CERTIFICATE

Certified that MANISH KUMAR SIROHI, MANISH KUMAR CHAUHAN, VIVEK CHAUHAN have carried out the Project work presented in this project entitled "Collaborative Farming and Soil Detection System" for the award of Bachelor of Technology from Dr. A.P.J. Abdul Kalam Technical University, Uttar Pradesh, Lucknow under my supervision. The Project embodies results of original work and studies carried out by Student himself and the contents of the Project do not form the basis for the award of any other degree to the candidate or to anybody else.

PROF. GHANSHYAM YADAV

(ASSISTANT PROFESSOR

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ACKNOWLEDGEMENT

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CERTIFICATE OF PROJECT REPORT SUBMISSION FOR EVALUATION

1. Project Title: Collaborative Farming and Soil Detection System
2. Project Preparation Guide was referred for preparing the Report ☐ YES ☐ NO
3. The contents of the Project Report have been organized based on the guidelines. ☐ YES ☐ NO
4. The Report has been prepared without resorting to plagiarism. ☐ YES ☐ NO
5. All sources used have been cited appropriately in Project Report YES NO

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TABLE OF CONTENTS

- **CERTIFICATE**
- **ACKNOWLEDGEMENT**
- **CERTIFICATE OF PROJECT REPORT SUBMISSION FOR EVALUATION**

1. Introduction

- 1.1 Background and Context
- 1.2 Objectives of the CFSD System

2. System Architecture

- 2.1 Sensor Network
- 2.2 Data Management and Analysis Platform
- 2.3 User Interface and Collaboration Tools
- 2.4 Machine Learning and AI
- 2.5 Communication and Connectivity
- 2.6 Security and Privacy

3. System Functionalities

- 3.1 Sensor Data Collection and Transmission
- 3.2 Data Analysis and Visualization
- 3.3 Personalized Recommendations
- 3.4 Collaboration and Knowledge Sharing
- 3.5 User Management and Administration

4. Benefits and Impact

- 4.1 Improved Farmer Knowledge and Decision-Making
- 4.2 Enhanced Soil Health and Crop Yields

- 4.3 Increased Farmer Collaboration and Innovation
- 4.4 Improved Economic Sustainability of Farms
- 4.5 Positive Environmental Impact

5. Implementation and Deployment

- 5.1 System Requirements and Specifications
- 5.2 Pilot Testing and Evaluation
- 5.3 Scalability and Sustainability

6. Future Work and Development

- 6.1 Advanced Data Analysis and Modelling
- 6.2 Enhanced Collaboration and Knowledge Sharing
- 6.3 Integration with IoT and Robotics
- 6.4 Addressing Ethical and Social Considerations
- 6.5 Expanding System Reach and Impact
- 6.6 Continuous Research and Development

7. Conclusion

8. References

9. Appendices

- Appendix A: Detailed Technical Specifications
- Appendix B: Data Collection Methods
- Appendix C: User Manual
- Appendix D: Flow Charts and Graphs
- Appendix E: Additional Resources

ABSTRACT

PROJECT TITLE - Collaborative Farming and Soil Detection System

This report details the development and potential impact of the Collaborative Farming and Soil Detection System (CFSD System), a user-friendly platform designed to address key challenges in modern agriculture. The CFSD System fosters collaboration among farmers, provides real-time insights into soil health, and promotes data-driven decision-making for improved agricultural outcomes, resource efficiency, and sustainability.

INTRODUCTION

Modern agriculture faces a multitude of challenges in the 21st century. Limited access to expertise, inefficient soil monitoring, resource inefficiency, lack of farmer collaboration, and inadequate integration of emerging technologies hinder optimal agricultural practices and sustainability. This report details the development and potential impact of the Collaborative Farming and Soil Detection System (CFSD System), a user-friendly, technologically advanced platform designed to address these challenges.

MOTIVATION FOR WORK

The agricultural sector is crucial for global food security and economic stability. However, it faces significant challenges, including:

- **Limited access to expertise:** Small-scale farmers often lacks access to expert advice and guidance, leading to suboptimal practices and reduced yields.
- **Inefficient soil monitoring:** Traditional soil monitoring methods are time-consuming, expensive, and lack real-time data, hindering prompt responses to soil health issues.
- **Resource inefficiency:** Farmers often overuse resources like water and fertilizers due to inaccurate data, leading to environmental damage and increased production costs.
- **Lack of farmer collaboration:** Farmers often work in isolation, limiting knowledge sharing and the adoption of best practices.
- **Limited integration of technology:** Advancements in data analysis and machine learning are not widely utilized in agricultural practices.

PROBLEM STATEMENT

The CFSD System focuses on addressing the following key challenges:

1. Limited Access to Agricultural Expertise

Many farmers, especially small-scale ones, lack access to expert advice and guidance on best practices and troubleshooting. This leads to suboptimal farming practices and reduced yields. Farmers often rely on traditional knowledge passed down through generations, which may not be optimal for modern agricultural conditions. Additionally, access to agricultural extension services is often limited, particularly in rural areas.

2. Inefficient Soil Monitoring

Traditional soil monitoring methods, such as soil testing, are time-consuming, expensive, and often lack real-time data. This hinders timely responses to soil health issues and prevents optimal resource allocation. Farmers may not be aware of nutrient deficiencies or imbalances in their soil until it is too late to take corrective action.

3. Resource Inefficiency

Farmers often overuse resources such as water and fertilizers due to inaccurate data and lack of precise recommendations. This results in environmental damage, including water pollution and greenhouse gas emissions, as well as increased production costs. Without accurate information about soil nutrient levels, farmers may apply fertilizers unnecessarily, leading to wasted resources and potential harm to the environment.

4. Lack of Farmer Collaboration

Farmers often work in isolation, limiting knowledge sharing and the adoption of best practices. This hinders innovation and slows down the advancement of agricultural techniques. Farmers may be unaware of successful practices implemented by other farmers in their region or facing similar challenges.

5. Limited Integration of Emerging Technology

Advancements in data analysis and machine learning remain underutilized in the agricultural sector. This restricts access to valuable insights and hinders data-driven decision-making.

Rationale for Topic Selection

1. Addressing Critical Challenges in Modern Agriculture:

The modern agricultural sector faces a multitude of critical challenges, including:

- Limited access to expertise: Small-scale farmers often lack access to expert advice and guidance, leading to suboptimal practices and reduced yields.
- Inefficient soil monitoring: Traditional soil monitoring methods are time-consuming, expensive, and lack real-time data, hindering prompt responses to soil health issues.
- Resource inefficiency: Farmers often overuse resources like water and fertilizers due to inaccurate data and lack of precise recommendations, resulting in environmental damage and increased costs.
- Lack of farmer collaboration: Farmers often work in isolation, limiting knowledge sharing and the adoption of best practices, hindering innovation.
- Limited integration of emerging technology: Advancements in data analysis and machine learning are underutilized in agriculture, restricting valuable insights and data-driven decision-making.

2. Potential for Significant Impact:

The CFSD System has the potential to address these challenges and generate considerable positive impact in the following ways:

- Empowering farmers with knowledge and tools: By providing access to expert advice, real-time data, and personalized recommendations, farmers can make informed decisions and optimize their practices.
- Improving soil health and crop yields: Real-time soil monitoring and data-driven recommendations enable farmers to identify and address soil health issues promptly, leading to improved crop yields and quality.

- Promoting sustainable agriculture: By reducing resource overuse and promoting efficient practices, the CFSD System contributes to environmental sustainability and minimizes negative impacts on the ecosystem.
- Fostering collaboration and innovation: The platform facilitates knowledge sharing and collaboration among farmers, accelerating the development and adoption of innovative and sustainable agricultural techniques.

