Challenges and Opportunities in Precision Agriculture:A Survey

Sandip Sonawane[1], Dr. Nitin N. Patil[2]
1Research Scholar, India, sandipsonawane2006@gmail.com
2Associate Professor, India, er.nitinpatil@gmail.com

ABSTRACT
Agriculture is the backbone of India and it playsamajor role inthe employment and economy around the world. In India, this sector supplies required foods for ever-growing population and offers around 52% of the total number of jobs existing in India and it contributes near about 18 percent to the Gross Domestic Product (GDP). It is the primary source of living for near about 58 percent of India's population. In India,approximately two-thirds of the working population live their life through agricultural tasks. While other recent studies claimed that, if India will focus on minimizing the food staple spoilage/ wastage,grows its food productivity and progress its infrastructure and then it will not only feeds its growing population but also exports the basic required foods like wheat, rice and sugarcane to the entire world. With the rapidly increase in the demand for food, precision farming is necessary to enhance thefarm productivity by adoptingadvancement in the agricultural technology.This paperprovides a survey of challenges and opportunities for maintaining the sustainability in agriculturefield.

Keywords: Agriculture, Sustainability, IOT based, Machine Learning,Decision Support System, Recommendation System, Organic manureetc.

1. INTRODUCTION

In India, majority of the population depends on agriculture. farm sector is the major source of live for society as well as human being to live as they require food grains and other raw materials [1]. It plays a major part in the overall growth of economy of developing countries. Unfortunately, farmers use traditional method of agriculture which reduces the farm productivity due to some environment relatedfactors such as changing weather, soil moisture, soil nutrient contentsandhumidity. Agricultural issues are biggest challenges to developing country. To solve these many agricultural issues, it is necessary to revolutionize the agriculture sector by adaptingadvanced technologies and techniqueswhich drastically increases thecrop productivity in farm [2].

To accomplish the food requirements of continuously increased population throughout the world, it is necessary to increasethe crop productivityin agriculture rapidly. Now a days, Precision agriculture is one of the modern farmingtechniques used by farmers in the field of agriculture.Precision agriculture combines several latest technologies, collectsdata from various sources, and efficiently examines it to progress production efficiency while reducing the costs[3].Precision agriculture involves recommendations of crop, management of fertilizers and pesticides, water management, weed detection and control etc.The primary objective of precision agriculture is to reduce waste, increase profits and maintain the quality of the environment.

The rest of the paper is organised as follows. First, the major challenges faced by farmers in the field of Indianagriculture arepresented in section 2. Section 3presents the opportunities to work in the different area of agriculture. Summary of the work done by researchers in the major area of precision agriculture is also given in this section.Section 4 presents future scope in the field of agriculture.Finally, we concluded in the section 5.

2. CHALLENGES IN AGRICULTURE SECTOR

2.1 Fragmented and SmallLand Holdings

Typically, the conventional inheritance lawsin our country are completelyaccountablefor division of farming area into small fragment. Our farm yield mainly decreases because of division of land holdings and thus causes problem of irrigation.Then it is very difficult to provide irrigation to the breaked land holding is quite complicated task.Enacting the consolidation of land holdings is one of the solutions over problem of fragmented land holdings, Consolidation of land holdings is nothing but relocation of the fragmented land area and formation of the farmsbut unfortunately, this didn't get completely success [4].Cooperative farming is one of the other solutions of this problem in which farmers can share their profit and pools the resources in certain areas of activity.

2.2 Lack of good quality seeds for poor and needyfarmers

Seed is amajor components and basic input in agriculture for achieving higher productivity and responsible for sustained growth in agricultural production. It is expected that good quality seed should be distributed among the poor farmers with affordable prices.

For this purpose, National Seeds Corporation (NSC) and State Government Company - State Farmers Corporation of India (SFCI) was established in March1963and May 1969 respectively.In order to minimize workload of NSC and toprovidebetter quality seeds to farmers, State Seed Corporation (SSC) was established.

2.3 Manures, Biocides and Fertilizers

Without taking any care, Indian farmer is using soil for growth of crops for many years. This will cause depletion and exhaustion of soil and results in the poor farm production. This problem leads need of manures, biocides and fertilizers for the land.For the security of food, Pesticides and Fertilizers are considered as important tools in farming area [5].

Soil and fertilizers are important for the growth of foods. However, many farmers are facing real-world problems related to chemical fertilizers like they are expensive and therefore poor farmers do not have enough money to buy them.

The manure made from cow dung is very good forsoil but use of such soil is very limited in our country and because of shortage of fuel, most of the cow dung is used in kitchenas domestic fuel.To keep good health of soil,Organic manures are essential in farming. Hence the fertilizer problem is very critical in Indian agriculture.

