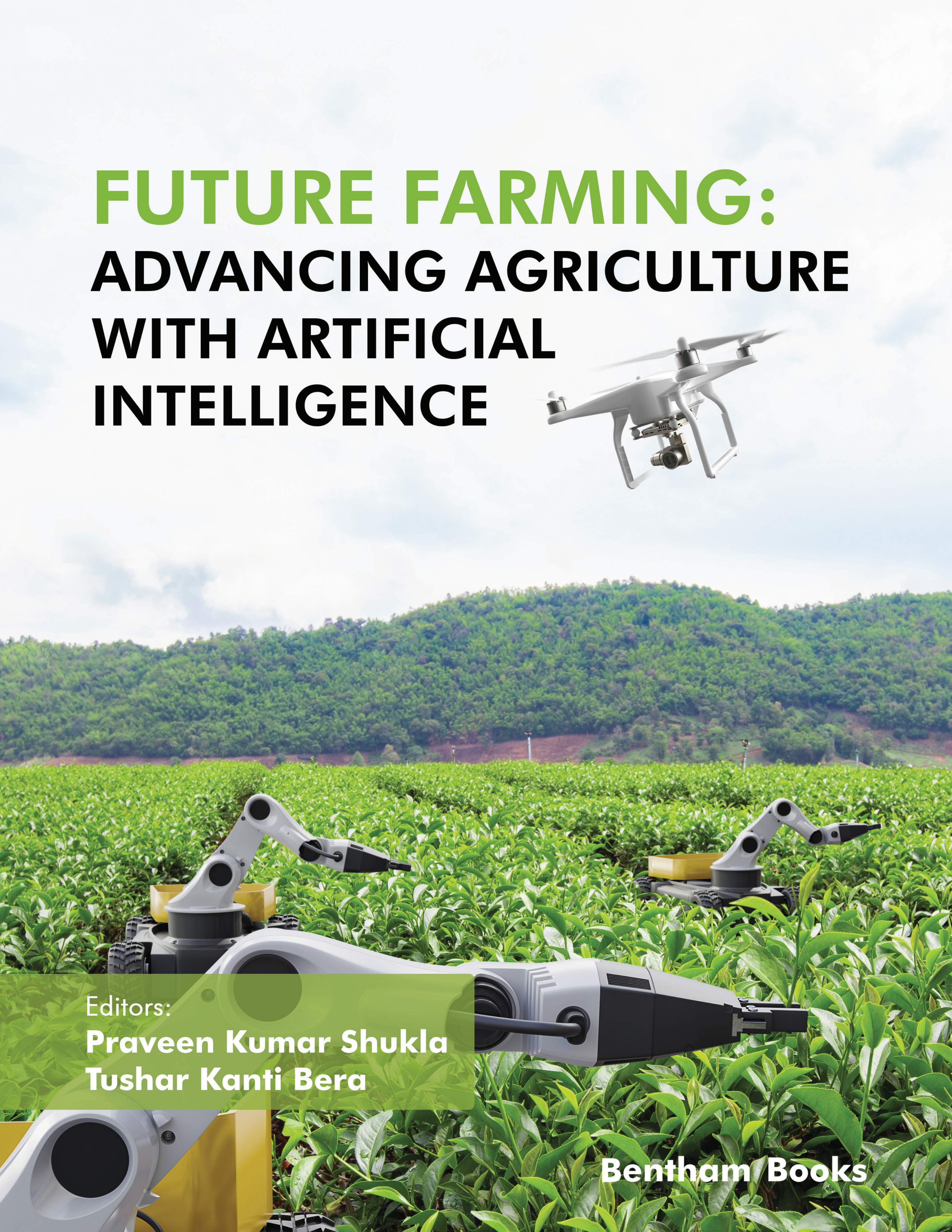
# FUTURE FARMING:
# ADVANCING AGRICULTURE WITH ARTIFICIAL INTELLIGENCE



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# Future Farming: Advancing Agriculture with Artificial Intelligence

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**Future Farming: Advancing Agriculture with Artificial Intelligence**

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ISBN (Online): 978-981-5124-72-9

ISBN (Print): 978-981-5124-73-6

ISBN (Paperback): 978-981-5124-74-3



First published in 2023.

**Bentham Science Publishers Pte. Ltd.**
80 Robinson Road #02-00
Singapore 068898
Singapore
Email: subscriptions@benthamscience.net

BENTHAM SCIENCE

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# FOREWORD

It gives me immense pleasure to introduce the book "***Future Farming: Advancing Agriculture with Artificial Intelligence***" edited by Dr. Praveen Kumar Shukla, Department of Computer Science & Engineering, School of Engineering, Babu Banarasi Das University, Lucknow, India and Dr. Tushar Kanti Bera, Department of Electrical Engineering, National Institute of Technology, Durgapur, India. I appreciate the sincere efforts of the editors and authors of the book in framing the content on the most recent and promising area of smart agriculture.

The application of technology-driven solutions in the implementation of agricultural activities is a key concern in the agriculture sector nowadays. Basically, it is one of the most effective ways of raising agricultural production and subsequently fulfilling the food requirements in society. *Artificial Intelligence, the Internet of Things (IoT), Robotics, Drones, Sensors, Telecommunications, Data Analytics, Satellite, Geo-positioning Systems, Unmanned Aerial Vehicles, etc*. are the most promising technologies being utilized in smart agriculture. The implementation of smart agriculture is helping farmers by automating agricultural activities, *i.e.* monitoring of crop health, prediction of crop yield, variable rate irrigation, precise use of fertilizers, diagnosis and curing the crop diseases.

Although there are many advantages of applying technology in the agricultural activities, but its adoption in society is still facing problems. The reasons may be of social acceptance and lack of awareness, lack of light weight intelligent algorithms for precise decision making, data and quality of data for real time decision making, financial issues, security concerns for the deployed systems, *etc*.

I feel that this book will be an outstanding contribution to the researchers working in the area of smart and precision agriculture.

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# PREFACE

Agriculture is one of the oldest professions in the world for feeding the global population. Due to the growth of population and reduction in agricultural land, it is to be planned to move towards smart farming with the help of technology. Artificial Intelligence is playing a vital role in implementing smart methods for agriculture and it will change the aspects of performing agricultural activities. The objective of this book is to explore the applications of artificial intelligence in improving agricultural activities.

The book addresses several aspects of artificial intelligence applications in smart agriculture including, pest control, leaf disease identification, identification of weeds, field security, and applications of drones in smart farming.

A pest control and leaf disease identification system using machine learning technique is implemented where a novel algorithm is proposed, titled Black Window Optimization Algorithm with MayFly Optimization Algorithm (BWO-MA). Also, intelligent recognition and classification of Tomato Leaf Diseases using the Transfer Learning Model are discussed. A pre-trained Squeeze Net Model is used to implement the Transfer Learning Model. Another leaf disease detection system for Millet Leaves is elaborated on in the book. The proposed approach is implemented using Convolutional Neural Network.