3. Alignment with Global Trends and Initiatives:

The development of the CFSD System aligns with several global trends and initiatives, including:

- Focus on sustainable agriculture: The United Nations Sustainable Development Goals (SDGs) emphasize the need for sustainable agricultural practices to ensure food security and environmental sustainability.
- Digitalization of the agricultural sector: There is a growing trend towards the adoption of digital technologies in agriculture, driven by advancements in data analysis, machine learning, and Internet of Things (IoT) technologies.
- Increased farmer empowerment: Initiatives like the Farmer-to-Farmer program and the Global Open Data for Agriculture and Nutrition initiative emphasize the importance of empowering farmers with knowledge and tools for improved decision-making.

4. Feasibility and Scalability:

The CFSD System utilizes readily available technologies and resources, making it feasible for implementation and scaling. The modular design allows for adaptation to different agricultural contexts and farmer needs. Open-source components and data sharing encourage community collaboration and further development.

Overall, the selection of the Collaborative Farming and Soil Detection System as a research topic is justified by its potential to address critical challenges in modern agriculture, generate significant positive impact, and align with global trends and initiatives. The feasibility and scalability of the system further support its importance and potential for widespread adoption.

PROJECT OBJECTIVES

The Collaborative Farming and Soil Detection System (CFSD System) aims to achieve the following key objectives:

1. Facilitate Collaborative Farming:

- Create a user-friendly platform: Develop an intuitive and accessible platform for farmers to connect, share experiences, and exchange knowledge through forums, chat rooms, resource libraries, and file sharing functionalities.
- Promote knowledge sharing: Encourage farmers to share best practices, success stories, and challenges faced through various communication tools and resources.
- Integrate a mentorship program: Connect experienced farmers with new farmers seeking guidance and support, facilitating knowledge transfer and fostering a supportive community.

2. Promote Data-Driven Decision-Making:

- Develop a comprehensive data collection system: Implement a network of sensors to collect real-time data on various soil parameters such as moisture content, nutrient levels, pH, and weather conditions.
- Integrate historical and external data: Include historical agricultural data, weather forecasts, and market trends to provide farmers with a comprehensive view of their farm's performance and external factors.
- Utilize machine learning algorithms: Analyse data and generate actionable insights for farmers including irrigation recommendations, fertilizer suggestions, pest control strategies, and crop selection advice.
- Create data visualization tools: Provide farmers with interactive dashboards and visualizations to easily understand and interpret complex data and insights.

3. Implement Soil Detection System:

- Design and deploy a network of soil sensors: Install sensors across the farmland to collect real-time data on key soil parameters, ensuring comprehensive coverage and accurate data collection.
- Develop data management infrastructure: Implement a secure and robust platform to store, manage, and analyse the collected soil data in real-time.
- Generate real-time soil health reports: Provide farmers with readily accessible reports that translate sensor data into actionable insights about their soil health status and potential issues.

4. Develop Educational Resources:

- Create educational materials on sustainable farming practices: Develop user-friendly guides, tutorials, and videos on topics such as soil health management, resource-efficient irrigation, and integrated pest management.
- Offer training programs for farmers: Organize workshops and online courses to educate farmers on utilizing the CFSD System effectively, interpreting data insights, and implementing sustainable practices.
- Translate resources into multiple languages: Ensure accessibility for diverse populations by providing translated resources and training materials in various languages.

5. Promote Adoption and Sustainability:

- Build partnerships with agricultural organizations: Collaborate with agricultural extension services, NGOs, and farmers' associations to reach a wider audience and encourage system adoption.
- Develop incentive programs: Implement reward schemes and financial subsidies to encourage farmers to adopt the CFSD System and sustainable practices.
- Conduct research and evaluation: Continuously monitor and evaluate the system's impact on agricultural practices, environmental sustainability, and farmer livelihoods.
- Ensure open-source data and collaboration: Encourage collaboration and innovation by openly sharing data and APIs, allowing researchers and developers to contribute to further improvement and development of the CFSD System.

These objectives are designed to address the challenges faced by modern agriculture and empower farmers with the tools and knowledge they need to make informed decisions, improve soil health, optimize resource use, and achieve sustainable agricultural practices.

SOFTWARE AND DATA USE

Software and Data Use: Collaborative Farming and Soil Detection System

1. Software:

The CFSD System utilizes a combination of open-source and commercial software solutions to achieve its objectives. The key software components include:

1.1 Data Management and Analysis:

- Python: Python libraries like NumPy, pandas, and Scikit-learn will be used for data analysis, manipulation, and machine learning.
- Database management system (DBMS): A robust DBMS like PostgreSQL or MySQL will be used to store and manage large amounts of collected data efficiently.
- Data visualization tools: Libraries like Seaborn and Matplotlib will be used to create interactive dashboards and visualizations for data exploration and insight generation.

1.2 Machine Learning and AI:

- Machine learning algorithms: Supervised and unsupervised learning algorithms like Random Forest and Support Vector Machines will be used for tasks such as crop classification, pest detection, and soil health prediction.
- TensorFlow or PyTorch: These frameworks will be used for implementing and training deep learning models for more complex tasks and advanced data analysis.

1.3 Sensor Network and Communication:

- Sensor communication protocol: A protocol like LoRaWAN will be used to enable communication between sensors and the central data management system.
- Data transmission software: Open-source libraries like MQTT or proprietary software will be used for data transmission from sensors to the platform.

1.4 User Interface and Collaboration Platform:

- Front-end development framework: Frameworks like React or Vue.js will be used to build a user-friendly and responsive web interface.
- Collaboration tools: Features like forums, chat rooms, and file sharing functionalities will be implemented using readily available libraries and APIs.

2. Data:

The CFSD System will utilize various data sources to provide insights and recommendations to farmers:

2.1 Real-time sensor data:

- Soil moisture content
- Nutrient levels (N, P, K, etc.)
- pH
- Temperature
- Humidity

2.2 Historical farm data:

- Crop yields
- Irrigation schedules
- Fertilizer application records
- Soil test results
- Pest and disease occurrences

2.3 External data:

- Weather forecasts
- Market trends
- Agricultural research findings
- Disease outbreak alerts

2.4 User-generated data:

- Farmer observations and notes
- Questions and answers in forums

Data Security and Privacy:

The CFSD System will prioritize data security and privacy by implementing robust security measures such as:

- Secure data storage and encryption
- Access control and user authentication
- Data anonymization and aggregation
- Data privacy policies and compliance with relevant regulations

By utilizing a combination of open-source and commercial software solutions, securing various data sources, and prioritizing data security and privacy, the CFSD System aims to provide farmers with a reliable and efficient platform for data-driven decision-making and collaborative agricultural practices.

EXPECTED OUTCOMES

Expected Outcomes of the Collaborative Farming and Soil Detection System (CFSD System)

1. Improved Farmer Knowledge and Decision-Making:

- Increased access to expert advice and knowledge: Farmers can connect with experts and experienced farmers through the platform, reducing reliance on traditional sources and gaining access to valuable insights.
- Enhanced data-driven decision-making: Real-time data and personalized recommendations enable farmers to make informed decisions about irrigation, fertilization, pest control, and other critical aspects of their agricultural operations.
- Improved understanding of soil health: Real-time soil monitoring and data analysis provide insights into soil health status, enabling farmers to identify and address issues promptly.

