JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

REVOLUTIONALIZING AGRICULTURE WITH DIGITAL TECHNOLOGY :A COMPREHENSIVE STUDY

[1]Prof. Rupa Kawchale, [2]Atharva Deshpande, [3]Atharva Joshi, [4]Manas Kulkarni, [5]Pragati Patil, [6]Revati Aute
Faculty, Student, Student, Student, Student, Student
Department of Electronics and Telecommunications Engineering
Vishwakarma Institute of Information Technology, Pune, India

Abstract : This research paper explores various aspects of Agriculture, focusing on the various sectors within it, such as crop production, livestock, technology, and trade. Additionally, it highlights the challenges faced by Indian agriculture, including those intensified by the COVID-19 pandemic, and discusses the importance of sustainable practices in the face of climate change. A significant portion of the paper focuses on Indian millets, detailing their nutritional value and their historical significance. The export trends, global destinations, and the resilience of millets in varied climates are also explored. The latter part of the paper introduces AgriPy, a Python-based solution developed by our group to tackle challenges in agriculture by integrating diverse modules, namely Water Management, Automation for Agriculture, Predicting Crop Yields, Logistics and Supply Chains, Plant Disease Detection, Crop Simulation, and Livestock Management. By amalgamating these modules, our project strives to simplify farming tasks, foster sustainability, and empower farmers with valuable insights. The research concludes by emphasizing the vital role technology, particularly Python programming, plays in shaping the future of agriculture.

IndexTerms –

1. **AgriPy: Name of the Python Project**
2. **Tkinter: GUI utilized in the project**
3. **OpenWeatherMap: API utilized in the project**
4. **ImageTk: Module from Pillow library in Python**
5. **PlantDiseaseDetectionApp: Class utilized in the project**
6. **analyze_image: Method utilized in the project**
7. **update_image_label: Method utilized in the project**
8. **update_image_label_from_frame: Method utilized in the project**

INTRODUCTION

The agriculture industry refers to a sector that involves the production, processing, and distribution of agricultural products. It consists of all activities related to cultivating crops, raising livestock, and producing various food and non-food products derived from agricultural resources. Some of the common agriculture products are categorized under fibres, foods, and raw materials. The agriculture industry is diverse and comprises various sectors and sub-sectors, such as crop production, livestock production, agricultural technology, food processing, agricultural inputs (seeds, fertilizers, pesticides), agricultural services, equipment, trade and distribution, and retail. Precision agriculture or smart Agriculture relies on emerging technologies such as AI, ML, Python Programming and data analytics to revolutionize farming practices.

The use of digital technologies to integrate agricultural production from paddock to market is known as digital agriculture. This has become important because it will aid the farmers in making well-informed decisions regarding the cultivation of crops and also boost their productivity. Internet of Things (IoT), different types of sensors, sophisticated machinery, robotics and other technology can be used in farms to maximize crop yield. The obtaining of data related to weather and soil patterns of a particular region and its processing is of utmost importance if we aim to successfully integrate technology and agriculture. Also, we need to bring in new, state-of-the-art road and power generation infrastructure if we want to improve our crop productivity. We should also look to reduce our dependency on ground water for irrigation of crops as this has led to depletion in the groundwater reserves and poor water quality.

I. RESEARCH METHODOLOGY

The integration of Python programming language in agriculture has sparked a new era of innovation and efficiency in farming practices. This research paper delves into the various applications of Python in agriculture, exploring its role in data analysis, crop management, predictive modelling, and automation. Through the utilization of Python, farmers can optimize their yields, minimize water wastage, can generate invoice, detect diseases and make informed decisions for sustainable agricultural practices.

Features of AgriPy, the Python software are as follows:

1. Water Management

- Makes use of Python libraries (e.g.- Tkinter, requests) and date time module for calculating the amount of time required for filling of the water storage facility.

- Interactive, easy-to-use GUI helps in displaying the output in an organized manner.