Robots are important components in the implementation of smart farming and are playing a big role. A solar-powered robot for the identification of weeds and damage in vegetables is developed and is one of the prime works published in the book. The proposed approach provides the capability for effective control of weeds and damage to crops and also assists in harvesting.

Apart from machine learning and robotics systems, the Internet of Things (IoT) systems are also playing a vital role in the implementation of smart farming and precision agriculture. An IoT-based system powered with AI classification technique is developed for the security of the field and it is mentioned and explained in the book.

Weather conditions are very important for the agricultural system. The prediction of weather conditions will play a big role in planning agricultural activities and dealing with adverse weather conditions. A weather forecasting system for smart farming is also developed using machine learning techniques.

The book also addresses the role of artificial intelligence and drones in smart farming along with the introduction of precision farming, intelligent crop planning and climate smart agriculture.

We hope that the book will surely help the people working in the area of smart agriculture and precision agriculture as it addresses many real-world problems of the agriculture sector through machine learning, IoT, deep learning, *etc*.

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CHAPTER 1

# Enhanced Machine Learning Techniques for Pest Control and Leaf Disease Identification

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**Abstract:** The agricultural sector has become an important income source for our country. In terms of nutrient absorption, plant diseases affecting the agricultural yield are creating a great hazard. In agriculture, recognizing infectious plants seems challenging due to the premise of the needed infrastructure. To prevent the spread of diseases, the identification of infectious leaves in the plant is observed to be a necessary step. This work aims to propose a machine learning technique on the ANN method for plant diseases identification and classification. This paper proposes a novel hybrid algorithm, called Black Widow Optimization Algorithm with Mayfly Optimization Algorithm (BWO-MA), for solving global optimization problems.

In this paper, a BWO-MA with Artificial Neural Networks (ANN) based diagnostic model for earlier diagnosis of plant diseases is developed. Comparison has been done with existing machine learning methods with the proposed BWO-MA-based ANN architecture to accommodate greater performance. The comprehensive analysis showed that our proposal achieved splendid state-of-the-art performance.

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**Keywords:** Artificial Neural Networks (ANN), Hybrid black widow optimization algorithm with mayfly optimization algorithm (BWO-MA), Improved canny algorithm, Median filtering, Plant disease.

## INTRODUCTION

The agricultural industry has a vital contribution to global food security and provides a significant amount of nutrients to the population. Besides its ecological significance, the value of farming has expanded across the world, for both human foods and as a tourist attraction. For instance, consumption per capita increased from 9.0 kg in 1961 to 20.2 kg in 2015 [1 - 4]. Agricultural products are one of the most important nutritious foods for humans, as they are high in proteins, vitamins, and minerals, and low in fat. Vitamins A, C, D, K, and Vitamin B2, omega-3 fatty acids, calcium, phosphorus, and minerals such as zinc, iodine, iron, *etc*. are all abundant in them. As a result, they can be considered as a potential remedy to various human health issues. In recent times, agricultural demand is continuing to increase as the world's population grows and the advantages of agricultural products as a source have become more widely acknowledged. The global agricultural production in 2018 was 179.2 million tonnes. Human consumption accounts for around 156 million tonnes of the world's total, which equates to an average of 19.5 kilograms per person. Furthermore, agriculture accounted for 51.5% of the total amount consumed by humans, or 80.3 million tonnes, retaining the remaining for the agricultural industry. Consumption has demonstrated a strong trend of demand in both developed and developing countries in recent years [5 - 11]. The plant species are identified based on their specimens and these specimens identified are based on visual features such as texture, shape, head shape, and color.

Meanwhile, the accurate identification of various species supports scientific research such as ecology, evolutionary studies, plant medicine, and taxonomy [7, 8]. As the agriculture business expands, several concerns develop from current techniques, including the constant occurrence of infectious illnesses in farms, as well as environmental issues that limit agricultural output [1]. Plant illness is one of the most serious risks to many farms; therefore, the use of quick techniques for effective diagnosis is required in addition to experience and knowledge of plant health. Some of the common sources of infection are bacterial, parasitic, fungal infections, and viral infections. Furthermore, the frequency and severity of infections were enhanced by a combination of stressful farm conditions caused by high stocking rates and worsening environmental variables [9 - 13]. Many incurable diseases need the use of professional diagnosis specialists to properly diagnose and treat them. Some plant infections are particularly contagious and spread fast. If the diagnosis is delayed and proper treatment is not administered promptly, the agricultural products will become contaminated and become unusable in a short amount of time. A real-time and remote diagnostic expert system for plant illness is built based on contemporary internet communication technology to accomplish plant disease diagnosis and treatment on time, therefore reducing the risk of damage created to plants [3]. As observation and information technology become advanced, more and more photographs were taken [2]. There are various techniques to detect various plant diseases based on parameters such as visible external signs, atmospheric conditions, and symptoms, behavior signs, water conditions, a captured image of the infected plant, microscopic images, and others. Changes in viewpoint, lighting conditions, and occlusion, among other things, are all issues related to the plant's illness detection. However, image-based tracking and detection are more important for the early illness and recognition of a complex pattern in decision-making of a plant's illness [10]. Pattern matching, physical and statistical behavior, and feature extraction are the essential components of automated plant disease recognition. Plant disease identification is also crucial for plant species counts, population assessments, plant counting, plant association studies, and ecosystem monitoring [7]. Usually, monitoring is done visually in the field or by analyzing photos recorded at crucial points, which necessitates specialized training in addition to being a laborious, time-consuming, and expensive operation. Automatic solutions based on computer vision have been developed to help in the identification of plant species to address these challenges [5, 6].

## RELATED WORK

Jing Hu *et al*. [14] have presented the multi-class support vector machine (MSVM) approach for categorizing plant species through texture features and color. Here, for the classification process, MSVM based one-against-one algorithm was employed. Likewise, Md. Shoaib Ahmed *et al*. [14, 15] have developed the Support Vector Machine (SVM) approach to recognize disease-affected plants. The working process was divided into two phases. The initial phase includes the denoising progression. In the second phase, the classification process was conducted through the SVM with a kernel function. On the other hand, Meng-Che Chuang *et al*. [16, 17] have presented the error-resilient classifier and unsupervised feature learning approaches to recognize plant diseases. Furthermore, an unsupervised clustering approach was utilized for the presented classifier. Likewise, Anderson Aparecido dos Santos, *et al*. [17] have presented the Convolutional Neural Network (CNN) to identify the Pantanal plant species. Similarly, Sourav Kumar Bhoi *et al*. [18, 19] have presented the fuzzy logic-based method and Triangular Membership Function (TMFN) to recognize them as Leaf spots, Leaf Blights, Rusts, Powdery Mildew, Downy Mildew, and Black spot disease in plants. Further, a canny edge detector was utilized to process

