CROP RECOMMENDATION SYSTEM (WEB APP)

ROHIT GANESH PADALKAR

ABSTRACT

In the ever-evolving landscape of global agriculture, the imperative for precision and sustainability has given rise to innovative solutions. The Crop Recommendation System presented herein represents a pioneering approach to address the nuanced challenges faced by contemporary farmers and agribusinesses. By integrating a comprehensive set of factors, including Nitrogen, Phosphorus, Potassium (NPK), Temperature, Humidity, pH level, and rainfall, our system goes beyond conventional norms, providing tailored recommendations to optimize crop selection.

At its core, the system leverages advanced machine learning models to distill vast datasets, capturing the intricacies of soil composition and climatic conditions. By considering NPK levels, the system ensures the fulfillment of crops' nutritional needs, fostering optimal growth and enhanced yield. Moreover, its evaluation of environmental parameters empowers farmers to make informed decisions, influencing crop health, irrigation practices, and sustainable choices.

This Crop Recommendation System not only maximizes productivity but also fosters environmental responsibility. Its holistic approach creates a dynamic understanding of the agricultural ecosystem, minimizing resource wastage and mitigating environmental impact. Positioned at the intersection of technology and agriculture, our system represents a transformative tool, promising a harmonious balance between increased yield and sustainable farming practices in the pursuit of a resilient and prosperous agricultural future.

1. Problem Statement

Agriculture, serving as the bedrock of global economies, plays a paramount role in sustaining livelihoods and fostering economic growth. In this context, the strategic selection of crops tailored to the unique characteristics of a given region is indispensable for ensuring the longevity and profitability of farming endeavors. The pivotal challenge faced by contemporary agriculture is the nuanced and dynamic nature of environmental and soil conditions, which vary significantly across different geographical areas.

The crux of the matter lies in empowering farmers with precise and data-driven insights to make informed decisions about the crops they cultivate. Traditional farming practices often rely on historical knowledge and intuition, which may not be sufficiently adaptive to the evolving complexities of climate change, soil health, and market dynamics. Therefore, the need for a sophisticated Crop Recommendation System becomes apparent, aiming to bridge the gap between conventional wisdom and cutting-edge technology.

2. Market/Customer/Business Need Assessment

In a global agricultural landscape marked by complexity and change, the demand for precision solutions has reached a critical juncture. The agricultural sector is undergoing a paradigm shift, necessitating tools that not only optimize productivity but also align with sustainable practices. Our Crop Recommendation System is a response to these evolving needs, providing a tailored and data-driven approach to address the challenges faced by modern farmers and agribusinesses.

- **Market Need –**

The modern agricultural market requires innovative solutions that transcend traditional approaches to crop management. Farmers and agribusinesses are seeking tools that integrate advanced technologies, such as machine learning and data analytics, to enhance decision-making and drive efficiency. Our Crop Recommendation System aligns seamlessly with this market need by offering comprehensive solution that goes beyond generic recommendations, catering to the specific and diverse requirements of individual farmers.

- **Customer Need –**

Individual farmers form the core of our customer base, and their needs are diverse, influenced by the unique characteristics of their land, crops, and local environmental conditions. Our system addresses these nuanced needs by considering crucial factors such as Nitrogen, Phosphorus, Potassium (NPK), Temperature, Humidity, pH level, and rainfall. By tailoring recommendations to these specific variables, the system becomes a valuable asset for farmers looking to optimize crop selection, maximize yield, and make informed decisions that align with sustainable farming practices.

- **Business Need –**

From a business perspective, the Crop Recommendation System responds to the imperative of offering not just a product but a comprehensive and consultative solution. The system's ability to integrate real-life data, industry expertise, and collaboration with agricultural professionals positions it as a strategic asset. This holistic approach ensures that the system not only meets immediate market demands but also establishes a foundation for long-term business viability. As the agricultural sector increasingly recognizes the value of precision and sustainability, our system becomes not just a tool but a catalyst for cultivating enduring relationships with farmers and agribusinesses.

3. Target Specifications and Characterization

Primary Goal: Recommend the most suitable crop for a given set of environmental and agricultural conditions, maximizing yield and economic return for the farmer.

Secondary Goals:

- Provide information on optimal planting and harvesting times.
- Offer guidance on water and fertilizer requirements.