Presently, India produces enough compost for both rural and urban area but to utilize this compost, suitable Waste Management System is be required.Administration is releasing subsidies on the use of chemical based fertilizers and it is very supportive for poor and needy farmers.

2.4 Lack of Mechanization

Despite of the available recent technologies in farming, still many farmers are using the traditional instruments for agricultural tasks like sowing,ploughing, irrigating,harvesting and thinning. Small farmers are using much of the manpower, which consequences lower yields and wastages the human labour. To solve this problem, farmers are encouraged continuously by the administration to use the technically innovativeinstruments in farming [6].

2.5 Problem of Irrigation

As we all know that in our country farming is completely relies on rainfall, which is unreliable, erratic and uncertain. Our country is second largest irrigated country in the world but still only one-third of the cropped field of our agriculture is under irrigation. This will lead the need for suitable irrigation system [6].

Currently, about 51% of the agricultural area cultivating food grains is covered by irrigation. Sources of irrigation includes surface water (canals, tanks) and ground water (wells, tube-wells). Table 1 given below shows the various sources of irrigation used in agriculture [7].

Table 1: Sources of irrigation

Source of Irrigation	Number of holdings	% share of holdings
Tube wells	31,722	44.20%
Canals	18,414	25.70%

Wells	14,101	19.70%
Tanks	4,180	5.80%
Other sources	6,046	8.40%

2.6 Soil Erosion

Soil is the most precious element in agriculture and its productivity ensure good crop productivity. Soil erosion is a naturally occurring process that affects all landforms and is responsible for loss of soil productivity.

Elements like water, wind, animals, etc. are responsible for soil erosion Water and wind are the most influencing and significant agent in the soil erosion process. Water wash away the top layer of the soil and if the soil has eroded, the crops will not grow very well [6].

2.7 Agricultural Marketing

Agriculture marketing is another major threat in the rural areas where the farmers are dependent on local traders and middlemen for the transfer of their agriculture produce which is sold at low cost.In rural areas under socio-economic conditions farmers sell their agriculture products to the middlemen, money lender, local traders etc. [8].

2.8 Inadequate Transport

Lack of cheap and effective means of transportation is one of the major challenges faced by agriculture sector of our country. Even today most of the rural areas are not well connected by good quality roads. Most roads become unusable during the rainy season. Market availability is the most significant for the economy of country. Farmers will not reach on right time up to the market because to the absence of roads. Connecting all villages by metaled road is the challenging task as it requires lots of fund [8].

2.9 Scarcity of Capital

Like all other industries agriculture also requires capital. The role of capital is becoming more and more important with the advancement in the agricultural technology.Traders, commission agents and money lendersare the main providers of money to farmers and they charge high rate of interest and buy the foods from the farmers at very nominal prices [8].

Table given below shows distribution ofGDP and workforce across economic sectors in last five years.

2.10 Inadequate Storage Facilities

Storage facilities available in our rural areas are either inadequate or totally absent. Under such conditions the farmers are forced to sell their produce immediately after the harvest at the prevailing market prices which are sure to be low. To resolve this problem, we need to develop the system which maintains storage in proper manner [8].

Below given table 2 shows share of GDP as well as workforce in three different economic sectors [9,10].

Table 2: Share of GDP and Workforce in economic sectors

Year	Agriculture		Services		Industry	
	Share of GDP (%)	Share of Work force (%)	Share of GDP (%)	Share of Work force (%)	Share of GDP (%)	Share of Workforce(%)
2019	15.96	42.39	49.88	32.04	24.88	25.58
2018	15.41	43.33	48.81	31.72	26.13	24.95
2017	16.36	44.05	47.89	31.25	26.48	24.7
2016	16.36	45.14	47.75	30.87	26.62	23.98
2015	16.17	45.67	47.78	30.27	27.35	24.06

3. OPPORTUNITIES TO WORK IN AREA OF INDIAN AGRICULTURE

3.1 Crop Recommendations

The common problem with the Indian farmers is that they do not selects the appropriate crop for cultivation depending upon the requirements of their soil. Due to this farmer suffers a major and serious setback in the productivity of crop. By using Precision Agriculture,it is possible to resolve this issue related to the farmers. Precision agriculture is a state of art farming technique that facilitates crop recommendation systems which suggests the farmers to select the appropriate crop for cultivation based ondifferent site-specific parameters such as specific soil types, soil characteristics etc. to solve problems regarding the crop selection and thereby increases thefarm productivity.