**CHAPTER 2**

# Automatic Recognition and Classification of Tomato Leaf Diseases Using Transfer Learning Model

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**Abstract:** Timely diagnosis of plant disease is important to get better crop yields. Infected plants can cause significant financial losses to farmers by lowering crop yields. It is extremely desirable to detect early signs and symptoms of plant diseases in a nation like India, where agriculture supports the majority of the population. More accurate and faster plant disease detection might assist in lowering the damage. With tremendous improvements and advancements in deep learning, the effectiveness and precision of plant disease detection and identification systems may be improved. The goal of this study is to discover leaf illnesses found in tomato crops and reduce the financial losses caused by the diseases. We have implemented transfer learning using a pre-trained Squeeze Net Model to detect and classify tomato leaf diseases. Our model can automatically detect 9 types of deadly diseases that are very common in tomato crops. We have acquired 10 classes (one healthy leaf class and 9 diseased leaf classes) consisting of 16,012 tomato leaf samples from a benchmarked Plant Village dataset to train and validate the suggested method. On the public dataset, the class-wise classification precision rate varies from 77.9% to 99.6%, and the overall classification accuracy of the suggested model is observed as 93.1% which is a significant enhancement in performance over previous tomato disease detection techniques.

**Keywords:** CNN, Deep learning, Plant disease, Tomato, Transfer learning, SqueezeNet.

## INTRODUCTION

Tomato is the globe's most common vegetable, and it may be seen in every kitchen, regardless of region and culture. Most people across the globe like tomatoes and their product very much. It is consumed in many different ways.

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Tomato is the 3rd most often planted crop after potato and sweet potato. India comes at the second position in the world for producing tomatoes. However, due to numerous infections, the quantity and quality of the tomato crop suffer. These losses can be reduced by providing an efficient disease diagnosis system in farming [1]. Plant illnesses are now very difficult to identify using the traditional approach of visual observation by humans. Conventional methods concentrate mostly on professionals' expertise, and manuals [2], but the bulk of them are costly, time-taking, and labour-intensive, and these methods face difficulty to identify exactly [3]. As a result, a speedy and precise method for identifying plant diseases plays a vital role in the welfare of agriculture's business and environment.

Computer vision systems have been advanced to the point where they can provide quick, normalised, and correct solutions to these issues. The adoption of an automated disease diagnosis approach is advantageous in detecting a plant disease in its early stages. Deep learning has recently achieved outstanding results in disciplines such as object detection [4], voice recognition [5], biomedical image classification [6, 7], and object recognition. The deep Convolution Network has shown excellent results in the field of crop disease recognition. In the present study, we have applied CNN based. Among these 9 diseases to diagnose and classify 9 types of tomato diseases. Of these 9 diseases, 5 diseases namely target spot, early blight, late blight, tomato leaf mold, and Septoria leaf spot are caused by fungal infection, 2 diseases namely tomato yellow leaf curl virus and tomato mosaic virus are caused by the virus infection, 1 disease namely bacterial spot is caused by bacterial infection and one disease namely two-spotted spider mite is caused by spider mite. Leaf samples of these tomato diseases are depicted in Fig. (**1**) in section 3.2.1.

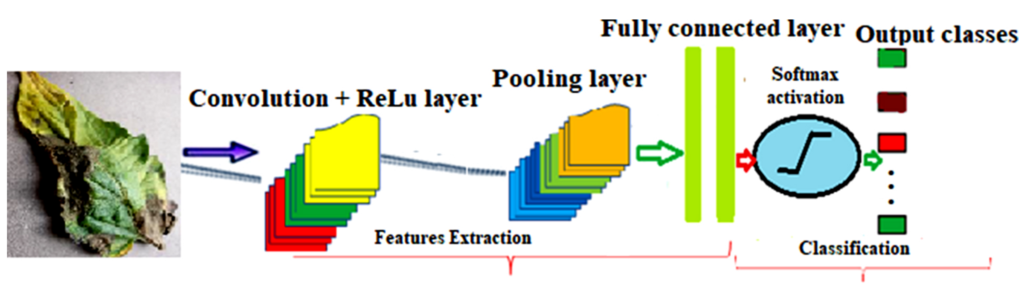


**Fig. (1).** Basic structure of CNN.

The following is a breakdown of the chapter's structure: Sect. 2 discusses related studies, emphasizing key contributions. Sect. 3 discusses the materials and methods. The database of infected leaves is discussed, which covers plant category illnesses types, and the number of image samples in each disease class.

The methods explain how the dataset was processed, how the model was implemented, and how the model was trained. The experimental findings and analysis are presented in Section 4, which includes a comparison of existing methodologies with the suggested method. Finally, Section 5 brings the study to a close and suggests some future enhancements.

## EXISTING WORKS

El-Helly *et al*. [8] employed an artificial neural network to diagnose leaf miner-damaged, downy and powdery mildew-infected leaves in cucumber plants in 2004. Liu *et al*. [9] employed backpropagation neural networks to forecast the incidence of illnesses and pests in apple plants in 2005. The authors have used the preceding eleven years' field information to train the network. Sammany and Medhat [10] employed a genetic algorithm to refine learning parameters and the design of neural networks (NN) used in disease detection. Refinement was done to achieve optimal parameters. These optimized NNs and support vector machines (SVMs) were utilized to detect plant diseases.

Tian *et al*. [11] presented a plant disease recognition system using an SVM classifier for wheat crops. They converted the RGB color format of input leaf images into HIS format, then GLCM was used to find 7 immutable moments as shape features. Finally, the SVM classifier used extracted features to identify wheat leaf diseases. Dhaygude *et al*. [12] utilized Spatial Gray-level Dependence Matrices to get texture information from leaf images. The RGB image is transformed into HSV format to remove the green part from the image. Thus, infected portions are extracted and further segmented into equal-sized patches. Patches covering more than fifty percent of information are further analyzed.

Selvaraj *et al*. [13] proposed an SVM-based plant disease detection system. They have developed a 4 steps procedure: first, a color transformation scheme is constructed for the input RGB image, then the green pixels are masked and changed using various threshold levels, and next, segmentation is performed. Texture statistics are generated for usable segments, and the resultant features are then sent to the support vector machine for classification. Further, Pujari *et al*. [14] introduced a plant disease diagnosis and classification model based on SVM and ANN. They have taken samples of leaf illness caused by fungi in cereals for study. The k-means clustering method was used to separate the infected regions from the leaf. The features related to the texture and color properties of the infected region were retrieved and utilized as inputs for the classification model.

To improve the classification rate, Zhang *et al*. [15] proposed a strategy for identifying cucumber illness based on the breakdown of the global-local singular value. The SVM model was used to classify the illness of leaf images.

