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Land Pulse: Real-Time Agriculture Parameter Forecasting

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Abstract— **Growing crops and trees together is known as agroforestry, and it is often regarded as an integrated strategy for sustainable land management. The proposed project explores the possibility of generating geographically precise estimates of crop output in an agroforestry system using Sentinel-2 time series data. Sentinel-2 is a European Space Agency (ESA) satellite mission that provides high-resolution multispectral imagery for land and water monitoring. Since agroforestry systems (AFSs) are thought to be better able to capture and utilize growth resources (light, nutrients, and water) than single-species crop or pasture systems, they are thought to have a higher capacity to store carbon (C). Sentinel-2's high-resolution multispectral imaging allows for precise land cover mapping in agroforestry landscapes. Sentinel-2 data aids in determining the size and distribution of agroforestry areas by differentiating between various land cover types, such as forests, crops, and grasslands. Additionally, Sentinel-2's spectral reflectance data makes it possible to monitor vegetation and measure the health and growth of plants. The Normalized Difference in Vegetation Index (NDVI), one of the vegetation indices obtained from Sentinel-2 data, offers insights into the vigor and productivity of both trees and crops within agroforestry systems. Understanding light interception, water usage effectiveness, and general ecosystem functioning in agroforestry depends on evaluating tree canopy properties. The structure and density of tree canopies can be learned from Sentinel-2 data by estimating metrics like the Leaf Area Index (LAI) and Fractional Vegetation Cover (FVC). Sentinel-2 data also makes it possible to monitor and assess crop growth in agroforestry systems. Farmers can maximize yields by monitoring crop phenology changes and identifying stress factors.**

***Index Terms*— component, formatting, style, styling, insert.**

I. INTRODUCTION

Agriculture, as one of the cornerstones of human civilization, is facing unprecedented; challenges in the 21st century. With a rapidly growing global population and the need to sustainably manage our natural resources, farmers are under increasing pressure to optimize their land use and crop management practices. The key to addressing these challenges lies in harnessing advanced technologies to make informed decisions about agricultural land parameters and crop suitability.

The proposed project focuses on the integration of cutting-edge tools and techniques to forecast agricultural land parameters and predict the most suitable practices for growing crops. Specifically, it combines Sentinel-2 Synthetic Aperture Radar (SAR) imagery, which provides invaluable data on land conditions regardless of weather or daylight, with on-field soil sensors to obtain real-time, ground-level information. By merging these data sources

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and employing advanced data analytics and machine learning algorithms, this project aims to empower farmers with the knowledge they need to optimize their agricultural practices.

II. Literature Survey

Burkina Faso et al. proposed the Potential of Sentinel-2 for Crop Production Estimation in a Smallholder Agroforestry Landscape and have explored the use of Sentinel-2 time series data for crop production estimation in a smallholder agroforestry landscape in central Burkina Faso. The study measured total above-ground biomass and grain yield in 22 field plots over two growing seasons with different rainfall timings and amounts. The results showed that Sentinel-2 data could explain 41-80% of the variation in in situ crop production measurements, with relative root mean square errors for AGB estimates ranging between 31-63 percent in 2017 and 2018. The study suggests Sentinel-2 data could be a valuable resource for scaling up field measurements of crop yield in Burkinabe agroforestry systems [1].

Golsa Shirazinejad, Mohammad Javad Valadan Zoej, Hooman Latifi, et al. proposed Applying multidate Sentinel-2 data for forest-type classification in complex broadleaf forest stands. They classified ten forest types using a random forest algorithm and computed area-adjusted confusion matrices. Results showed overall classification accuracy of 67-74% for single-date S2 data, and 28% for multidate S2 images. Joint use of DEM data and multidate S2 images improved overall accuracy by 3%. The study also examined the effect of topographic correction of S2 data on classification performance, finding no significant impact. The findings demonstrate the high potential of freely available multisource remotely sensed data for broadleaf tree species classification across complex broad-leaved forest landscapes [2].

Keiko Nomura et al. proposed More Than Meets the Eye: Using Sentinel-2 to Map Small Plantations in Complex Forest Landscapes, including oil palm, rubber, and betel nut farms in Southern Myanmar. The study used a Random Forest classifier for all 13 Sentinel-2 bands, vegetation, and textural indices over a 13,330ha area. Despite the visually similar tree crop classifications at a 20 m resolution, the median overall accuracy was 96%. The freely available Sentinel-2 data, revisited every five days, can distinguish between identical tree crop kinds. The large number of spectral bands in Sentinel-2 data suggests potential for a wider application of Sentinel-2 data for tiny land parcel classification without relying on object-based classification [3].

