STM JOURNALS

Research & Reviews: A Journal of
Crop Science and Technology

ISSN: 2319-3395
Volume 15, Issue 2, 2026
May–August
DOI (Journal): 10.37591/RRJoCST

https://journals.stmjournals.com/rrjocst

Research RRJoCST

Multivariant Disease Detection from Different Plant Leaves and Classification

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Abstract

Agricultural growth is significant in Indian GDP which is based on yield of crops, quality of the plants and procedure of the plants taken. To maintain good quality of plant, the plant diseases should be identified and then given proper suggestions to farmers for specific fertilizers and pesticides to be used. The use of specific fertilizers or pesticides makes plant more health with good quality so that farmers can get more yield than traditional way of farming with same fertilizers of all plants and for all types of diseases. Manual test of diseases in plants is costlier as well as time taking process so to avoid that in this application, web application has been designed which taken input plant leaf and then predicts the plant is either healthy or having disease with disease specifications also includes pesticides or fertilizers. Convolutional Neural Networks (CNNs) are used for finding the type of disease present in plant and it has ability to find multivariate diseases. Proposed deep learning classifier predicts the healthy or disease plant and if there is disease plant then as per the disease there are few specifications given as requirement of water, requirement of soil PH and requirement of rainfall for specific plant with disease. Compared to state of art techniques of machine learning such as K-nearest neighbor and support vector machine, proposed CNN model outperforms the existing models. For easy access to this application in proposed method web application using Django Framework has been designed which make this application user friendly and easily accessible. This proposed system minimizers the cost and time at it reduces the requirement of experts needed in this field which helps in better yield as well as better production.

Keywords: Smart agriculture, detection of multivariate disease, fertilizers, rainfall, water requirement recommendations, Crop yield improvement

INTRODUCTION

Agriculture forms the backbone of food security and it also contributes considerably to the world economy. Plant diseases are still a big drawback, as they cause lowered yield and quality of crops. Leaves are the most affected plant part; therefore, they are mostly used in detection of diseases [1]. Conventional disease surveillance involves the manual observation of agricultural professionals who are expensive, inefficient and in many situations impossible to practice on large farms [2]. That is why an automated and intelligent system of disease detection is badly needed to help farmers, and enhance agricultural sustainability.

Classical methods of image processing have been used in a number of works on plant disease detection. Color transformation, segmentation, and handcrafted feature extraction have been used together with machine learning classifiers such as Support Vector Machines (SVM) and Decision Trees and K-Nearest Neighbor (KNN) [3, 4]. Despite the fact that these methods have been

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Received Date: May 11, 2026
Accepted Date: May 16, 2026
Published Date: June 30, 2026

Citation: V NarasimhaReddy, D. Srikar. Multivariant Disease Detection from Different Plant Leaves and Classification. Research & Reviews: Journal of Crop Science and Technology. 2026; 15(2): 27–35p.

proven to be effective when it comes to operating under controlled conditions, there have been cases whereby they have not been effective in real-field situations as far as varying illumination, complex backgrounds, and limited generalization is concerned [5].

Since the advent of deep learning and the accompanying rapid development of Convolutional Neural Networks (CNNs) they have demonstrated the ability to excel at automatically deriving features of leaf images [6]. MobileNetV2 and EfficientNetB0 are mobile and web friendly lightweight that have claimed more than 97% classification accuracy, at a much lower computation cost. They too have proposed hybrid schemes in which the CNN-computed deep features are combined with hand-designed descriptors, including Local Binary Patterns (LBP) to his definition of fine texture in leaves [7].

Apple, tomato and grape leaves data are used to evaluate the models providing coming-in accuracy of more than 96 percent in both validation and test accuracy [8]. These methods indicate a necessity to utilize a combination of handcrafted and deep features to detect robustly plant diseases. In addition, dense CNN structures have been used to cope with inter- and intra-variation across varieties and difficult suffers field conditions. After training the model, the average percentage accuracy of cross-validation and test error detected was 99.58 and 99.19 respectively, whereas the processing time required to detect one picture was 0.016 sec., which means it is possible to detect in real-time [9].