A.M. Rajeswari et. al demonstrated a Fuzzy Decision Support System which recommendsthe crop for cultivation based on the soil characteristics and soil types [11]. In this work, fuzzy-based rough set approach is implemented and the outcomes are generatedbystandard algorithms like CN2,

LEM2, AQ and Indiscernibility. These algorithms are used to generate the fuzzy rules. For experimental purposes the fuzzified and discretized datasets are considered. The performance of algorithm is estimated depending on the evaluation of parameters such as accuracy,accuracy,recall andf1 score.

Suchithra M S and Maya L Pai developed a crop recommendation system for the particular crops which gatheredthe specimen data from 6different talukas of Thrissurdistrict in Kerala state[12].To identify the most appropriate crops for a location, this system proposed a rank-based recommendation system. To mine a hugenumber of cropsand geospatial data and soil,clustering method called Density-Based Spatial Clustering of Applications with Noise (DBSCAN) were used in this system with the ball-tree algorithm.

Meeradevi and Hrishikesh Salpekarhave developed android mobile application that allows the farmers to forecast the productivity of specific crops in regiondepending upon the physical characteristics suchtemperature,location and rainwater. The objective of this paper was to develop a tool which will predicts based on the individual crop.The proposed system offersfarmers with the full recommendation for crop selection based on individual parameters such as temperature, farm size,location, rainwater etc. All data used in this approach are publicly available [13].

Nidhi H Kulkarni et. al. proposed crop recommendation system with soil dataset consisting of four different crops Wheat, Sugarcane, Rice, Cotton. This system presents ensembling technique of machine learning to create a model that merges the predictions obtained from several machine learning models and recommends the appropriate crop based on the site-specific parameters such as soil characteristicsand soil type with high accuracy [14]. This system is specifically developed for predicting the productivity of crop.This system uses three different autonomous base learners such asNaive Bayes,Linear SVM andRandom Forestto create theensemble model.

A fuzzy based crop recommendation system developed by Gouravmoy Banerjee et. al. considers theparameters like soil characteristics, rainfall and fuzzy based terrain pattern.The system performanceis tested for eight different major crops cultivated in West Bengal state. To achieve faster parallel processing, fuzzy rule sets were designed for each crop. The model performance has been checked by a varied dataset and achievedaround 92 percent of accuracy [15].

3.2 Pesticides and Fertilizer Management

Now a days, agriculture is totally dependent on the chemicals-basedfertilizers andpesticides. These chemical-based pesticides and fertilizers are requiredfor industrial agriculture. Even though they are important for global food safety, their adverse effects cannot be ignored particularly when precision agriculture is the universal focus.The intensive use of these chemical fertilizers and pesticides has resulted in the deterioration of environmental quality and soil systems andcreates along-term dangerous effect on health of human and animals [16].

Avinash Kumar et. al. proposed a Recommendation System which predicts the most appropriate crop to the farmersfor cultivation and detects the pest that effects on crops andsuggest techniques to control the pest [17]. They applied algorithms like Decision Tree, Logistic Regression and SVM classification and observed that SVM based classification model gives the improved performance as compared to other existing algorithms. Proposed work addresses problem of farmer related to selection of the appropriate pest and diseases that can affects the crops.

Archana Chougule et. al. experimented with a system for suitability of crop and fertilizers recommendation using concept of Ontology [18]. The system suggestsappropriate crop for the farmerbased on the type and characteristics of soil in Maharashtra state. It suggestssuitable recommendation of fertilizer based on Nitrogen, Phosphorus and Potassium (NPK) contents in soil and usedpreviouslygathered data that is kept in Ontology. The performance of data mining algorithms like random forest and K-means clustering is measured in terms of parameters like precision and accuracy.

Venkata Subba Rao P and Srinivasa Rao Gorantla proposedlow cost Unmanned Ariel Vehicles (UAV) based

Pesticide Sprayer inagricultureapplications. This spraying of pesticides can be done by hand or semi autonomouslyusing Mission planner software. UAV is designed with the intension to minimize the effect of the pesticides on human beings, animals etc.and to spray it in a minimumduration for huge area [19].

An IOT(Internet of Things) based approach was investigated by D. Devi et. al for prediction of pesticides and diseases in the fruit. To find an accurate and a real time output, the approach uses simulation of hardware and software using Deep Learning and IoT. IoT system were used to obtain the data about the presence of pesticides and the contents of pesticides and the values generated from IoT enables sensors are kept in theThikSpeakIoT analytics platform. DeepLearning algorithms like CNN and SVM are used for disease identification in the fruits [20].

