location specific farmers' crop database, crops information service system may be created (Fig. 2). The extension workers or coordinators could visit the farm or may take images using GPS/GIS and may advise the farmers for taking appropriate steps regarding application of fertilizer and spraying of the pesticides. Moreover, production techniques, production equipment's and information inquiry system should be created. The farmers follow the remedial measures and provide the feedback to the extension worker.

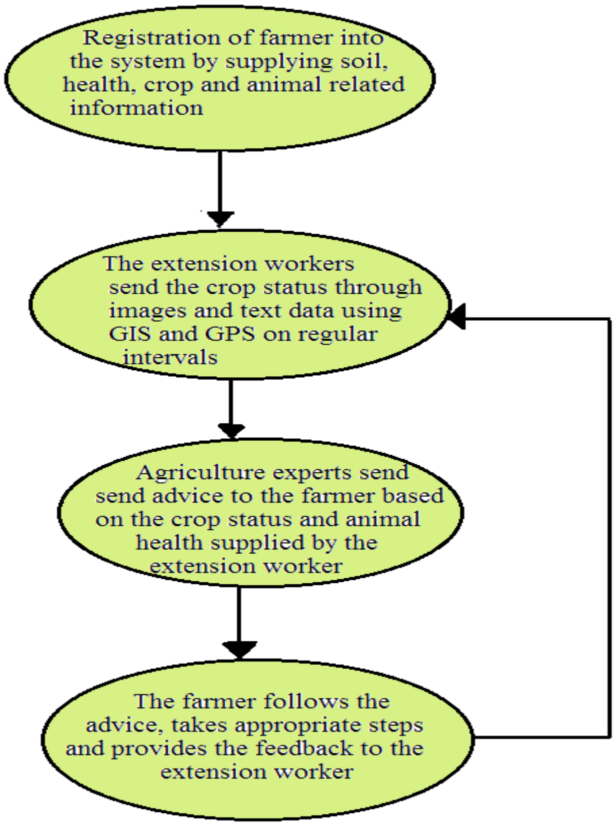

Fig. 2. Interaction between farmer and extension worker is critical for taking appropriate steps using ICT system.

Precision farming (site specific crop management) is generally defined as information and technology based management system to identify, analyse and manage variables within fields for optimum sustainability, profitability and protection of the land resource. In this mode of farming, new information technologies are used to make better decisions about many aspects of crop production. It involves looking at the increased efficiencies that can be realised by understanding and dealing with natural variability found within a field.

Climate smart agriculture is approach that helps to guide action needed to transform and reorient agricultural systems to effectively support development and ensure food security based on weather and crop information under changing climate scenario. Enhancing food security while contributing to mitigate climate change and preserving the natural resource base and vital ecosystem services requires the transition to agricultural production systems that are more productive, use inputs more efficiently, have less variability and greater stability in their outputs, and are more resilient to risks, shocks and long-term climate variability. The farmers will improve their farm productivity using real time climate smart agriculture system thus will result in contribution to agricultural growth.

4. APPLICATIONS OF ICT IN AGRICULTURE

In agriculture, farmers have many queries regarding the kind of soil and climatic conditions for cultivation of a specific crop and the timelines corresponding with each activity related to agriculture. Therefore, application of ICT and office automation will enhance the efficiency and inter-connectivity of the employees working in the field of agriculture.

4.1. Enhancing agricultural production

ICT could be used in increasing the efficiency, productivity and sustainability of small scale farms. This technology is dramatically increasing the amount of land each farmer can work effectively. Information could be supplied about pest and disease control, especially early warning systems, new varieties, new ways to optimize production and regulations for quality control. Remote management of grain storage facility may be used for high quality of agricultural products. Remote environmental monitoring system via the internet could be developed. Real-time monitoring and analysis of temperature variation in the storage facility could be arranged. Precise application of recommended fertilizers and pesticides reduces the wastage of inputs and improves the yield of crops.