Even our own experimental evidence can testify to the fact that the use of CNN-based detection systems gives better results in accuracy, precision, and recall, when compared with traditional machine learning. We also incorporate advisory module in our system and this will suggest practical recommendations to farmers in terms of fertilizer types, NPK ratio, water cost, and soil pH level, making it very useful to farmers [10].

In this paper, we suggest a multivariant plant disease recognition and advisory utilization based on CNN. The application has been deployed as a web-based application in Django so that farmers could provide the images of the plant leaves and detect diseases automatically and get recommendations about patient care.

LITERATURE SURVEY

Identification and timely detection of plant diseases has become the critical aspect of crop productivity. Conventional techniques are cumbersome, time consuming and furthermore inaccurate, but deep learning methods fitted with CNN have proven excellent in manipulating images diagonally in classifying diseases. Lightweight networks, including MobileNetV2 and EfficientNet show good performance in the trade-off between computing expense and accuracy, which is applicable in environments like mobiles. Surveys document classification accuracies of more than 97 percent that greatly surpass classical machine learning algorithms. The developments indicate CNNs as a viable approach in detecting disease on plants in real-time, in an automated way in agriculture [11].

Organic farming is heavily using intelligent technologies to keep check of health of crops. Adversity like drought, too much water, or the lack of nutrients would have a direct effect on output and hence it is critical that stress in plants be noticed early. Obtaining accurate and routine results in manual monitoring of diseases like early blight, bacterial spot, leaf mold and rust of tomato, potato, grape, apple and corn is time consuming and only expertise can assist it. Image processing technologies, including acquisition, preprocessing, segmentation and feature extraction, are therefore commonplace. Multiclass SVM classifiers have also been used in studies to classify diseases correctly, so less manual work was needed and diagnosis can be done in shorter time [12].

Plant diseases also highly damage the quality and quantity of agricultural production, and early detection is crucial in helping avert catastrophic losses to the agricultural production. The past few years have seen the rise of lightweight variants of deep CNN based models that automatically learn hidden features and that are further augmented with hand-designed features like Local Binary Patterns (LBP) in order to capture more refined texture information. These hybrid methods were tested on data sets

Apple, Tomato and Grape leaves with validation accuracies of 99%, 96.6 and 98.5 and similar test accuracy. This indicates that CNN based models, when combined with conventional features, based on their highly accurate and stable performance, provide an effective solution to diagnosing diseases and protecting crops successfully [13].

Plant diseases are yet another problematic issue in the agricultural sector and detecting them as early as possible is the key to crop monitoring in this respect. Leaf-based diagnosis by experts is very costly and time consuming therefore deep learning approaches have been introduced as an efficient process. Recent developments have used dense CNN-based architectures trained on large diversified datasets that cover six crops and 27 disease classes both under lab and field conditions. This model covers inter class and intra-class variations, as well as being robust since it was tested using five-fold cross-validation. The validation accuracy was an average of 99.58%, and test accuracy was 99.19%, and the time required was 0.016s to process each image, which suggested possibility of real-time plant disease recognition [14] fewer than 50 in the center plate, fewer than 50 in the upper plate, and fewer than 50 in the lower plate, or less than a total of 150 in any of the plates. Leaves are the commonest part of plants to be studied in terms of infections and researchers have been automating this process by use of computer vision and machine learning. There are several studies investigating the detection approaches based on the image-based analysis, which have their advantages and disadvantages with respect to various crops and disease categories. The surveys in this field review the work of current models and approaches which can be generalized under different conditions. These works also highlight the difficulties in feature extraction, diversity of the dataset, and deployment in the real-world. With the integration of the current approaches, the recent reviews can offer some useful findings and directions to focus on future studies to develop reliable plant disease detection through computer-visions methods [15].

High-quality and low-cost plant disease detection is needed especially in developing regions whereby expert plant disease detection is not only costly but time consuming. To deal with this, image-processing-based strategies are designed such as the integration of color transformation, K-means clustering, extraction of texture features, and neural network classifiers. Experimental works based on local crop data have shown that such hybrid approaches can be used successfully on detecting and classifying different diseases in the leaves. The reported findings indicate a precision of about 93 percent, which proves the effectiveness of integrating clustering and neural networks. These results demonstrate image-processing pipelines as cost-effective and feasible method in automatic plant disease recognition [16].

