International Journal of Engineering and Techniques-Volume 11 Issue 1, January - February 2025

AGRIASSIST: AI- ENHANCED CROP, FERTILIZER, AND PEST MANAGEMENT SOLUTION

M.UDAY KIRAN
21TQ1A6703
(Dept of CSE, Siddartha Institute of Technology and Sciences)
21tq1a6703@siddartha.co.in

K. VIJAY
(Dept of CSE, Siddartha Institute of Technology and Sciences)
vijakoraveni.cse@siddartha.co.in

B. SANDEEP
21TQ1A6704
(Dept of CSE, Siddartha Institute of Technology and Sciences)
21tq1a6704@siddartha.co.in

B. NAVANEETHA
21TQ1A6706
(Dept of CSE, Siddartha Institute of Technology and Sciences)
21tq1a6706@siddartha.co.in

LVSR.RAJ KUMER
21TQ1A6733
(Dept of CSE, Siddartha Institute of Technology and Sciences)
21tq1a6733@siddartha.co.in

ABSTRACT:

AgriAssist is a web-based platform that leverages Machine Learning (ML) and Deep Learning (DL) to optimize crop production and protect crops through data-driven recommendations. It provides real-time crop selection guidance using critical soil and environmental parameters, such as nitrogen, phosphorus, potassium, temperature, rainfall, humidity, and pH, ensuring sustainable yield improvement. For farmers maintaining the same crop, the platform offers tailored fertilizer recommendations to enhance soil fertility. Additionally, a unique pest management system powered by Convolutional Neural Networks (CNN) identifies pests from uploaded images or manual selection, recommending effective pesticides with dosage guidelines. By bridging the gap between soil analysis and actionable insights, AgriAssist empowers farmers with a user-friendly interface to enhance productivity and sustainability.

Keywords— Crop optimization, Machine Learning (ML), Deep Learning (DL), Convolutional Neural Networks (CNN), pest identification, fertilizer recommendation, precision farming, sustainable agriculture, soil health management.

INTRODUCTION:

Agriculture remains a critical sector for ensuring global food security, but it is increasingly challenged by issues such as soil degradation, inefficient resource utilization, pest infestations, and climate variability. To meet these challenges, integrating technological advancements into farming practices has become essential. AgriAssist is a comprehensive, web-based platform that seeks to revolutionize agriculture by leveraging data-driven approaches to optimize crop production and protect crops effectively.

The platform utilizes Machine Learning (ML) to analyze key environmental and soil parameters such as nitrogen (N), phosphorus (P), potassium (K), temperature, rainfall, relative humidity, and pH levels. Based on these factors, it provides real-time crop recommendations that maximize yield and ensure sustainable farming practices. For farmers who wish to maintain the same crop, AgriAssist offers precise fertilizer recommendations tailored to soil nutrient deficiencies, promoting soil health and fertility.

Pest management, another major agricultural challenge, is addressed through AgriAssist's advanced Deep Learning (DL) capabilities. Powered by Convolutional Neural Networks (CNN), the platform allows farmers to upload pest images for identification or manually select known pests. It then recommends effective pesticides and dosage guidelines to mitigate crop loss while ensuring optimal application.

By bridging the gap between soil analysis and actionable farming decisions, AgriAssist empowers farmers with intuitive tools to make informed choices. This paper discusses the design, architecture, and practical impact of AgriAssist, demonstrating its potential to enhance productivity, sustainability, and resource efficiency in modern agriculture.

RELATED WORK:

Recent advancements in agricultural technology have increasingly focused on leveraging data-driven approaches to improve productivity and sustainability. Several platforms and systems have been developed to assist farmers in making informed decisions regarding crop selection, fertilizer application, and pest management.

Existing crop recommendation systems, such as CropSage and Croplytics, primarily use Machine Learning (ML) algorithms to analyze soil and environmental parameters for yield optimization. However, these systems often lack real-time adaptability or fail to address the dynamic nature of agricultural challenges such as pest infestations. Similarly, fertilizer recommendation systems, like NutrientManager and GreenPlan, provide general suggestions based on soil tests but are limited in offering precise, crop-specific recommendations.

