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Green Agriculture: Sustainable Farming for Tribal Farmers Using Deep Learning

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ABSTRACT:

Selecting the right crop and fertilizer according to the soil's needs is a challenge that many young farmers face, often resulting in decreased productivity. In the past, farmers relied on practical experience to identify the most appropriate crops. based on the soil properties. However, this method is no longer sufficient. To address this issue, a recommendation system has been developed, utilizing deep learning to suggest the best crops for specific soil types. The primary objective of this application is to recommend crops and fertilizers tailored to the soil. Our system employs a deep learning model designed to detect and identify suitable crops from soil images. The dataset used for training is sourced from a soil database available on Kaggle, which contains two separate folders for training and testing. The process begins with uploading the dataset. Next, the input image undergoes preprocessing to eliminate noise. The cleaned image is then segmented to focus on the region of interest. This segmented image is fed into a feature extraction phase, producing feature vectors. In the classification phase, the CNN model classifies the soil type (e.g., Black Soil, Cinder Soil, Laterite Soil, Peat Soil, Yellow Soil). Based on the soil classification, the system automatically suggests the most suitable crop and fertilizer using a pattern matching approach.

Keywords: Soil Classification, Deep Learning, Crop Recommendation, Fertilizer Recommendation, Convolutional Neural Network (CNN), Soil Image Analysis, Image Segmentation, Feature Extraction, Pattern Matching.

1. Introduction

Both practical and spiritual. For centuries, indigenous and tribal farmers have practiced

1.1 historical context

Sustainable farming methods, working in harmony the history of agriculture in tribal communities is with the natural environment. These communities, deeply rooted in a relationship with the land that is often living in isolated or rural areas, have developed unique agricultural practices that prioritize ecological balance, resilience, and longterm resource preservation.

Tribal farming communities have historically followed agriculture practices that were inherently sustainable and ecologically balanced. These practices, Transmitted across generations, they were rooted in a profound knowledge of the environment, soil health, and the cycles of nature. Methods such as mixed cropping, agroforestry, and organic composting were common in tribal regions, promoting biodiversity, enriching soil, and conserving water.

1.2 Significance of Agriculture for Tribal Communities

Agriculture holds a central role in the lives of tribal communities, serving as both a primary source of livelihood and an integral part of their cultural identity. For centuries, These communities have cultivated close-knit relationships with the land, rooted in an understanding of ecological balance and the rhythms of nature. Agriculture is not merely a means of survival for tribal farmers; it is a way of life This is closely connected to social structures, traditions, and economic well-being.

1.3 Challenges faced by tribal farmers in modern agricultural practices

Tribal farmers, while having a rich history of traditional knowledge and expertise in sustainable agriculture., face numerous challenges when adapting to or integrating modern agricultural practices. These challenges are often exacerbated by socio-economic, environmental, and political factors, creating barriers to the widespread adoption of green agriculture techniques that could enhance their productivity and environmental sustainability.

2. Analysis

2.1 Research Design

This study adopts a mixed-methods research design, integrating both **qualitative** and **quantitative** data collection techniques. The qualitative approach provides in-depth insights into the experiences, perspectives, and challenges of tribal farmers, while the quantitative approach allows for measurable comparisons and assessments of the effectiveness of green agricultural practices. The research is conducted in selected tribal regions that have varying agricultural practices, access to resources, and exposure to green farming initiatives.

2.2 Study Area Selection

The study focuses on tribal communities in specific regions known for their agricultural activity. Criteria for selection include:

Geographical diversity: Tribal regions from different ecological zones (e.g., temperate, tropical, arid) to assess the adaptability of green agriculture practices to varied environments.

Variation in farming practices: Incorporating communities that mainly engage in traditional farming, along with those who have adopted ecofriendly agricultural methods.

Accessibility and involvement in sustainability programs: Areas that have some involvement in governmental or NGO-driven green agriculture initiatives.
The study is conducted in close collaboration with local community leaders, agricultural extension officers, and NGOs working in the region to ensure the relevance and accuracy of the data collected.

2.3 Data Analysis

Qualitative Analysis: The interviews, focus group discussions, and field notes are transcribed and analysed using thematic analysis. This method identifies common themes, patterns, and insights that emerge from the data. Software like NVivo or other qualitative data analysis tools can be utilized to assist in coding and organizing responses.