Spoorthi. S et. al. implemented a FREYR Drone- pesticide spraying quad-copter which sprays the pesticides all over the land and helps the farmer to reduce their work. An android app is developed for the farmer to control the drone and farmer can connect to this android app using Wi-Fi module (ESP 8266) which is interfaced in thedrone. Here the Arduino board is interfaced with the GPS and Wi-Fi module to locate the crop field [21].

3.3 Water Management

Water is considered as the most important source in the development of sustainable agricultural worldwide.In addition to the industry and agriculture,it is also the most essential for the atmosphere as it will create the effect on health and nature conservation.In the arid areas of agriculture highest priority is given on the use of irrigation water [22].

Kanchan Rufus Dabre et. al. used a Decision Support System which integrates various ecological factors such as temperature, moisture, pest sound frequency, soil nutrients such as NPK level, and soil PH to evaluate watering requirement of individual crop [23]. System provides alert and recommendation on individual cropwatering, pesticide and fertilizer requirement. By considering human expert opinion learning through feedback provided system starts and stops irrigation automatically.

V. Basil Hans discussed water irrigation related issue and the approaches and provisions to mark the water scarcity for irrigation [24]. This paper presented the challenges and problems faced by farmers related to water management andfocuses on the areas for proper water management.

Jisha RC et. al. providedanessentially efficient water management solution for domestic sectors and large agricultural fields. This proposed model provides an IoT based applicationfor water monitoring for the purpose of both domestic and agriculture and build a warning system to avoid wastage of water [25]. The objective of this work is to minimize the burden of the user in monitoring the water level and makes it a user-friendly system.

Haikal Hafiz Kadar et. al. proposedsmart water management prototype system calledAGRI2L[26]. The key objective of proposed prototype is to design a smart water level and leakage monitoring system. Here the system uses two types of IoT enabled sensors to sense the water leakage. First sensor called flow rate sensor is used to compute anomaly rate in the physical water movement.The second sensor is the water sensor that can detect a small leakage and triggers areal- time alertto system and the users.

Abdelhadi Saad et. al. conducted a survey on current challenges and technological solutions related to water management and monitoring in agriculture sector. Paper discusses some open challenges for future research direction and presents recent innovative technologies for water monitoring and management in the Indian farming. It covers four major and current challenges regardinguse and distribution of water - water irrigation, water pipeline monitoring, water reuse and water pollution monitoring, drinking water for livestock [27].

3.4Weed Control

A weed is considered as unwanted plant in the wrong field. Weeds are competitive, fighting with the main the plant for sunlight, water,essential nutrients and resources from the soil.

If weed can be controlled and removed effectively then it willincrease the overall productivity of the farm but detection and removal of weeds in the farming area is quite a challenging task [28].

Gurpreet Khurana et. al. presented an image processing-based approach for detection and controlling of the weed relatedissues in the filed area [29]. In their approach, the authors used a technique of morphological scanning, segmentation and textural feature analysis to apply it to sugar beet plant. To classify crop and weed, K-nearest neighbor (KNN) classifier were used. The performance evaluation of this approach was estimated in terms of execution time and accuracy and it was found that accuracy in the proposed approachwas increased up to eight percent.

Alessandro dos Santos Ferreira et. al. experimented the Deep Learning architecture - Convolutional Neural Networks (ConvNets or CNNs) to perform weed detection in soybean crop images and classify these weeds among broadleaf and grass [30].Professional drone camera were used to capture the images and imagedatabase was created which containsnear about15000 images of the soil, soybean crop, grass weeds and broadleaf. For training of Neural Network, the CaffeNet architecture was used. Image dataset was built by using Superpixel Segmentation Algorithm SLIC and images were classified using the model which was trained by Caffe software. Proposed approach achieved accuracy more than 98% usingConvNets.

Jialin Yu et. al. constructed Convolutional Neural networks (DCNN) for detection of weed species such as Glechoma hederacea, Taraxacumofficinale and Euphorbia maculatein perennial ryegrass.Dataset contains 17000 positive images and 15486 negative images. Two types of DeepConvolutional Neural Network (DCNN) Architectures i.e. DetectNet and VGGNet were used for object detection and image classification respectively. Performance is evaluated in terms of parameters like Precision, F1 Score, Recall and Matthews Correlation Coefficient (MCC) [31].

Sarvini T, Sneha et. al. detected weed from crop using machine learning algorithms. The dataset is collected for two types of weeds such as Para grass and Nutsedge and four different commercial crops. For masking the soil and extracting the region of interest the Excess green method and Otsu's thresholding is used. For classification purpose three different classifiers were used i.e. Artificial Neural Network (ANN), Convolutional Neural Network (CNN) and Support Vector Machine (SVM). CNN gives better performance compared to SVM and ANN.Open CV and Keras platform were used for the performance analysis of weed detection algorithms [32].