CHAPTER 3

# Detection and Categorization of Diseases in Pearl Millet Leaves using Novel Convolutional Neural Network Model

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**Abstract:** Pearl millet is a staple food crop in areas with drought, low soil fertility, and higher temperatures. Fifty percent is the share of pearl millet in global millet production. Numerous types of diseases like Blast, Rust, Bacterial blight, *etc*., are targeting the leaves of the pearl millet crop at an alarming rate, resulting in reduced yield and poor production quality. Every disease could have distinctive remedies, so, wrong detection can result in incorrect corrective actions. Automatic detection of crop fitness with the use of images enables taking well-timed action to improve yield and in the meantime bring down input charges. Deep learning techniques, especially convolutional neural networks (CNN), have made huge progress in image processing these days. CNNs have been used in identifying and classifying different diseases across many crops. We lack any such work in the pearl millet crop. So, to detect pearl millet crop diseases with great confidence, we used CNN to construct a model in this paper. Neural network models use automatic function retrieval to help in classify the input image into the respective disease classes. Our model outcomes are very encouraging, as we realized an accuracy of 98.08% by classifying images of pearl millet leaves into two different categories namely: Rust and Blast.

**Keywords:** Convolutional neural network, Deep learning, Machine learning, Plant disease detection, Pearl Millet Leaves.

## INTRODUCTION

Pearl millet is a staple food crop in regions characterized by drought, low soil fertility and extreme temperatures. Greater than 90 million desperately terrible

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individuals who live inside the drier components of Africa and Asia, locations where other crops just won't grow, rely on pearl millet for their revenue and daily diet. Fortunately, pearl millet is not only an irrepressible and reliable basis of energy in these areas, but also a better resource for other food requirements, particularly micronutrients. It is cultivated over 26 million hectares in some of the toughest semi-arid tropical environments. It is also eaten as food and feed for livestock. It is the 6th largest cereal crop in the world after maize, rice, wheat, barley, and sorghum. One of the biggest threats to pearl millet production to the farmer is the irreparable crop damage caused due to plant diseases. Millet diseases that affect crops can reduce the quality and quantity of the product by reducing productivity or by completely destroying the crop. Plant diseases found with bare eyes are not always accurate, and in areas where pearl millet is cultivated, finding trained workers or plant pathologists is very difficult. Early detection and identification of plant disease are often impossible in different regions of the earth because of insufficient trained manpower and plant pathologists.

The leaves of the plants initiate the process of photosynthesis whereby the plants obtain their energy. Illnesses/disorders alter the leaves of crops to such an extent that they do not supply adequate food for healthy crop growth, thereby causing poor health or even crop demise. The Food and Agriculture Organization predicts that diseases can cause damage to up to 10 to 30 percent of the world's food production, which is a bigger threat to achieving food security. Thus, manual monitoring of plant diseases is very challenging owing to its complicated nature and lengthy procedure. The traditional method of disease diagnosis is to physically examine specimens by qualified peasants or trained workers or plant pathologists. However, it does take a long time and consequently, it can impact the crop production. In some cases, owing to geographical limitations and inadequate skills of farmers, the plant disease cannot be identified properly [1]. Traditional techniques involve a great deal of time to investigate diseases, while at a similar point in time, crops can suffer from more harm due to real diseases. In addition, situations have arisen where, because of insufficient disease knowledge or wrong interpretation of the severity of the disease, an excessive or inadequate dose of the insecticide has caused severe crop loss. Consequently, it is necessary to reduce manual effort, at the same time making correct predictions and making sure that the lives of farmers are hassle-free. A lot of work has been carried out on the automatic identification of diseases for various crops using image processing techniques [2 - 6]. But not a good amount of work has been carried out in pearl millet disease identification with novel techniques like image processing [7]. So, automatic disease identification using the image has the potential to address all the above issues by automatically detecting and classifying diseases. The novel image processing techniques such as computer vision, and deep learning methods can be valuable in identifying plant disease. From the year 2012, Deep Neural

Networks (DNNs), and especially CNNs have been extremely popular in numerous computer vision tasks, like image detection, identification, and categorization [8].

The goal of this study is to construct a model using CNN to automatically identify the diseases of pearl millet crops from images. This document is organized as follows: Section 2 deals with relevant and significant work in this area. Section 3 explains about the data, data pre-processing and methodology used to build the model and the measures taken to achieve the desired results. In Section 4, we have discussed the results obtained. Section 5 contains the concluding remarks about our work and highlights the opportunity for future work.

## LITERATURE STUDY AND RELATED WORK

A new light CNN with channel mixing operation and multiple size module (L-CSMS) for identifying the severity of plant diseases is proposed [9]. Advanced feature extraction techniques for several crop categories are used [9 - 11]. A method for automatic detection of crop diseases using deep ensemble neural networks (DENN) is also proposed [9]. The performance of DENN surpasses advanced pre-formed algorithms like ResNet 50 and 101, InceptionV3, DenseNet 121 and 201, MobileNetV3 and NasNet. A two-step CNN model to identify crop diseases and classify citrus diseases using leaf images has been developed [12]. The model provided 94.37% precision in citrus fruit disease detection with a 95.8% precision score. The AlexNet algorithm is to rapidly and accurately identify corn diseases [13]. Using various iterations such as 25, 50, 75 and 100, the model achieved 99.16% precision. An adaptive snake segmentation model has also been developed to segment and identify infected areas [14]. Adaptive snake segmentation model is a 2-stage model, *i.e*., common segmentation and absolute segmentation. A threshold is also proposed based on adaptive intensity for the automated segmentation of powdery mildew disease, making this technique invariant for image quality and stochasticity [15]. The proposed technique has been validated on the complete cherry leaf image series with 99% accuracy. An automatic system, computer-based method of identifying yellow disease, also known as chlorosis is proposed in a study [16] which is a major pulse crop such as Vigna mungo.

A process of optimizing Henry gas solubility (MHGSO) based on mutation to optimize the hyperparameters of the DenseNet-121 architecture is introduced in a study [17]. When tested with a field dataset with complex backgrounds, the MHGSO-optimised DenseNet-121 architecture achieves accuracy and recall scores of 98.81%, 98.60% and 98.75%, respectively. The Philodendron leaf was obtained from a natural grayscale color and tinting, saturation and value technique

# CHAPTER 4

# Artificial Intelligence-based Solar Powered Robot to Identify Weed and Damage in Vegetables

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**Abstract:** The agriculture sector plays a vital role in the Indian Economy and is known as one of the key areas where automation is emerging to enable farmers to increase the yield, prevent damage to the crop, reduce harvesting cost, *etc*. Artificial Intelligence (AI) offers a large number of direct applications across various sectors and it can bring a paradigm shift in the Indian farming sector. According to the report of the United Nations, the land area for cultivation will be 4% by the year 2050 so smart farming processes are the need of the hour and AI can help in finding solutions to increase the yield of crops and ensure food security. The chapter focuses on the role of solar-powered robots in the agriculture sector with the application of computer vision which is capable of recognizing the physical properties of vegetables and helps in monitoring the yield. We analyse a vegetable image data set with mass and dimension values collected using a computer vision system and accurate measuring devices. After successful detection and instance-wise segmentation, we extract the real-world dimensions of the selected vegetable. After monitoring the health of vegetables, the robot shares the profile through IoT in real-time and thus with low labour cost and without exhaustive search, the crop can be prevented from damage by weeds which can be identified at an early stage. Initial evaluation of the developed prototype exhibited a noteworthy potential of this system in the area of effective control of weeds and crop damage and assisting in harvesting.

