

# BHUPHALA: Computer Vision-Based Soil Analysis for Efficient Crop Recommendation

Mr. Prashanth H S<sup>1</sup>, Nishanth C P<sup>2</sup>, Priyanka M<sup>3</sup>, Punya Shree B<sup>4</sup>, Rajath Kumar Y G<sup>5</sup>

Assistant Professor, Dept of Computer Science and Engineering, KSIT, Karnataka, India<sup>1</sup>

Student, Dept of Computer Science and Engineering, KSIT, Karnataka, India<sup>2-5</sup>

## Abstract

Soil condition has a strong effect on crop growth and overall agricultural productivity. Choosing a suitable crop based on soil characteristics is necessary to achieve better yield and efficient use of resources. Traditional soil testing methods usually depend on laboratory-based procedures, which are accurate but require more time, higher cost, and proper facilities. These limitations make it difficult for farmers, especially in rural areas, to analyze soil regularly, which may lead to improper crop selection.

In our proposed system, soil images are examined using computer vision and image processing techniques. Important features such as color, texture, and moisture are extracted to identify soil type, and appropriate crops are suggested based on the analysis. This approach provides a quicker, cost-effective, and simple solution compared to conventional methods. It helps farmers make better decisions and enhances agricultural productivity while supporting sustainable farming practices.

**Keywords** - Soil Analysis, Computer Vision, Image Processing, Soil Classification, Crop Recommendation

## INTRODUCTION

Agriculture is an important part of human life and plays an important role in economic development. The growth and productivity of crops largely depend on soil quality, as different crops require specific soil conditions such as texture, moisture, and nutrient content. If the soil is not suitable, it can directly affect crop yield and result in losses for farmers.

Usually, soil testing is carried out using laboratory methods where soil samples are collected and examined. Although these methods provide accurate results, they require more time, higher cost, and proper facilities. In many rural areas, access to such facilities is limited, which makes regular soil testing difficult. As a result, farmers often select crops without having complete knowledge of soil properties.

With the development of modern technology, it has become possible to analyze soil using images with the help of computer vision and image processing techniques. By capturing soil images, important features such as color, texture, and moisture can be observed and used to understand soil characteristics. This method is quicker, easy to use, and can be implemented using commonly available devices like smartphones.

In our proposed system, soil images are taken as input and processed to identify soil characteristics. Based on this analysis, suitable crops are suggested for cultivation. The main objective of this work is to provide a practical and efficient solution that helps farmers make better decisions and improves agricultural productivity.

## LITERATURE REVIEW

### 1) Computer Vision-Based Soil Texture Classification

Soil texture is an important parameter that affects water retention, aeration, and nutrient availability. In earlier studies, traditional methods such as hydrometer analysis and sieve analysis were used to determine soil texture. Although these methods provided accurate results, they required laboratory setup, more time, and skilled labor. To overcome these

limitations, computer vision and image processing techniques were introduced. These methods analyze soil images to extract features like color distribution, texture patterns, and moisture. However, the performance of these systems was affected by lighting variations, camera quality, and environmental conditions. In addition, manual feature extraction made the process less efficient and limited scalability.

## 2) Soil Type Detection Using Image-Based Techniques

Researchers have explored various image-based approaches to classify soil types. Early methods used feature extraction techniques such as histogram analysis, edge detection, and texture analysis to differentiate soil categories. Machine learning algorithms like Support Vector Machines (SVM), k-Nearest Neighbors (KNN), and Decision Trees were then applied to improve classification accuracy. These methods achieved moderate success but depended heavily on the quality of extracted features. With advancements in technology, deep learning models such as Convolutional Neural Networks (CNN) were introduced, which automatically learn features from images and improve performance. Some systems also integrated mobile applications and satellite imagery for faster detection. However, these models often require large datasets and high computational resources.

## 3) Machine Learning and IoT-Based Soil Analysis

Recent developments have combined machine learning techniques with Internet of Things (IoT) devices to monitor soil conditions in real time. Sensors are used to measure important parameters such as soil moisture, temperature, pH level, and nutrient content. The collected data is then processed using machine learning algorithms to analyze soil health and provide recommendations. These systems improve accuracy and enable continuous monitoring. However, challenges such as sensor reliability, maintenance cost, data transmission issues, and scalability limit their widespread adoption, especially in rural areas.