Tao Liangliang et al. proposed a modified vegetation backscattering model to retrieve plant-covered soil moisture from SAR and optical data. The model considers the scattering effects of bare soil and vegetation canopy, integrating the advantages of optical and radar approaches. The model separated the scattering mechanism of the plant from the bare soil component in a pixel using vegetation coverage. An advanced integral equation method was proposed to define the dispersion of underlying bare soil. Crown water content was determined using the PROSAIL optical model. The improved model performed better in soil moisture retrieval on March 29, 2014, and can be applied in agricultural locations with moderately sparse to complete cover surfaces [4].

Wen Zhuo et al. proposed Assimilating Soil Moisture Retrieved from Sentinel-1 and Sentinel-2 Data into WOFOST Model to Improve Winter Wheat Yield Estimation. The study aims to improve the precision of winter wheat yield estimation by incorporating time series soil moisture images into the crop model. Optical remote sensing data is more sensitive to clouds and rain than synthetic aperture radar (SAR), making it more reliable and consistent. The data was collected from optical pictures of Hengshui City in Hebei, China, and SAR images from C-band SAR sensors mounted on Sentinel-1 satellites. The water cloud model was used to create time series soil moisture images using the normalized difference vegetation index (NDVI) backscattering coefficients and polarimetric indicators. The Ensemble Kalman Filter (EnKF) technique was used to include the remotely sensed soil moisture into the World Food Studies (WOFOST) model, enhancing the prediction of crop yields at the field scale. The results showed that the assimilation of remotely sensed soil moisture improved the correlation between observed and simulated yields, demonstrating the potential of incorporating SM from Sentinel-1 C-band SAR and Sentinel-2 MSI optical remote sensing data into the WOFOST model for estimating winter wheat yield [5].

Huang et al. proposed the Evaluation of regional estimates of winter wheat yield by Assimilating three remotely sensed reflectance datasets into the coupled WOFOST–PROSAIL Model. A new data-assimilation technique has been developed to calculate regional-scale winter wheat yield using remotely sensed reflectance. The technique combines MODIS surface reflectance data with Landsat surface reflectance to produce an 8-day, 30-m resolution synthetic Kalman Smoothed reflectance time series. The researchers assessed the assimilation performance of the coupled WOFOST-PROSAIL model using various datasets. They created a four-dimensional variational data assimilation (4DVar) cost function to account for variations between observed and simulated reflectance. The optimized parameters were used to calculate county-level winter wheat yield in China. The most precise yield estimates were obtained at the county level, followed by Landsat reflectance and MODIS reflectance. This approach enhances crop production estimations at the regional level [6].

Massimiliano et al. proposed Agriculture, climate change and sustainability: The case of EU-28.Agricultural practices and climate change have a complicated cause-and-effect relationship. The agricultural industry produces significant greenhouse gas emissions, which impact the volume, quality, and stability of agricultural and zoo technical production, as well as the natural environment. The study uses the Wroclaw Taxonomic Method to create the Index of Sustainable Agriculture (ISA) and analyzes 28 EU-28 nations between 2005 and 2014. The Granger-causality test is used to confirm the causal link between the ISA, climate change, and agricultural productivity. The report provides a comprehensive summary of European nations' ranking in the ISA and its three key pillars: environmental, economic, and social factors. The study finds significant causality relationships between the ISA, climate change, and agricultural production, including a negative bidirectional causal relationship between climate change and agricultural yields, a negative bidirectional causal relationship between climate change and sustainable agriculture, and a negative reciprocal relationship between conventional and sustainable agriculture [7].

Ren, Chenchen, et al. proposed the impact of farm size on agricultural sustainability. As it can significantly impact the efficiency of agricultural production, such as the overuse of mineral fertilizers. However, the scale of these effects and their primary causes are not well understood, especially in countries like China where the agricultural sector is predominantly controlled by smallholder farms. The study evaluates the existing understanding of farm size's impact on agricultural sustainability using crop farming in China as an economic, environmental, and social example. It examines implications from both a Chinese and a global perspective to identify opportunities for intervention to improve agricultural performance [8].