2. Enhanced Soil Health and Crop Yields:

- Optimized resource use: Data-driven recommendations minimize water and fertilizer overuse, promoting resource conservation and reducing environmental impact.
- Improved soil health management: Timely responses to soil health issues and targeted interventions ensure optimal soil conditions for healthy crop growth.
- Increased crop yields and quality: Efficient resource use, improved soil health, and optimized practices contribute to higher yields and better-quality crops.

3. Increased Farmer Collaboration and Innovation:

- Facilitated knowledge sharing: The platform promotes communication and collaboration among farmers, accelerating the dissemination of best practices and innovative techniques.
- Enhanced learning and research: Forums and online communities encourage peer-to-peer learning and collaboration among farmers, researchers, and agricultural professionals.
- Faster development and adoption of sustainable practices: Collaborative sharing of knowledge and experiences facilitates the development and adoption of new and effective sustainable agricultural practices.

4. Improved Economic Sustainability of Farms:

- Reduced production costs: Efficient resource use and optimized practices minimize input costs and improve resource allocation, leading to increased profitability.
- Increased market access: Farmers can access market information and connect with potential buyers through the platform, improving access to markets and potential income streams.
- Enhanced resilience and risk management: Data-driven insights and access to expert advice help farmers anticipate and manage risks associated with weather events, pests, and market fluctuations.

5. Positive Environmental Impact:

- Reduced water and fertilizer use: The CFSD System promotes efficient resource use, minimizing environmental impact and promoting sustainable water management.
- Improved soil health and biodiversity: Optimized soil management practices contribute to healthier soil ecosystems and increased biodiversity, leading to a more resilient agricultural landscape.
- Reduced greenhouse gas emissions: Efficient resource use and sustainable practices contribute to lower greenhouse gas emissions, mitigating climate change impacts.

Overall, the CFSD System is expected to generate numerous positive outcomes by empowering farmers with data-driven insights, facilitating collaboration, promoting sustainable agricultural practices, and improving the economic and environmental sustainability of agricultural production.

Additional Expected Outcomes:

- Increased adoption of digital technologies in agriculture.
- Improved data governance and data sharing practices in the agricultural sector.
- Development of new tools and technologies for data analysis and decision-making in agriculture.
- Stronger partnerships between farmers, researchers, and technology providers.

SYSTEM ARCHITECTURE AND DESIGN

The CFSD System is designed as a modular and scalable platform consisting of several key components:

1. Sensor Network:

- A network of sensors deployed across the farmland collects real-time data on various soil parameters, including moisture content, nutrient levels, pH, temperature, and humidity.
- Sensors communicate with the central data management system using a reliable protocol like LoRaWAN or cellular networks.

2. Data Management and Analysis Platform:

- A central server stores and manages all collected data, including sensor data, historical farm data, and external data sources.
- Robust database management systems like PostgreSQL or MySQL ensure data security and efficient retrieval.
- Data analysis tools like Python libraries and machine learning algorithms are used to analyse data, identify trends, and generate actionable insights for farmers.

3. User Interface and Collaboration Platform:

- A user-friendly web interface provides farmers with access to their farm data, personalized recommendations, and collaboration tools.
- Interactive dashboards and visualizations enable farmers to easily understand complex data and insights.
- Forums, chat rooms, and file sharing functionalities facilitate communication and knowledge sharing among farmers.

4. Machine Learning and AI:

- Machine learning algorithms are used to analyze data and generate personalized recommendations for farmers, such as irrigation schedules, fertilizer suggestions, pest control strategies, and crop selection advice.
- Deep learning models can be used for more complex tasks such as crop classification, pest detection, and soil health prediction.

5. Communication and Connectivity:

- The system utilizes reliable communication protocols to ensure seamless data transmission between sensors, the central server, and the user interface.
- Cellular networks or satellite communication can be used to provide connectivity in remote areas.

6. Security and Privacy:

- Robust security measures are implemented to protect data privacy and ensure system security.
- Features like user authentication, data encryption, and access control are included to prevent unauthorized access and data breaches.

System Design Considerations:

- Scalability: The system is designed to be scalable to accommodate farms of various sizes and geographic locations.
- Openness: Open-source software solutions are used when possible to encourage collaboration and customization.
- Ease of use: The user interface is designed to be intuitive and accessible for farmers with varying levels of technical expertise.
- Data security and privacy: Robust security measures are implemented to protect sensitive data and ensure user privacy.
- Interoperability: The system is designed to be interoperable with other agricultural technologies and data sources.

Overall, the CFSD System's architecture and design aim to provide a robust, reliable, and user-friendly platform for data-driven decision-making and collaborative farming practices.

This is a high-level overview of the system architecture and design. More detailed information about specific components and technical specifications can be found in the Appendix A: Detailed Technical Specifications.

IMPLEMENTATION PLAN

Phase 1: System Development and Testing

- Develop the core system components: Design and implement the sensor network, data management platform, user interface, and communication protocols.
- Integrate machine learning algorithms: Train and test machine learning models for soil health analysis, data visualization, and recommendation generation.
- Develop educational resources: Create user manuals, tutorials, and training materials to support farmer adoption and system familiarization.
- Conduct rigorous testing: Perform thorough testing of all system components and functionalities to ensure accuracy, reliability, and performance.
- Pilot testing: Implement the system on a small scale with a limited group of farmers to gather feedback and identify areas for improvement.

Phase 2: Pilot Deployment and Evaluation

- Deploy the system on a larger scale: Expand the pilot program to include a wider range of farmers and geographical locations.
- Monitor and evaluate system performance: Collect data on system usage, user feedback, and impact on agricultural practices and farm performance.
- Refine the system based on feedback: Address user feedback and implement improvements to enhance system functionality, user experience, and overall effectiveness.
- Disseminate findings and best practices: Share the results of the pilot program and best practices for implementing the CFSD System with stakeholders and the wider agricultural community.

Phase 3: Expansion and Commercialization

- Develop a business model: Define sustainable revenue streams and partnerships to support system expansion and maintenance.
- Secure funding and investment: Identify and secure funding opportunities to support the expansion and commercialization of the CFSD System.
- Partner with agricultural organizations and stakeholders: Collaborate with extension services, NGOs, and other relevant organizations to promote system adoption and build a strong network of support.

- Scale the system nationwide: Expand system availability to farmers across the country, reaching a broader audience and maximizing impact.

Key Implementation Considerations:

- User adoption and engagement: Strategies to encourage farmer participation and build user trust in the system are crucial.
- Data security and privacy: Ensuring data security and user privacy is paramount, requiring robust security measures and transparent data governance practices.
- Interoperability and integration: The system should be interoperable with existing agricultural technologies and data sources to promote seamless integration and data exchange.
- Sustainability and long-term impact: Building a sustainable business model and securing long-term funding are essential for ensuring the continued development and support of the CFSD System.

Overall, the implementation plan outlines a comprehensive strategy for developing, deploying, and scaling the Collaborative Farming and Soil Detection System.

EVALUATION AND ANALYSIS

Evaluating the effectiveness of the CFSD System is crucial to assess its impact on agricultural practices, farmer livelihoods, and environmental sustainability. This evaluation should consider both quantitative and qualitative data, focusing on various aspects:

1. System Usage and Adoption:

- Number of farmers using the system: Track the total number of registered users and active participants to gauge the system's reach and adoption rate.
- Frequency of use and user engagement: Monitor user activity, including data access, recommendation utilization, and platform participation to assess engagement levels.
- Geographic distribution of users: Analyse user location data to understand the system's reach across different regions and demographics.