2. Automation for Agriculture
   - Utilizes OpenWeatherMap API to extract soil moisture information of a particular region.
   - Sends a request to the OpenWeatherMap API, retrieves the JSON response, and extracts relevant weather information such as main weather conditions, temperature, and humidity.

3. Predict Crop Yields
   - Employs a simple linear regression model to predict crop yield based on rainfall.
   - Rainfall is then used to predict the crop yield by applying the linear regression equation.

4. Logistics & Supply Chain
   - Code creates a graphical user interface to facilitate the ordering process for agricultural crops.
   - The code calculates and opens a new window displaying order details.

5. Plant Disease Detection
   - Contains methods for opening and capturing images, and it uses OpenCV and NumPy for image processing.
   - The code integrates the default camera using OpenCV, allowing users to capture real-time images for disease detection.

6. Crop Simulation
   - Prompts the user to enter a city name and fetches the weather data for that city.
   - Calculates the daily growth of the crop based on temperature, rainfall, and soil moisture factors using a mathematical model.

7. Livestock Management
   - Represents livestock animals with attributes such as name, breed, age, gender, weight, and health status.
   - The program includes functions for saving and loading data to/from a JSON file. Data is stored in JSON format, allowing for persistent storage of livestock information between program executions.

3.1 Automation for Agriculture, Predicting Crop Yields & Plant Disease Detection

Automation for Agriculture, often associated with "smart farming," uses various technological devices to improve and automate agriculture operations, making farms more efficient. It includes the use of machinery and equipment, from simple hand tools to more sophisticated and motorized machinery, in agricultural operations. This can optimize the food production process and improve quality.

Predicting Crop Yields involves analyzing various factors such as weather conditions, soil characteristics, crop genetics, and management practices to make informed predictions about the likely harvest. Machine learning models are used to predict crop yield in India, taking into account factors like fertilizer consumption, temperature, humidity, pH, and rainfall.

Plant Disease Detection is a crucial aspect of machine vision technology. It uses machine vision equipment to acquire images and judge whether there are diseases and pests in the collected plant images. Deep learning has made breakthroughs in this field, far superior to traditional methods. This technology can identify and locate diseased or pest plants in images, which is essential for maintaining crop health and yield.

In conclusion, the production of millets in India is closely related to Automation for Agriculture, Predict Crop Yields, and Plant Disease Detection. These technologies can help optimize production, predict yields accurately, and detect plant diseases early, thereby contributing to sustainable and efficient millet production.

3.2 Automation For Agriculture

Farmers often face challenges in determining the optimal watering schedule for their crops. Our code addresses this issue by utilizing the OpenWeatherMap API to extract soil moisture information of a particular region. The code then provides clear indications, stating whether the soil is dry, moist, or wet. This information serves as valuable guidance for farmers, helping them make informed decisions on whether watering their crops is necessary.

1. API Integration:
- The code integrates with the OpenWeatherMap API to fetch current weather data for a specific city. - An API key is used for authentication and access to weather information.
2. GUI Design with Tkinter:
- The script utilizes the Tkinter library to create a graphical user interface (GUI) for the application.
- The GUI includes an entry field for the user to input the city name and a button to trigger the weather and moisture level retrieval.
3. Weather Data Retrieval:
- The get_weather function is executed when the user clicks the "Get Weather and Moisture Level" button.
- It sends a request to the OpenWeatherMap API, retrieves the JSON response, and extracts relevant weather information such as main weather conditions, temperature, and humidity.
4. Moisture Level Calculation:
- The code calculates the moisture level based on the humidity data obtained from the weather API response.
- Different messages are displayed in the result label to indicate whether the soil is dry, moist, or wet, providing guidance on watering plants accordingly.
5. User Interface Feedback:
- The GUI presents a user-friendly interface, allowing users to input a city, fetch weather information, and receive feedback on both weather conditions and soil moisture levels.
- The result label dynamically updates to display the fetched data and moisture level information. The overall design enhances user interaction and understanding.