Ismail Fawaz, Hassan, et al. proposed Deep Neural Networks (DNNs) as a potential solution for Time Series Classification (TSC) in data mining. DNNs have transformed computer vision with their deep architectures, such as Residual and Convolutional Neural Networks. They can analyze sequential data, such as text and audio, to achieve state-of-the-art performance in speech recognition and document classification. The study provides an empirical study of the most effective DNN architectures for TSC, a review of the most effective applications in various time series domains, and an open-source deep learning framework for the TSC community. The study includes 8,730 deep-learning models trained on 97 time series datasets [9].

Pelletier et al. proposed a Temporal convolutional neural network for the classification of satellite image time series. They used new remote sensing instruments with high spatial and spectral resolution. Temp CNNs are a deep learning method that applies convolutions to the temporal dimension, allowing for better accuracy in SITS classification. The research, conducted on a million-time series from 46 Formosat-2 pictures, found that Temp CNNs are more accurate than state-of-the-art RF and RNNs for SITS classification. The study also highlights differences between the findings and those from computer vision, such as pooling layers. The research provides general instructions on network architecture, regularization techniques, and hyper-parameter values [10].

Ameline, Mael, et al. proposed the Estimation of corn yield by assimilating SAR and optical time series into a simplified agro-meteorological Model: from diagnostic to forecast. The model uses the green area index (GAI) derived from optical satellite images and synthetic aperture radar (SAR) satellite images acquired over two crop seasons in France. The SAFY-WB model is used to control the yield model combined with a water balance. The model's robustness is attributed to the combination of GAI from SAR and optical data. The model can simulate dry masses and produce diagnostic approaches under specific conditions, enhancing the management of food supply and decision-making [11].

Tripathi, Akshar, et al. proposed a synergetic utilization of sentinel-1 SAR and sentinel-2 optical remote sensing data for surface soil moisture estimation in Rupnagar, Punjab, India. The study aims to address the issue of decreased crop yields due to poor agricultural and soil management, particularly in India due to its large population. Optical remote sensing has been used for soil health monitoring and mapping since its advent in scientific agriculture management. The study used Sentinel 1 A, C-band SAR remote sensing data with VV and VH polarization channels to measure alluvial soil and its subtypes in Rupnagar. The Normalized Differential Moisture Index (NDMI) was used to validate the Index-based OLS Regression approach, which estimated soil moisture using backscatter from Sentinel-1A SAR data. The study is important for its simpler approach to surface soil moisture estimation using freely available optical and SAR remote sensing data parameters, with results comparable to those reported by commercial data and sophisticated modeling techniques [12].

Alebele, Yeshanbele, et al. proposed Gaussian kernel regression for estimating crop yield from optical and SAR imagery. The study used in situ measured yield data from Xinghua County, China, in 2019 and 2020. The results showed that Gaussian kernel regression outperformed Bayesian linear inference and probabilistic Gaussian regression in terms of prediction accuracy. The optical red edge difference vegetation index (RDVI1) outperformed the interferometric coherence in terms of prediction accuracy. The study suggests that combining optical indices with satellite interferometric coherence can improve crop yield mapping using Gaussian kernel regression. The findings highlight the benefits of combining optical indices with satellite interferometric coherence for accurate crop yield predictions [13].

Vaishali G. proposed Crop Biophysical Parameters Estimation Using SAR Imagery for Precision Agriculture Applications. The methods of farm management supported by observation, measurement, and answers to the inspection for the type of crops are known as precision agriculture (PA) and satellite farming. SAR data is effective for retrieving vegetation data, enabling crop disease prediction, crop categorization, yield estimation, and crop and farmland parameter estimation. The study also discusses the advantages and drawbacks of current precision agriculture techniques and highlights the need for intelligent agriculture. The generalized model is deemed the requirement for intelligent agriculture, as per the literature review conducted for this study [14].

Rajendra P. Sishodia et al. proposed Applications of Remote Sensing in Precision Agriculture. The study highlights the importance of using technologies like geospatial technology, IoT, big data analysis, and AI to optimize agricultural inputs and reduce input losses. Remote sensing has been used in crop monitoring, irrigation management, nutrient application, disease and pest management, and yield prediction due to the availability of high-resolution satellite images. The study also discusses the increasing popularity of unmanned aerial vehicles (UAVs) for producing high-resolution photographs for PA applications. The study emphasizes the need for a straightforward workflow for real-time remote sensing in PA, and the development of accurate, user-friendly devices [15].

