International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 03 | March - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

AGROCONNECT - CONNECTING FARMERSTO SMART AGRICULTURE

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Abstract— Crop yield prediction focuses mostly on agricultural research, which have an enormous impact on taking decisions for example import-export, price, along with crop management. Soil is the main component and plays a significant role in agriculture. Based on the nutrients and pH value of the soil, crop yielding is determined. Farmers are still using traditional approach to analysis the soil quality. The techniques like Data Mining, Artificial Intelligence, Machine Learning, Deep learning and Predictive Analytics are the emerging technologies in research to improve the agricultural field. Predictive analysis is a technique of machine learning that predicts the future outcomes and analysis is based on the historical or past data. In agriculture, predictive analytics helps to predict or identify the soil nutrients level required for the crops like Paddy, Raagi, etc., Predicting the crop yield well ahead of its harvest would help farmers and market contractors strategize befitting actions to market and store their produce. These kinds of predictions will also help farmers minimize losses due to crop failure and can also help businesses that depend on agricultural products to plan their business logistics and resources. In this project, a method is proposed which would help predict the estimate of the crop yield for a specific land based on the analysis of geographical and climatic data using Machine Learning using LSTM. Firstly, it is able to capture the time dependency on temperature and rainfall. Secondly, it is able to work on a large and diverse dataset, unlike most models which only perform well in small regions. Lastly, it is able to use several diverse features - geographical, social, and economic to make a prediction. In addition to crop prediction, the system helps farmers to monitor the soil nutrients evolution so that action can be done on real time. The main chemical elements which are taken into the proposed model are nitrogen, phosphorus, potassium, hydrogen along with rainfall and temperature.

Keywords—Crop, Machine Learning, LSTM, deep learning (**key words**)

I. INTRODUCTION

Agriculture and cultivation have been part of human civilization for centuries and is evolving with technology, giving rise to smart farms. The agriculture sector is the backbone of the economy and prosperity of a nation. India is the second-largest producer of agriculture commodities, and the agriculture sector contributes to 17.32% of the country's GDP, which signifies the importance of the agriculture market. The analysis of these data provides valuable insights- known as Precision agriculture (PA)- that can help the farmers to increase productivity, reduce cost, restrict the use of chemical fertilizers and water, increase revenue, understand the seasonal trend demand, etc., which has an impact on the agricultural market. The agriculture markets contribute a significant portion to the economic prosperity of a nation. However, the traditional practices of farming are encountering formidable challenges in the face of climate change, market volatility, and resource scarcity. To address these challenges and usher in a new era of sustainable agriculture, innovative solutions leveraging technology and data-driven approaches are essential. "AgroConnect" emerges as a pioneering initiative aimed at revolutionizing the agricultural landscape by bridging farmers to smart agriculture solutions. This introduction provides an overview of AgroConnect, outlining its objectives, key features, and the transformative potential it holds for farmers and stakeholders across the agricultural value chain. Modern agriculture is confronted with a myriad of challenges that pose significant threats to food production, environmental sustainability, and the livelihoods of millions of farmers globally. Crops are plants grown by the farmers. Agriculture plays a very important role in the Indian economy. It is the backbone of our country. 70% of the Indian population depends on agriculture for food and money. It is the major occupation in the rural areas. The cultivation of crops depends primarily on the weather and soil conditions. Animals and Plants are the two major sources of food. People have always collected plants and hunted animals to fulfil the needs of food and nutrition. Later, people who started agriculture became dependent on it for their nutritional needs.

Climate change-induced disruptions, including erratic weather patterns, extreme weather events, and shifts in growing seasons, have destabilized agricultural systems, leading to yield losses and decreased resilience. Additionally, the volatility of agricultural commodity prices, influenced by factors such as market speculation, trade policies, and supply chain disruptions, exacerbates financial uncertainties for farmers, affecting their livelihoods and economic well-being. The cornerstone of AgroConnect lies in its innovative features and functionalities tailored to the specific needs of farmers. The platform integrates user-generated data, such as soil type, geographical location, and crop preferences to provide personalized recommendations and insights. By leveraging predictive analytics and machine learning algorithms, AgroConnect offers farmers actionable insights into optimal crop selection, planting schedules, and resource management practices.