Quantitative Analysis: The survey data is analysed using statistical tools such as SPSS or Excel. Descriptive statistics (mean, median, standard deviation) are calculated for variables like crop yield, income levels, and resource usage. Inferential statistics, such as chi-square tests or tests, are used to determine if there are significant differences between groups using traditional green agriculture methods. Correlation analysis helps assess the relationship between environmental health indicators (e.g., soil fertility) and farming practices.

3. Modules

3.1 Dataset Collection

The dataset contained information soil images. It contains two separate folders, train and test, where the train folder is consists of classes, and every category contains various images. After that user can able to upload dataset through browse option.
Dataset image may be png or jpeg format.

3.2 Data Pre-Processing

Data preprocessing is done to ready it for primary processing or additional analysis. CNN model is that they cannot be trained on a different dimension of images. It is essential for all images in the dataset to have the same dimensions, allowing them to be processed into uniform sizes. In this dataset, the images have a very dynamic range of dimensions, CNNs usually range between 64 × 64 and 256 × 256 hence cannot be passed directly to the CNN model.

3.4 Image segmentation

Image segmentation is one of the important process to identify soil images on user upload image Segmentation is the process by which a digital image is partitioned into various subgroups (of pixels) called Image Objects, This helps simplify the image, making it easier to analyze by reducing its complexity.

3.5 Frame extraction

The frame extraction module segments the soil image captured into different frames. It retrieves each frame by utilizing the extraction function.
This extraction usually performs with some specific time interval.

3.6 CNN Model

This can be used for tasks such as object recognition, classification. The Convolution Neural Network is trained using Stochastic Gradient Descent with Momentum. The network consists of an input layer, followed by three convolutions and average pooling layers and followed by a soft max fully connected output layer to extract features. After extracting features, 2 layer hidden neural-networks is used for classification. We used different configuration setups to extract features from the given data. In all these configurations pooling layer window size is fixed as 2 × 2, and we tried with different epochs with a batch size of 100. This has capability of extract and recommends crop result effectively.

3.7 Crop and Fertilizer recommendation

Each and every Test image analysis using neural networks will recommend the crops effectively using our model. Feed the image as an input to the feature extraction stage, where the output will be the feature vectors. The next stage is the classification stage, where the input will be the feature vectors, and output is the classified label as crop name using Convolutional Neural Network (C6N) model. This model recommend crop information and gives fertilizer of the soil to the user in images effectively.

4. Implementation

4.1 Training and Capacity Building

In many tribal areas, farmers may lack formal education or exposure to modern sustainable farming techniques. Training programs that focus on practical experience and impart real-world knowledge of sustainable agriculture practices are crucial for developing capacity..

Agroecological Practices Training: Provide comprehensive training on key green agriculture practices, such as organic farming, agroforestry, crop rotation, integrated pest management, and water conservation techniques.

Soil Health and Fertility Management: Educate farmers on sustainable soil management techniques, such as composting, mulching, cover cropping, and reducing chemical inputs. This will help enhance soil fertility, reduce erosion, and increase crop yields over time.

Water Conservation and Irrigation: Provide training on water management techniques such as rainwater harvesting, the use of drip irrigation systems, and the construction of water ponds. This is crucial, especially in regions facing water scarcity or erratic rainfall patterns.

4.2 Access to Resources and Financial Support

The successful implementation of green agriculture relies on the availability of resources, including financial assistance, materials, and inputs. Ensuring access to these resources is vital to overcoming the barriers faced by tribal farmers.

Access to Organic Inputs and Tools: Facilitate access to affordable organic seeds, fertilizers, and pest control solutions. This could involve working with local suppliers or creating community-level seed banks to ensure that farmers can access quality, affordable inputs.

Financial Support and Microfinance: Work with banks, microfinance institutions, and government programs to provide financial support for farmers looking to transition to green agriculture. This could include low-interest loans or subsidies for organic farming inputs, water conservation technologies, and other green practices.

5. Results

5.1 Improved Soil Health and Fertility

Increase in Soil Organic Matter: Adoption of organic farming practices, such as composting and mulching, led to an improvement in soil organic matter. Farmers reported enhanced soil structure, reduced erosion, and better water retention, which positively impacted crop yields.

Reduced Soil Degradation: By avoiding chemical fertilizers and pesticides, soil degradation slowed, and soil health indicators (e.g., soil pH, nutrient content) showed improvements

5.2 Higher Crop Yields

Diversified Crop Production: Green agriculture techniques encouraged crop diversification, leading to improved resilience against pests, diseases, and climate variability. Farmers saw a steady increase in the variety of crops grown, including organic vegetables, fruits, and pulses.