PREDICT CROP YIELDS

Farmers often face challenges in predicting their crop yields. Our code addresses this issue by leveraging rainfall data obtained from the OpenWeatherMap API to predict crop yields. This prediction serves as a valuable tool for farmers, enabling them to plan their finances proactively based on anticipated agricultural outcomes.

1. Weather and Crop Yield Prediction: The code allows users to input a city and the corresponding rainfall (in mm). It utilizes the OpenWeatherMap API to fetch current weather details for the specified city, including temperature, humidity & Rainfall.
2. Linear Regression Model: The program employs a simple linear regression model to predict crop yield based on rainfall. It uses pre-defined example data for rainfall, temperature, and crop yield to calculate the slope (m) and intercept (c) for the linear regression equation.
3. Prediction: The rainfall is then used to predict the crop yield by applying the linear regression equation. The predicted crop yield is displayed as the result.
4. Graphical User Interface (GUI): The code utilizes the Tkinter library to create a graphical user interface (GUI). Users can enter their city through entry widgets, and the result is displayed on the GUI.
5. Visual Representation: The code provides a practical example of using weather data (rainfall) to make predictions about agricultural outcomes. It showcases the potential applications of data-driven decision-making in agriculture, aiding farmers in anticipating crop yields based on weather conditions.

PLANT DISEASE DETECTION

Farmers often struggle to identify whether their crops are diseased or healthy. Our code addresses this issue by providing a user-friendly plant disease detection application. Farmers can conveniently capture real-time images of their crops using their mobile's camera through our intuitive graphical interface. The application analyses the images, assessing the average intensity to determine if a disease is present. The result is displayed on the interface, allowing farmers to quickly identify the health status of their crops, facilitating timely interventions and promoting better crop management practices.

1. GUI Setup:
- The code uses the tkinter library to create a graphical user interface (GUI) for a plant disease detection application.
- It includes "Open Image" and "Capture Image" buttons for loading images from files or capturing them using the default camera.
2. Image Analysis:
- The PlantDiseaseDetectionApp class contains methods for opening and capturing images, and it uses OpenCV and NumPy for image processing.
- The analyze_image method converts the image to grayscale and calculates the average intensity. If the intensity exceeds a threshold (200 in this case), it indicates a disease.
3. Result Display:
- The GUI displays the analysis result with a label, stating whether a disease is detected or not.
4. Image Display: - The captured or opened image is displayed on the GUI using the ImageTk module from the Pillow (PIL) library.
- The update_image_label and update_image_label_from_frame methods handle the conversion and updating of images on the GUI.
5. Camera Integration:
- The code integrates the default camera using OpenCV, allowing users to capture real-time images for disease detection.
- The update method continuously updates the camera feed on the GUI, creating a live preview for users.

3.4Statistical tools

Millets and Their Importance: Indian millets are a diverse group of small-seeded grains that have been integral to the country's culinary and agricultural heritage for centuries. These ancient grains, which include varieties such as pearl millet (bajra), finger millet (ragi), foxtail millet (kangni), and little millet (kutki), have sustained communities across India with their exceptional nutritional content and adaptability to varying climates. From a nutritional standpoint, millets are rich sources of essential nutrients such as fiber, proteins, vitamins, and minerals. They contribute to a well-rounded and balanced diet, offering tons of health benefits and the prevention of various lifestyle-related diseases.

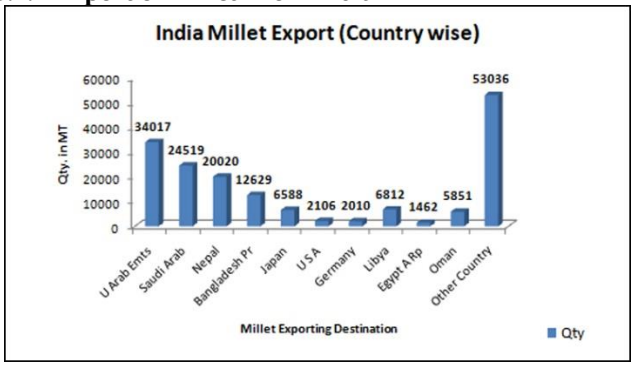
To create domestic and global demand and to provide nutritional food to the people, Government of India had proposed to the United Nations for declaring 2023 as International Year of Millets (IYoM-2023). The proposal of India was supported by 72 countries and United Nations' General Assembly (UNGA) declared 2023 as International Year of Millets on 5th March, 2021. This led to the Hon'ble Union Finance Minister making a budget announcement on 1st February 2022: "2023 has been announced as the International Year of Millets. Support will be provided for post-harvest value addition, enhancing domestic consumption and branding of millet products nationally and internationally.