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Edaphic or soil factors that affect crop growth include water stress (flooding and drought), temperature (extreme cold and heat), nutrient deficiency and toxicity (major and minor elements), soil pH (acidic or salinity), excess light, and mechanical stress. Soil is a thin layer of the earth's crust that serves as a natural medium for plant growth. It is formed from parent rock by the process of weathering over a long period due to rainwater, temperature, and plant and animal residues.

Crop prediction has become increasingly important in recent years, as the global population continues to grow and demand for food increases. Accurate predictions can help ensure that enough food is produced to meet the needs of the population while minimizing waste and optimizing resource use. Crops are plants grown by the farmers. Agriculture plays a very important role in the Indian economy. It is the backbone of our country. 70% of the Indian population depends on agriculture for food and money. It is the major occupation in the rural areas. The cultivation of crops depends primarily on the weather and soil conditions. Animals and Plants are the two major sources of food. People have always collected plants and hunted animals to fulfil the needs of food and nutrition. Later, people who started agriculture became dependent on it for their nutritional needs. “Agriculture” is a complex term encompassing all the human activities in which the Earth’s resources are used appropriately to meet human needs for food, fiber, feed, fuel, etc.

Therefore, the classification of crops has been done to utilize the resources properly. In agriculture, a crop is a plant that can be grown and harvested on a large scale for profit or subsistence purposes. The majority of crops are grown in agriculture or aquaculture. Among the crops are macroscopic fungi (such as mushrooms) and marine macroalgae (such as seaweed).

Deep learning algorithms play a crucial role in determining the features and can handle the large number of processes for the data that might be structured or unstructured. Although, deep learning algorithms can overkill some tasks that might involve complex problems because they need access to huge amounts of data so that they can function effectively.

LSTMs can be defined as Recurrent Neural Networks (RNN) that are programmed to learn and adapt for dependencies for the long term. It can memorize and recall past data for a greater period and by default, it is its sole behaviour. LSTMs are designed to retain over time and henceforth they are majorly used in time series predictions because they can restrain memory or previous inputs.

By using, we present an overview of AgroConnect, highlighting its key features, functionalities, and the underlying technologies that drive its effectiveness. We delve into the significance of predictive analytics in agriculture, particularly in the context of price fluctuations and climate variability, and discuss how AgroConnect leverages these technologies to provide actionable insights and recommendations to farmers.

II. Literature Review

J.D.Mohite et al (2023) proposed approach synthesizes existing knowledge by integrating the strengths of remote sensing and weather observations. The literature reveals that the combination of these two data sources enhances the accuracy and reliability of crop yield predictions by offering a comprehensive view of the interacting factors affecting soybean cultivation. Several studies have emphasized the need for sophisticated modeling techniques to effectively incorporate remote sensing and meteorological data into the prediction framework. The regression modeling conducted in Mohite's research aligns with this trend, as it allows for a systematic analysis of the relationships between municipality-level soybean yield and the diverse set of features derived from remote sensing and weather observations.The literature review underscores the growing consensus that such integrated approaches have the potential to revolutionize crop yield forecasting, providing actionable insights for farmers to make informed decisions. This capability enables timely interventions in response to emerging crop issues, helping farmers optimize resource allocation and management practices. By integrating these advancements into soybean yield prediction, Mohite's work contributes to the ongoing discourse in agricultural research, emphasizing the importance of multidimensional data integration for enhancing the resilience and productivity of crop cultivation systems.

Alejandro Morales and Francisco J et al (2023) proposed a model that focusing on data- driven predictions of crop yields derived from farm-level information encompassing soil, climate, and management practices. The increasing reliance on ML for yield prediction, with a multitude of studies highlighting the potential of these models in leveraging diverse datasets to enhance accuracy and inform decision-making in agriculture. The application ofML in crop yield prediction is especially pertinent given the complexity of factors influencing agricultural outcomes, including climatic conditions, soil characteristics, and management practices. The choice of algorithms, such as regularized linear models, randomforest, and artificial neural networks, is scrutinized in the context of predicting sunflower and wheat yields across different regions in Spain that specifically employing ordered data to simulate predictive performance in future years based on historical trends.