## 4) Machine Learning-Based Crop Recommendation Systems

Many researchers have focused on developing crop recommendation systems using machine learning algorithms. These systems analyze soil properties, weather conditions, and environmental factors to suggest suitable crops. Techniques such as Decision Trees, Random Forest, Support Vector Machines, and Neural Networks have been used to predict crop suitability. These approaches help in improving decision-making and increasing agricultural productivity. However, they require large datasets for training and may not perform well if the input data is incomplete or inaccurate. In addition, the complexity of these models makes them difficult to implement for real-time use.

## 5) Soil Image Analysis Using Advanced Models

Recent research has introduced advanced models such as deep learning architectures and Vision Language Models (VLMs) for soil analysis. These models combine image understanding with contextual information to provide more accurate results. They are capable of handling complex datasets and improving classification performance. However, these systems are computationally intensive and require powerful hardware, making them less suitable for small-scale applications. Therefore, there is a need for a simpler, cost-effective, and user-friendly solution.

From the above papers, it is observed that although many techniques have been developed for soil analysis and crop recommendation, there are still limitations in terms of cost, complexity, and accessibility. The proposed system focuses on developing a simple image-based approach that provides faster and practical solutions for farmers.

### Literature Review Summary

SL.NO	Paper Title	Methodology	Advantages	Limitations
1	Computer Vision-Based Soil Texture Classification	Image processing techniques were used to analyze soil texture.	Faster than traditional methods.	Affected by lighting conditions.
2	Soil Type Detection Using Image-Based Techniques	Machine learning algorithms such as SVM, KNN, and CNN were used.	Improves classification accuracy.	Requires large datasets.
3	Machine Learning and IoT-Based Soil Analysis	IoT sensors and ML techniques were used for soil monitoring.	Supports real-time monitoring.	Sensor maintenance issues.
4	Machine Learning-Based Crop Recommendation Systems	ML models were used for crop recommendation.	Helps improve productivity.	Depends on accurate data.
5	Soil Image Analysis Using Advanced Models	Deep learning and VLM models were used for analysis.	Provides better accuracy.	Requires high computational power.
6	AI-Based Soil Analysis and Crop Recommendation System	AI techniques were used for crop recommendation.	Improves crop selection.	Needs proper training data.

### OBJECTIVES

The main objectives of our project are to design a system that analyzes soil images and recommends suitable crops based on soil characteristics.

1. To capture soil images and perform preprocessing to improve image quality.
2. To analyze soil using images and understand its properties like color, texture, and water content.
3. To identify and suggest suitable crops based on the analyzed soil so that better yield and productivity can be achieved.
4. To develop a simple and easy-to-use system that helps farmers make better decisions.

### METHODOLOGY

The proposed system is designed to analyze soil images and recommend suitable crops using computer vision techniques. The system follows a step-by-step process to ensure accurate analysis and better results.

#### A. System Architecture:

The system consists of different stages where each stage performs a specific task. The process starts from taking soil images and ends with crop recommendation.

1. Image Acquisition - Soil images are captured using a mobile camera or taken from a dataset. These images act as input for the system and play an important role in analysis.
2. Image Preprocessing - The input images are resized and cleaned to improve quality. Noise and unwanted elements are removed so that the image becomes clear and suitable for further processing.
3. Feature Extraction - From the processed images, important features such as color, texture, and water content are extracted. These features help in identifying soil characteristics.
4. Soil Analysis - The extracted features are analyzed and compared with predefined soil data to determine the soil type.

5. Crop Recommendation - Based on the identified soil type, suitable crops are suggested. This helps farmers choose the right crops and improve productivity.