PROPOSED METHOD

The proposed system aims to detect and classify plant leaf diseases automatically using image processing and deep learning. A Convolutional Neural Network (CNN) model is designed and integrated with an advisory module that provides crop care suggestions. The methodology is divided into several steps, as described below [17]:

Data Collection

Plant leaf images are gathered off of open sources like Plant Village and Kaggle and others. The dataset covers healthy and diseased leaves of crops at large.

Data Pre-processing

The Collected images are resized and standardized to have similar shade input sizes. Augmentation techniques of rotation, flipping, and scaling have been used to enhance model generalization and prevent the overfitting of models.

Segmentation and feature extraction

Animated paths are used and highlighted by diseased areas in the leaf. This removes the requirement to manually define features such as color, texture and patterns, which is very tedious, by automatically extracting them with the CNN.

CNN Model Structure CNN model training

A Convolutional Neural Network is learnt against the pre-processed dataset. It consists of convolution layers converging into feature (dimension reduction), pooling ones and fully connected [18]. Evaluation of performance is done on the basis of metrics like accuracy, precision, recall and F1-score.

Disease Detection Module

When a farmer posts an image of plant leaf to it, the trained CNN decodes the image and classify it as either healthy or diseased. When diseased the type of disease is determined.

Advisory Module

In addition to detecting the disease, the system also suggests actionable input e.g. kind of fertilizer to use, NPK ratio, water and soil pH range. This renders the system more realistic to farmers.

User interface and report generation

The system is launched as a web based system (using Django framework). The user can sign up, log in, upload leaf pictures, and see the results in an easy dashboard. Both the output can also be downloaded as PDF reports or shared on WhatsApp to make the results easily available.

RESULTS

The products of the Plant Disease Care Advisor system are elaborated in this publication. Besides offering advising advice on the fertilizer application, NPK balance, water usage, and soil pH, the project uses Convolutional Neural Networks (CNNs) to identify plant diseases [19, 20]. The results that give a detailed description of each of the system stages are shown in Figure 1.

Homepage

In Figure 2, The Plant Disease Care Advisor system's primary entry point is the homepage. Users may easily explore the site to its clear, simple UI. Both new and current users can log in to the system or create an account from this primary panel. The interface, which was created with an emphasis on accessibility and simplicity, guarantees easy navigation to important functions like disease detection and advisory services, allowing users to easily access the system's essential features.

User Registration

In Figure 3, New users can register and create an account on the system using this interface. Important details including a username, email address, and password are gathered throughout the registration process. A personalised experience is made possible by the registration system, which guarantees the safe storage of user data, including disease detection history and advisory advice. Additionally, it facilitates service continuity by enabling users to access their prior records and outcomes anytime they return to the platform.

Login page

In Figure 4, the instance, authorised users utilise valid credentials to authenticate themselves. The login procedure ensures security and protects against unauthorised access. Customers are taken to the main dashboard after logging in, where they can see their customised plant care recommendations along with services like CNN training and plant disease diagnosis.

Dashboard: In Figure

The dashboard functions as the main control interface of the Plant Disease Care Advisor system. Through this panel, users can initiate CNN model training using plant datasets, perform disease detection by uploading leaf images, or securely log out of the system. The design of the dashboard emphasizes clarity and simplicity, allowing users to navigate between different modules efficiently and access system features without any difficulty.