Thomas van Klompenburg et al (2023) proposed application of machine learning in crop yield prediction, shedding light on the diverse algorithms and features employed in this domain. The investigation unveiled the predominant use of machine learning as a crucial decision support tool for crop yield prediction, aiding decisions related to crop selection andmanagement throughout the growing season. The findings underscore the significance of temperature, rainfall, and soil type as the most commonly utilized features in crop yield prediction models. Artificial Neural Networks emerged as the dominant algorithm among the various machine learning techniques employed in the selected studies. It also offers valuable suggestions for future research directions in crop yield prediction. Within this subset, Convolutional Neural Networks (CNN) emerged as the most widely applied deep learning algorithm, indicating its effectiveness in addressing the complexities of crop yield prediction tasks. Additionally, Long-Short Term Memory (LSTM) and Deep Neural Networks (DNN) were identified as other prominent deep learning algorithms.

III. PROPOSED WORK

A. Synthetic Procedure

The project is to develop a web-based application that predicts the best crops to grow based on climate, soil, and other relevant features. The project aims to provide an accurate and reliable crop recommendation system to farmers and other end-users, enabling them to make informed decisions on what to grow and when to plant.

This can help farmers to make informed decisions about crop selection and optimize their yield and profits. The project involves data collection, pre-processing, feature extraction, classification using LSTM, and performance analysis.

The proposed system "Crops2Go" is a web-based application that aims to predict the appropriate crops to grow based on several environmental factors such as temperature, humidity, pH, rainfall, and soil nutrients (N, P, K). The system collects the data from reliable sources and pre-processes it by removing null, missing values, redundant data, and misspelled data. After pre-processing, feature extraction is done using a confusing matrix to identify the most important features for crop prediction.

The system uses the LSTM algorithm for classification and prediction of crops based on the extracted features. The LSTM model is trained on a dataset of historical crop data and environmental factors to predict the best crops to grow in a given area. The trained model is deployed in the production environment and can be accessed through a user-friendly web interface. The end-users of the system are system administrators who train and maintain the model and farmers who want to predict which crops to grow based on the climate, soil, and water features of their region. Farmers can access the system through a web-based interface and get recommendations, suggestions, and alert notifications based on the predictions made by the model.

The proposed system uses Python Flask, Tensor Flow, and MySQL for its development and deployment. Performance analysis is done regularly to ensure that the system is accurate and up-to-date with the latest data. Overall, the proposed system is an effective tool for farmers to make informed decisions about which crops to grow based on environmental factors.

- Data Collection: The first step is to collect climate, water, and rainfall data from reliable sources. This may include government agencies, weather stations, and other relevant sources. The collected data should be in a format that can be easily processed, such as CSV or JSON.
- Data Pre-processing: The collected data needs to be pre-processed to remove any noise and inconsistencies. This involves several steps, including removing null and missing values, removing redundant data, correcting misspelled data, and handling outliers. The data will also be transformed into a format suitable for analysis and modelling.
- **Feature Extraction:** Feature extraction is the process of selecting and transforming the elevant features from the pre-processed data. This may involve statistical techniques, such as Principal Component Analysis (PCA), or machine learning algorithms, such as Confusion Matrix. The goal is to identify the most relevant features that have the most impact on crop yields.
- **Classification using LSTM:** LSTM is a type of deep learning algorithm that is well suited for time-series data such as climate, water, and rainfall data. The pre-processed and extracted features will be used to train the LSTM model to classify the optimal crops to grow in a given region. The LSTM model will learn the patterns and relationships between the data and crop yield and use this information to make predictions about the optimal crops to grow.
- **Prediction:** Once the LSTM model is trained, it will be used to predict the optimal crops to grow in a given region based on the climate, water, and rainfall data. The predictions will be displayed to the user in a user-friendly web-based application.
- **Performance Analysis:** The performance of the LSTM model will be evaluated using various metrics such as accuracy, precision, recall, F1-score, and AUC. The analysis will help to identify any areas where the model may need further improvement.
- **Deployment:** The final step is to deploy the web-based application to a cloud server, making it accessible to farmers and agricultural businesses from anywhere with an internet connection.