**Keywords:** Plant disease detection, Pearl millet leaves, Deep learning, Machine learning, Convolutional neural network.

## INTRODUCTION

India is known to be an agricultural country due to the fact that agriculture and its allied industries still act as one of the main resources of income for the majority of

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the population in rural India. It also is an essential sector that affects the Indian economy and adds around 17% of the total GDP of the nation.

India is the largest Global manufacturer of milk, pulses and jute, and is the second-largest manufacturer of rice, wheat, sugarcane, groundnut, vegetables,

fruit, and cotton. It is furthermore one of the most important producers of spices, fish, poultry and livestock, and plantation crops [1].

For agriculture, the environment in India has huge variations that differ from extreme humid conditions to tropical regions that are very dry in the southern region of the country. The northern region on the other hand has temperate and high-altitude which results in a great diversity of ecosystems. Despite the fact that the agricultural sector is accomplishing abundance in food when it comes to production, still India plays a significant role in providing food for a part of the world's hunger and thus have a responsibility to provide over 190 million undernourished people [2].

Since Indian Agriculture is a resource of the various inventive ways of irrigation, it now raises serious issues of sustainability and thus it is very essential that there is improvement in its management of agricultural practices on numerous facades. With the rapid spread of the Digital India movement, the Indian Agri-sector is also rapidly changing and is readily accepting automation in the sector and Artificial Intelligence is the main technology that is moving from the conventional methodologies and traits within the latest years [3].

AI is a data-driven technology and a large amount of ever-changing data lead to uncertainty, inaccuracy, and contradictions. Currently, the systems for approaching features are typical with the assistance of utilization of iterative techniques, and the neural community architectures related to each difference, which are together studied under the terms "Deep Learning" and "Machine Learning" [4, 5].

The application of robotics in agriculture might be an innovative step to change the productivity of labour. By either mimicking human skills or escalating them, robots can help in removing the critical human constraints which include the ability to operate in difficult agricultural environments [6, 7].

The quality of vegetables depends on the aspect of the vegetable image which is of morphological features. Colour is the primarily used feature to distinguish whether the vegetable is affected by weeds or not. Out of the various factors like colour, size, and texture and shape, colour is the most important feature which indicates a high impact on the quality of the vegetable.

## DIGITAL AGRICULTURE: IMPACT & CHALLENGES

In spite of the fact that a large segment of the population is involved in agriculture in India yet, there are a lot of challenges. In recent years, there is an increase in the shortage of labour and youth participation in the sector [8]. Indian agriculture also faces inadequate resources and information on mechanization. So there is an increased need for good equipment and improved techniques for increasing production in terms of both quality and quantity.

The practices in agriculture are majorly dependent on the factors like climatic conditions, water level, temperature, fertility of the soil, forecasting of weather, availability of fertilizers, use of pesticides, presence of weeds, and the method of harvesting.

In many of the cases, the farmers in India use the conventional methods to predict crop yield which is dependent on the knowledge that is based on their previous experiences, nonetheless, this approach alone possibly will not be an efficient way of prediction because climatic conditions have drastic changes regularly due to the overall change in the weather forecast at the global level. For addressing this issue, there can be an additional scientific practice with the advent of technology which is known as agro-based big data analytics [9]. Big data analysis can be used as an opportunity which can be used to analyse crucial factors which will help in controlling the crop yield. This method can also be used for the analysis of social, economic, and political impacts on the success rates of the different agricultural practices.

For better yield of crops, one of the basic solutions is to increase the overall cultivable land that is appropriate for the growth of a particular crop. It also requires a reduction in the damage of the crop and a decrease in the net operating cost by the implementation of various upright agricultural practices.

To improve the crop yield, there is a need of controlling the key factors that are used in the Indian agricultural practice including the type and quantity of fertilizer, the level of water and the resource from where it is obtained, seed quality that is used in cropping, reduction of the biotic stress which is caused by weeds and pests.

There is also a practice of manual inspection of the field by the farmers and the removal of weeds and contamination found if any is done manually which is a less effective approach and it does not produce any significant limitation in support of higher crop yield so it can be replaced by sensor network mounted in the field which can effectively understand the needs of the crop at real-time [10 - 12].

## CHAPTER 5

# Field Prevention System from Wild Animals

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**Abstract:** Preventing wild animal attacks in fields is a highly challenging task for farmers and field holders, especially during nighttime. Continuous monitoring is difficult to maintain consistently. Therefore, we have designed an Intrusion Detection System based on the Internet of Things (IoT). Our system utilizes the ESP8266 as its central component, allowing for the implementation of an automated solution to repel animals from fields without human intervention. Various devices, such as hooters, flashlights with day-night vision cameras, and AI algorithms, are incorporated to detect and differentiate animals from humans. Additionally, mobile applications provide a convenient means to remotely monitor the system's actions from home.

**Keywords:** IoT technology, Intrusion detection, Field rrotection, ESP8266, Artificial intelligence, Mobile application, Day-night vision camera.

## INTRODUCTION

The agriculture sector is the largest sector in India, encompassing a wide range of activities. Unfortunately, it is also one of the most severely affected areas, with farmers encountering numerous difficulties and challenges in their livelihoods and cultivation [1]. The challenges faced by farmers are extensive, impacting approximately 40% of the farming sector nationwide.

Given that the agricultural sector is crucial to the global economy, it holds significant importance for India as well [2]. Therefore, it becomes imperative to address the issues faced by farmers and find effective solutions to combat these problems. Field preservation is a critical aspect that needs to be prioritized in order to safeguard the sector and ensure its sustainable growth.

Farmers have emerged as the true backbone of India's development, with agriculture covering the largest sector in the country. However, Indian farmers face numerous day-to-day challenges and problems, which vary based on various factors [3].

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One major challenge is the encroachment of wild animals into agricultural areas due to the loss of habitat and increased urbanization. As cities expand and forest areas shrink, animals are forced to search for prey in agricultural fields. This situation, although unusual, has become a common concern for farmers, causing worry and affecting cultivation. Animals now directly enter fields, posing a threat to both humans and their food. This sudden aggression by animals towards humans necessitates the adoption of eco-friendly methods to keep them away from fields and prevent their entry.