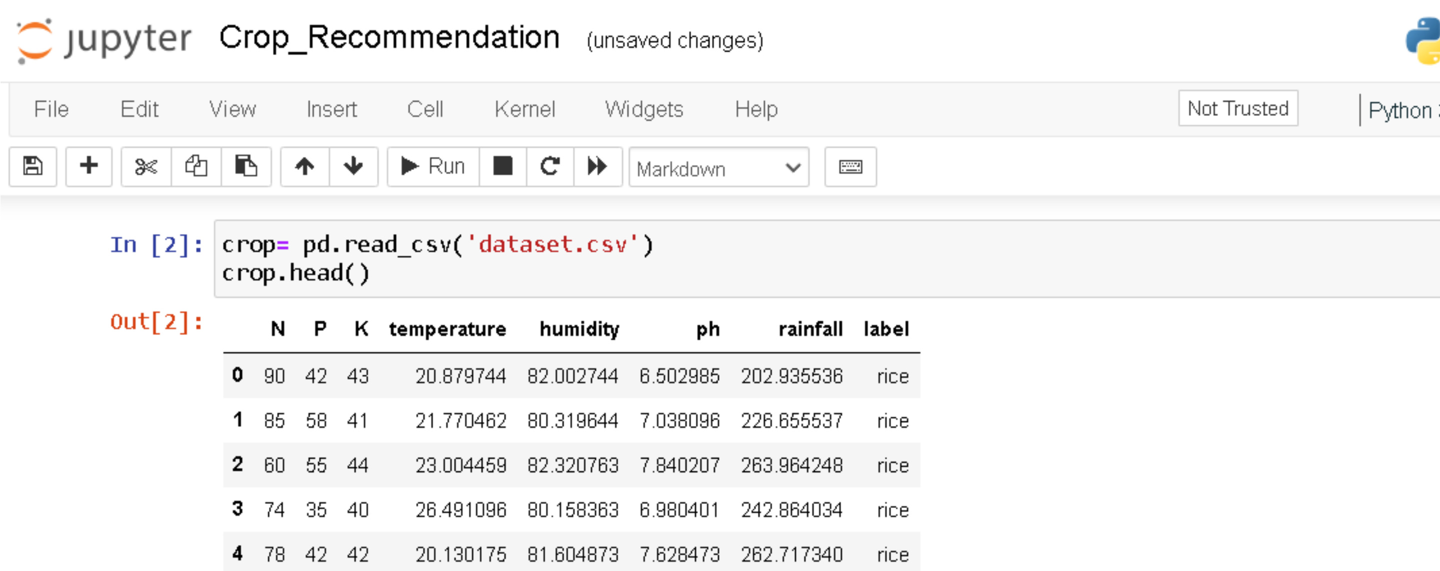
- Consider potential risks and suggest mitigation strategies (pests, diseases, weather extremes).
- Integrate with other agricultural tools and platforms seamlessly.

➢ **Characterization:**
  - Scalability: Ability to handle diverse farm sizes, locations, and cropping systems.
  - Adaptability: Capacity to update recommendations based on changing environmental conditions and new crop varieties.
  - Accessibility: User-friendly interface accessible on multiple devices, even with limited internet connectivity.
  - Transparency: Clear explanation of the recommendation process and underlying data sources.
  - Ethics: Consideration of social, economic, and environmental factors alongside profitability.

4. External Search (information sources/references)

The Dataset used in this project can be found on this Link.

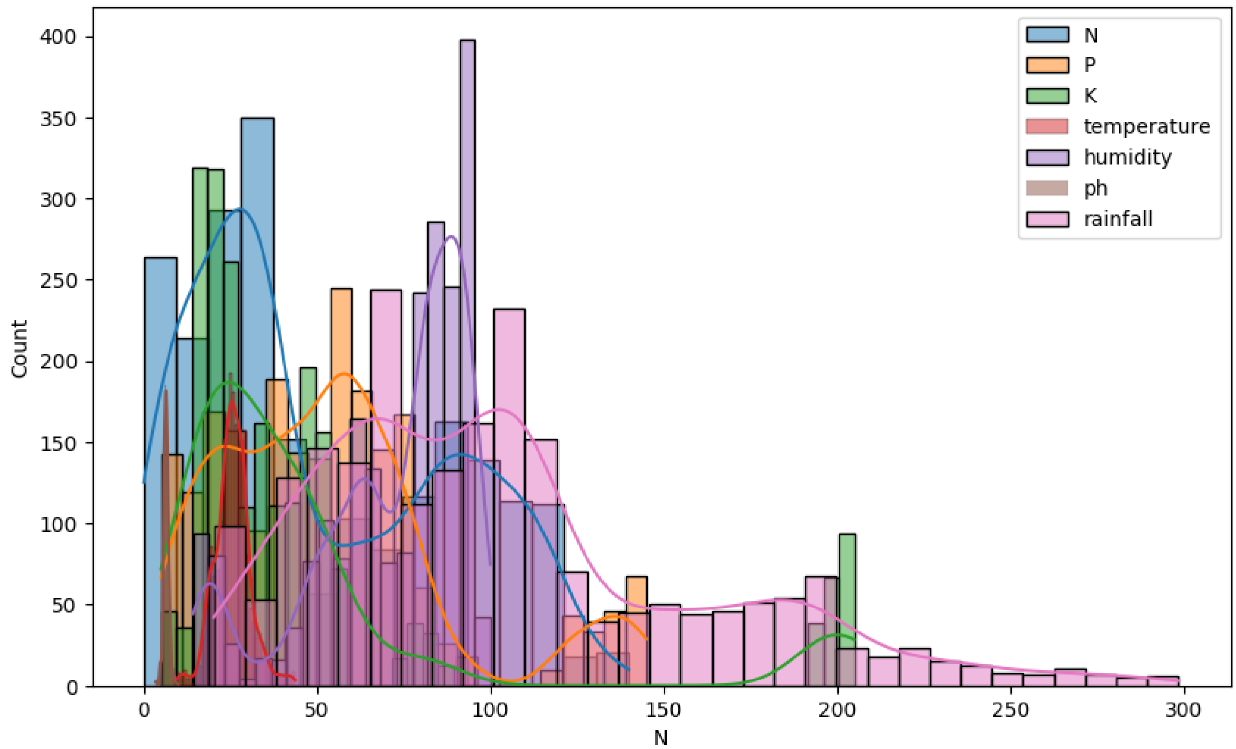
The Dataset consist of the various parameters that are useful for the Crop Recommendation such as Nitrogen, Phosphorus, Potassium (NPK), Temperature, Humidity, pH level, and rainfall.