To empower farmers with data-driven crop selection. It utilizes machine learning to analyze environmental factors like climate, soil nutrients, and water availability. By collecting data from reliable sources and pre-processing it for quality, Crops2Go trains an LSTM model to identify the optimal crops for a specific region. Farmers can then access this information through a user-friendly interface, receiving recommendations and predictions tailored to their local conditions. This system continuously updates with the latest data to ensure its accuracy and provide farmers with the tools to make informed decisions for their crops.

B. Existing System

Traditionally, farmers and agricultural experts have relied on manual methods to predict which crops to grow in a given region. Some of the commonly used manual methods include:

- **Decision trees:** Decision tree algorithms are commonly used for crop prediction. They work by constructing a tree-like model of decisions and their possible consequences. The algorithm splits the data into different nodes based on various attributes and determines the optimal crop based on the attributes of the region.
- **Support vector machines (SVM):** SVM algorithms are a type of machine learning algorithm that can be used for crop prediction. SVM works by mapping the data into a high-dimensional feature space and

identifying a hyperplane that separates the different classes of crops.

- **Artificial neural networks (ANN):** ANNs are another commonly used algorithm for crop prediction. ANNs are modelled on the structure and function of the human brain and can be used to model complex relationships between different variables, including climate, water, and rainfall data.
- **Random forests:** Random forests are a type of ensemble learning algorithm that can be used for crop prediction. The algorithm works by constructing multiple decision trees and combining their predictions to produce a final output.
- **K-nearest neighbour (KNN):** KNN is a simple but effective algorithm for crop prediction. The algorithm works by finding the K-nearest data points in the training set to a given point and determining the optimal crop based on the attributes of the nearest data points.

C. Scope of the project

The scope of the project is to develop a web-based application that predicts the crop that can be grown in a particular region based on various environmental factors such as temperature, humidity, pH, rainfall, and soil nutrients like nitrogen, phosphorus, and potassium. The web application will be user-friendly, and end-users will be able to input environmental factors and soil nutrient values of their region and get a prediction of the most suitable crop that can be grown. The system will also provide recommendation and suggestion notifications to the farmers or users based on the prediction. The project aims to provide a reliable and accurate prediction of the crop that can be grown in a particular region, taking into consideration various environmental and soil nutrient factors. The system will be helpful to farmers, researchers, and other end-users who are interested in crop production and management.

D. System Study

The system "Crops2Go: Web based Crops to grow Prediction with Temperature, Humidity, pH, Rainfall, Soil NPK Features using LSTM" can be implemented using various technologies and frameworks. Here is one possible implementation:

- Backend: Python Flask, which is a lightweight web framework that can handle HTTP requests and responses. Flask can also be used to implement a RESTful API for the system.
- Database: MySQL, which is a popular open-source relational database management system. MySQL can store the dataset and the trained model parameters.
- Machine Learning: TensorFlow, which is an open-source software library for dataflow and differentiable programming across a range of tasks. TensorFlow can be used to implement the LSTM model for crop prediction.

The system is implemented in the following way:

1. Web Admin uploads the dataset to the MySQL database.
2. Data pre-processing is done on the dataset, which includes removing null values, missing values, redundant data, and misspelled data.
3. Feature extraction is performed on the dataset using a confusion matrix to select the best features for training the LSTM model.
4. The LSTM model is built and trained using TensorFlow on the pre-processed and feature extracted dataset.
5. The performance of the trained model is evaluated using performance metrics such as accuracy, precision, recall, and F1 score.
6. The trained LSTM model is saved to disk.
7. The trained LSTM model is deployed on the Flask web framework, and the web application is made available to farmers or end-users for testing.
8. The farmer or end-user inputs the required environmental parameters such as temperature, humidity, pH, rainfall, soil NPK, and the LSTM model predicts the best crops to grow based on those parameters.