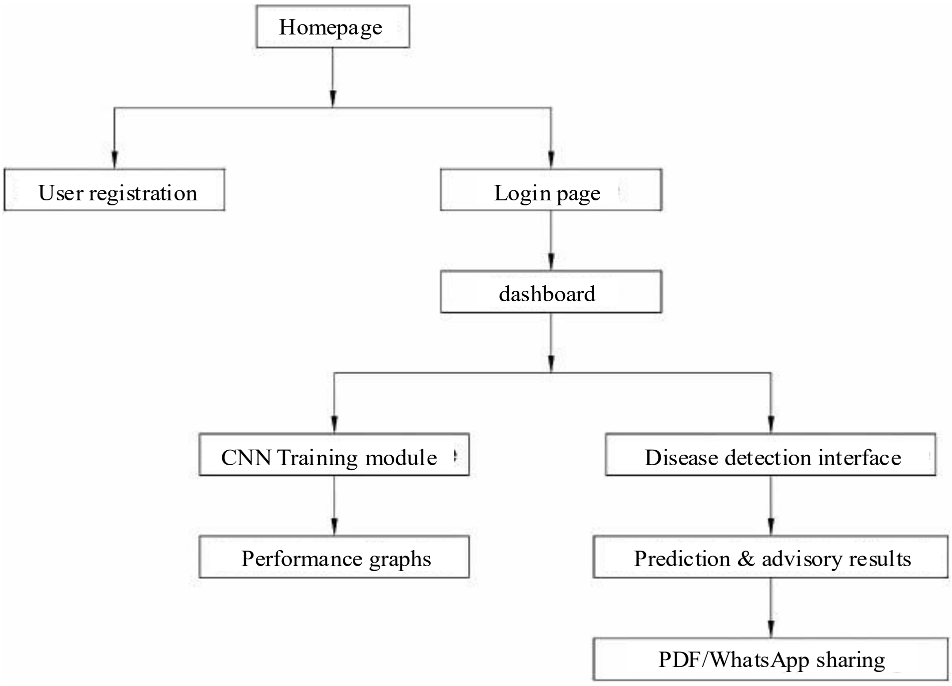

Figure 1. Block diagram for proposed method.

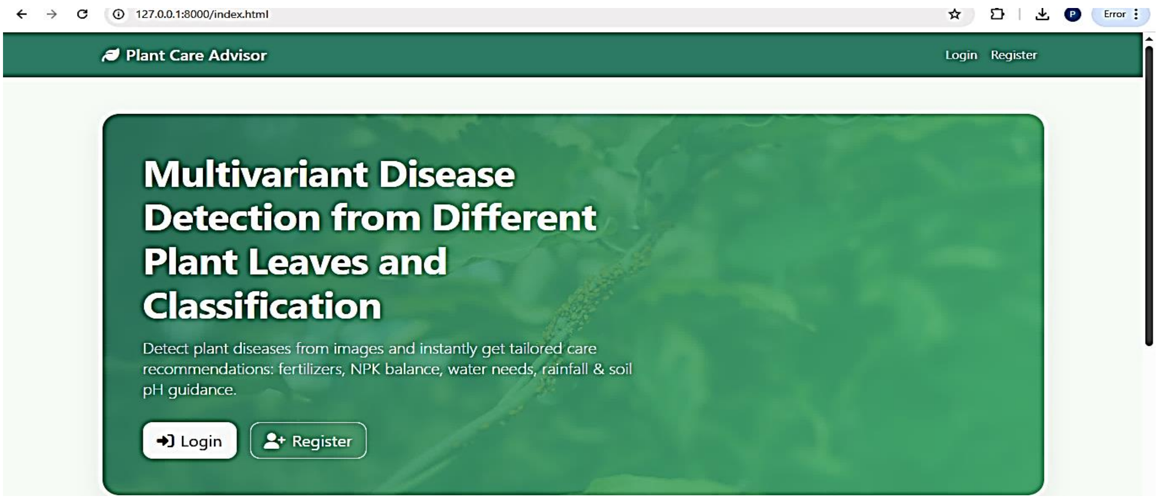

Figure 2. Homepage.