Umamaheswari S et. al have used a real time weed detection system that detect and locate the weed plants among the cultivated farm crops and captures real time image of farm as input for classification and detects the type and the location of weed in the image. The Parallelized Weed Detection System (PWDS) is developed using Convolutional Neural Networks and TensorFlow framework. For system evaluation, publicly available benchmark dataset Crop /Weed Field Image Dataset (CWFID) were used, and it comprised 60 images with annotations. The performance is evaluated in terms of metrics such as precision, accuracy etc. The proposed system achieves a precision of 91.1percent [33].

Summary of the work done by researchers in the major areas of precision agriculture is given in below table 3.

4. CONCLUSION

Agriculture is a significant area in the overall growth of society and economy of nation and that allows to sustain the food demand of rapidly growing global population.However, agriculture is facing tremendous challenges like the climate change, extreme weather conditions, uncertain rainfall, severe shortcoming of cultivable land and water resources, as well as threat from plant diseases, weeds and insect pests. Thus, much efforts will be required by researchers and farmers to overcome over these challenges and to increase the farm productivity.

This paper presents a survey on several open challenges faced by farmers in Indian agriculture. In this context, precision agriculture plays a major role in the field of agriculture. Precision Agriculture provides an opportunity to work in the

area of agricultural domain like Crop Recommendations, Pesticides and Fertilizer Management, Water Management, Weed Detection and Control etc. This paper also presents a summary of the work done by researchers in the major areas of precision agriculture.

5. FUTURE SCOPE

With global demand for agriculture and food grains increasing in the future, farmers are hopeful of increase in production as well as quality of their crops. It is possible to fulfill the dream of the Indian economy of five thousand billion dollars by growing the GDP of country by using the state-of-the-art technology. In future, we will try to provide innovative method(s), tool(s)to farmers for improving crop quality and productivity by using emerging technologies like IOT and Machine Learning.

Table 3: Summary of work done by researcher in the major areas of precision agriculture.

Major Area	Reference Number	Contribution of Author
Crop Recommendations	11	Design a system which recommends crop for cultivation based on specific soil type and characteristics.
	12	Generates a rank-based recommendation system which identifies the most appropriate crops for selected location using clustering method Density-Based Spatial Clustering of Applications with Noise (DBSCAN).
	13	Developed an android application which predicts crop yields based on the individual crop provides recommendation farmers to optimize their crop selection.
	14	Developed crop recommendation system that uses ensembling technique and suggests the appropriate crop depending on the specific soil type and other relevant parameters.
	15	Proposed fuzzy logic-based crop recommendation system to assist rural farmers of the state West Bengal.
Pesticides and Fertilizer Management	17	Developed a recommendation system and suggests the best appropriate crop and detects the pest that affects pest control technique in agriculture.
	18	Developed an ontology-based system for fertilizersrecommendation and suggests crop suitability.
	19	Proposed low cost Unmanned Ariel Vehicles (UAV) based Pesticide Sprayer in agriculture applications.
	20	Presented an IOT based approach for prediction of pesticide contents and disease in the fruit.
	21	Implemented a FREYR Drone - pesticide spraying quadcopter which sprays the pesticides all over the land and helps the farmer to reduce their work.
Water Management	23	Developed a Decision Support System which integrates various ecological factors to evaluate watering requirement of individual crop.
	24	Presented the water management related issues and challenges faced by farmers in the agriculture of India.
	25	Implemented IoT based application for water monitoring and thereby minimize the burden of the user.
	26	Proposed IOT based AGRI2L smart water management system prototype for water level and leakage monitoring system.
	27	Presented a review on recent challenges and technical solutions regarding water managementand monitoring in agriculture sector.
Weed Control	29	Presented an image processing-based approach for detecting and controlling the weed related issues in the filed crop.
	30	Proposed Deep Learning architecture - Convolutional Neural Networks (CNNs or ConvNets) for detection of weeds in soybean crop images and classify these weeds among broadleaf and grass.

	31	Constructed Convolutional Neural Networks (DCNN) for detection of three types of weed species in perennial ryegrass.
	32	Developed a mechanism to detect weed from crop using three different types of classifiers ANN, CNN and SVM.
	33	Proposed a weed detection system that recognizes and locates the weed in real time cultivated farm crops and captures livepictures of farm as an input for the purpose of classification and identifies the type of weeds in the field image.

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