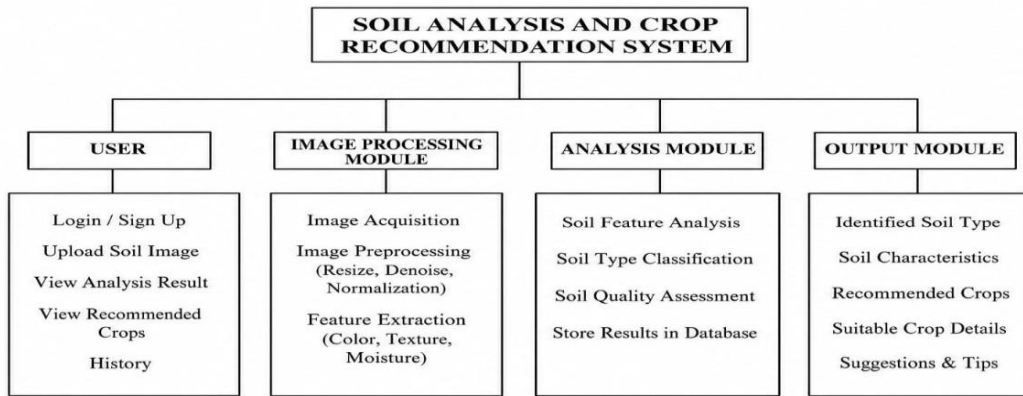


Fig 1: Block Diagram

B. Workflow of the System:

The workflow of the system follows a simple sequence:

- (1) The system takes a soil image as input.
- (2) The image is preprocessed to improve clarity.
- (3) Important features are extracted from the image.
- (4) Soil type is identified based on extracted features.
- (5) Suitable crops are recommended based on soil characteristics.
- (6) The final result is displayed to the user.

This workflow provides a simple, efficient, and cost-effective solution for soil analysis and crop recommendation.

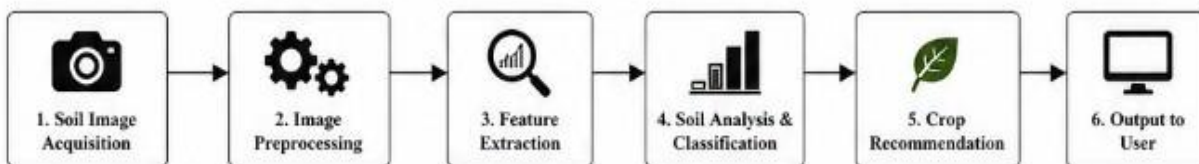


Fig 2: Workflow

**CONCLUSION**

In our project, we developed a system that analyzes soil using images and recommends suitable crops based on soil characteristics. The system uses image processing techniques to identify features such as color, texture, and water content, which help in understanding soil properties.

The proposed approach is simple, cost-effective, and easy to use. It reduces the need for traditional soil testing methods and provides faster results. This system can support farmers in making better decisions and improving agricultural productivity. In future, the system can be enhanced by using advanced models and real-time data for better accuracy. Farmers can easily understand which crops are suitable for their soil, saving time and improving efficiency.

**ACKNOWLEDGEMENT**

We would like to express our sincere gratitude to our guide, Mr. Prashanth H S, Assistant Professor, for their valuable guidance, continuous support, and time throughout our project. We also thank our institution for providing the necessary facilities and support to carry out our work. Although the project is still in progress, the guidance and encouragement we received have been very helpful in developing this work.

## REFERENCES

- [1] S. S. Nodi, et al. (2026), "Soil Image Analysis using Vision Language Models," Soil Advances.
- [2] P. Chaudhary, et al. (2026), "Machine Learning for Soil Analysis in Smart Farming," Scientific Reports.
- [3] M. Gowrisanker, et al. (2026), "Soil Texture Classification using Convolutional Neural Networks," IEEE.
- [4] A. Mitra, et al. (2026), "Soil Type Detection with Real-Time Image and Explainability," SN Computer Science (Springer).
- [5] K. Reddy, et al. (2026), "Real-Time Soil Texture Classification using Image Processing Techniques," Journal of Agricultural Informatics.
- [6] S. Mehta, et al. (2026), "AI-Based Soil Analysis and Crop Recommendation System," International Journal of Emerging Technologies.
- [7] R. Kumar, S. Verma, and P. Singh (2024), "Computer Vision-Based Soil Classification for Smart Agriculture," International Journal of Agricultural Science and Technology, vol. 15, no. 4, pp. 210–218.
- [8] N. Sharma and A. Patel (2025), "Deep Learning Approaches for Soil Analysis and Crop Recommendation Systems," IEEE Access, vol. 13, pp. 10234–10245.