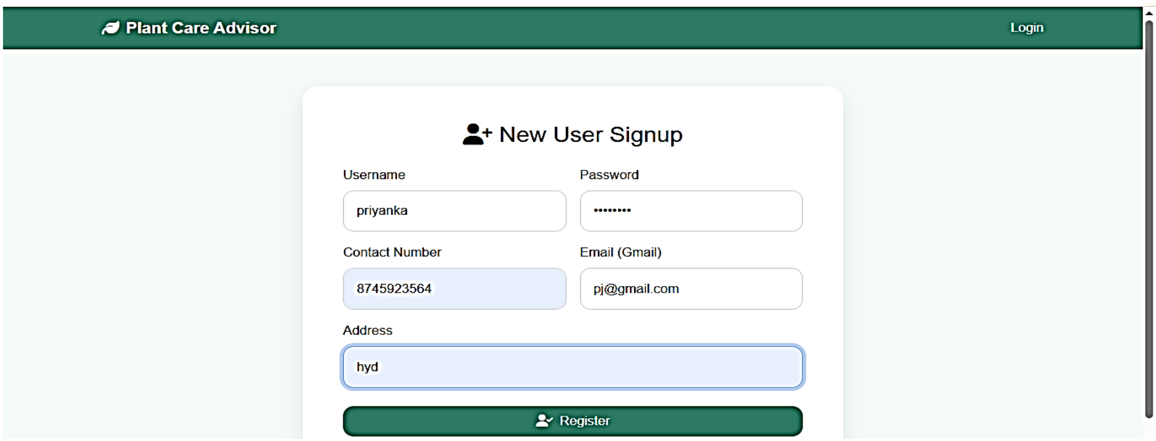

Figure 3. User registration.

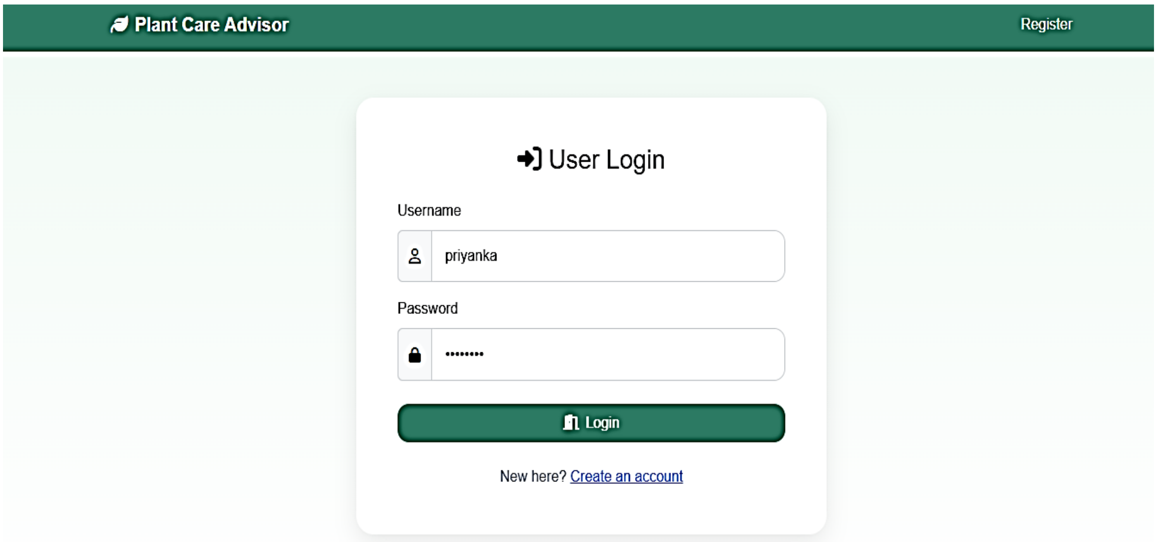

Figure 4. Login page.