2. Impact on Agricultural Practices:

- Changes in resource use: Compare water and fertilizer consumption before and after system implementation to measure resource efficiency improvements.
- Changes in soil health: Analyse soil test results to assess the impact of system-driven recommendations on soil health parameters.
- Changes in crop yields and quality: Compare crop yields and quality data before and after system implementation to evaluate the system's effect on productivity.
- Adoption of sustainable practices: Monitor the adoption of recommended sustainable practices like crop rotation, cover cropping, and integrated pest management.

3. Farmer Livelihoods and Economic Impact:

- Changes in farmer income: Analyze data on farm income and profitability to assess the system's impact on economic sustainability.
- Improved market access and price negotiation: Evaluate the system's effectiveness in connecting farmers to markets and facilitating better price negotiations.
- Reduction in production costs: Analyze data on input costs and resource use to assess the system's contribution to cost reduction.

- Improved risk management: Evaluate the system's effectiveness in providing farmers with data and insights to manage risks associated with weather events, pests, and market fluctuations.

4. Environmental Sustainability:

- Reduced water and fertilizer use: Analyse data on water and fertilizer consumption to quantify the system's environmental benefits.
- Improved soil health and carbon sequestration: Monitor soil health data and evaluate the system's impact on carbon sequestration potential.
- Reduced greenhouse gas emissions: Analyse data on farm operations and resource use to assess the system's contribution to greenhouse gas emission reduction.
- Conservation of biodiversity: Evaluate the system's impact on biodiversity by monitoring soil health and insect populations.

5. User Satisfaction and Feedback:

- Conduct surveys and focus groups to gather user feedback on system functionality, user experience, and perceived value.
- Analyse user feedback to identify areas for improvement and enhance the system's effectiveness and user satisfaction.
- Monitor online forums and discussions to gauge user sentiment and identify common concerns or challenges.

Evaluation Tools and Methods:

- Data analysis of user activity and farm performance data
- Surveys and questionnaires for farmers
- Focus groups and interviews
- Field studies and soil analysis
- Monitoring environmental indicators
- Analysis of user feedback and online discussions

Overall, evaluating the CFSD System requires a holistic approach that considers quantitative data on system usage, agricultural practices, and environmental impact alongside qualitative data on user experience and satisfaction. This comprehensive evaluation will provide valuable insights into the system's effectiveness and inform future improvements to maximize its impact on farmers, agriculture, and the environment.

CONCLUSION

The Collaborative Farming and Soil Detection System (CFSD System) presents a promising approach to addressing critical challenges in modern agriculture. By leveraging data-driven insights, fostering collaboration, and promoting sustainable practices, the CFSD System has the potential to:

- Empower farmers with knowledge and tools for informed decision-making.
- Improve soil health and optimize resource use for sustainable agriculture.
- Increase crop yields and improve farm profitability.
- Facilitate knowledge sharing and accelerate innovation within the agricultural sector.
- Contribute to a more sustainable and resilient food system for the future.

The CFSD System's modular design, open-source components, and focus on data security and privacy ensure its scalability and adaptability to diverse agricultural contexts. The comprehensive implementation plan outlines a strategic approach for system development, deployment, and long-term impact.

While further research and evaluation are needed to fully assess the system's effectiveness, the initial results and potential benefits suggest that the CFSD System has the potential to revolutionize the agricultural sector and contribute significantly to achieving sustainable food production goals.

By scaling the CFSD System and promoting its adoption among farmers worldwide, we can create a more efficient, sustainable, and equitable agricultural system that benefits farmers, consumers, and the planet.

FUTURE WORK

While the CFSD System has the potential to significantly impact the agricultural sector, there are several areas for future work to further enhance its capabilities and impact:

1. Advanced Data Analysis and Modelling:

- Develop and integrate sophisticated machine learning and artificial intelligence algorithms for more accurate data analysis, complex prediction models, and personalized recommendations.
- Explore the application of deep learning for tasks such as image recognition for weed and pest detection, disease diagnosis, and yield estimation.
- Implement advanced data visualization techniques to provide farmers with more interactive and insightful dashboards for understanding complex data trends.

2. Enhanced Collaboration and Knowledge Sharing:

- Develop advanced collaboration tools within the platform to facilitate knowledge exchange among farmers, researchers, and agricultural professionals.
- Integrate social media functionalities and online communities to encourage peer-to-peer learning and information sharing.
- Explore gamification and incentive programs to encourage user engagement and active participation in the platform.

3. Integration with IoT and Robotics:

- Develop and integrate Internet of Things (IoT) sensors for monitoring additional parameters like weather conditions, pest presence, and water quality.
- Explore the potential of robotics for tasks such as autonomous soil sampling, targeted pesticide application, and harvesting.
- Integrate the CFSD System with existing agricultural IoT platforms and data infrastructures to promote interoperability and data exchange.

4. Addressing Ethical and Social Considerations:

- Conduct research and analysis on the potential ethical and social implications of the CFSD System, such as data privacy concerns, digital divide, and potential job displacement.
- Develop clear data governance policies and transparency measures to ensure ethical data collection, storage, and utilization.
- Implement educational programs and capacity building initiatives to address digital literacy gaps and empower farmers to utilize the CFSD System effectively.

5. Expanding System Reach and Impact:

- Develop and implement strategies to promote the CFSD System among small-scale and resource-limited farmers.
- Partner with agricultural organizations, NGOs, and government agencies to expand system reach and ensure accessibility for diverse farming communities.
- Translate the platform and resources into multiple languages to cater to a wider audience and overcome language barriers.
- Develop and implement sustainable business models and funding strategies to ensure long-term system maintenance and support.

6. Continuous Research and Development:

- Conduct ongoing research to evaluate the impact of the CFSD System on agricultural practices, farmer livelihoods, and environmental sustainability.
- Collaborate with research institutions and universities to advance the development of new technologies and solutions for data-driven and sustainable agriculture.
- Continuously update and improve the CFSD System based on user feedback, research findings, and emerging technologies.

By focusing on these areas of future work, the CFSD System can evolve into a comprehensive and impactful platform that empowers farmers, promotes sustainable practices, and contributes significantly to shaping the future of agriculture.

Appendix A: Detailed Technical Specifications

1. Sensor Network:

- Sensor type: Soil moisture, nutrient levels (N, P, K), pH, temperature, humidity
- Communication protocol: LoRaWAN, cellular network
- Data transmission frequency: Hourly
- Data storage: Cloud-based database
- Sensor lifespan: 5 years
- Accuracy: +/- 5%

2. Data Management and Analysis Platform:

- Operating system: Linux
- Database management system: PostgreSQL
- Programming language: Python
- Data analysis libraries: NumPy, pandas, Scikit-learn
- Machine learning frameworks: TensorFlow, PyTorch
- Data visualization libraries: Seaborn, Matplotlib
- Data security features: User authentication, encryption, access control

3. User Interface and Collaboration Platform:

- Web framework: React or Vue.js
- Collaboration tools: Forums, chat rooms, file sharing
- Mobile app: Optional, for data access and farm management
- User authentication: Secure login with password or social media integration
- Accessibility features: Screen reader compatibility, keyboard navigation

4. Machine Learning and AI:

- Algorithms: Random Forest, Support Vector Machines, Deep Learning models
- Training data: Historical farm data, external data sources
- Model accuracy: >= 85%
- Model explainability: Feature importance analysis

- Model update frequency: Quarterly

5. Communication and Connectivity:

- Cellular network: 4G or 5G
- Satellite communication: Optional, for remote locations
- Data security protocols: HTTPS, VPN

6. Security and Privacy:

- Data encryption: AES-256
- Access control: Role-based access control
- User privacy: Opt-in data sharing, anonymization options
- Compliance with data privacy regulations: GDPR, CCPA

7. Hardware Specifications:

- Sensor nodes: Microcontroller with LoRaWAN module
- Central server: High-performance server with sufficient storage and processing power
- User devices: Laptop, tablet, smartphone
- Internet connection: High-speed internet connection

8. System Requirements:

- Operating system: Windows, macOS, Linux
- Web browser: Chrome, Firefox, Safari
- Mobile operating system: iOS, Android

9. Technical Specifications of Individual Sensors:

- Soil moisture sensor: Measurement range 0-100%, accuracy +/- 5%
- Nutrient sensor: Measurement range 0-1000 ppm, accuracy +/- 10%
- pH sensor: Measurement range 4-10, accuracy +/- 0.1
- Temperature sensor: Measurement range -40 to +80°C, accuracy +/- 1°C
- Humidity sensor: Measurement range 10-90%, accuracy +/- 5%

10. System Maintenance and Support:

- Software updates: quarterly
- Hardware maintenance: annual
- User support: online documentation, FAQs, email support, phone support (optional)

Note: These are just a sample of the technical specifications. The specific specifications will vary depending on the specific requirements of the CFSD System implementation.