Jagielska et al. [22] described applications of data mining to agricultural related areas in relation to yield prediction. In the past, yield prediction was achieved by considering farmer's experience on particular field, crop and climate condition. Veenadhari [23] studied the influence of climatic factors on major kharif and rabi crops production in Bhopal district of Madhya Pradesh state. The results showed that the productivity of soybean crop was mostly influenced by comparative humidity followed by temperature and rainfall by using the decision tree analysis technique. The same technique showed that the productivity of paddy crop was mostly inclined by rainfall followed by comparative evaporation and humidity. For wheat crop, the analysis revealed that the productivity is mostly influenced by temperature followed by relative humidity and rainfall. The rules formed from the decision tree were useful for identifying the conditions required for high crop productivity.

4.2. Forecasting of climate and weather conditions

Agricultural activities are very sensitive to climate and weather conditions. Weather remains one of the most important natural factors determining success or failure of agricultural production in India. The possibility of risk management could be managed by providing weather information on real time basis to the farmers. This can be accomplished only by good network of information kiosks with fast communication facilities. The forecast of the weather events helps for suitable planning of farm and to undertake or withheld the sowing operation, irrigation scheduling, time of harvesting, transportation and storage of food grains. The losses in the crop production can be reduced by adopting proper crop management practices with the help of timely and accurate weather forecasts. This will enable local farmers to move from low productivity risk-aversion orientation approach to a tactical 'response' approach that optimizes production potential towards sustainability while also reducing their vulnerability to climate extremes.

The dissemination of weather and crop information to the farming community is a major problem. To make the outreach the weather based crop information to be effective, a dense setup of Information Kiosk, mobile app and mobile SMS services is required. The dense communication system will also help in developing response to farming practices and advice that can help them make strategic and tactical decisions for their farms. Inter and intra-seasonal variations in weather/climate carry considerable impact on the timing as well as efficiency of routine agricultural operations such as planting, weeding and harvesting. They determine the efficacy of application of inputs such as fertilizers, insecticides and pesticides. Early forecasts of such events have the potential to help farmers take appropriate remedial measures that could avoid or reduce economic losses. The main strategic decisions for which the information is needed include assessment of crop production potential and identification of appropriate regions for a specific crop, choice of crops/cropping systems, management practices and marketing of agricultural products.

For simulation of daily precipitations and other weather variables, k-nearest neighbor approach technique can be applied [24]. It helps in the forecasting of climate and in the estimation of soil water parameters [25]. These sensors produce potentially useful data in enormous quantity on daily basis. This quantity of data also presents a challenge of data interpretation and classification to the researchers. Scientists have been widely using techniques such as k-means, k-nearest neighbour and artificial neural network for classification of remotely sensed images. Somvanshi et al. [26] designed the model for the prediction of rainfall using artificial neural networks and Box-Jenkins methodology. Other applications of artificial neural networks in hydrology are forecasting daily water hassle and flow forecasting. Sawaitul et al. [27] focused the information about weather and the recorded parameters were used to forecast weather. If there is a change in any one of the recorded parameters like wind speed, wind direction, temperature, rainfall and humidity, then the upcoming climatic conditions can be predicted using artificial neural networks and back propagation techniques. Farmers are being issued information from the state agricultural universities and government kissan portals through e-mails or SMS about the weather conditions, sowing of crops and prevalence/prevention of pathogens and pests in different geographical regions and agro-ecosystems.

CCS Haryana Agricultural University, Hisar (Haryana) has prepared the agro-climatic Atlas of Haryana. This university has developed the web portal www.emausamhau.gov.in for the farmers of Haryana with the collaboration of National Informatics Centre, Hisar. At present 1.50 Lac farmers have been registered for weather information on the web portal. This university also issues medium range forecasting twice in a week (Tuesday and Friday) with 91% accuracy in rainfall. Weather based agro-advisory bulletins are issued (on mobile phone) to farmers and other stake holders of the State throughout the year. Cotton and paddy crop advisory services are also issued during the respective crop season.

4.3. Classification of soils and prediction of soil fertility

The improved clustering algorithm is a good method for comprehensive evaluation of soil fertility. The k-means algorithm is used for soil classifications using GPS-based technologies [28], classification of plant, soil and residue regions of interest by color images [29]. A range of spectral reflectance patterns in the visible and infrared range were examined by deploying remote sensing for detection of plant stress, particularly nutrient deficiency [30]. This approach can potentially lower operating cost of fertilization and may minimize loss of crop productivity.