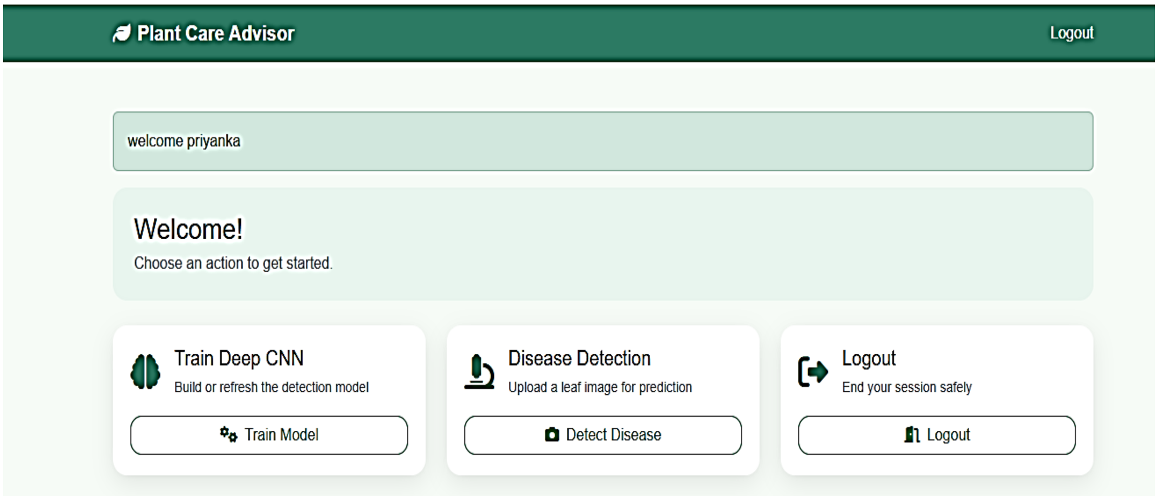

Figure 5. Dashboard.

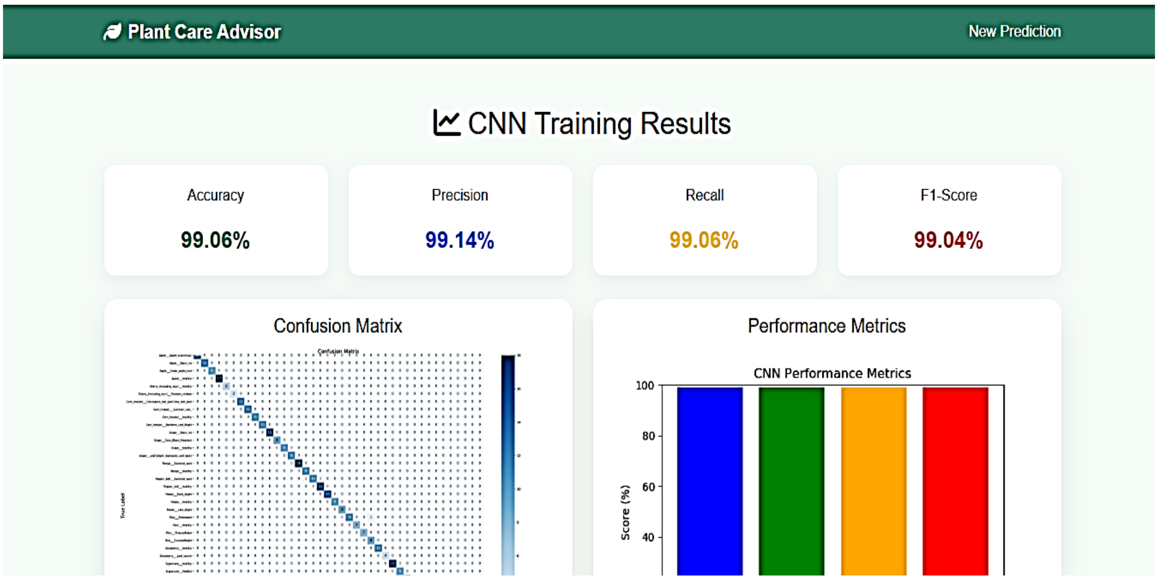

Figure 6. CNN Training results.

CNN Training results

In Figure 6, presents the outcomes of the CNN model training process. Key evaluation metrics, including accuracy, precision, recall, and F1-score, are used to assess the performance of the trained model. Higher values of these metrics indicate that the model is effective in accurately identifying and classifying plant diseases. These data are the base of the system since the advisory recommendations are based on the proper diagnosis of the disease.

Performance Graphs

In this module, you can visualize CNN model training. The graphs include Accuracy vs. Epochs and Loss vs. Epochs. These plots are important to monitor the learning behaviour of the CNN model. The model is in effect converging over time, as the error rate is steadily declining, and the loss is also declining (Table 1).

Disease Detection Interface: In Figure 7, Users can upload an image of a plant leaf for analysis on this screen. The picture that was uploaded under CNN Training Results: The CNN model training results are shown in the screenshot. The trained model's performance is demonstrated by performance metrics such as accuracy, precision, recall, and F1-score is preprocessed before being fed into the CNN model that has been trained. Even individuals with little technical expertise can easily run the system and get fast results thanks to its user-friendly interface.