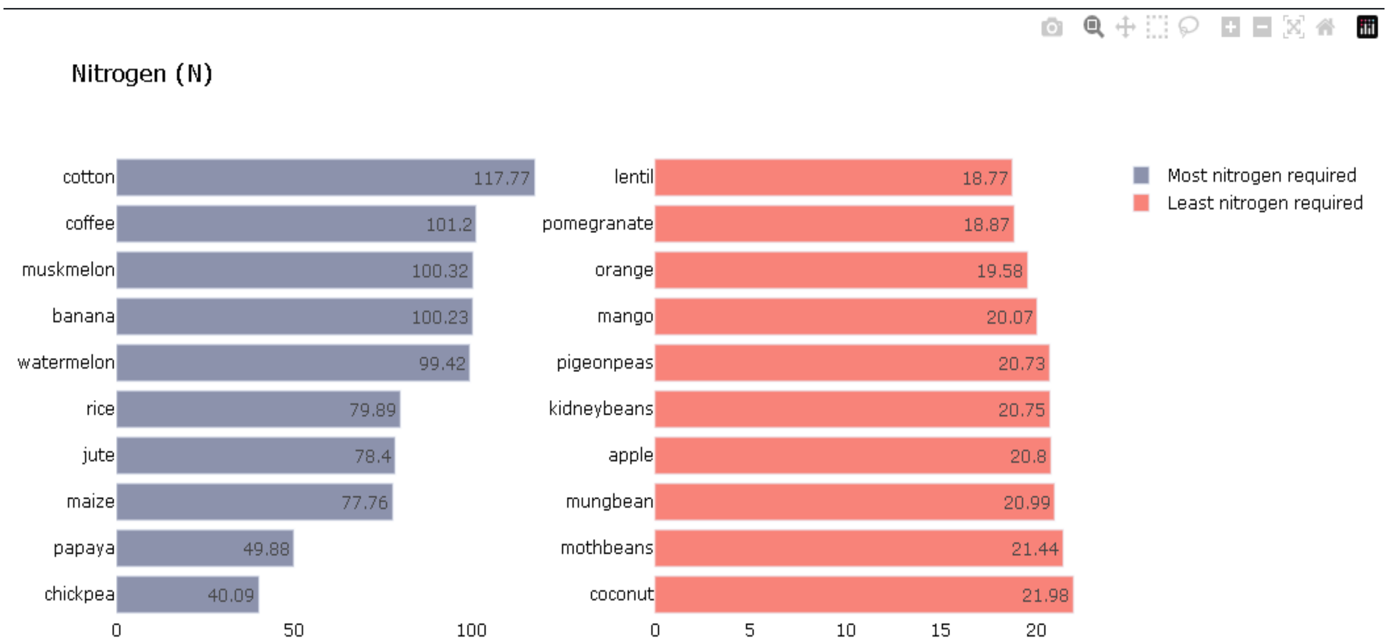

```
crop= pd.read_csv('dataset.csv')
crop.head()
```

	N	P	K	temperature	humidity	ph	rainfall	label
0	90	42	43	20.879744	82.002744	6.502985	202.935536	rice
1	85	58	41	21.770462	80.319644	7.038096	226.655537	rice
2	60	55	44	23.004459	82.320763	7.840207	263.964248	rice
3	74	35	40	26.491096	80.158363	6.980401	242.864034	rice
4	78	42	42	20.130175	81.604873	7.628473	262.717340	rice