Overall, the system implementation of "Crops2Go: Web based Crops to grow Prediction with Temperature, Humidity, pH, Rainfall, Soil NPK Features using LSTM" involves the use of various technologies to provide an easy-to-use web application that can predict the best crops to grow based on environmental parameters.

E. LSTM Model

The Crops2Go LSTM model has two main modules: the build module and the train module. The build module is responsible for building the LSTM model architecture. This includes defining the input layer, the hidden layer, and the output layer. The input layer accepts the input features such as temperature, humidity, pH, rainfall, and soil NPK values. The hidden layer is where the LSTM algorithm is applied to the input features to learn and extract the relevant features for crop prediction. The output layer produces the final prediction for the crop to be grown based on the input features. The train module is responsible for training the LSTM model using the training dataset. This involves defining the loss function, the optimizer, and the training metrics. The loss function measures the difference between the predicted output and the actual output. The optimizer adjusts the model parameters to minimize the loss function. The training metrics measure the performance of the model during training, such as accuracy and loss. Once the LSTM model is built and trained, it can be used to predict the crop to be grown based on the input features such as temperature, humidity, pH, rainfall, and soil NPK values. The model performance can be analysed using metrics such as accuracy, precision, recall, and F1-score.

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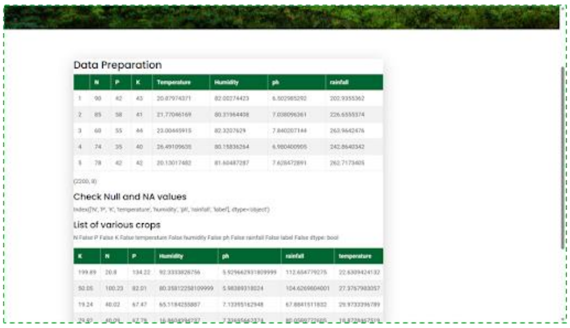

Fig 1.Data Preparation

The pre-processing module in "Crops2Go" is responsible for cleaning and transforming the data to prepare it for use in the LSTM model. The following are the steps involved in the pre-processing module:

- Remove Null and Missing Values: Null and missing values are removed from the dataset as they can cause errors in the LSTM model.
- Remove Redundant Data: Redundant data is also removed to reduce the size of the dataset.
- Remove Misspelled Data: Misspelled data is corrected or removed as it can cause errors in the LSTM model.
- Feature Scaling: Feature scaling is applied to the input features to ensure that they have the same scale.
- Convert Data to Tensors: The dataset is converted into tensors, which is the required input format for the LSTM model.
- Reshape Data: The input data is reshaped into the format expected by the LSTM model.
- By performing these steps, the pre-processing module ensures that the data is clean, consistent, and properly formatted for use in the LSTM model.

F. Feature Extraction

In the Feature Extraction module of "Crops2Go", we extract the relevant features from the pre-processed data that will be fed into the LSTM model for classification and prediction. This is a critical step as it can significantly impact the accuracy and efficiency of the model. One common approach for feature extraction in LSTM models is to use a Confusion Matrix. The confusion matrix is a table that is used to evaluate the performance of a classification model. It shows the number of correct and incorrect predictions that the model made compared to the actual outcomes. From this, we can extract information about the model's sensitivity, specificity, accuracy, and other metrics.