Prediction and Advisory Results

This is the system's most important output. Following analysis, a leaf's identified ailment is shown in figure 8 along with comprehensive treatment instructions. The recommended fertiliser types, ideal NPK ratio, rainfall/water needs, and soil pH levels are all included in the recommendation. The uploaded image may also be annotated by the system to draw attention to areas afflicted by the condition. This thorough guidance offers farmers and agriculturalists genuine benefit by bridging the gap between disease identification and practical remedies (Figure 8).

Table 1. Training results.

Metric	Performance Values of Model
Accuracy	99.06%
Precision	99.14%
Recall	99.06%
F1-Score	99.04%

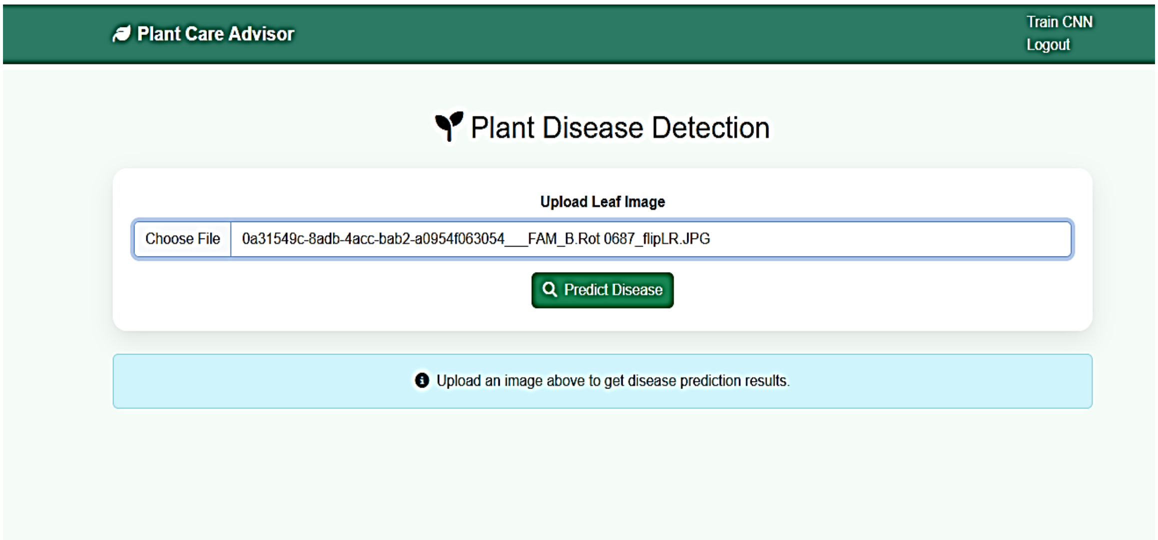

Figure 7. Disease detection interface.