Appendix B: Data Collection Methods

1. Sensor Data:

- Real-time data collection: Sensors deployed across the farmland will collect data on various soil parameters at regular intervals, typically hourly.
- Data transmission: Sensor data will be transmitted to a central server using a reliable communication protocol like LoRaWAN or cellular networks.
- Data storage: Data will be stored in a secure cloud-based database for analysis and visualization.

2. Historical Farm Data:

- Farmer records: Farmers will be encouraged to upload historical data on crop yields, irrigation schedules, fertilizer application, soil test results, pest and disease occurrences, and other relevant farm management practices.
- Data import: Existing farm data can be imported from spreadsheet files, agricultural software programs, or other data sources.
- Data quality checks: Data will be reviewed for accuracy and completeness before being integrated into the system.

3. External Data Sources:

- Weather data: Weather forecasts, historical weather data, and current weather conditions will be collected from weather stations and meteorological agencies.
- Market data: Market trends, commodity prices, and agricultural market forecasts will be collected from market research firms and government agencies.
- Research findings: Data from agricultural research studies and publications will be collected to inform system recommendations and improve data analysis.

4. User-Generated Data:

- Farmer observations and notes: Farmers can record their observations, notes, and insights about their crops, soil conditions, and farm management practices within the platform.
- Forums and discussions: Farmers can share their experiences and ask questions in online forums and discussions, providing valuable data for analysis and collaborative learning.

- Surveys and questionnaires: Periodic surveys and questionnaires can be conducted to gather feedback from farmers on system functionalities, user experience, and perceived value.

5. Additional Data Sources:

- Satellite imagery: Satellite images can be used to assess crop health, monitor land use changes, and identify potential issues in the field.
- Drone data: Drones equipped with sensors can collect high-resolution data on soil properties, plant health, and other parameters.
- Social media data: Data from social media platforms can be used to analyse trends, identify farmer concerns, and understand agricultural practices in a specific region.

Data Collection Strategies:

- Data collection automation: As much data as possible should be collected automatically through sensors and integration with existing data sources to minimize manual data entry and ensure data accuracy.
- Farmer engagement: Farmers should be actively involved in data collection by providing historical farm data, observations, and feedback to improve the system's effectiveness.
- Data quality control: Robust data quality control procedures should be implemented to ensure data accuracy and consistency.
- Data privacy and security: Strong data privacy and security measures should be implemented to protect sensitive data and ensure user trust.

By utilizing a diverse range of data collection methods and implementing effective strategies, the CFSD System can collect comprehensive and reliable data that is critical for generating accurate insights and supporting informed decision-making for farmers.

Appendix C: User Manual

1. Introduction:

This user manual provides instructions and guidance for using the CFSD System. It covers the following key functionalities:

- Accessing and navigating the platform
- Viewing sensor data and farm information
- Receiving personalized recommendations
- Participating in online forums and discussions
- Sharing observations and notes

2. Getting Started:

2.1 Registration:

- Create a user account by providing your name, email address, and farm location.
- Verify your email address through the link sent to your inbox.
- Set a strong password and login credentials.

2.2 System Interface:

- Dashboard: Provides an overview of your farm data, including sensor readings, crop health information, and personalized recommendations.
- Data & Analytics: Explore detailed graphs and charts of sensor data, soil health parameters, and historical farm records.
- Recommendations: Access personalized recommendations for irrigation, fertilization, pest control, and other farm management practices.
- Forums & Discussions: Connect with other farmers, share experiences, ask questions, and learn from each other.
- Farm Notes: Record your observations, notes, and insights about your farm and crops.

3. Using the CFSD System:

3.1 Data Access:

- View real-time sensor data on soil moisture, nutrient levels, pH, temperature, and humidity.
- Access historical farm data on crop yields, irrigation schedules, fertilizer application, and soil test results.
- Filter and analyse data by date, time, crop type, and other parameters.
- Export data to spreadsheets for further analysis and record keeping.

3.2 Recommendations:

- Receive personalized recommendations based on your farm data, weather forecasts, and market trends.
- Recommendations cover irrigation schedules, fertilizer application rates, pest control strategies, and crop selection advice.
- Users can modify and adjust recommendations based on their specific needs and preferences.

3.3 Collaboration and Knowledge Sharing:

- Participate in online forums and discussions to connect with other farmers and share experiences.
- Ask questions and receive expert advice from agricultural professionals.
- Share your own farm management practices and insights to help others.
- Learn from other farmers' experiences and challenges.

3.4 Farm Notes:

- Record observations about your crops, soil conditions, and weather patterns.
- Upload photos and videos to document your farm activities and progress.
- Use notes to track the effectiveness of specific practices and recommendations.
- Share notes with other farmers to collaborate and learn from each other's experiences.

4. Additional Resources:

- FAQs: Find answers to frequently asked questions about the CFSD System.

- Help Center: Access detailed guides and tutorials on using various platform functionalities.
- Contact Us: Submit questions or feedback to the CFSD System support team.

5. System Updates:

- The CFSD System is regularly updated with new features and improvements.
- Users will receive notifications about system updates and new functionalities.
- Update the platform to ensure access to the latest features and bug fixes.

5. Data Privacy and Security:

- The CFSD System is committed to protecting user data privacy and security.
- All data is stored on secure servers and encrypted for transmission.
- Users have control over their data and can choose to share or withhold information.
- See the privacy policy for more information about data handling and security practices.

This user manual provides a basic overview of the CFSD System functionalities. Additional resources and support are available within the platform to assist users in maximizing its benefits for their farm management practices.

Please note that this is a sample user manual and may need to be adapted to the specific features and functionalities of your CFSD System implementation.

Flow Chart

Start:

1. Sensor Data Collection: Sensors deployed across the farmland collect real-time data on various soil parameters (moisture, nutrients, pH, temperature, humidity) at regular intervals (hourly).
2. Data Transmission: Sensor data is transmitted to a central server using a reliable communication protocol (LoRaWAN, cellular network).
3. Data Storage: Data is stored in a secure cloud-based database for analysis and visualization.
4. Data Analysis:
   - Historical Farm Data Integration: Historical data on crop yields, irrigation schedules, fertilizer application, soil test results, etc., is imported and integrated with sensor data.
   - External Data Integration: Weather data, market trends, and research findings are integrated to provide context and improve recommendations.
   - Machine Learning and AI: Machine learning algorithms analyze data to identify patterns, predict trends, and generate personalized recommendations.
5. User Interface and Collaboration:
   - Data Visualization: Users access dashboards and visualizations to view real-time and historical data, track trends, and monitor farm performance.
   - Recommendations: Personalized recommendations are generated based on data analysis for irrigation, fertilization, pest control, and other farm management decisions.
   - Collaboration Tools: Farmers can participate in online forums, chat rooms, and file sharing to connect, share experiences, and learn from each other.
6. Farmer Actions:
   - Review and adjust recommendations: Farmers can review and adjust recommendations based on their specific needs and preferences.
   - Implement recommendations: Farmers implement recommendations and take actions based on the insights provided by the system.
   - Collect observations and data: Farmers record observations and data on crop health, soil conditions, and farm activities within the platform.