Despite being the most economically significant sector in India, the agricultural sector is plagued by the issue of human-animal conflict. Wild animals entering fields, destroying crops, and disrupting the livelihoods of small-scale farmers are major concerns. Traditional methods still in use today can be dangerous for all parties involved. Given that field owners cannot guard their land 24/7, there is an urgent need to implement an eco-friendly system that can effectively deter animals from entering fields and ensure their safe escape.

## LITERATURE REVIEW

The current system still in use today relies on electrical fencing surrounding the field, which delivers electrical shocks to animals, posing a danger Fig. (**1**). Various methods are currently employed, including the use of flambeaus, firecrackers, egg repellents, fish smell, *etc* [4]. Some attempts have been made to address the issue using motion sensors. However, the sensitivity of these sensors can present a barrier to accurately detecting animal's entry into the field.

**Fig. (1).** Figures showing the existing methods.

Many individuals and organizations resort to trial and error, as they lack technological and eco-friendly solutions to solve such problems [5]. The most prevalent method currently employed is the electric fence, consisting of a wire perimeter charged with electricity [6]. This method serves as a deterrent for both animals and humans. The electric charge can be adjusted by varying the potential, resulting in effects ranging from discomfort to death. Electric fences are commonly used for agricultural fencing and animal control purposes. They work by creating an electrical circuit when touched by a person or animal [7]. A power energizer, a key component, converts power into brief high-voltage pulses. One terminal of the power energizer releases these pulses along a connected bare wire approximately once per second. The other terminal is connected to a metal rod, known as a ground or earth rod, which is implanted in the earth [8]. When a person or animal touches both the wire and the earth during a pulse, an electrical circuit is completed, resulting in an electric shock.

In the aforementioned pictures, we observed the use of flambeaus and firecrackers by farmers in the agricultural sector as a means to deter animals. However, it is important to note that this method carries a risk, as it could potentially result in an unexpected counter-attack [9].

Many farmers resort to electrical fencing, which involves the installation of simple wires around the field. The fencing is powered by electricity, and when an animal touches or comes into contact with it, they receive a sudden electric shock, posing a potential threat to their life [10].

## PROPOSED INNOVATION SYSTEM

When animals enter or attempt to enter the field, the continuity of the two-level laser fencing is disrupted, triggering the capture of images by a day-night vision camera. These images are then sent to a server. Simultaneously, irritating sounds are emitted from a sound-producing device, and high-intensity flashlights are directed towards the location of the animal Fig. (**2**). To notify the field owner and provide intrusion information, alert notifications are sent *via* messages. The entire data can be accessed through a hybrid application platform that receives updates from the server.

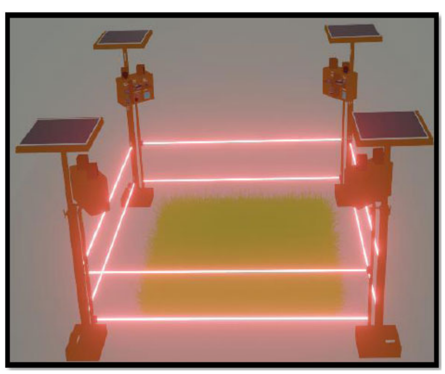

**Fig. (2).** The image of proposed System.

# CHAPTER 6

# Weather Forecasting using Machine Learning for Smart Farming

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**Abstract:** Weather forecast is of prime attention of the researchers working in the smart agriculture domain. In India, approximately 55% of the total crops are dependent on weather (monsoon season). An accurate weather forecast model requires abundant data to get the most accurate predictions. However, the weather forecast is a key area of research and is always challenging from historical data. Hence, the current system used for weather forecasting is an amalgamation of forecasting models, opinions, and information trends, and specific patterns. This work presents the application of the linear regression model and polynomial regression model for weather forecasting; like a scheme to forecast rainfall, and precipitation using historical weather data. The sample weather dataset covers 75 districts of Uttar Pradesh state which is received from the Indian Meteorological Department (IMD). Furthermore, analysing the impact of forecasts with different parameters is realized over six major crops Triticum (biological name of wheat), Gram, Barley, Mustard, Sugarcane, and Maize of Uttar Pradesh State. The main objective of the state-of-the-art is efficient crop management and passing the appropriate message to farmers to make suitable decisions as per the weather conditions.

**Keywords:** Future Farming, Linear Regression, Machine Learning, Weather forecast.

## INTRODUCTION

Accurate weather forecasting is a critical task depending on several parameters. Many advanced techniques like machine learning, deep learning, *etc*. are being used to design and develop weather forecasting systems for agriculture purposes with higher precision and accuracy [1, 2].

Uttar Pradesh is the 4th largest state in India and has the highest population. It is situated in the predominantly subtropical region. The weather depends on

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elevation; the average temperature varies from 12.5°C -17.5°C in January and 27.5°C–32.5°C from May to June. The distribution of rainfall may vary from 1000 to 2000 mm, most of the rainfall occurs during the southwest monsoon starting from mid-June to September months when most of the crops depend on rainfall. The annual rainfall affects the profit or loss of farm products. Crop loss may be minimized by taking precautions based on accurate weather forecasts. So, getting essential information about weather like temperature, rainfall, or natural disasters such as droughts, flood storms, *etc*. helps the farmers to manage their jobs.

Machine learning techniques usually consider historical data to forecast different parameters of weather datasets. The performance of the model depends on two factors; first, whether it is short-term or long-term predictions, second spatial scale, and global scale predictions. The long-term and global scale predictions have better performance rather than short-term and spatial scales. Many applications have used short-term temperature predictions focused on support vector machine (SVM) [1], Multilayer Perceptron (MLP) [2], and Random Forest (RF) [3]. Artificial Neural Networks (ANN) (inspired by biological neurons) [4] are widely used in developing such systems. ANNs are based on the theory of enormous interconnection and the parallel computing model of a biological system. It is a mathematical model that is capable of solving complex engineering problems and is useful in identifying the typical non-linear relationships between input variables to target variables in the dataset. The relationship between input and output variables can be mathematically formulated as given below [5].

$$Y = f(X^n) \quad \textbf{(1)}$$

Where, $X^n$ denotes the input vector of n-dimensional such as variables $X_1$, ... $X_i$, ... $X_n$ and Y denotes the output vector. The function $f(.)$ represented in equation (1) cannot be exposed explicitly from the model; rather, it is represented by the network parameters.

The structure of ANN consists of three layers *i.e.*, input, hidden, and output layers. There is no relationship between the input and output data layer. The hidden layers are often connected by bias, activation functions, and weight matrices. Fig. (**1**) shows the typical structure of ANN.

The complexity of ANN depends on the number of hidden layers. It also depends on the nature of the dataset such as data size, data types *etc*. but there is no standard rule that defines the number of hidden layers in a neural network architecture.