Millets are exceptionally resilient crops, thriving in rain-fed and arid climates with minimal water, fertilizer, and pesticide requirements. Beyond their adaptability, millets boast a superior micronutrient profile and bioactive flavonoids, making them a health-promoting, gluten-free alternative. Moreover, millet cultivation contributes to reducing the carbon footprint, emphasizing its holistic benefits.

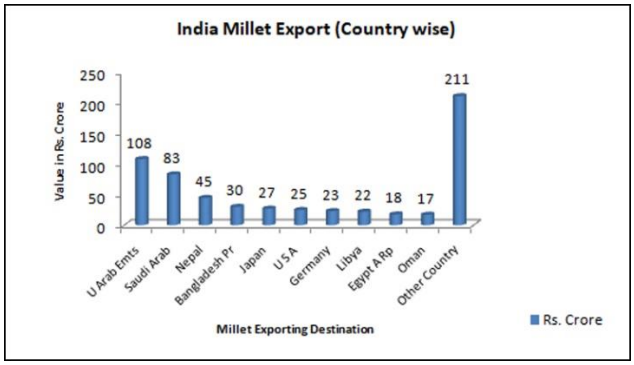
3.4.1 Descriptive Statistics

India's export of Millets is 64 million USD in the year 2021-22. There is an increase in export of Millets by 12.5 % during the period April-December 2023 as compared to the same period last year. Export of millets has witnessed a change in paradigm in the last decade. The major importing countries were USA, Australia, Japan, Belgium etc. in 2011-12 which had been shifted to Nepal (USD 6.09 million), UAE (USD 4.84 million) and Saudi Arabia (USD 3.84 million) in 2021-22. Kenya, Pakistan were also among the potential import destinations for India in the last decade. The other seven destinations in the current top-ten list of India's millet exports are Libya, Tunisia, Morocco, UK, Yemen, Oman and Algeria. India is exporting millets to 139 countries across the globe. The export of value-added products from Indian millets is also spread across the world.