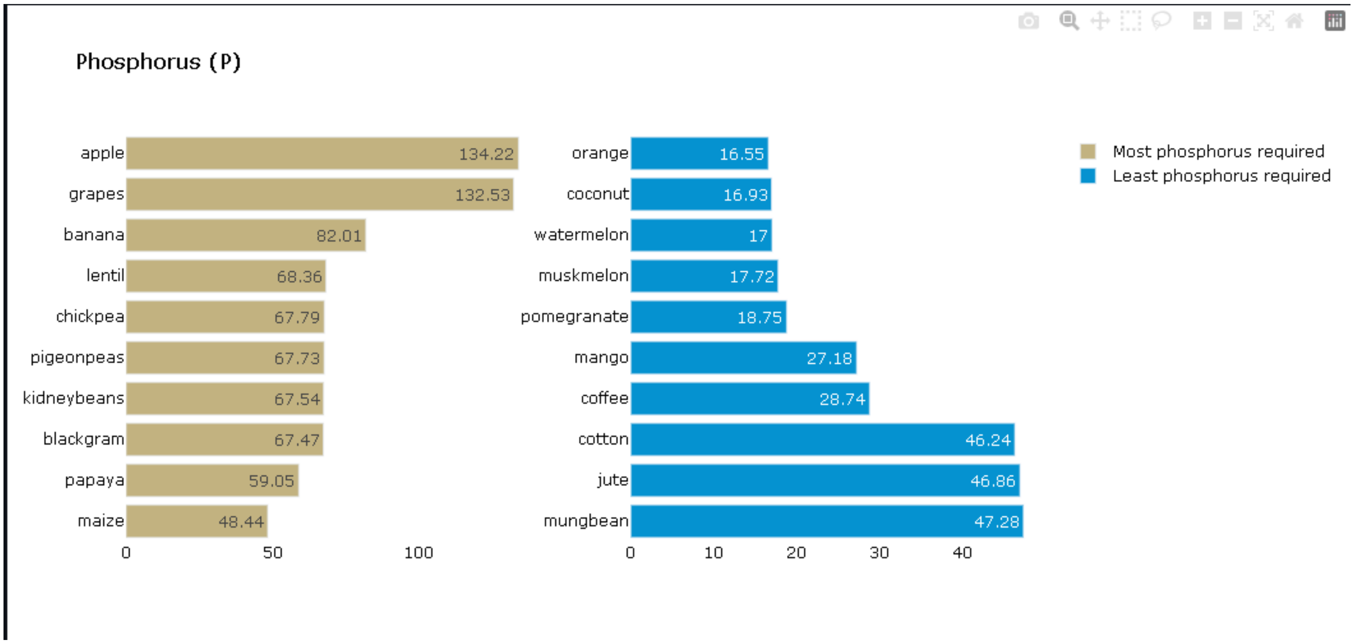
5.**Benchmarking**



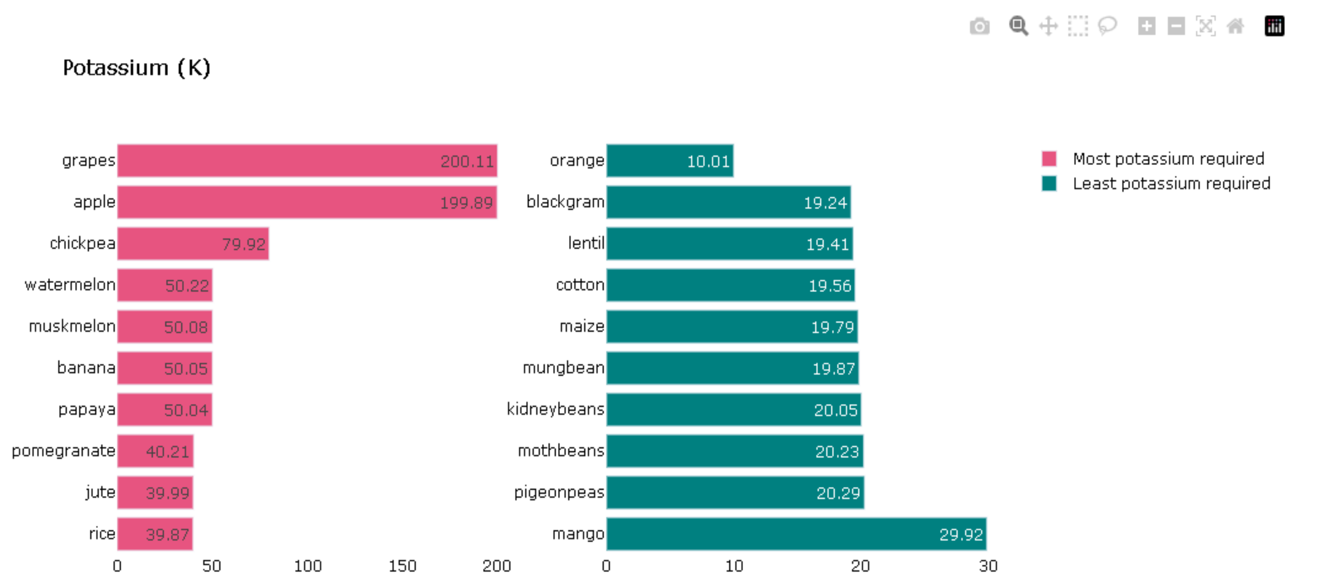
➢ Nitrogen Analysis



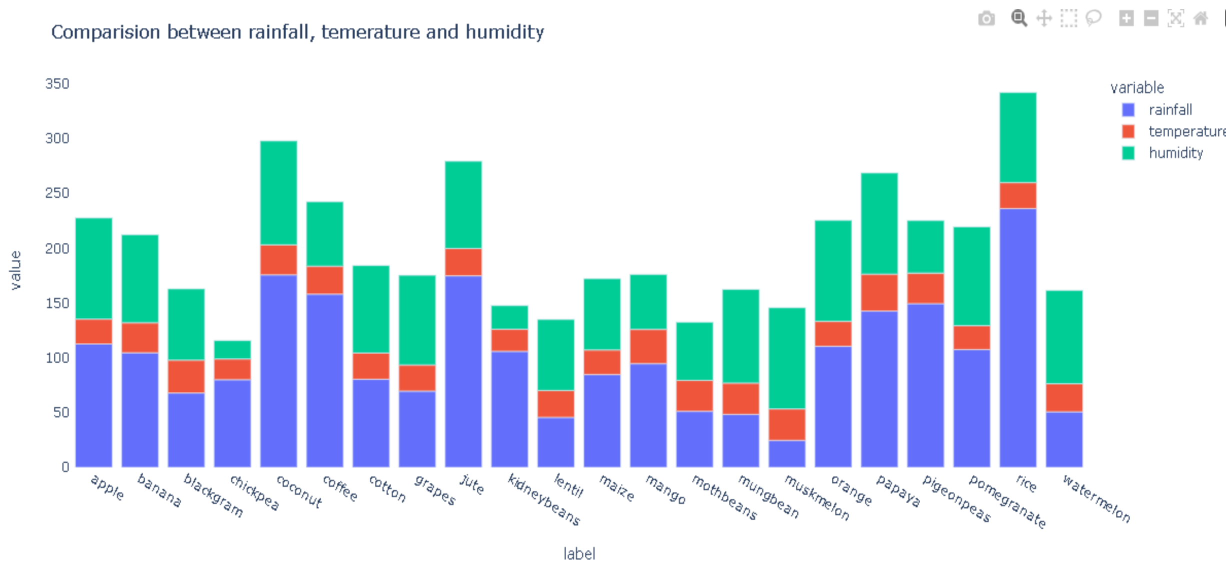
➢ Phosphorus Analysis



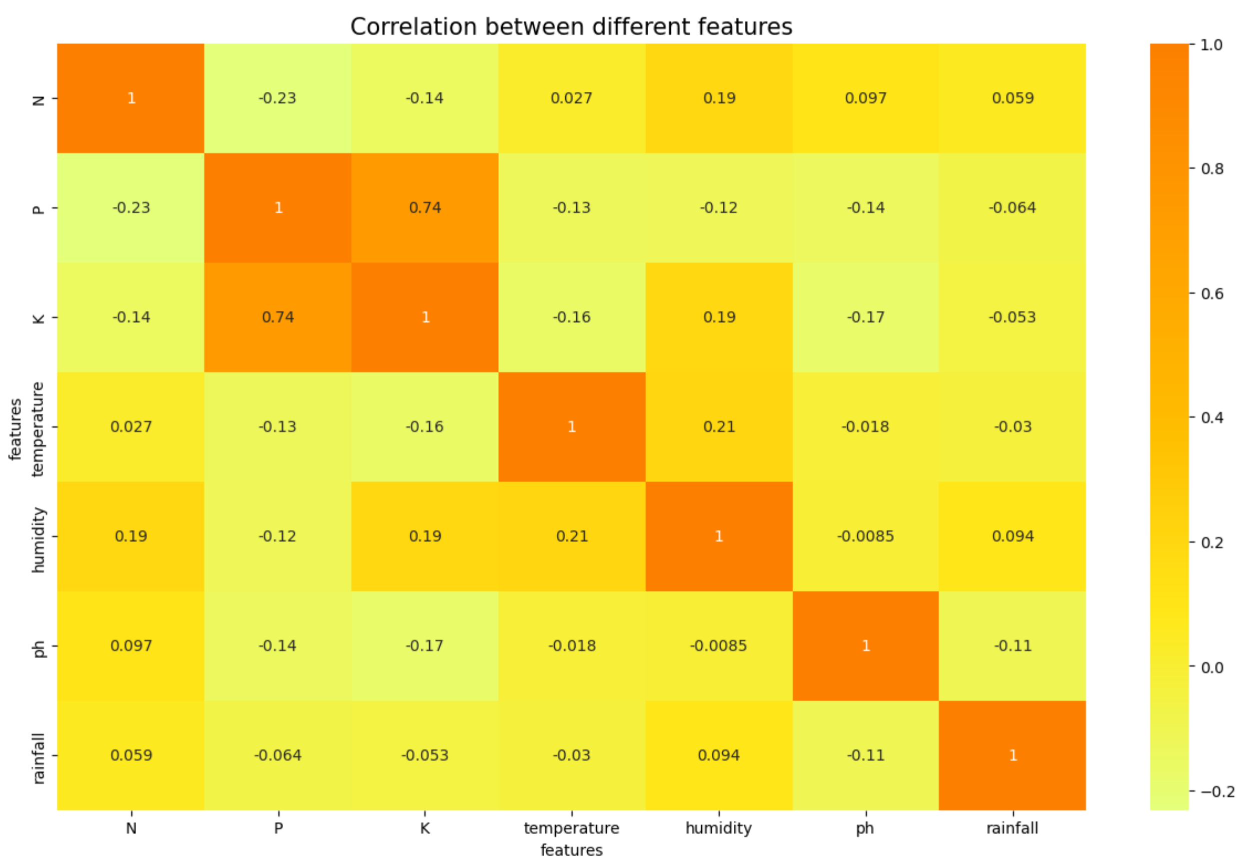
➢ Potassium Analysis



➢ Comparison Between rainfall, temperature and humidity



➢ Correlation Between Different Features



6. Applicable Patents

N/A (Currently, no specific patent is directly applicable to the generic machine learning and web development technologies used in this project.)

7. Applicable Regulations

The implementation of the Crop Recommendation System necessitates strict adherence to a myriad of regulations governing data privacy, environmental protection, and agricultural practices across diverse jurisdictions. Key areas of regulatory considerations include.

Data Privacy and Security:

- Stringent compliance with the General Data Protection Regulation (GDPR) and analogous data protection laws.
- Implementation of robust data security protocols to ensure confidentiality and integrity.

Environmental Protection:

- Conformance with regulations pertaining to environmental conservation and sustainable agriculture practices.
- Adherence to guidelines regulating water usage and conservation practices.

Agricultural Standards:

- Alignment with national and international agricultural standards dictating permissible cultivation practices.
- Consideration of regulations concerning the deployment of genetically modified organisms (GMOs).

Ethical Data Use:

- Strict adherence to ethical guidelines governing data collection, processing, and utilization.
- Acquiring explicit consents from farmers for the ethical and responsible handling of their data.

Cross-Border Compliance:

- Recognition and compliance with varied agricultural policies across borders.
- Adapting to regional nuances to ensure seamless compliance.

Resource Conservation: Adherence to policies fostering sustainable agriculture, encompassing soil conservation and responsible land management practices.

8. Applicable Constraints

While developing the Crop Recommendation System, several constraints must be acknowledged to ensure realistic expectations and effective project management. These constraints encompass various aspects, including technical, resource-related, and environmental considerations.

Data Availability and Quality:

- Constraint: The accuracy and relevance of recommendations heavily depend on the availability and quality of data related to soil composition, climate conditions, and historical crop performance.
- Mitigation: Collaborating with reliable data sources, implementing robust data validation processes, and continuously updating datasets can help mitigate this constraint.

Technological Infrastructure:

- Constraint: The system's performance may be constrained by the technological infrastructure available to end-users, especially in regions with limited internet connectivity or outdated hardware.
- Mitigation: Developing a system that allows for both online and offline functionalities, optimizing for resource-efficient performance, and providing clear system requirements can address this constraint.