In the domain of pest management, significant work has been done using image processing and Deep Learning (DL) techniques to identify pests. For instance, models based on Convolutional Neural Networks (CNN) have shown promising results in pest identification from images. However, many of these systems are standalone solutions that do not integrate pest management with other critical farming aspects such as soil health or crop recommendations.

AgriAssist addresses these gaps by offering a holistic platform that combines ML-based crop and fertilizer recommendations with a robust CNN-powered pest management system. Unlike existing solutions, AgriAssist integrates soil nutrient analysis, environmental factors, and pest identification into a unified, user-friendly interface, empowering farmers with actionable insights for end-to-end agricultural decision-making.

A. Maintaining the Integrity of the Specifications

The template is used to format your paper and style the text. All margins, column widths, line spaces, and text fonts are prescribed; please do not alter them. You may note peculiarities. For example, the head margin in this template measures proportionately more than is customary. This measurement and others are deliberate, using specifications that anticipate your paper as one part of the entire proceedings, and not as an independent document. Please do not revise any of the current designations

LITERATURE SURVEY:

(Rajak et al. 951-952) i.e. paper [1] talks about crop prediction using various learners like SVM used as a classifier, Naive Bayes, Multilayer perceptron (ANN) and lastly Random Forest. The parameters used for crop prediction are: pH, depth, water holding capacity,drainage, erosion

(Dighe et al. 476-480) i.e. paper [2] reviewed CHAID, KNN, K-means, Decision Tree, Neural Network, Naïve Bayes, C4.5, LAD, IBK and SVM algorithms and generated rules for recommendation system. Considering various factors like pH level of soil, month of cultivation, weather in the region, temperature, type of soil, etc. factors were considered to select maximum likely crops for plantation.

(Mokarrama and Arefin) i.e. paper [3] discussed Location Detection, Data analysis and storage, Similar location detection and Recommendation generation module. Physiographic database, Thermal zone database, Crop growing period database, crop production rate database and seasonal crop database were used to get the final crop.

(Gandge and Sandhya) i.e. paper [4] talks about Attribute selection, Multiple Linear Regression, Decision Tree using ID3, SVM, Neural Networks, C4.5, K-means and KNN. The proposed system consists of firstly Selection of agricultural field then Selection of crop previously planted, it takes input from user, preprocesses it, then in backend there is attribute selection followed by classification algorithm on data and then crop is recommended.

(Mishra et al.) i.e. paper [5] uses J48, LAD Tree, LWL, IBK algorithm, firstly WEKA tool is used, LAD tree showed the lowest accuracy, though pruning the tree can minimize the errors, IBK gave good accuracy.

DATASET:

Precision agriculture is in trend nowadays. It helps the farmers to get informed decision about the farming strategy. Here, I present you a dataset which would allow the users to build a predictive model to recommend the most suitable crops to grow in a particular farm based on various parameters.
This dataset was build by augmenting datasets of rainfall, climate and fertilizer data available for India.

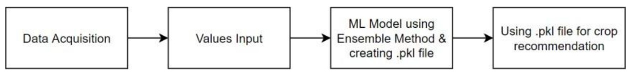
Data fields

- N - ratio of Nitrogen content in soil
- P - ratio of Phosphorous content in soil
- K - ratio of Potassium content in soil
- temperature - temperature in degree Celsius
- humidity - relative humidity in %
- ph - ph value of the soil
- rainfall - rainfall in mm

METHODOLOGY:

"Agriassit" has three different features. Methodology for all the modules will be discussed one by one.

Crop Recommendation:



This module can be implemented in four steps as discussed below and shown in Figure:

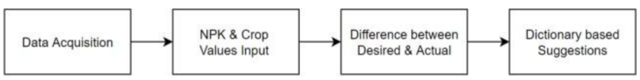
Step 1: Data Acquisition Dataset can be acquired from kaggle.