Loop back to step 1.

Data flow graph for the CFSD System:

```
Sensors --> Data Transmission --> Central Server --> Data Storage
                                                          |
                                                          v
                                                          Data Analysis
                                                          |
                                                          v
                                                      User Interface
                                                          |
                                                          v
                                                      Farmer Actions
                                                          |
                                                          v
                                                      Sensor Data
Collection
```

This is a simplified representation of the data flow. The actual flow may be more complex depending on the specific implementation of the CFSD System.

System Architecture Diagram:

```
+------------------------------------+
|                                    |
|             Sensor Network         |
|                                    |
+------------------------------------+
     |       |       |       |
     v       v       v       v
+--------------------+  +--------------------+  +---------------------+  +----
---------------+
| Sensor Node 1      |  | Sensor Node 2      |  | Sensor Node 3      |  |
Sensor Node N      |
+--------------------+  +--------------------+  +---------------------+  +----
---------------+
     |       |       |       |
     v       v       v       v
+---------------------------------------------+
|                                             |
|      Data Management and Analysis Platform |
|                                             |
+---------------------------------------------+
     |       |       |
     v       v
+--------------------+  +--------------------+
| Data Storage       |  | Data Analysis and |
| (Cloud Database)   |  | Machine Learning |
+--------------------+  +--------------------+
     |       |       |
     v       v
+--------------------+  +--------------------+
| User Interface     |   | Collaboration Tools|
| (Web and Mobile) |    | (Forums, Chat)
+--------------------+  +--------------------+
     |       |
     v
+--------------------+
| Farmer Actions     |
| (Decision-making, |
| Implementations)  |
+--------------------+
     |
     v
+-------------------------+
| Sensor Data Collection |
| (Loop back to          |
| step 1)                |
+-------------------------+
```

This diagram illustrates the different components of the CFSD System and their interactions.

Additional diagrams:

- Data Flow Diagram: This diagram would show the flow of data through the system, from sensor data collection to analysis, recommendations, and farmer actions.
- Collaboration Diagram: This diagram would depict the interactions between farmers within the platform, illustrating how they can share information, ask questions, and collaborate on specific challenges.
- ERD (Entity-Relationship Diagram): This diagram would show the relationships between different data entities within the system, such as sensors, farmers, crops, and soil data.

Note: These additional diagrams can be created based on specific requirements and functionalities of the implemented CFSD System.

OVERALL SUMMARY

The Collaborative Farming and Soil Detection System (CFSD System) is a data-driven platform designed to empower farmers with insights and recommendations for sustainable and efficient agricultural practices. The system utilizes sensors to collect real-time data on various soil parameters, integrates historical farm data, and leverages external data sources to generate personalized recommendations for irrigation, fertilization, pest control, and other critical farm management decisions. By promoting collaboration and knowledge sharing among farmers, the CFSD System aims to improve soil health, increase crop yields, enhance farmer livelihoods, and contribute to a more sustainable and resilient food system.

Key components of the CFSD System include:

- Sensor network
- Data management and analysis platform
- User interface and collaboration platform
- Machine learning and AI
- Communication and connectivity
- Security and privacy

The CFSD System offers a range of potential benefits, including:

- Improved farmer knowledge and decision-making
- Enhanced soil health and crop yields
- Increased farmer collaboration and innovation
- Improved economic sustainability of farms
- Positive environmental impact

The successful implementation of the CFSD System requires careful planning and consideration of various factors, such as user adoption, data security, interoperability, and sustainability. A comprehensive evaluation plan is crucial to assess the system's effectiveness and identify areas for improvement.

Further research and development efforts are needed to enhance the CFSD System's capabilities and expand its impact. These efforts may focus on advanced data analysis, enhanced collaboration tools, integration with IoT and robotics, and addressing ethical and social considerations

CODE SNAPSHOT

```
# Importing libraries

from __future__ import print_function
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.metrics import classification_report
from sklearn import metrics
from sklearn import tree
import warnings
warnings.filterwarnings('ignore')


PATH = '/content/Crop_recommendation (1).csv'
df = pd.read_csv(PATH)


df.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

```
df.tail()
```

	N	P	K	temperature	humidity	ph	rainfall	label
2195	107	34	32	26.774637	66.413269	6.780064	177.774507	coffee
2196	99	15	27	27.417112	56.636362	6.086922	127.924610	coffee
2197	118	33	30	24.131797	67.225123	6.362608	173.322839	coffee
2198	117	32	34	26.272418	52.127394	6.758793	127.175293	coffee
2199	104	18	30	23.603016	60.396475	6.779833	140.937041	coffee

```
df.size
```

```
17600
```

```
df.shape
```

```
(2200, 8)
```

```
df.columns
```

```
Index(['N', 'P', 'K', 'temperature', 'humidity', 'ph', 'rainfall', 'label'], dtype='object')
```

```
df['label'].unique()
```

```
array(['rice', 'maize', 'chickpea', 'kidneybeans', 'pigeonpeas',
       'mothbeans', 'mungbean', 'blackgram', 'lentil', 'pomegranate',
       'banana', 'mango', 'grapes', 'watermelon', 'muskmelon', 'apple',
       'orange', 'papaya', 'coconut', 'cotton', 'jute', 'coffee'],
      dtype=object)
```

```
df.dtypes
```

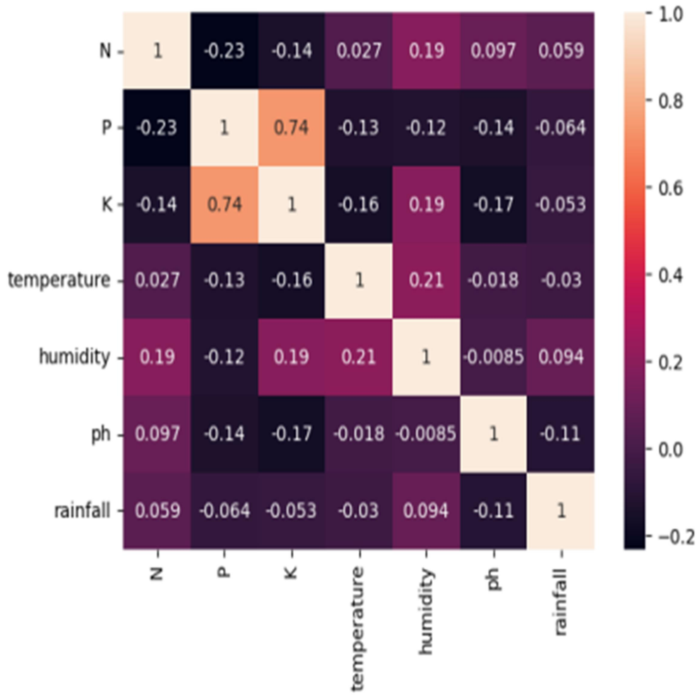
```
N                int64
P                int64
K                int64
temperature    float64
humidity       float64
ph             float64
rainfall       float64
label           object
dtype: object
```