4.4. Application of remote sensing, GPS and GIS

Remote sensing and GIS is fast emerging technology that has witnessed phenomenal growth over the recent decades. These technological tools (i.e. remote sensing, GIS and GPS; together often termed as Geoinformatics) enhanced our capability for exploring, mapping and monitoring resources at local, regional and global scale. Worldwide researches on this technology and broad range of data available globally, have intensified the areas of its applications in all spatial sciences in general and agriculture in particular. RS-GIS have vast applications in the field of agricultural meteorology. Geographic information systems are extensively used in agriculture, especially in precision farming. Land is mapped digitally and pertinent geodetic data such as topography and contours are combined with other statistical data for easier analysis of the soil. Based on historical data and sampling. GIS is used in decision making such as what to plant and where to plant.

In agriculture, the use of the global positioning system provides benefits in geo-fencing, map-making and surveying. Collection and distribution of crop growth stage information and pest information could be monitored using GPS. The farmers can produce highly accurate digitized map without the help of a professional cartographer using the GPS vocational device and sensors in the field. With the advancement of satellite remote sensing technologies, the forest and agricultural land observations have become very convenient. In Kenya, for example, the solution to prevent an elephant bull from wandering into farms and destroying precious crops was to tag the elephant with a device that sends a text message when it crosses a geo-fence. Using the technology of SMS and GPS, the elephant can roam freely and the authorities are alerted whenever it is near the farm.

4.5. Control of weeds among the crop plants in the field

Weeds pose a serious constraint to agricultural production and usually result in 12-30% losses of the world's agricultural output. Therefore, weed control is indispensable in every crop production system [31]. They decrease quantity and quality of produce/food, fibre, oil, forage/fodder and animal products (meat and milk), and cause health hazards to humans and animals. Large amounts of human labour and technology is used to for removing the weeds from the field to prevent greater crop losses. Goel et al. [32] reported a strong correlation between the digital information, e.g., spectral data of the aerial image and soybean crop physiological parameters such as chlorophyll fluorescence, leaf greenness, leaf area index, photosynthesis rate and plant height. They used multi-spectral (24 wave band with a range of 475.12 nm to 910.01 nm) airborne optical remote sensing technique for detecting weed infestation in site-specific managed field crops. Tellaeche et al. [33] purposed an approach for the detection of weeds in agriculture and summarized an automatic computer vision system for the detection and differential spraying of Avena sterilis, a toxic weed found in cereal crops.

4.6. Optimization of pesticide use

The attack of plant pests and pathogens reduce crop yields by 20 - 40% annually. For the control of pests and pytopathogens in agriculture, farmers have mostly relied on the application of synthetic agrochemicals and pesticides [34]. However, indiscriminate use of pesticides has generated several problems including resistance to insecticides/fungicides, outbreak of secondary pests as well as safety risks for humans and domestic animals. Moreover, residual toxic chemicals may enter in the food chain. Hence, excessive use of pesticides is harming the farmers with adverse financial, environmental and social impacts. Recently, attempts of cotton crop yield maximization have led to a dangerously high pesticide use. Coarse estimates of the cotton pest scouting data recorded stands at around 1.5 million records and growing. Using the cotton pest scouting data along with the meteorological recordings, the reduction in pesticide use was shown by application of data mining. Clustering of data revealed interesting patterns of farmer practices along with pesticide use dynamics and hence help in identifying the reasons for this pesticide abuse [35]. Creating a novel Pilot Agriculture Extension Data Warehouse followed by analysis through querying and data mining, some interesting discoveries were made, such as pesticides sprayed at the wrong time, wrong pesticides used for the right reasons and temporal relationship between pesticide usage and day of the week [36].

4.7. Use of mobile technology in agriculture

Use of mobile technologies as a tool of intervention in agriculture is increasingly becoming popular. Smartphone penetration enhance the multi-dimensional positive impact on sustainable poverty reduction and identify accessibility as the main challenge in harnessing the full potential [37] in agricultural space. Reach of smart phone even in rural areas extended the ICT services beyond simple voice or text messages. Several smartphone apps are now available for agriculture, horticulture, animal husbandry and farm machinery. Smartphone mobile applications designed and developed by Jayalaxmi agrotech Pvt. Ltd. are the most commonly used agriculture apps in India. Their mobile apps are designed in regional language to break the literacy barrier and deliver the information in most simple manner. Several thousands of farmers across Asia are empowered with these apps.