Step 2: Values Input Users are expected to input the site specific parameters like: N, P, K (all of them in %), temperature (in °C), relative humidity (in %), rainfall (in mm) and pH.

Step 3: ML Model Training and creating .pkl file Recommendation system is based on the ensemble model with majority voting technique. The constituent models are: 1. SVM 2. Random Forest 3. Naive Bayes 4. kNN After the model is trained, a .pkl file is created.

Step 4: Crop Recommendation .pkl file is loaded to recommend the crop based on input.

Fertilizer Recommendation:



This module can be implemented in four steps as discussed below and shown in Figure:

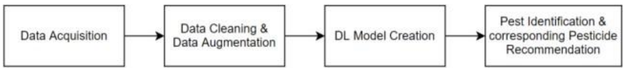
Step 1: Data Acquisition Dataset will be created manually after collecting data from verified sources listed below: 1. The Fertilizer Association of India 2. Indian Institute of Water Management 3. Kaggle The columns of the dataset are: N, P, K (all of them in %) and crop.

Step 2: Values Input Users are expected to input the site specific parameters like: N, P, K (all of them in %), and crop (select from list - only 22 crops supported).

Step 3: Difference between desired and actual Difference is calculated between desired value of N, P, K as per crop and the farm's actual value, based on it there are 3 outcomes possible for all three nutrients: 1. High 2. Low 3. Upto the mark

Step 4: Fertilizer Recommendation Based on the outcomes from the above step, a dictionary based solution (organic fertilizers) will be displayed.

Pesticide Recommendation:



This module can be implemented in four steps as discussed below and shown in Figure:

Step 1: Data Acquisition: Dataset will be created by scraping images from Google via automatic script using Selenium and Chrome Driver. Along with that, pest labels will be provided as well.

Step 2: Data Cleaning and Data Augmentation: The data collected from Google needs to be cleaned manually to get rid of non-useful content e.g: In case of scraping images of pest named "beetle" there are also few images of "car called beetle". Later on, the dataset needs to be augmented so as to increase variability.

Step 3: DL Model Creation: This involves model configuration, training configuration and model evaluation. Later on, .h5 file will be created to store the model.

Step 4: Pest Identification and corresponding Pesticide Recommendation: .h5 model will be loaded to identify the pest, later on based on the result, corresponding pesticide will be recommended based on dictionary based solution.

FUNCTIONAL REQUIREMENT:

"Agriassit" has three different feautures namely: Crop Recommendation, Fertilizer Recommendation and Pesticide Recommendation. So this section will define functional requirements for all the modules separately.

1. **Crop Recommendation**: The system will recommend the crop as per site specific parameters entered by the user.

2. **Fertilizer Recommendation:** The system will recommend the organic fertilizers as per the values entered by the user.

3. **Pesticide Recommendation**:

3.1 Uploading the image: The user will upload the image which clearly shows the pest.

3.2 Manual selection of pest: The user can choose to select the pest (alternative to uploading an image).

3.3 Pest Identification: The website will identify the pest.

3.4 Pesticide Recommendation: Based on the pest identified, the corresponding pesticide (as per ISO 9001, ISO 14001, ISO 17025 standards) will be recommended.

Non-Functional Requirements:

To judge the operation of "Irrigreat", rather than specific behavior, there are certain non functional requirements given below which really plays role in Irrigreat's usability, success, and effectiveness.

Performance Requirements:

The website has a feature of crop recommendation. The performance measuring variable for this module will be accuracy scores since the crop is displayed based on the pickle file created from the ML model. The desired accuracy score is >= 90%. For the other feature which is Fertilizer Recommendation, the performance metric is based on the effectiveness of organic solutions. Thirdly, the module of Pesticide Recommendation is based on Pest Identification and corresponding Pesticide Recommendation. The pests are identified by DL model, so training and testing accuracy as well as loss are performance metrics. The desired training and testing accuracy must be >= 90% and the pesticides must be as per ISO standards (ISO 9001, ISO 14001, ISO 17025).