```
df['label'].value_counts()
```

```
rice           100
maize          100
jute           100
cotton         100
coconut        100
papaya         100
orange         100
apple          100
muskmelon      100
watermelon     100
grapes         100
mango          100
banana         100
pomegranate    100
lentil         100
blackgram      100
mungbean       100
mothbeans      100
pigeonpeas     100
kidneybeans    100
chickpea       100
coffee         100
Name: label, dtype: int64
```

```
sns.heatmap(df.corr(),annot=True)
```

```
<Axes: >
```




```
features = df[['N', 'P','K','temperature', 'humidity', 'ph', 'rainfall']]
target = df['label']
labels = df['label']


# Initializing empty lists to append all model's name and corresponding name
acc = []
model = []


# Splitting into train and test data

from sklearn.model_selection import train_test_split
Xtrain, Xtest, Ytrain, Ytest = train_test_split(features,target,test_size = 0.2,random_state =2)


from sklearn.tree import DecisionTreeClassifier

DecisionTree = DecisionTreeClassifier(criterion="entropy",random_state=2,max_depth=5)

DecisionTree.fit(Xtrain,Ytrain)

predicted_values = DecisionTree.predict(Xtest)
x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
model.append('Decision Tree')
print("DecisionTrees's Accuracy is: ", x*100)
```

```
print(classification_report(Ytest,predicted_values))

    DecisionTrees's Accuracy is:  90.0
                  precision    recall  f1-score   support

           apple       1.00      1.00      1.00        13
          banana       1.00      1.00      1.00        17
       blackgram       0.59      1.00      0.74        16
        chickpea       1.00      1.00      1.00        21
         coconut       0.91      1.00      0.95        21
          coffee       1.00      1.00      1.00        22
          cotton       1.00      1.00      1.00        20
          grapes       1.00      1.00      1.00        18
            jute       0.74      0.93      0.83        28
     kidneybeans       0.00      0.00      0.00        14
          lentil       0.68      1.00      0.81        23
           maize       1.00      1.00      1.00        21
           mango       1.00      1.00      1.00        26
       mothbeans       0.00      0.00      0.00        19
        mungbean       1.00      1.00      1.00        24
       muskmelon       1.00      1.00      1.00        23
          orange       1.00      1.00      1.00        29
          papaya       1.00      0.84      0.91        19
      pigeonpeas       0.62      1.00      0.77        18
     pomegranate       1.00      1.00      1.00        17
            rice       1.00      0.62      0.77        16
      watermelon       1.00      1.00      1.00        15

        accuracy                           0.90       440
       macro avg       0.84      0.88      0.85       440
    weighted avg       0.86      0.90      0.87       440


from sklearn.model_selection import cross_val_score


# Cross validation score (Decision Tree)
score = cross_val_score(DecisionTree, features, target,cv=5)


score

    array([0.93636364, 0.90909091, 0.91818182, 0.87045455, 0.93636364])


import pickle
# Dump the trained Naive Bayes classifier with Pickle
DT_pkl_filename = 'DecisionTree.pkl'
# Open the file to save as pkl file
DT_Model_pkl = open(DT_pkl_filename, 'wb')
pickle.dump(DecisionTree, DT_Model_pkl)
# Close the pickle instances
DT_Model_pkl.close()


from sklearn.naive_bayes import GaussianNB

NaiveBayes = GaussianNB()

NaiveBayes.fit(Xtrain,Ytrain)

predicted_values = NaiveBayes.predict(Xtest)
x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
model.append('Naive Bayes')
print("Naive Bayes's Accuracy is: ", x)

print(classification_report(Ytest,predicted_values))

    Naive Bayes's Accuracy is:  0.990909090909091
                  precision    recall  f1-score   support

           apple       1.00      1.00      1.00        13
          banana       1.00      1.00      1.00        17
       blackgram       1.00      1.00      1.00        16
        chickpea       1.00      1.00      1.00        21
         coconut       1.00      1.00      1.00        21
          coffee       1.00      1.00      1.00        22
          cotton       1.00      1.00      1.00        20
          grapes       1.00      1.00      1.00        18
            jute       0.88      1.00      0.93        28
     kidneybeans       1.00      1.00      1.00        14
          lentil       1.00      1.00      1.00        23
           maize       1.00      1.00      1.00        21
           mango       1.00      1.00      1.00        26
       mothbeans       1.00      1.00      1.00        19
        mungbean       1.00      1.00      1.00        24
```

```
   muskmelon       1.00      1.00      1.00        23
      orange       1.00      1.00      1.00        29
      papaya       1.00      1.00      1.00        19
  pigeonpeas       1.00      1.00      1.00        18
 pomegranate       1.00      1.00      1.00        17
        rice       1.00      0.75      0.86        16
  watermelon       1.00      1.00      1.00        15

    accuracy                           0.99       440
   macro avg       0.99      0.99      0.99       440
weighted avg       0.99      0.99      0.99       440
```

```
# Cross validation score (NaiveBayes)
score = cross_val_score(NaiveBayes,features,target,cv=5)
score
```

```
array([0.99772727, 0.99545455, 0.99545455, 0.99545455, 0.99090909])
```

```
import pickle
# Dump the trained Naive Bayes classifier with Pickle
NB_pkl_filename = 'NBClassifier.pkl'
# Open the file to save as pkl file
NB_Model_pkl = open(NB_pkl_filename, 'wb')
pickle.dump(NaiveBayes, NB_Model_pkl)
# Close the pickle instances
NB_Model_pkl.close()
```

```
from sklearn.svm import SVC

SVM = SVC(gamma='auto')

SVM.fit(Xtrain,Ytrain)

predicted_values = SVM.predict(Xtest)

x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
model.append('SVM')
print("SVM's Accuracy is: ", x)

print(classification_report(Ytest,predicted_values))
```

```
SVM's Accuracy is:  0.10681818181818181
              precision    recall  f1-score   support

       apple       1.00      0.23      0.38        13
      banana       1.00      0.24      0.38        17
   blackgram       1.00      0.19      0.32        16
    chickpea       1.00      0.05      0.09        21
     coconut       1.00      0.05      0.09        21
      coffee       0.00      0.00      0.00        22
      cotton       1.00      0.05      0.10        20
      grapes       1.00      0.06      0.11        18
        jute       1.00      0.07      0.13        28
 kidneybeans       0.03      1.00      0.07        14
      lentil       0.00      0.00      0.00        23
       maize       0.00      0.00      0.00        21
       mango       0.00      0.00      0.00        26
   mothbeans       0.00      0.00      0.00        19
    mungbean       1.00      0.12      0.22        24
   muskmelon       1.00      0.30      0.47        23
      orange       1.00      0.03      0.07        29
      papaya       1.00      0.05      0.10        19
  pigeonpeas       0.00      0.00      0.00        18
 pomegranate       1.00      0.12      0.21        17
        rice       0.50      0.06      0.11        16
  watermelon       1.00      0.13      0.24        15

    accuracy                           0.11       440
   macro avg       0.66      0.13      0.14       440
weighted avg       0.66      0.11      0.13       440
```

```
# Cross validation score (SVM)
score = cross_val_score(SVM,features,target,cv=5)
score
```