TCS' mobile agro-advisory system i.e. mKrishi uses mobile phones and sensor technology to let farmers send queries, receive information on microclimate, local mandi prices, seek expert's advice and other information relevant to them in their local language, supports text, voice and pictures. Another mobile technology, mKisan, is used to strengthen farmer-extension-expert-linkages in India. Its objective is to use mobile-based agro-advisory for small land holders and livestock producers with actionable information. It provides the solutions through mobile channels like voice/text messages, on-demand videos and farmer helpline. It offers advice on relevant crop and livestock issues, and provide platform for exchange of knowledge. It also provide daily bulletins (meteorology forecasts, pest attacks and livestock disease outbreaks), strengthen market linkages by providing up to date information on prevailing market prices and improve access to advisory services by providing information on local service provision sources.

4.8. Computer controlled automatic milking systems

Automatic milking systems use computer controlled systems that milk the dairy cattle without human labour. The complete automation of the milking process is controlled by an agricultural robot, complex herd management software and specialized computers. Automatic milking eliminates the farmer from the actual milking process, allowing for more time for supervision of the farm and the herd. By analyzing the effect of various animal feeds on milk yield, farmers may adjust accordingly to obtain optimal milk yields. Since the data is available down to individual level, each cow may be tracked and examined, and the farmer may be alerted when there are unusual changes that could mean sickness or injuries.

4.9. Livestock-tracking program using RFID technology

Radio Frequency Identification (RFID) technology is being most popular in the field of communication, privacy and security for modern society. From the first patent covering radio-frequency identification (RFID) (#3,914,762 in 1975), the application of RFID for tracking animals has seen millions of tags applied on, or in, a variety of animals [38]. A number of countries have implemented mandatory tagging of domestic animals, such as New Zealand requiring all licensed dogs, with the exception of farm dogs, be tagged. Similarly, Northern Ireland and Israel have requirements for all dogs to be tagged. Australia and the United States have established national livestock or animal identification systems, with the emphasis on farm animal identification. The International Standards Organization (ISO) has developed two standards: ISO-11784 Radio Frequency Identification for Animals - Code Structure and ISO-11785 Radio Frequency Identification for Animals - Technical Concept, as standards for RFID use in animal tracking.

To provide fast, accurate, cost effective, easy to implement, stable and reliable system, RFID has shown its potential and it can overcome the limitation of existing system. As per the requirement it can integrate with key technologies and may be used for accurate real-time indoor positioning and tracking. Damade and Mishra [39] discussed the various existing algorithms and their applications in terms of applicability, measuring parameters, advantages and limitation and concluded RFID as the best algorithm for accurate real-time indoor positioning and tracking. The Veterinary department of Malaysia's Ministry of Agriculture introduced a livestock-tracking program in 2009 to track the estimated 80,000 cattle all across the country. Each cattle is tagged with the use of RFID technology for easier identification, providing access to relevant data such as bearer's location, name of breeder, origin of livestock, sex and dates of movement. This program is the first of its kind in Asia and is expected to increase the competitiveness of Malaysian livestock industry in international markets by satisfying the regulatory requirements of importing countries like United States, Europe and Middle East. Tracking by RFID will also help producers meet the dietary standards by halal market. The program will also provide improvements in controlling disease outbreaks in livestock.

4.10. Detection of diseases from sounds of animals

The early detection of the diseases can allow the farmer to cure the animal as soon as the disease appears and can impact positively the productivity of the farm. The sound provided by pigs due to coughing can be used to monitor possible health problems. An expert could analyze whether the cough of a pig signals the presence of a potential disease and eventually check the health of the pig. Systems for the automatic control of the pig houses are useful to avoid the infection of humans because of the presence of contagious diseases. Therefore, considerable efforts have been undertaken to develop and apply sensing techniques for diagnosis of diseases in pig farms. A neural network approach for cough recognition is described [40]. The training set is obtained by experimental observations, where the sounds produced by pigs are recorded and where each record is labeled by an expert in different ways. A metal construction has been built in order to perform the experiments, where pig sounds are recorded. The construction is covered with transparent plastic material for controlling the environment around the animal. The time signal of these sounds is analyzed mathematically. The variations are mainly due to the distance and direction between the pigs and the microphone. A neural network is trained using the training set obtained during the experiments. The network is firstly trained to discriminate between coughs and metal clanging, and it is able to reach percentages of correct recognition greater than 90%.