3.4.2 Export of Millet From India

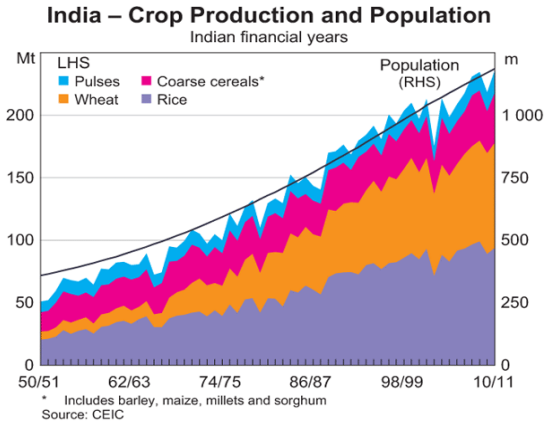


[1] fig 1.1

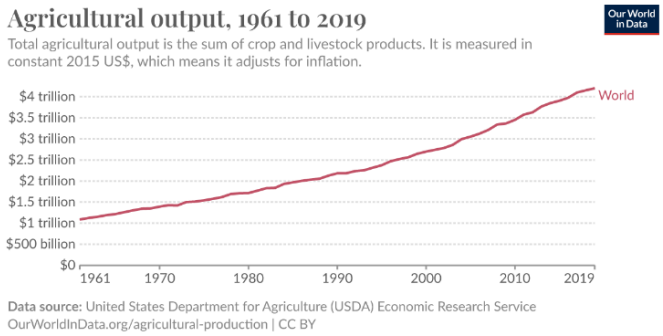


[2] fig 1.2

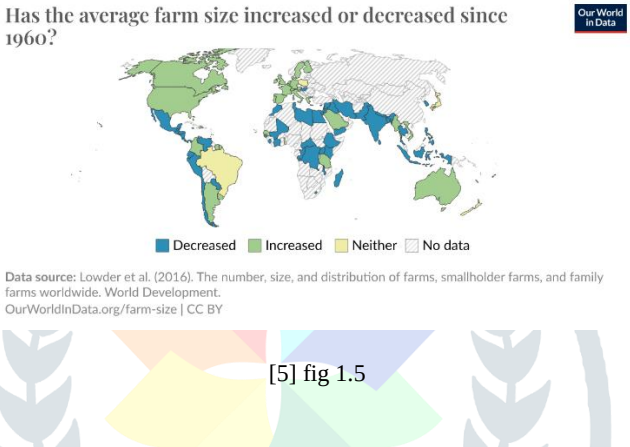
3.4.2.1 Agricultural Output and Average Farm Size Across the World



[3] fig 1.3



[4] fig 1.4



[5] fig 1.5

3.4.3 Methodology

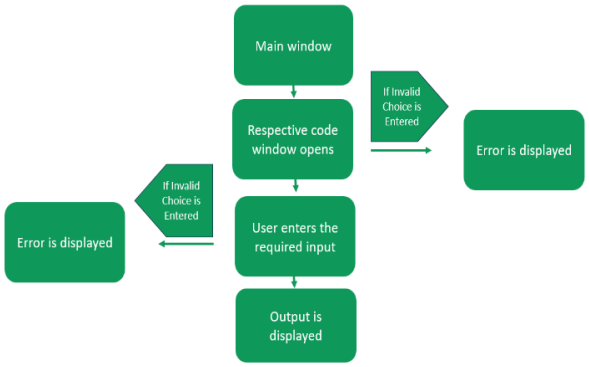


fig 1.6

3.4.3.1 Flow of the Program

1. Common Window/GUI:
   - Display options: Water Management, Automation, Crop Yield Prediction, Logistics, Disease Detection, Crop Simulation, Livestock Management.
   - User inputs the option number.
2. Option Selection Handling:
   - Based on the user input:
     - If 1 (Water Management): Navigate to Water Management module.
     - If 2 (Automation for Agriculture): Navigate to Automation module.
     - If 3 (Predict crop yields): Navigate to Crop Yield Prediction module.
     - If 4 (Logistics and Supply Chain): Navigate to Logistics and Supply Chain module.
     - If 5 (Plant Disease Detection): Navigate to Plant Disease Detection module.
     - If 6 (Crop Simulation): Navigate to Crop Simulation module.
     - If 7 (Livestock Management): Navigate to Livestock Management module.
3. Water Management Module:
   - Implement features related to water usage optimization, irrigation scheduling, etc.
4. Automation Module:

- Develop functionalities for automating tasks in agriculture, like watering the farm.

5. Crop Yield Prediction Module:
   - Integrate algorithms using real-time weather API data for predicting crop yields.
6. Logistics Module:
   - Implement features for supply chain optimization, including transportation and storage.
7. Disease Detection Module:
   - Use image processing techniques to detect and diagnose plant diseases.
8. Crop Simulation Module:
   - Create simulations for crop growth based on various parameters and conditions.
9. Livestock Management Module:
   - Include features for monitoring and managing livestock health, breeding, and other relevant aspects.

This flow provides a structured approach for users to navigate through different aspects of AgriPy based on their specific needs in agriculture.

3.4.4 Importance of Water Management

Ground water depletion is one of the major concerns for farmers in India. Due to usage of water for irrigation and household purposes, groundwater levels are decreasing at an alarming rate. In drought prone areas, groundwater is the only source for the irrigation of crops due to lack of rainfall. This has led to overextraction of groundwater. Inadequate regulations related to usage of groundwater has further aggravated the issue. Hence, it has become of prime importance to monitor the groundwater levels and to conserve them.