Safety and Security Requirements:

So as to ensure safety and security, one time sign up is allowed and during sign up only three basic entries are to be made: email id, username, password. Hence, no personal information is asked for, which implies that there won't be any safety or security concerns. Also, the password will be stored in hashed format (SHA256). Post signup only, one can login into the system after authentication and avail any service. For login, the user requires username and password. Minimum password length is 8 characters.

User friendliness:

The interface is quite simple, easy to use and intuitive.

Compatibility:

The website is compatible with all popular browsers (Google Chrome, Mozilla Firefox, Microsoft Edge, Safari, Opera) and can be opened on PC, laptops, mobiles but to get the best experience use Google Chrome and laptop/PC (if using mobile, the user can use Moto G4, Samsung phones, iPhone 5, 6, 7, 8, Plus, X, iPad, iPad Pro, Surface Duo, Galaxy Fold).

Scalability:

The system can be scaled to 100K+ users, 10+ pests, 22+ crops and more pesticides, fertilizers.

Cost Analysis:

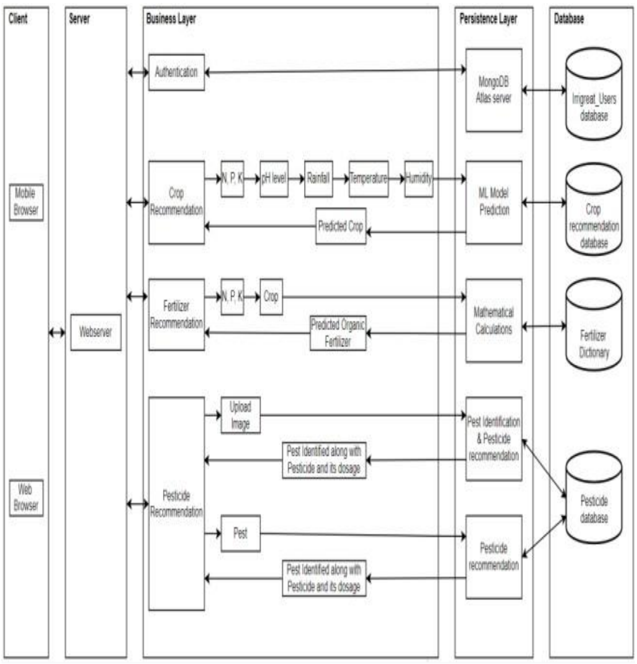
Agrissist doesn't involve any hardware. All the datasets are custom made by gathering the data from verified resources, Hence no paid dataset is used. The user must have the internet access to avail the services of Irrigreat and account on the website. This makes it really economical for Indian farmers.

Risk Analysis:

The crop recommendation module of Irrigreat recommends the crop on the basis of site specific parameters, which means environment factors are taken into account but not the economical aspects. Hence economic profitability is at risk. The crop performance could also be affected by the weather. Low rainfall or drought may lead to low yields while heavy rail could damage the crops. Not only crop but also the care of the crop decides the yields. Unmeasured dosage of pesticide could ruin the yield. The uncertainty factors, how the farmers grow the crop, the process carried out while using natural fertilizers and the pesticide dosage could ruin or increase the productivity.

SYSTEM ARCHITECTURE:

Figure shows the layered architecture of the product, constituting client, server, business layer, persistence layer, database



IMPLEMENTATIONAND EXPERIMENTAL RESULTS:

This section deals with discussion of implementation and experimentation with regards to the project. It also mentions all the test plans including the features to be tested, the test cases and discusses the inference drawn from the results. This doesn't end here, this section will also discuss algorithms used, system screenshots and in the end validate project objectives.