4.11. Capacity building

Trainings organized related to the prices of input and output, land claims, resource rights and infrastructure projects strengthens farmers' capacities. Capacity building trainings reduce social isolation, widen the perspective of local communities in terms of national or global developments, open up new business opportunities and allow easier contact with friends and relatives. Various conditions are needed to provide a conducive environment for improving the benefit to the stakeholders. These conditions include; need for relevant agricultural information, timely information in relevant formats such as language, print, softcopy etc., institution and human capacity to link rural communities, connectivity and access to ICT tools.

4.12. Marketing of agriculture products: Electronic commerce

Electronic commerce, commonly abbreviated as **E-commerce**, is the trading or facilitation of trading in products or services using computer networks, such as the internet. ICT intervention provides better markets resulting from informed decisions about future crops and commodities and best time and place to sell and buy goods [41]. It also provides up-to-date market information on prices for commodities, inputs and consumer trends. Systems could be developed for betterment of markets resulting from informed decisions about future crops and commodities as well as about best time and place to sell and buy the goods. Electronic commerce draws on technologies such as mobile commerce, electronic funds transfer, supply chain management, internet marketing, online transaction processing, electronic data interchange, inventory management systems and automated data collection systems. Modern electronic commerce typically uses the World Wide Web for at least one part of the transaction's life cycle, although it may also use other technologies such as e-mail. E-commerce businesses related to production and sale of farm produce in agriculture may employ some or all of the following:

1. Online shopping web sites for retail sales direct to consumers
2. Providing or participating in online marketplaces, which process third-party business-to-consumer or consumer-to-consumer sales
3. Business-to-business buying and selling
4. Gathering and using demographic data through web contacts and social media
5. Business-to-business electronic data interchange
6. Marketing to prospective and established customers by e-mail or fax
7. Engaging in pretail for launching new products and services

5. CONCLUSION

Recent information and communication technologies are able to provide a lot of information on agricultural-related activities, which can then be analyzed using database and data mining techniques in order to provide important information to the farmers. A lot of work has to be done on this emerging and interesting research field involving multidisciplinary approach consisting of mathematicians and computer scientists to help agronomists and farmers to find solutions to the complex problems for impoving agriculture productivity leading to sustainable agriculture. In this article, the framework for an ICT-based agricultural information dissemination system is proposed and it can be rightly stated that ICT will be one of the most important areas in the near future for agricultural development. More sophisticated and user friendly techniques can be developed to address complex problems in agriculture-related fields, which will enhance food production for ever-increasing world population.

References

[1] A. Wezel, M. Casagrande, F. Celette, J.F. Vian, A. Ferrer, J. Peigne, "Agroecological practices for sustainable agriculture. A review", Agronomy and Sustainable Development, 34, pp. 1-20, 2014.

[2] P. Nikos, "Plant disease diagnosis based on image processing; Appropriate for mobile phone implementation", In: Proceedings of 7th International Conference on Information and Technologies in Agriculture, Food and Environment, Kvala, Greece, pp. 238-246, 2015.

[3] N.R. Deore, C.A. Khade, P.R Kotwal, K.J. Patil, "Plant leaf disease identification and prevention by mobile vision system", Imperial Journal of interdisciplinary Research, 2(5): 1711-1715, 2016.

[4] X. Xie, B. He, D. Liang, D. Zhang, "Asystem for diagnosis of wheat leaf diseases based on android smartphone", In: Proceedings SPIE 10155, Optical Measurement Technology and Instrumentation, 1015526 9, 2016. doi: http://ds.doi.org.10.1117/12.2246919

[5] J. Hartigan, "Clustering algorithms", John Wiles & Sons, New York, 1975.

[6] S. Sindhu, S. Singh, "Clustering algorithms: Mean shift and K-means algorithm", International Journal of Technical Research, 3(2), pp. 1-6, 2014.