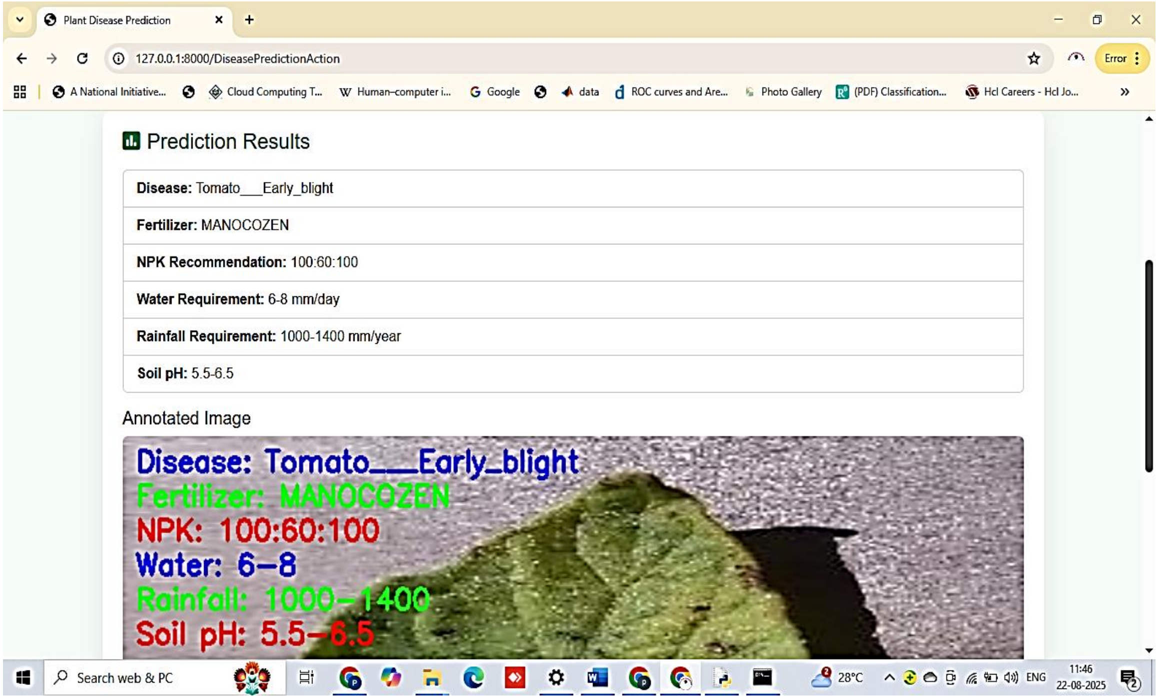

Figure 8. Prediction and advisory results.

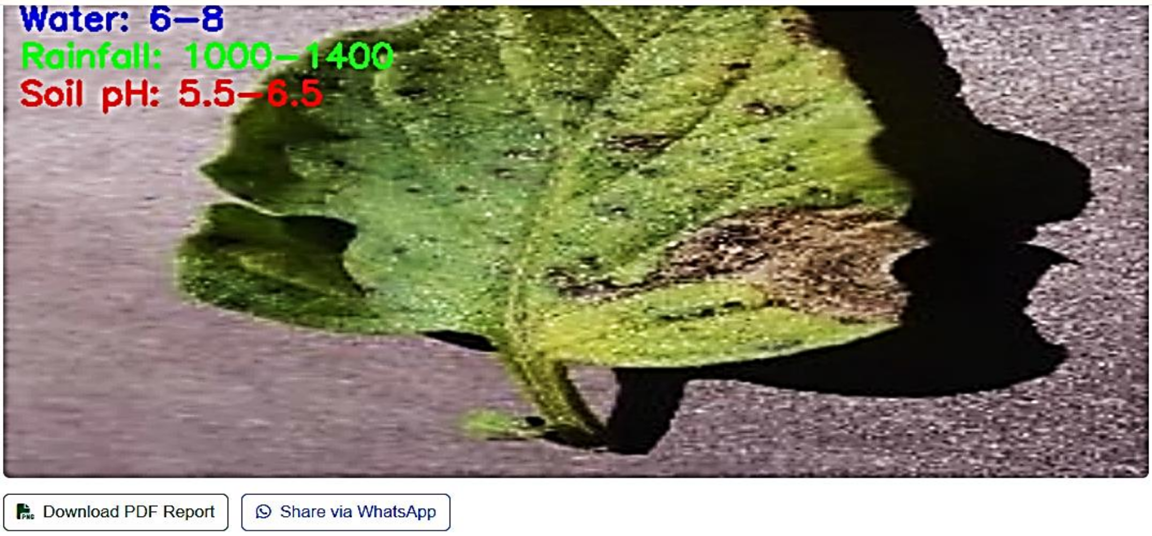

Figure 9. This result we can download as pdf and also share via whatsapp.

CONCLUSION

In recognizing various plant diseases, the proposed framework based on Convolutional Neural Networks (CNN) successfully overcomes the drawbacks of standard machine learning techniques and manual inspection. The system gives farmers precise data and fast, useful crop management recommendations by automating the disease identification procedure. The model performs well in terms of precision, accuracy, and memory efficiency, making it appropriate for practical agricultural applications. Additionally, even farmers with little technical expertise can take use of cutting-edge AI-based solutions thanks to the system's straightforward and user-friendly interface. By increasing crop productivity, reducing losses, and encouraging sustainable farming methods, this strategy promotes the idea of smart farming. In order to improve usability and reach, the system can be further improved in the future by creating mobile applications, incorporating IoT sensors for real-time monitoring, and offering advisory outputs in many languages.

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