Improved Yield with Organic Practices: Despite initial challenges, some tribal farmers reported increased yields from organic farming over time, particularly when they combined green methods with traditional crop rotation and soil management practices.

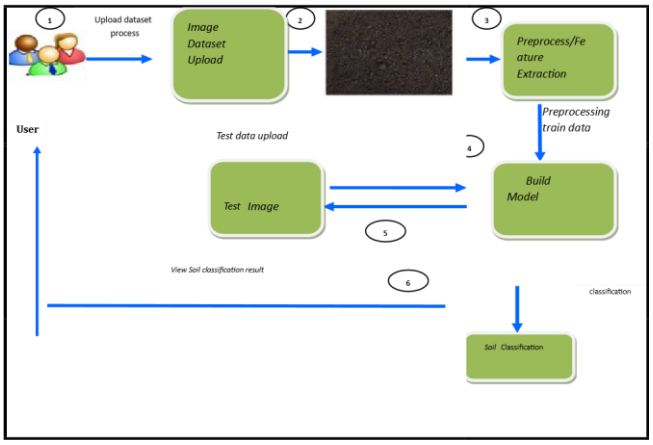
5.3 Enhanced Water Conservation

Efficient Water Use: Implementation of water saving technologies such as rainwater harvesting, drip irrigation, and water-efficient cropping techniques led to reduced water wastage and better water management, particularly in areas prone to drought.

Increased Access to Water Resources: Communities that adopted water conservation methods were able to maintain agricultural productivity even during periods of erratic rainfall, improving food security.

6. Diagram

System flow diagram



7. Discussion

7.1 Role of Government and NGOs

Government policies and the involvement of NGOs play a crucial role in facilitating the adoption of green agriculture. Many tribal farmers benefit from subsidies, grants, and training programs provided by government bodies and non-governmental organizations. These support mechanisms are essential in addressing financial constraints and providing the necessary resources for the successful implementation of green agriculture.

The study also emphasizes that there is frequently a disconnect between the formulation of policies and their actual execution. While there are policies promoting sustainable agriculture, they may not always reach tribal areas or may not be tailored to the specific needs of these communities. Strengthening partnerships between governments, NGOs, and local communities is key to ensuring that these policies are effectively implemented and reach the intended beneficiaries.

7.2 Social Impacts and Community Empowerment

Green agriculture has also had positive social outcomes, particularly in terms of empowering women and marginalized groups in tribal communities. Many green agriculture initiatives have focused on improving women's participation in farming, providing them with skills, resources, and leadership opportunities. This has helped increase gender equity and foster community cohesion.

Additionally, the collective efforts of tribal farmers in adopting green practices have led to stronger community ties. Farmer cooperatives and community-led initiatives have enabled farmers to exchange knowledge, resources, and tools, fostering a more collaborative approach to farming. This sense of unity is crucial for ensuring the long term viability of sustainable agriculture in tribal regions.

8. Conclusion

Green agriculture presents a transformative pathway for tribal farmers, offering both environmental and socio-economic benefits While securing the long-term viability of their farming methods. By integrating sustainable farming techniques with traditional knowledge, tribal communities can overcome some of the most pressing challenges faced in modern agriculture, such as soil degradation, water scarcity, and declining biodiversity.

The results of implementing green agriculture highlight significant improvements in soil health, water conservation, crop diversification, and enhanced biodiversity, all of which contribute to greater ecological balance and increased resilience to climate change. Furthermore, the adoption of organic and sustainable practices has shown promising economic outcomes, including reduced production costs, improved yields, and access to premium markets for organic produce. These benefits have provided tribal farmers with an opportunity for economic empowerment, particularly as they become more connected to higher-value markets for sustainably produced goods.

9. Future Work and Limitations

Future work should focus on conducting long-term studies to assess the full impact of green agriculture on soil health, biodiversity, economic stability, and social welfare in tribal farming communities. These studies will help refine sustainable practices and policies. Additionally, the use of technology, such as mobile apps and sensors, for real-time data collection on soil moisture, temperature, and crop health will enable farmers to make informed decisions and adapt to changing conditions. Public awareness campaigns should be launched to highlight the benefits of green agriculture, not only for tribal communities but also for the broader population. These campaigns can promote sustainable farming practices and encourage consumers to choose organic, sustainably sourced products. Furthermore, there is a need to advocate for the role of green agriculture in climate change mitigation, exploring how promoting sustainable practices among tribal farmers can contribute to carbon sequestration, biodiversity preservation, and reducing agricultural greenhouse gas emissions.

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