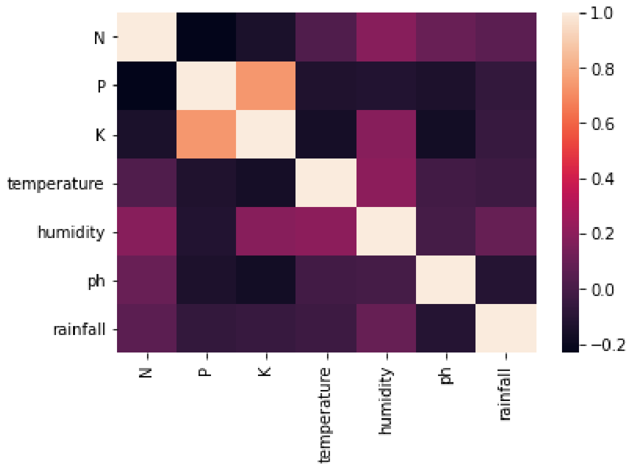

Fig 2. Feature Extraction

After analysing the confusion matrix, we can select the most relevant features for the model. These features can include variables such as temperature, humidity, rainfall, and soil moisture levels. We can also use techniques such as Principal Component Analysis (PCA) to reduce the number of features without losing too much information. Once the relevant features have been selected, we can prepare the data for classification using the LSTM model. This involves converting the data into a suitable format for the model, such as creating time series data or normalizing the data to a specific range. The data is then split into training and testing sets to evaluate the performance of the model. This helps to reduce the complexity of the model and improve its accuracy. The selected features are then used as inputs to the LSTM model for training and prediction. The Feature Extraction module is developed using Python and various Python libraries such as NumPy, Pandas, and Scikit-learn.

The feature extraction modules in the Crops2Go project are responsible for extracting important features from the input data that are relevant to predicting the type of crops to be grown.

The modules focus on extracting features related to temperature, humidity, pH, rainfall, and soil NPK.

- **Temperature Feature**
  The temperature feature extraction module pre-processes the temperature data and extracts important statistical features such as mean, median, mode, variance, standard deviation, maximum, minimum, and range. These features are used as inputs to the LSTM model.
- **Humidity Feature**
  The humidity feature extraction module extracts statistical features such as mean, median, mode, variance, standard deviation, maximum, minimum, and range from the humidity data. These features provide important information that can be used to predict the type of crops that can be grown in a particular area.
- **PH Feature**
  The pH feature extraction module extracts statistical features such as mean, median, mode, variance, standard deviation, maximum, minimum, and range from the pH data. These features are important in

determining the acidity or alkalinity of the soil, which is a crucial factor in deciding the type of crops that can be grown in a particular soil.

- **Rainfall Feature**
  The rainfall feature extraction module extracts statistical features such as mean, median, mode, variance, standard deviation, maximum, minimum, and range from the rainfall data. These features provide important information on the amount of rainfall in a particular area, which is a crucial factor in deciding the type of crops that can be grown in a particular area.
- **Soil NPK Feature**
  The soil NPK feature extraction module extracts important features related to soil nutrients such as Nitrogen, Phosphorus, and Potassium. These features are important in determining the fertility of the soil and the type of crops that can be grown in the soil.

Overall, these feature extraction modules help in extracting important features from the input data that are relevant to predicting the type of crops to be grown in a particular area.

IV. Results and Discussions

The results obtained from the AgroConnect project highlight the potential of data-driven decision support systems to transform agricultural practices and improve farmer livelihoods. By leveraging advanced algorithms, machine learning techniques, and external data sources, the AgroConnect platform provides farmers with actionable insights and recommendations tailored

to their specific needs and conditions. The integration of real-time crop prediction based of pH, Nitrogen, Potassium, Phosphorous and fertilizer recommendations enhance farmers' ability to optimize resource allocation, mitigate risks, and maximize returns on investment.

Furthermore, the modular design of the AgroConnect platform facilitates scalability and adaptability, allowing for the integration of additional modules and functionalities in the future. This enables continuous improvement and expansion of the platform to address evolving challenges and opportunities in the agricultural sector. Moreover, the user-friendly interface and accessibility features of the platform ensure inclusivity and usability for farmers of all backgrounds and technical abilities.

In conclusion, "Crops2Go" is a web-based application that allows farmers or users to predict the best crops to grow based on climate, water, soil NPK and rainfall features using LSTM. The application has been developed using Python Flask, Tensor Flow, Keras, and MySQL, and it has undergone extensive testing to ensure its functionality, reliability, and accuracy. The system has several modules such as Data Collection, Pre-processing, Feature Extraction, Classification, Prediction, Performance Analysis, and Alerts/Notification module.

The datasets used for training and testing the model have been obtained from Kaggle, and they have been adequately described the feasibility study showed that the project is viable and can be successfully implemented. The software testing phase ensured that the system is robust and meets the requirements of the end-users.

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