Budgetary Constraints:

- Constraint: The project's scope and development may be limited by budgetary constraints, affecting the depth of features, data sources, and scalability.
- Mitigation: Careful resource allocation, prioritizing essential features, and exploring cost-effective technologies can help adhere to budget constraints.

Expertise and Training:

- Constraint: The effectiveness of the system relies on end-users' understanding and adoption. Limited agricultural knowledge or technical expertise among users may impact the system's utilization.
- Mitigation: Developing user-friendly interfaces, providing comprehensive documentation, and conducting training sessions or workshops can help overcome this constraint.

9. <u>Business Model (Monetization Idea)</u>

The success and sustainability of the Crop Recommendation System depend on a robust and viable business model that aligns with the value it provides to farmers and agribusinesses. The chosen monetization strategy should balance affordability for users with revenue generation for the continued development and improvement of the system.

Subscription-Based Model:

- Offer tiered subscription plans catering to different user segments, such as individual farmers and larger agribusinesses.
- Basic plans could provide essential recommendations, while premium plans offer advanced features such as real-time data updates, personalized insights, and integration with farm management systems.

Pay-Per-Use or Pay-Per-Acre Model:

- Implement a pay-per-use model where users pay based on the number of acres or hectares for which they seek recommendations.
- This model is particularly suitable for individual farmers with smaller landholdings who may prefer a more flexible and cost-effective approach.

Consultation and Expert Advice:

- Introduce a consultancy service where users can opt for personalized consultations with agricultural experts.
- This premium service can provide in-depth analysis, customized strategies, and expert guidance based on the Crop Recommendation System's insights.

10.<u>Concept Generation</u>

This product requires the tool of machine learning models to be written from scratch in order to suit our needs. Tweaking these models for our use is less daunting than coding it up from scratch. A well-trained model can either be repurposed or built. But building a model with the resources and data we have is dilatory but possible. The customer might want to spend the least amount of time giving input data. This accuracy will take a little effort to nail, because it’s imprudent to rely purely on Classic Machine Learning algorithm.

- **Clean the data**
- **Split the data in X,Y variables.**

```
Click here to ask Blackbox to help you code faster
X = crop.drop(['label','crop_num'],axis=1)
Y = crop['crop_num']
```

train_test_split data into x_train,x_test,y_train,y_test.

```
Click here to ask Blackbox to help you code faster
x_train,x_test,y_train,y_test  = train_test_split(x,y,test_size=0.4,random_state=42)
print(x_train.shape)
print(x_test.shape)
print(y_train.shape)
print(y_test.shape)
```

[21] ✓ 0.0s Python

```
(1320, 7)
(880, 7)
(1320,)
(880,)
```

We will use multiple models and will select the model with good accuracy.

```
Click here to ask Blackbox to help you code faster
from sklearn.linear_model import LogisticRegression
from sklearn.naive_bayes import GaussianNB
from sklearn.svm import SVC
from sklearn.neighbors import KNeighborsClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.tree import ExtraTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import BaggingClassifier
from sklearn.ensemble import GradientBoostingClassifier
from sklearn.metrics import accuracy_score

# create instances of all models
models = {
    'Logistic Regression': LogisticRegression(),
    'Naive Bayes': GaussianNB(),
    'Support Vector Machine': SVC(),
    'K-Nearest Neighbors': KNeighborsClassifier(),
    'Decision Tree': DecisionTreeClassifier(),
    'Random Forest': RandomForestClassifier(),
    'Bagging': BaggingClassifier(),
    'Gradient Boosting': GradientBoostingClassifier(),
    'Extra Trees': ExtraTreeClassifier(),
}


for name, md in models.items():
    md.fit(x_train,y_train)
    ypred = md.predict(x_test)

    print(f"{name}  with accuracy : {accuracy_score(y_test,ypred)}")
```

[24] ✓ 34.0s

```
Logistic Regression  with accuracy : 0.9579545454545455
Naive Bayes  with accuracy : 0.9931818181818182
Support Vector Machine  with accuracy : 0.9761363636363637
K-Nearest Neighbors  with accuracy : 0.9670454545454545
Decision Tree  with accuracy : 0.9818181818181818
Random Forest  with accuracy : 0.9920454545454546
Bagging  with accuracy : 0.990909090909091
Gradient Boosting  with accuracy : 0.9863636363636363
Extra Trees  with accuracy : 0.9568181818181818
```

By analyzing all the models, we can see that Random Forest is giving good accuracy.

```
Click here to ask Blackbox to help you code faster
from sklearn.model_selection import RandomizedSearchCV

rf = RandomForestClassifier()
param_grid = {'n_estimators':np.arange(50,200),
    'criterion':['gini','entropy'],
    'max_depth':np.arange(2,25),
    'min_samples_split':np.arange(2,25),
    'min_samples_leaf':np.arange(2,25)}

rscv_model = RandomizedSearchCV(rf,param_grid, cv=5)
rscv_model.fit(x_train,y_train)
rscv_model.best_estimator_
✓ 1m 5.9s

RandomForestClassifier
RandomForestClassifier(criterion='entropy', max_depth=22, min_samples_leaf=3,
                       min_samples_split=19, n_estimators=167)
```

11.<u>Concept Development</u>

The concept can be developed by using The appropriate API (flask in this case) using for its deployment , The cloud services has to be choosen accordingly to the need

I created a web app using the flask framework and deployed a machine learning model in the Render platform

12.<u>Final Product Prototype</u>

The primary goal of the prototype is to provide personalized crop recommendations based on various factors such as soil quality, Nitrogen, potassium, humidity, PH level, rainfall, historical yield data, and crop-specific requirements.