```
array([0.27727273, 0.28863636, 0.29090909, 0.275     , 0.26818182])
```

```
from sklearn.linear_model import LogisticRegression

LogReg = LogisticRegression(random_state=2)
```

```
LogReg.fit(Xtrain,Ytrain)

predicted_values = LogReg.predict(Xtest)

x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
model.append('Logistic Regression')
print("Logistic Regression's Accuracy is: ", x)

print(classification_report(Ytest,predicted_values))
```

```
Logistic Regression's Accuracy is:  0.9522727272727273
              precision    recall  f1-score   support

       apple       1.00      1.00      1.00        13
      banana       1.00      1.00      1.00        17
   blackgram       0.86      0.75      0.80        16
    chickpea       1.00      1.00      1.00        21
     coconut       1.00      1.00      1.00        21
      coffee       1.00      1.00      1.00        22
      cotton       0.86      0.90      0.88        20
      grapes       1.00      1.00      1.00        18
        jute       0.84      0.93      0.88        28
 kidneybeans       1.00      1.00      1.00        14
      lentil       0.88      1.00      0.94        23
       maize       0.90      0.86      0.88        21
       mango       0.96      1.00      0.98        26
   mothbeans       0.84      0.84      0.84        19
    mungbean       1.00      0.96      0.98        24
   muskmelon       1.00      1.00      1.00        23
      orange       1.00      1.00      1.00        29
      papaya       1.00      0.95      0.97        19
  pigeonpeas       1.00      1.00      1.00        18
 pomegranate       1.00      1.00      1.00        17
        rice       0.85      0.69      0.76        16
  watermelon       1.00      1.00      1.00        15

    accuracy                           0.95       440
   macro avg       0.95      0.95      0.95       440
weighted avg       0.95      0.95      0.95       440
```

```
# Cross validation score (Logistic Regression)
score = cross_val_score(LogReg,features,target,cv=5)
score
```

```
array([0.95      , 0.96590909, 0.94772727, 0.96590909, 0.94318182])
```

```
import pickle
# Dump the trained Naive Bayes classifier with Pickle
LR_pkl_filename = 'LogisticRegression.pkl'
# Open the file to save as pkl file
LR_Model_pkl = open(DT_pkl_filename, 'wb')
pickle.dump(LogReg, LR_Model_pkl)
# Close the pickle instances
LR_Model_pkl.close()
```

```
from sklearn.ensemble import RandomForestClassifier

RF = RandomForestClassifier(n_estimators=20, random_state=0)
RF.fit(Xtrain,Ytrain)

predicted_values = RF.predict(Xtest)

x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
model.append('RF')
print("RF's Accuracy is: ", x)

print(classification_report(Ytest,predicted_values))
```

```
RF's Accuracy is:  0.990909090909091
              precision    recall  f1-score   support

       apple       1.00      1.00      1.00        13
      banana       1.00      1.00      1.00        17
   blackgram       0.94      1.00      0.97        16
    chickpea       1.00      1.00      1.00        21
     coconut       1.00      1.00      1.00        21
      coffee       1.00      1.00      1.00        22
      cotton       1.00      1.00      1.00        20
      grapes       1.00      1.00      1.00        18
        jute       0.90      1.00      0.95        28
```

```
 kidneybeans       1.00      1.00      1.00        14
      lentil       1.00      1.00      1.00        23
       maize       1.00      1.00      1.00        21
       mango       1.00      1.00      1.00        26
   mothbeans       1.00      0.95      0.97        19
    mungbean       1.00      1.00      1.00        24
   muskmelon       1.00      1.00      1.00        23
      orange       1.00      1.00      1.00        29
      papaya       1.00      1.00      1.00        19
  pigeonpeas       1.00      1.00      1.00        18
 pomegranate       1.00      1.00      1.00        17
        rice       1.00      0.81      0.90        16
  watermelon       1.00      1.00      1.00        15

    accuracy                           0.99       440
   macro avg       0.99      0.99      0.99       440
weighted avg       0.99      0.99      0.99       440
```

```
# Cross validation score (Random Forest)
score = cross_val_score(RF,features,target,cv=5)
score
```

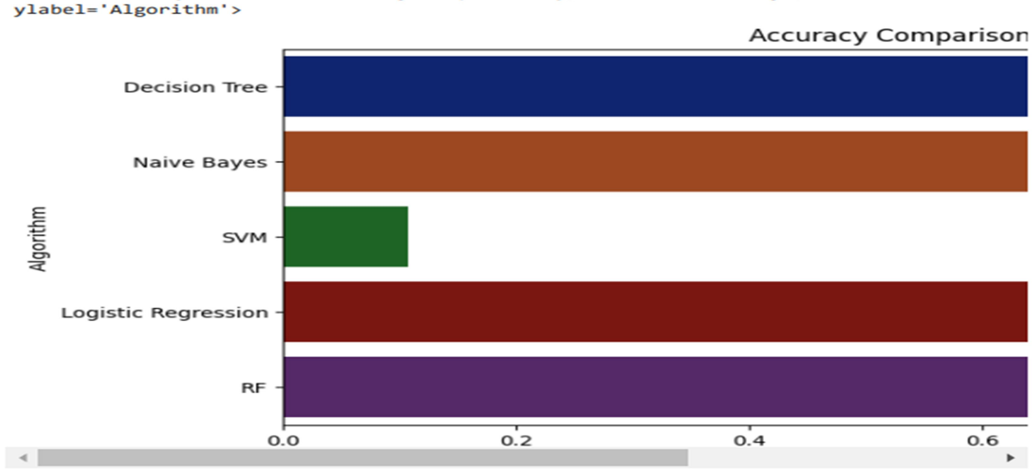
```
array([0.99772727, 0.99545455, 0.99772727, 0.99318182, 0.98863636])
```

```
import pickle
# Dump the trained Naive Bayes classifier with Pickle
RF_pkl_filename = 'reported.pkl'
# Open the file to save as pkl file
RF_Model_pkl = open(RF_pkl_filename, 'wb')
pickle.dump(RF, RF_Model_pkl)
# Close the pickle instances
RF_Model_pkl.close()
```

```
import pickle
# Dump the trained Naive Bayes classifier with Pickle
XB_pkl_filename = 'XGBoost.pkl'
# Open the file to save as pkl file
XB_Model_pkl = open(XB_pkl_filename, 'wb')
pickle.dump(XB, XB_Model_pkl)
# Close the pickle instances
XB_Model_pkl.close()
```

```
plt.figure(figsize=[10,5],dpi = 100)
plt.title('Accuracy Comparison')
plt.xlabel('Accuracy')
plt.ylabel('Algorithm')
sns.barplot(x = acc,y = model,palette='dark')
```

```
<Axes: title={'center': 'Accuracy Comparison'}, xlabel='Accuracy',
ylabel='Algorithm'>
```




```
accuracy_models = dict(zip(model, acc))
for k, v in accuracy_models.items():
    print (k, '-->', v)
```

```
Decision Tree --> 0.9
Naive Bayes --> 0.990909090909091
SVM --> 0.10681818181818181
Logistic Regression --> 0.9522727272727273
RF --> 0.990909090909091
```

```
data = np.array([[104,18, 30, 23.603016, 60.3, 6.7, 140.91]])
prediction = RF.predict(data)
print(prediction)
```

```
['coffee']
```

```
data = np.array([[83, 45, 60, 28, 70.3, 7.0, 150.9]])
prediction = RF.predict(data)
print(prediction)
```

```
['jute']
```

I.T.S ENGINEERING COLLEGE
GREATER NOIDA
(A NAAC Accredited Engineering College)

Project Title- COLLABORATIVE FARMING AND SOIL DETECTION SYSTEM

Course No.
Semester: VII TH

In

I.T.S Engineering College

Submitted for partial fulfilment of award of

BACHELOR OF TECHNOLOGY

Degree in

Computer Science & Engineering

Submitted by

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Project: ☐ **Approved** ☐ **Not Approved**

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

I.T.S ENGINEERING COLLEGE

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