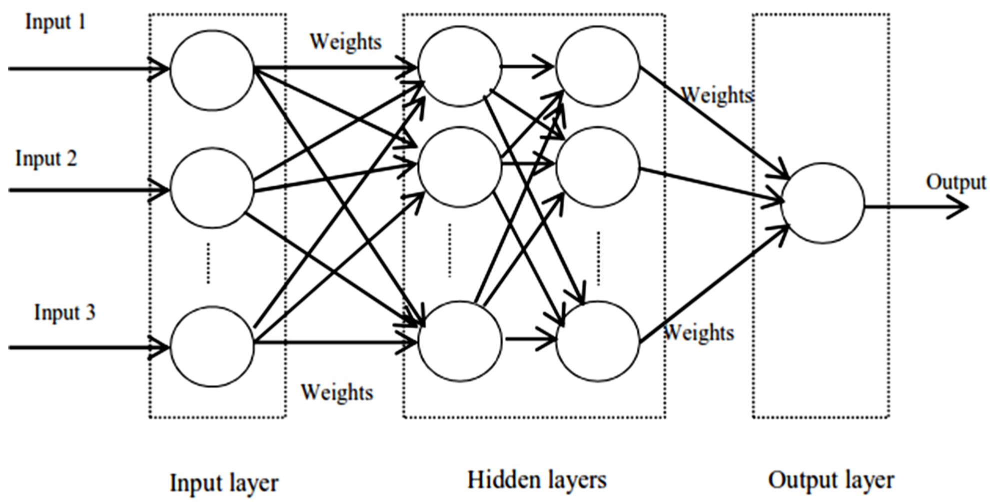


**Fig. (1).** Structure of Artificial Neural Network.

Typically, the gradient descent algorithm is used for training of neural network model and the back-propagation algorithm is used for synaptic weights modification based on the calculation of loss functions. The loss function can be defined as the difference between actual input and predicted output. It also depends on the type of problems. Different loss functions will be applied for the different problems because it has direct significance to the activation function used for calculating the output at the output layer.

The back propagation algorithm [6] is a supervised learning algorithm [7] that allows the update in the synaptic weights of the network by optimising the loss function. The calculated gradients of the loss function are fed to the previous layer of the network. It means that the values of gradients tend to reduce as the number of iterations moves backward in the previous layer of the network.

As a result, the learning rate of the earlier layer neurons slows down and the training period also increases along with a decrease in the accuracy of the model. This is known as the vanishing gradients problem, which is a very difficult problem when training neural networks by the backpropagation algorithm. Moreover, the ANN model has a significant limitation, for processing sequential data such as weather forecasts, finding the word for sentence completion problems, or computing time series data. The recurrent neural network (RNN) [8] is a type of ANN that is capable of handling the above discussed problems. The recurrent neural network was introduced in 1980 [9]. The structure of a recurrent

CHAPTER 7

# Intelligent Crop Planning and Precision Farming

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**Abstract:** Countries are more concerned about agricultural needs as it is considered to be the essential source of one's life. In our country, agriculture and farming play a vital role in the economy and provide 45% of overall support for economic development. In earlier research, the development of various agricultural support devices was introduced but all were stuck up to a certain level. Remote surveillance, SMS-based agricultural watering systems, and management are a few implementations in the area. But all these implementations are facing some technical challenges due to their complexity and it is hard to maintain the accuracy of these systems. Today's agricultural demands can be supported by Precision agriculture and Intelligent Crop Farming. This chapter focuses on different aspects of Precision Agriculture and Smart Farming.

**Keywords:** Artificial intelligence, Climate smart agriculture, Intelligent crop planning, Precision farming.

## INTRODUCTION

The word "agriculture" is derived from two Latin words, 'agricultura' from "ager" *i.e*. "field" and "cultura" *i.e*. "cultivation" or "growing". In common sense, agriculture is typically described as farming. It is an art and science of prudent endeavors to reshape a part of the earth's crust through the cultivation of plants and other crops as well as raising livestock for sustenance or other necessities for human beings and economic gain.

In layman's definition, farming is the basic process of food production which includes the in-depth use of traditional knowledge, land, known tools, natural resources, fertilizers, and the cultural faith of the farming society. But a production system solely based on traditional methods and cultural beliefs is inevitably followed by superstitions and speculative judgment in disguise of skilled predictions. Such an approach through repeated failures can be useful at

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one point in time after an innumerable number of experiments and resources are lost, it still needs for an upgrade that can reduce the problems and help farmers make informed decisions instead of speculative ones. And here is where modern technology comes into play. With the advent of Information Technology, nowadays scientists have come up with methods and technologies that are data-driven and take into account factors contributing to success and failures alike calculating the best possible route; thus recommending the farmers the precise action that needs to be taken to reach a specific end goal. This method of farming based on data intelligence is what we are calling precision farming.

To understand precision farming, we must understand how precise we can be by using the technology at our disposal; and here comes our use of data science and analytics. Data science is a field that deals with large volumes of data and its study uses modern tools and techniques to look for unknown patterns and derive from them meaningful information which can help in taking business decisions. Data science uses complex machine learning algorithms to build predictive models. The data used for analysis can come from many different sources and be presented in various formats. Now let us consider the attributes in farming such as plants, plant type, species, weather and climate, soil, *etc*. assets of data. Data Science algorithms and techniques will tell us precisely, when and at what time, what species of plant will be the most suited to the condition of soil structure at the moment and what weather to expect, and what steps are needed to be taken for proper maintenance concerning the weather and previous performances of other farmers on the same piece of land. This gives an exact farming model which will help in planting intelligently with precise actions that we will be taking for minimizing the loss of resources, time and overall expenditure and also giving the best yield and taking the current yield as another attribute. All of this coupled with the latest trends in agricultural technology gives us the ability to do precision planning which in turn helps us achieve an intelligent approach to farming.

## Precision Farming

The precision farming approach provides the precise amount of required inputs to achieve increased production yields in comparison with traditional cultivation techniques. It is the system through which information, technology, and management can be employed, to increase production efficiency, improve product quality, improve the efficiency of crop chemical use, conserve energy and protect the environment. Fig. (**1**) depicts the steps for precision farming.

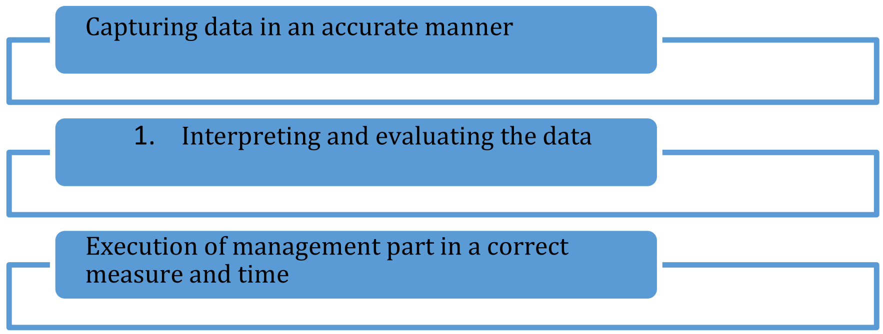


**Fig. (1).** Steps for precision farming.

Precision farming is a trending idea that naturally leads the way for higher profitability and fewer ill effects on the environment. Precision agricultural breakthroughs of today may provide the technology for the environmentally-friendly agriculture of tomorrow. Precision farming promises large yield improvement with low external input use. It is exponentially beneficial for small farmers in developing nations.