<u>Key Features:</u>

- Data Integration: The system integrates diverse datasets, including soil characteristics, various elements that help in crop growing, and crop performance history, to form a comprehensive knowledge base.
- Machine Learning Models: Utilizing state-of-the-art machine learning algorithms, the system employs predictive modeling to analyze input data and generate crop recommendations. These models are trained on historical data to enhance accuracy.
- User Interface: The prototype includes an intuitive

- e user interface accessible via web or mobile platforms. Farmers can input relevant information and receive real-time recommendations tailored to their specific agricultural conditions.

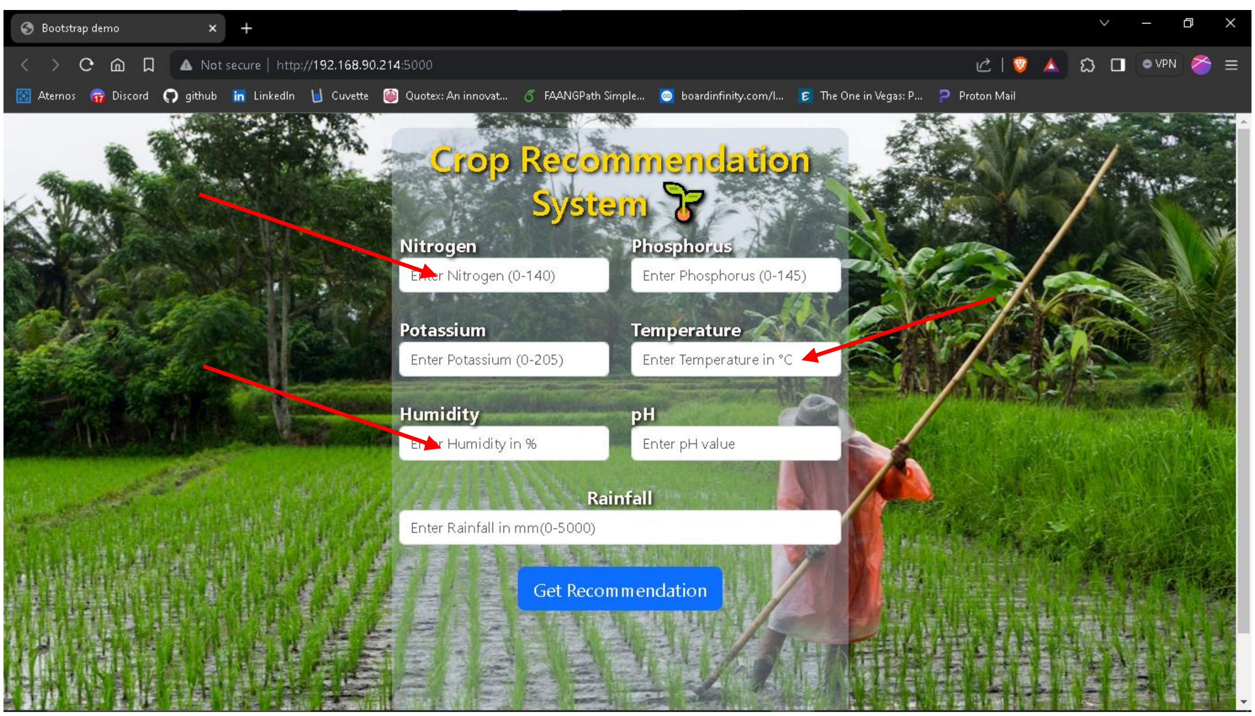
Benefits:

- Optimized Crop Selection: Farmers can make data-driven decisions, leading to optimized crop selection based on local conditions and historical performance.
- Increased Yield: By recommending crops that align with the environmental factors, the system aims to contribute to increased yield and overall farm productivity
- Resource Efficiency: Precision agriculture is promoted by suggesting crops that are well-suited to the available resources, minimizing waste and optimizing resource utilization.

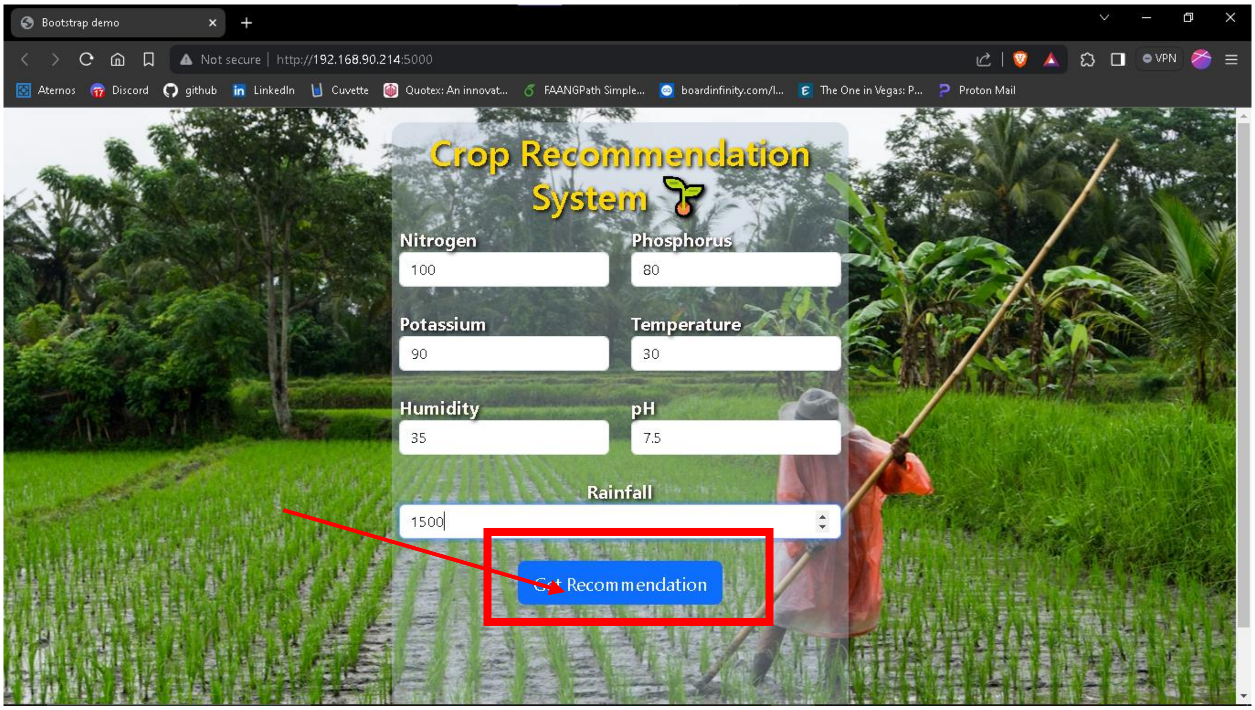
13.Product Detail - How Does it Work ?