Python's role in future water management is poised for further expansion and innovation. Integration with IoT devices and sensors will enable more precise data collection. Artificial Intelligence (AI) and machine learning will enhance predictive capabilities for water demand and infrastructure maintenance. Additionally, Python's versatility allows adaptation to emerging technologies and changing environmental conditions.

II. RESULTS AND DISCUSSION

4.1 Figures of Results

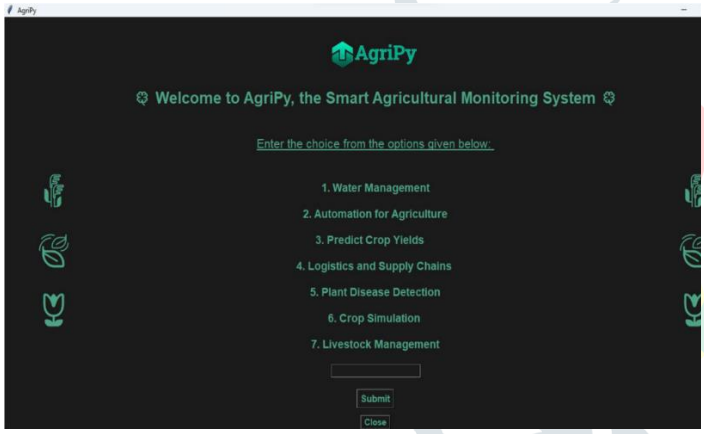


fig 1.7

fig 1.8

III. ACKNOWLEDGMENT

We would like to extend our sincere gratitude to Prof. Rupa Kawchale, our guide for this paper, for us presenting us with this wonderful opportunity to publish our work.

Our objectives are to improve its features, performance, user interface, to test it with real farmers and get their feedback and suggestions, to collaborate with other experts and organizations in the field of agriculture and technology, to make it accessible, affordable, and reliable for the farmers, and to make a positive impact on the agriculture community and the society through our project.

REFERENCES

Image Credits:

[1] https://apeda.gov.in/milletportal/assets/img/graph4.jpg
[2] https://apeda.gov.in/milletportal/assets/img/graph5.jpg
[3] https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.rba.gov.au%2Fpublications%2Fbulletin%2F2011%2Fjun%2F3.html&psig=AOvVaw39-ipzH8-5Fswn-cBxSROm&ust=1715438663539000&source=images&cd=vfe&opi=89978449&ved=0CBIQjRxqFwoTCMiyoZepg4YDFQAAAAAdAAAAABAH
[4] https://www.google.com/url?sa=i&url=https%3A%2F%2Fourworldindata.org%2Fgrapher%2Fagricultural-output-dollars&psig=AOvVaw39-ipzH8-5Fswn-cBxSROm&ust=1715438663539000&source=images&cd=vfe&opi=89978449&ved=0CBIQjRxqFwoTCMiyoZepg4YDFQAAAAAdAAAAABAD
[5] https://www.google.com/url?sa=i&url=https%3A%2F%2Fourworldindata.org%2Fgrapher%2Ffarm-size-

change&psig=AOvVaw0bwqak5UO6ZRQmzZleylYH&ust=1715438873987000&source=images&cd=vfe&opi=89978449&ved=0CBIQjRxqFwoTCMCliv2pg4YDFQAAAAAdAAAAABAI

Papers:

[1] Effect of Climate Variability and Change on Agriculture in India by Asha Sharma: https://tci.cornell.edu/wp-content/uploads/2021/07/TCI-TARINA-Policy-Brief-No.4-VD.pdf
[2] Journal of Agricultural Extension Management: https://www.manage.gov.in/publications/journal/jul-dec2022.pdf

Books:

[1] Conservation Agriculture in India: A Paradigm Shift for Sustainable Agriculture: Edited by A.R. Sharma