[7] S. Bashir, N. Sharma, "Remote area plant disease detection using image processing", IOSR Journal of Electronics and Communication Engineering, 2(6), pp. 31-32, 2012.

[8] Y. Yang, S. Huang, "Image segmentation of leaf spots in cucumber crop by Fuzzy C - Means clustering algorithm with a novel penalty term", Computing and Informatics, 26,17-37, 2007.

[9] S. Sindhu, S. Singh, "Image segmentation in various domains using two phase clustering approach", International Journal of Emerging Trends and Technology in Computer Science, 3(4), pp. 173-176, 2014.

[10] C.J.C. Burges, "A tutorial on support vector machines for pattern recognition", Data Mining and Knowledge Discovery, 2(2), pp. 955–974, 1998.

[11] S. Arivazhagan, S.R. Newlin, "Detection of unhealthy region of plant leaves and classification of plant leaf diseases using texture feature", Agriculture Engineering Institute: CIGR Journal, 15(1), pp. 211-217, 2013.

[12] J.R. Quinlan, "C4.5 programs for machine learning", Morgan Kaufmann, 1993.

[13] J. Gholap, "Performance tuning of j48 algorithm for prediction of soil fertility", Asian Journal of Computer Science and Information Technology, 2(8), pp. 251-252, 2012.

[14] C.A. Pollino, A.K. White, B.T. Hart, "Examination of conflicts and improved strategies for the management of an endangered Eucalypt species using Bayesian networks", Ecological Modelling, 201, pp. 37-59, 2007.

[15] P. Bhargavi, S. Jyothi, "Applying naive Bayes data mining technique for classification of agricultural land soils", International Journal of Computer Science and Network Security, 9(8), pp. 117-122, 2009.

[16] A. Nurnberger, W. Pedrycz, R. Kruse, "Neural network approaches", In: W. Klosgen, J.M. Zytkow, (eds), Handbook of data mining and knowledge discovery. Oxford University Press, 2002.

[17] D.A. Elizondo, R.W. McClendon, G. Hoogenboom, "Neural network models for predicting flowering and physiological maturity of soybean", Transactions of the ASAE (USA), 1994.

[18] H.R. Maier, G.C. Dandy, "Neural networks for the prediction and forecasting of water resources variables: a review of modelling issues and applications", Environmental Modelling and Software, 15(1), pp. 101-124, 2000.

[19] P.S. Landge, S.A. Patil, D.S. Khot, O.D. Otari, U.G. Malvkar, "Automatic detection and classification of plant disease through image processing", International Journal of Advanced Research in Computer Science and Software Engineering, 3(7), pp. 798-801, 2013.

[20] R. Agrawal, T. Imieliński, Swami, A., "Mining association rules between sets of items in large databases", ACM Sigmod Record, 22(2), pp. 207-216, 1993.

[21] M.J. Zaki, "Parallel and distributed association mining: A survey", IEEE Concurrency, 7(4), pp. 14-25, 1999.

[22] I. Jagielska, C. Mattehews, T. Whitfort, "An investigation into the application of neural networks, fuzzy logic, genetic algorithms, and rough sets to automated knowledge acquisition for classification problems", Neurocomputing, 24, pp. 37-54, 1999.

[23] S. Veenadhari, "Crop productivity mapping based on decision tree and Bayesian classification", M.Tech. Thesis, submitted to Makhanlal Chaturvedi National University of Journalism and Communication, Bhopal, 2007.

[24] B. Rajagopalan, U. Lall, "A k–nearest-neighbor simulator for daily precipitation and other weather variables", Water Resources Research, 35(10), pp. 3089-3101, 1999.

[25] S.S., Jagtap, U. Lall, J.W. Jones, A.J. Gijsman, J.T. Ritchie, "Dynamic nearest-neighbor method for estimating soil water parameters", Trans ASAE, 47(5), pp. 1437–1444, 2004.

[26] V.K. Somvanshi, O.P. Pandey, , P.K. Agrawal, N.V. Kalanker, M.R. Prakash, R. Chand, "Modeling and prediction of rainfall using artificial neural network and ARIMA Techniues", Journal of Indian Geophysics Union, 10(2), pp. 141-151, 2006.