EXPERIMENTAL DATA:

Agriassit is an agriculture based project, hence data plays a very crucial role here. Along with that, data needs to be from authentic resources.

1. Data Source for Crop Recommendation:

a. Dataset has labels: N, P, K (all in ratio), temperature (in °C), relative humidity (in %), rainfall (in mm) and pH.
b. Data Source: Kaggle

2. **Data Source for Fertilizer Recommendation:**

a. Required N, P, K for crops dataset i. Dataset labels: N, P, K, crop ii. Data Source: The Fertilizer Association of India (FAI), Indian Institute of Water Management, Kaggle
b. Fertilizer Dictionary (Source: Google)

3. Data Source for Pesticide Recommendation:

a. Type of dataset: Image Dataset
b. No. of training images: 300 images per pest c. No. of testing images: 50 images per pest d. Data Source: Automatic script to scrape images of pest from Google through Selenium and Chrome Driver e. Pesticide Dataset: From biostadt website

4. Data Cleaning:

a. It needs to be done on pest dataset (training images). For instance, in scraping images for beetles (a pest), images also had a beetle car.

5. Data Augmentation:

a. Data Augmentation is to be performed in training images of the pest, so as to increase the variability.

Experimental Setup:

Agriassit has majorly 3 feautures namely: Crop Recommendation. Fertilizer Recommendation, Pesticide Recommendation. Following will discuss the experimental setup for all the three modules.

1. For all the services, the user needs to have an account created on the website, post that user can login any no. of times to avail any of the three services. During signup, the user needs to have an email address. Along with that, the user will give any username and password (minimum 8 characters and maximum 20 characters). For one email address, the user can have only one account and the username must be unique, hence not be taken. During signup, the user just needs to enter username and password.
2. Post successful authentication, the user can avail any of the 3 services.
3. For the first module, which is crop recommendation, the user needs to fill in the values for N, P, K (all in ratio), temperature (in °C), relative humidity (in %), rainfall (in

mm) and pH. After that, the user will be recommended the most suitable crop as per the land.

4. For the second module which is Fertilizer Recommendation, the user needs to have values for N, P, K and select the crop, based on that natural fertilizers will be recommended as per deficiency or surplus of nutrients.

5. For the third module, the user can choose to select the pest manually if the user knows about the pest and directly pesticide would be recommended, otherwise the user can choose to upload the picture that clearly shows the pest, thereby pest will be identified in the backend and corresponding pesticide would be recommended.

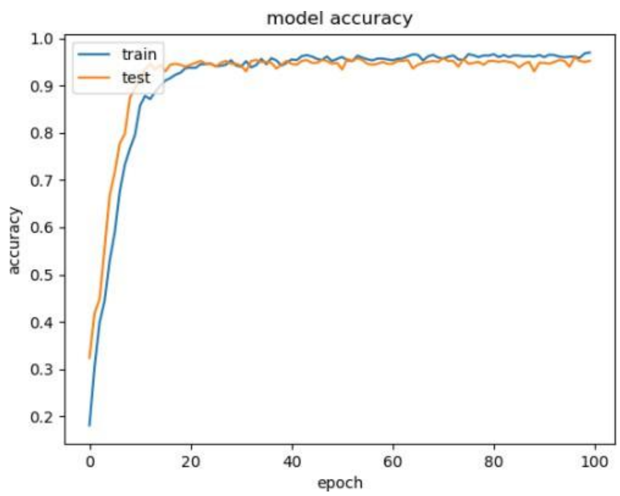
6. Post all the activities, the user can give optional feedback. Later on, he/she can again go to "Home" and look for services or logout.

