Introduction:

Agriculture is the foundation of human civilization, providing nutritional, livelihood and economic growth. However, as the world's population increases, the need for agricultural resources increases, necessitating a review of conventional farming practices. In order to meet the requirements for food from a growing population and boost yields, modern agriculture must also work to minimize its impact on the environment. According to the latest research, current agricultural food production must increase by more than 70% by 2050 (Thilakarathne et al., 2022).This need is driven by the need to earn a living for an expanding global population in. Maintaining this delicate balance desperately needs precision agricultural solutions that maximize resource efficiency, increase productivity, and reduce environmental impact.

The introduction of advanced technology in agriculture has led to the development of various intelligent agricultural products. Among these, the Crop Recommendation Scheme (CRS) has emerged as a promising approach to address the challenges of sustainable agricultural production CRS can use artificial intelligence technology, machine learning, and data analytics to make specific crop recommendations based on a variety of variables, including soil type, climate, historical yield data, market trends, etc., to make decisions consistent with their economic interests and environmental considerations (Jadhav & Bhaladhare, 2022).

As the world faces food security and conservation challenges, the role of technology in reshaping agriculture is becoming increasingly apparent Although the Crop Recommendation System (CRS) has made remarkable progress in changing the crop selection through data analysis -To provide synthetic yet accurate information to CRS benefits generated by agriculture and knowledge integration (Mani & Edinburgh, n.d.). CRS based on data-driven insights is only as robust as data capture. Finding the optimal mix of data types and volumes can be a challenging endeavor. Real-world agricultural datasets, especially at the granular level, are often scarce and variable in time and space (Chougule et al., 2019). This shortcoming hinders the flexibility and predictive accuracy of the system, especially in dynamic environments such as agricultural land.

The ability of Generative Adversarial Networks (GANs) to generate synthetic data that closely resembles extensive real-world segmentation has been proven (Li et al., 2019). In our approach, GANs work together with rule-based algorithms to generate synthetic farm records. GAN’s generator crafts data that match the underlying distribution of real agricultural records. A discriminator trained on real-world data ensures that the generated models are consistent with realistic, complex agricultural data.

The official website of Tamil Nadu Agriculture serves as a goldmine of valuable agricultural statistics, encompassing diverse variables such as soil composition, weather patterns, crop yields, and cultivation practices. This repository not only serves as a rich source of authentic data but also informs the rule-based algorithms guiding our GANs. By encapsulating the wisdom of Tamil Nadu's agricultural practices, we augment the realism and relevance of the synthetic data generated.

The synergy between GAN-generated synthetic data and rule-based algorithms imparts a newfound vitality to Crop Recommendation Systems. The enriched datasets overcome the limitations of real-world data scarcity, capturing relationships and subtle changes. Using this synthesis of data, CRS’s recommendations are deeper and more accurate, enabling farmers to gain insights that reflect a harmonious mix of established practices and new technologies.

The ensemble method shows a symbiotic unity between gradient boosting and SVM. Gradient boosting excels in capturing complex relationships and patterns, while SVM results in complex decision boundaries (Guerrero et al., 2012). By combining their results in a weighted manner, we develop an integrated model that provides comprehensive insights into crop selection (Fan et al., 2018).

This approach not only overcomes the challenge of data scarcity, but also promotes CRS with the predictive power of advanced machine learning. As we move forward on the journey of sustainable agriculture, this initiative will emerge as a beacon of innovation, promising to transform the way crops are grown, adapted and managed.

Literature review:

According to (Ujjainia et al., 2021), The impact of technology on agriculture cannot be ignored, as it has led many agricultural organizations and farmers to incorporate smart and innovative technologies into their practices and this trend has subsequently led to a significant increase in crop production, leading to the needs of the growing global population. However, the agricultural industry is facing an ongoing challenge to accurately predict the complexity of the ecological systems required for optimal yields and in this case, the application of machine learning appears as a potential solution to this issue (Gosai et al., 2021).

Machine learning techniques find utility in agriculture, where historical data sets are analyzed. These research methodologies have the potential to provide valuable insights for farmers and the national economy as a whole (Suresh et al., n.d.). (Madhuri & Indiramma, 2021) employed artificial neural networks to make agricultural recommendations depending on the features of the crop, the soil, and the climate. This recommendation model uses real-time input to advise the best crop for a given area. In general, there are only a few dimensions that machine learning models may handle. The model's complexity grows as the variety of variables rises. (Attaluri et al., 2020).

The reliability of these datasets directly impacts the accuracy and effectiveness of machine learning algorithms in providing informed crop suggestions. This paper introduces PSO-MDNN, recommendation model created using a classifier and an optimization of the classifier using a Modified DNN (Deep Neural Networks) and PSO (Particle Swarm Optimization) for crop cultivation (Mythili & Rangaraj, 2021). This suggests that deep learning approaches can be less expensive and scale well in locally collected samples. In this (Li et al., 2019) Generative Adversarial Networks (GANs) is employed to create new data instances that resemble the distribution of the original dataset, effectively increasing the diversity and size of the training data available for machine learning models. A generator and a discriminator comprise the initial GAN. In the original GAN, the generator's input is random noise (Tian et al., 2021).

The Support Vector Machine (SVM) is a non-parametric classification method that uses nonlinear kernel operations to distinguish between multimodal class distributions in feature spaces with high dimensions (Löw et al., 2013). It performs poorly on overlapping classes but has minimal effect on outliers (Ganesan et al., 2021)..

During training, many established AI models are intricate and computationally costly. Tree-based ensembles such as Gradient Boosting (GB), Random Forest (RF), and Extremely Randomized Trees (Extra-Trees) are examples of rule-based Decision Trees (DT) are gaining prominence due to their simplicity, strength, and predictive prowess (Fan et al., 2018). An analysis of the recommendation system describes methods of policy recommendation e.g. Collaborative, Content-Based Hybrid Recommender Systems and their limitations and possible extensions for those who can improve the recommendation capabilities of these systems (Kuanr et al., 2018).

This study (Oikonomidis et al., 2022), shows that the second best results were obtained with the XGBoost model, which took less time to implement than other DL-based models. By using efficient feature selection approaches and a heterogeneous methodology for estimating crop production, they had accounted for the majority of the necessary predictor factors (Iniyan & Jebakumar, 2022).

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