[27] S.D. Sawaitul, K.P. Wagh, P.N. Chatur, "Classification and prediction of future weather by using back propagation algorithm- An approach", International Journal of Emerging Technology and Advanced Engineering, 2(1), pp. 110-113, 2012.

[28] K. Verheyen, D. Adriaens, M. Hermy, S. Deckers, "High-resolution continuous soil classification using morphological soil profile descriptions", Geoderma, 101(3), pp. 31-48, 2001.

[29] G.E. Meyer, J. Camargo, D.D. NetoJones, T.W. Hindman, "Intensified fuzzy clusters for classifying plant, soil, and residue regions of interest from color images", Computers and electronics in agriculture, 42(3), pp. 161-180, 2004.

[30] C.Y. Mee, S.K. Balasundram, A.H.M. Hanif, "Detecting and monitoring plant nutrient stress using remote sensing approaches", Asian Journal of Plant Sciences, 16, pp. 1-8, 2017.

[31] S.S. Sindhu, Sehrawat, A., "Rhizosphere microorganisms: application of plant beneficial microbes in biological control of weeds. In: Microorganisms for Green Revolution, Microorganisms for Sustainability 6, D.G. Panpatte, V.K. Jhala, R.V. Vyas, H.N. Shelat, eds. Springer Nature, Singapore Pte Ltd., pp. 391-430, 2017.

[32] P.K. Goel, S.O. Prasher, J.A. Landry, R.M. Patel, R.B. Bonnell, A.A. Viau, J.R. Miller, "Potential of airborne hyperspectral remote sensing to detect nitrogen deficiency and weed infestation in corn", Computur and Electronics in Agriculture, 38(2), pp. 99-124, 2003.

[33] A. Tellaeche, X.P. Burgos Artizzu, G. Pajares, A. Ribeiro, "A vision-based hybrid classifier for weeds detection in precision agriculture through the Bayesian and Fuzzy k-Means paradigms", In: Innovations in Hybrid Intelligent Systems, Springer, Berlin, Heidelberg, pp. 72-79, 2007.

[34] BCC Research, "Biopesticides: the global market", BCC Research Report, CHM029C, 2010.

[35] A. Abdullah, S. Brobst, I. Pervaiz, M. Umar, A. Nisar, "Learning dynamics of pesticide abuse through data mining", Australasian Workshop on Data Mining and Web Intelligence, Dunedin, New Zealand, 2004.
[36] A. Abdullah, A. Hussain, "Data mining a new pilot agriculture extension data warehouse", Journal of Research and Practice in Information Technology, 38(3), pp. 229-249, 2006.
[37] J. Donner, "Research approaches to mobile use in the developing world: A review of the literature. The Information Society, 24 (3), pp. 1-40, 2008.
[38] R.E. Floyd, "Application of RFID for tracking animals. IEEE Potentials, 34(5), pp. 32-33, 2015. doi:10.1109/MPOT2015.2410308.
[39] J. Damade, A. Mishra, "RFID based application algorithms for communication system: A literature review", International Journal on Computer Science and Engineering, 9(3), pp. 61-69, 2017.
[40] A. Chedad, D. Moshou, J.M. Aerts, A. Van Hirtum, H. Ramon, D. Berckmans, "Recognition system for pig cough based on probabilistic neural networks", Journal of Agricultural Engineering Research, 79(4), pp. 449-457, 2001.
[41] L. Dan, Z. Qihong, "Development model of agricultural E-commerce in the context of social commerce", Journal of Chemical and Pharmaceutical Research, 6(7), pp. 1341-1345, 2014.

AUTHOR

Saurabh Sindhu received the B.C.A. and M.C.A. degrees from Guru Jambeshwar University of Science and Technology, Hisar. His areas of interest include data mining, data security, DNA computers, bioinformatics and cloud computing. He is presently working at the post of Assistant Professor in CRM Jat College, Hisar.

Divya Sindhu received the B. Tech. and M. Tech. degrees in Computer Science and Engineering from Guru Jambeshwar University of Science and Technology, Hisar in 2012 and 2014, respectively. Her areas of interest include computer algorithms, data mining, data security, cloud computing and computer networks. She is presently working at the post of Assistant Professor in CRM Jat College, Hisar.