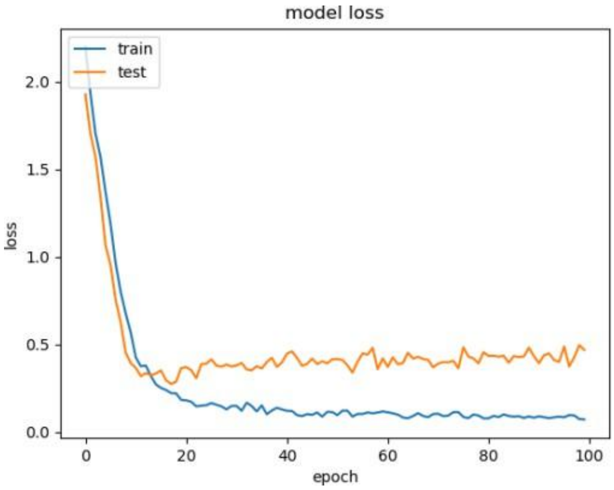
RESULTS:

The proposed model for "AgriAssist" can be judged in various aspects. Firstly, for the crop recommendation, since ML model is used to predict the crop which would be best suited as per site specific parameters, so here accuracy score helps to tell about how effective the solution is. Ensemble model using majority voting technique was used. The learners are: Naive Bayes, kNN, SVM and Random Forest. Accuracy Score came out to be 96.44%. The desired accuracy was >= 90%, but ML model is able to achieve 96.44%, hence it's appreciable. Since, Fertilizer Recommendation is simply a dictionary based solution, so it is based on research performed by the team members. Last module is Pesticide Recommendation. If the user chooses to upload an image, then pesticide would be recommended post identification of the pest and pests are identified through the DL model which is CNN. Here, the performance metric is training and validation accuracy, training and validation loss which are shown below.

	ACCURACY	LOSS
TRAINING	0.9699	0.0712
VALIDATION	0.9520	0.4681

The graphs for the same could be seen in Figure 40 and 41. Figure 43 represents model accuracy vs epochs. Figure 44 represents model loss vs epochs.

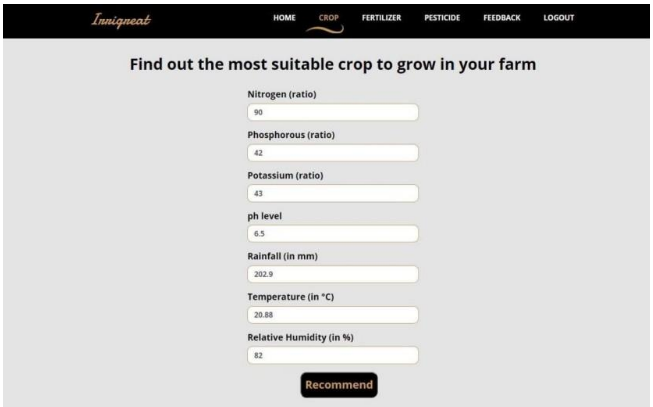




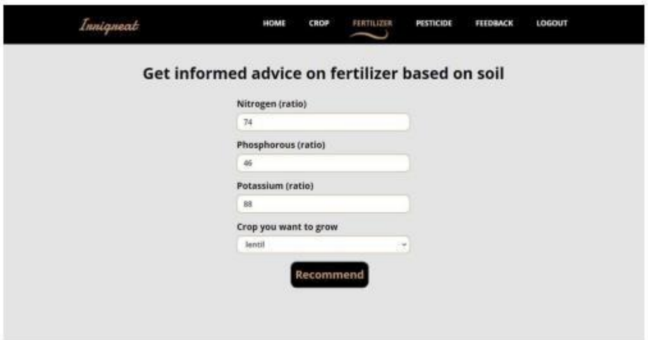
For pest identification, DL model is able to perform quite well but for some cases, DL model identifies "armyworm" as aphids due to close resemblance. Also, the system is not able to perform well with blur images, hence the user must upload the pictures that clearly show the pest.

Just like Indian farmers put in their heart and soul to grow crops,similarly we also made an attempt to put our efforts to help them. The screenshots for the system are given as under. First, when the user opens the website then the landing page appears (Figure 26), from here the user has 3 functionalities: Home, Login, SignUp.