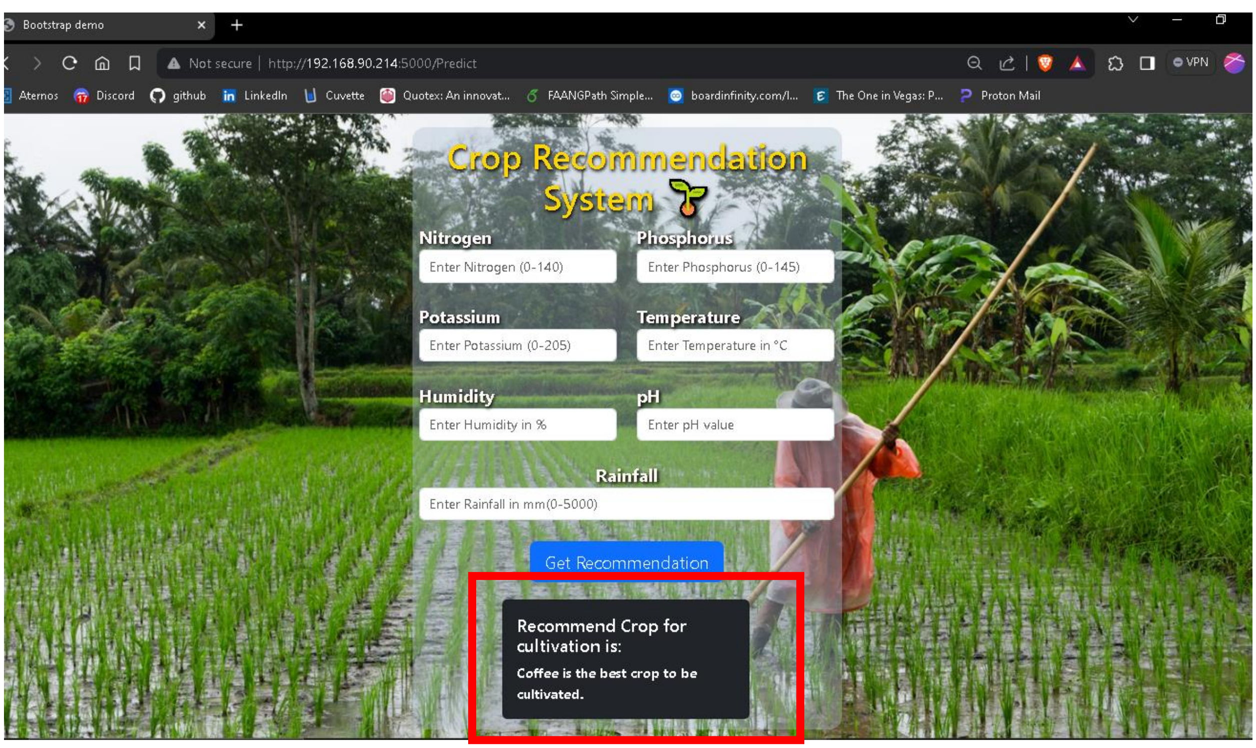
For Getting recommendation follow the steps :

1. Enter all the specified values.



2.**Click Get Recommendation**





14.Code Implementation

Github Link - https://github.com/rohit-padalkar/Crop-Recommendation-WebApp

15.Conclusion

- In conclusion, the Crop Recommendation System outlined in this report is a pioneering solution in response to the evolving challenges faced by modern agriculture. By incorporating a diverse set of factors such as Nitrogen, Phosphorus, Potassium (NPK), Temperature, Humidity, pH level, and rainfall, the system surpasses conventional norms, offering tailored recommendations for optimal crop selection. Utilizing advanced machine learning models, it effectively distills extensive datasets to provide a nuanced understanding of soil composition and climatic conditions.
- At its core, the system's focus on NPK levels ensures the fulfillment of crops' nutritional requirements, promoting optimal growth and increased yield. Moreover, its evaluation of environmental parameters empowers farmers to make informed decisions, influencing crop health, irrigation practices, and sustainable choices. Beyond its role in maximizing productivity, the Crop Recommendation System underscores a commitment to environmental responsibility, contributing to a dynamic understanding of the agricultural ecosystem and fostering a harmonious balance between increased yield and sustainable farming practices. Positioned at the intersection of technology and agriculture, this system represents a transformative tool, shaping a resilient and prosperous future for global agriculture.