III. METHODOLOGY

Developing a methodology for Agricultural Land Parameters Forecasting involves defining the step-by-step process and techniques used to achieve accurate predictions of suitable crop practices based on soil and environmental data.

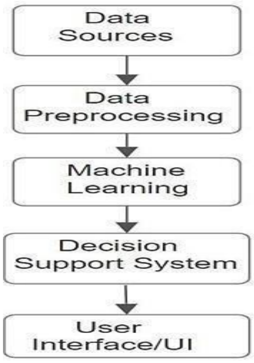

Figure 1 Architecture Diagram for Agricultural Land Parameter Forecasting.

This block diagram provides a high-level overview of the key components involved in an Agricultural Land Parameters Forecasting system, from data collection to user interaction.

IV. RESULTS

The proposed project seeks to revolutionize agricultural practices by integrating advanced technologies like Sentinel-2 Synthetic Aperture Radar (SAR) imagery and on-field soil sensors with cutting-edge data analytics and machine learning algorithms.

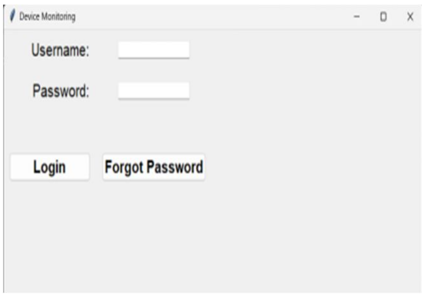

Figure 1: The User Login page

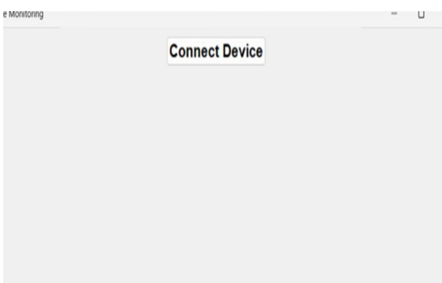

Figure 2: The Home Page

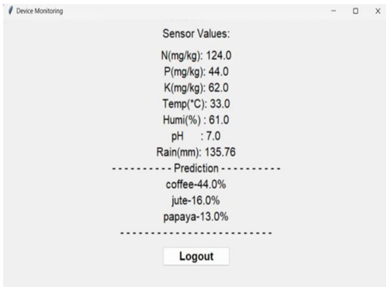

Figure 3: The Output Display page of the Prediction

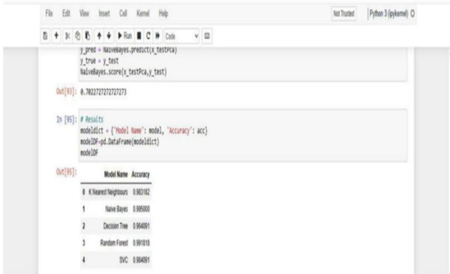

Figure 4: the Accuracy of the System

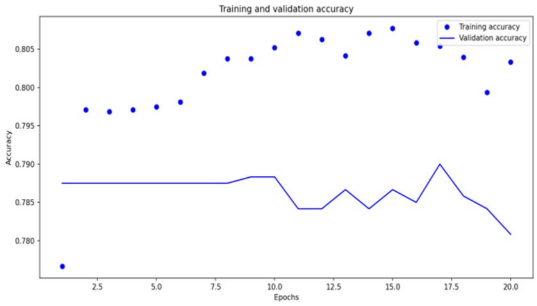

Figure 5: Graphical Analysis

This innovative approach aims to forecast agricultural land parameters and predict optimal crop practices, addressing the challenges posed by the growing global population and the need for sustainable land management. By harnessing the capabilities of Sentinel-2 SAR imagery, which provides real-time, all-weather land condition data, alongside high-resolution multispectral imaging, the system can offer precise estimates of crop output in agroforestry systems. By incorporating ground-level information from soil sensors, the system enhances accuracy, empowering farmers with actionable insights to optimize their agricultural practices and contribute to long-term sustainability.

V. Conclusion

The project team identified a project that can be helpful to the farmers in handling the problem caused by using the uneven amount of NPK in the soil. The team submitted a draft copy of the synopsis. Once the project is approved by the project coordinator, the team will do a literature survey, procure the materials needed, and start building the project.

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