Say that the user wants to avail the Crop Recommendation service then he/she can fill the values of N, P, K, pH, rainfall, temperature and relative humidity in the units specified to know about the crop that they must grow in their farm. See Figure for more details.



Now, after the user pressed the "Recommend" button then the result will be shown on the screen (Figure 31), here in this case, it recommends "rice". Hence this is most suitable to the soil as per current weather conditions and soil conditions.



Similarly the user can avail the "Fertilizer Recommendation" Service by filling the values for N, P, K and crop (Figure 32). Post that the user will know about the status of the soil and will tell the difference between the desired value of nutrients and the user's farm's nutrients and then "AgriAssist" will give informed advice on organic fertilizers to use as per the current condition of soil. See Figure for reference.

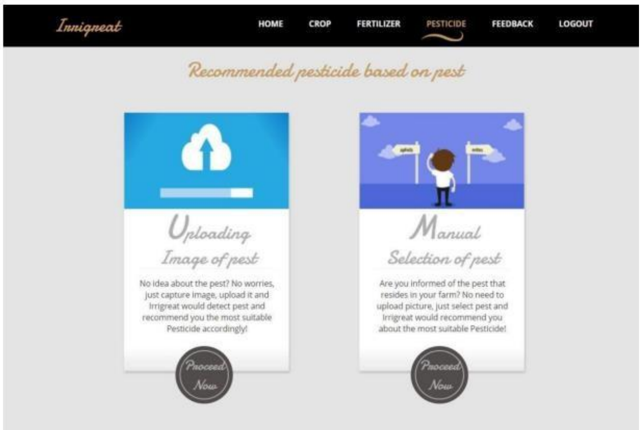
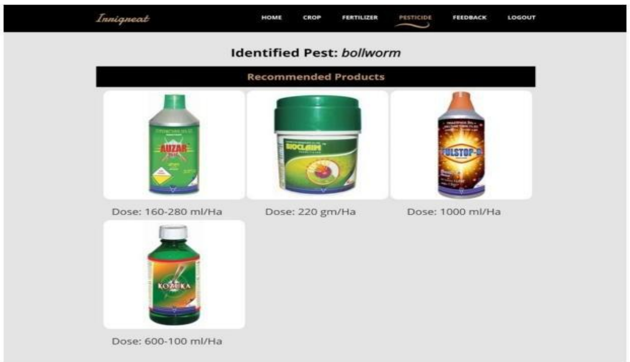


Figure shows the third module "Pesticide Recommendation" where the user can either upload an image of the pest or select the pest. If the user is informed of the pest that resides in his/her farm, then he/she can simply select the pest (Figure 37) and get the result for recommended pesticides (Figure 38), but if the user is unaware of the pests then he/she can upload the picture that clearly shows the pest (Figure 35) and then "AgriAssist" would identify the pest and recommended the pesticides accordingly (Figure 36). The user must take care that the picture must not be blur, since it may lead to wrong identification of the pest.



Conclusion:

India's farmers are hard at work. They help to feed a nation whose population is nearly 1.4 billion. However their productivity is threatened by some natural factors that can ruin their crops and their livelihoods.
So, this solution (AgriAssist) will benefit farmers to maximize productivity in agriculture, reduce soil degradation in cultivated fields, and have informed advice on organic fertilizers/ other fertilizers and also know about the right crop by considering various attributes. This would provide a comprehensive prediction and hence benefit both farmers and the environment. Not only this, but pest control would also be a major issue to be solved via this project.

Environmental/Economic/Social Benefits:
AgriAssist suggests the crops based on soil characteristics, thereby preventing soil degradation which saves the environment. Natural fertilizers also benefit the environment. Pesticides that are recommended are as per ISO standards. Social benefits include that it will be helping that section of India to feed the nation of 1.4 billion, which means Indian farmers. Economic benefits are abundant because availing services of AgriAssist just requires the user to have an account on the website which is absolutely free.