Multiple information to farmers from Precision agriculture can be listed as [1]- having better knowledge of the plant needs:

1. Real-time farm information

2. Helps the farmer in prompt decision making

3. Easy to trace

4. Enhance farm products quality

**Need for Precision Farming**

Traditional Agriculture faces educational and economic challenges as per the research. Aspects like the lack of local experts, funds, knowledgeable research, and extension personnel also add to these existing challenges in education [2]. There is a major need for precision agriculture in India to increase crop productivity and optimal use of water resources. The unnecessary use of heavy chemicals proves hazardous in crop production, which can be reduced by precision agriculture. Additionally, it helps in the prevention of soil degradation. Dissemination of modern farm practices to improve the quality, quantity, and reduced cost of production can be done through it. This way, this modern approach can also help in improving the socioeconomic status of farmers.

# CHAPTER 8

# Artificial Intelligence and Drones in Smart Farming

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**Abstract:** Since India is the second-highest populated country in the world and the seventh-largest country in terms of area, which includes hills, plateaus, coastal areas, *etc*., this situation of land makes a variety of crops and harvest timelines. These timelines seeped into India's culture and festivals. The harvest planning of farmers became a very challenging task due to the variety of land and multitude of harvest timelines as well. To execute this harvest plan, farmers must survey and map their land, but their limited reach restricts them. In view of these restrictions and limitations, drones can be very helpful for farmers; these drones can improve surveying quality and provide a proper harvest timeline as output. Artificial Intelligence-powered drones will give results in three stages: analysis of field planning, tracking the growth and counting of crops, and finally the ripeness tracking and timing of the harvest.

**Keywords:** Artificial intelligence, Drone, Gross domestic product and agriculture.

## INTRODUCTION

The agriculture sector has a long history in India, since the Indus Valley Civilization. After China, India is the world's second-most populous country, where agriculture is the primary source of income and nutrition for 70% of the population [1]. The traditional approach in the agriculture sector is a primitive method of farming that makes extensive use of indigenous knowledge, natural resources, traditional equipment, farmers' cultural values, and organic fertilizer [2]. However, due to the advancement of ICT in the agriculture sector, the working culture has improved over time.

From the invention of the plough to the development of the global positioning system (GPS) to the use of drones to control precise agricultural equipment, technological advancements have shaped agriculture significantly, and humans

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have devised innovative techniques to make farming more efficient and increase crop productivity [3, 4]. According to various types of research, the majority of the Indian population still lives in rural areas; improvement in rural marketing is a common way for the growth of the rural economy [5]. However, due to the advancement of ICT in the agriculture sector, the working culture has improved over time. The agriculture sector is the backbone of the Indian economy, and it plays a very vital role, therefore, it is necessary to discuss how agriculture has contributed to Indian Economy development [6]. The contribution of the agriculture sector may be measured from various aspects such as its share, namely employment generation, Gross Domestic Product (GDP), exports, *etc*. According to Statista, “the industry of agriculture sector employs a large number of people, approximately 60%, which accounts for about 18% of the country’s GDP [7]”. In India, most of the commercial groups and government plans have begun to work in this area and have seen different approaches in the rural sector, with an emphasis on agriculture [8]. This sector also plays a major role in supporting the industrial sector by providing basic raw materials and food for the industry's personnel. In addition, it generates industrial goods demand; these aspects must be investigated in order to determine the role and importance of agriculture in a given economy. Swarms of locusts have been known to eat plants, crops, and other trees; they have the potential to destroy cultivated crops. This feeding by Locust swarms may cause the shortage of food grains, deprivation, and starvation in societies that rely primarily on the survival of crops. Recently, it invaded different regions of India, including Rajasthan; across 20 regions with 90,000 (approx.) hectares of land devastated [9]. The majority of countries fighting locust swarms rely heavily on organophosphate insecticides. The utilization of technology in the agriculture sector helps to deal with such cases: in Rajasthan, drones have been stationed to ensure that the spraying is done efficiently. Drones can spray insecticides across a 2.5-acre area in under 15 minutes [10]. Drone usage combat locust swarms and provides a secure, immediate solution with this approach. After World War II, the drone concept was applied to coin the word for unmanned aerial vehicles used in target practice. This is a single-purpose mission that involves the destruction of an aircraft. Over the last decade, the meaning of the word has expanded further, and now it's military and civilian unmanned, from remote-controlled toy quad copters to advanced unmanned aerial vehicles used in a variety of commercial applications, including aerial photography. Drones are beneficial for a number of modest agriculture tasks, including crop spraying, soil and field study, irrigation, and day-to-day crop monitoring.

## CONTRIBUTION OF THE AGRICULTURE SECTOR IN DIFFERENT TERMS

### Contribution to Employment

This sector typically employs a huge number of workers as compared to other sectors. Since it is an equally important criterion for accessing the importance of agriculture that includes the population share of the total workforce. In addition, industrialization is increasing day by day in India, therefore, this share may go down in the near future. In India, the number of workers employed in agriculture is still relatively high, notwithstanding an increase in the proportion of workers employed in industry and services [11].

### Contribution to Exports

Another area in which agriculture plays a very important role is the export sector. As we know that nowadays, due to the availability of crop medicines and organic fertilizers, farming produces very high-quality crops, fruits, pulses, *etc*., and these high-quality products can export to different countries as per their requirement [12].

### Contribution to GDP

It has been noticed that agriculture contributed a significant portion of GDP in most economies prior to industrialization. According to Trading Economics, Agriculture's GDP in India climbed 4076.41 INR Billion to 6630.37 INR Billion from the third quarter to the fourth quarter of 2021 [13]. The agriculture sector in India is projected to account for only about 14% of the country's economy, but it is 42% of total employment [14]. For the least developed countries, agriculture acts as the heart of economic growth. The agriculture sector is an important pillar of the economy as it supplies the majority of essential foods, which range from 25 to 95%. This sector accounts for a considerable amount of GDP, ranging from 30 to 60%, and employs 40 to 90% of the labour force in the majority of situations. According to the 2020-2021 Economic Survey, the contribution of the agriculture sector to GDP has risen for the first time, nearly 20% in 17 years, as shown in Fig. (**1**), [15, 16]. All of this will be feasible due to the utilization of modern technology in agriculture.

As the accelerations in the industrialization process, the non-agricultural sectors raise the GDP share, and at the same time, agriculture's proportional share of the economy falls behind industry and services. It simply means that industrial and service sector production grows faster than agricultural production. The transformation in the economy's structure is because of more industrialization and

# SUBJECT INDEX

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