Reflections:
The whole journey of building "AgriAssist" has been a valuable experience, starting with the discovery of possible opportunities to think of the idea to the phase where the same idea was actually deployed. The team gained insight into the field of software development and now in the future, members shall feel more confident in the process of project development. Furthermore, it was learnt how to analyze the existing frameworks and perform literature surveys and utilize that analysis to identify the problem statement, research gaps and come up with the solution ideas. It was a learning of how to incorporate and take care of the user requirements. It was the time when the importance of documentation was realized and what are techniques involved in being organized about it. One of the takeaways was how to manage the resources in an efficient manner and most importantly to use common sense and build a viable and efficient model, but the best takeaway was development of analytical skills while working in the team and discussing 93 each point of the assigned task in detail. The whole project helped us in exploring the skills as a computer engineer and improved confidence levels, ability

to work under pressure and helped in learning project management techniques. It aided the members to be familiarized with the working and delivering of projects and how to build an entire product from just an idea.

REFERENCES:

[1] Rajak, Rohit Kumar, et al. "Crop Recommendation System to Maximize Crop Yield using Machine Learning Technique." International Research Journal of Engineering and Technology (IRJET), vol. 04, no. 12, 2017, pp. 951-952. IRJET, https://www.irjet.net/archives/V4/i12/IRJET-V4I12179.pdf.

[2] Dighe, Deepti, et al. "Crop Recommendation System for Precision Agriculture." IRJET, vol. 05, no. 11, 2018, pp. 476-480. IRJET, https://www.irjet.net/archives/V5/i11/IRJET-V5I1190.pdf.

[3] Mokarrama, Miftahul Jannat, and Mohammad Shamsul Arefin. "RSF: A Recommendation System for Farmers." Region 10 Humanitarian Technology Conference, vol. 2, no. 17, 2017, https://www.researchgate.net/publication/323203384_RSF_A_recommendation_system_for_far mers.

[4] Gandge, Yogesh, and Sandhya. "A study on various data mining techniques for crop yield prediction." IEEE Xplore, 2017. IEEE Xplore, https://ieeexplore.ieee.org/document/8284541.

[5] Mishra, Shruti, et al. Use of data mining in crop yield prediction. 2018. ResearchGate, https://www.researchgate.net/publication/326073480_Use_of_data_mining_in_crop_yield_predi ction.

[6] Wu, Xiaoping, et al. A Large-Scale Benchmark Dataset for Insect Pest Recognition. 2019. IEEE Xplore, 98 https://openaccess.thecvf.com/content_CVPR_2019/papers/Wu_IP102_A_Large-Scale_Benchmark_Dataset_for_Insect_Pest_Recognition_CVPR_2019_paper.pdf.

[7] Kasinathan, Thenmozhi, et al. Insect classification and detection in field crops using modern machine learning techniques. 2020. Science Direct, https://www.sciencedirect.com/science/article/pii/S2214317320302067.

[8] Ding, Weiguang, and Graham Taylor. Automatic moth detection from trap images for pest management. 2016. Science Direct, https://www.sciencedirect.com/science/article/pii/S0168169916300266?casa_token=EM_2nL 2k QswAAAAA:POy8LOCK6U1FOou5RxJujTtBAhO5ofZxktJ4jmUBcDryDZHXjbgvrNS5dJi 6x wsu9vZVnAULFoh_.

[9] TÜRKOĞLU, Muammer, and Davut HANBAY. Plant disease and pest detection using deep learning-based features. 2018. Turkish Journal of Electrical Engineering & Computer Sciences, https://journals.tubitak.gov.tr/elektrik/issues/elk-19-27-3/elk-27-3-6-1809-181.pdf.

[10] Selvaraj, Michael Gomez, et al. AI-powered banana diseases and pest detection. 2019. Plant Methods, https://plantmethods.biomedcentral.com/articles/10.1186/s13007-019-0475- z?utm_source=dlvr.it &utm_medium=twitter