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Data-Driven Smart Agriculture: Use of AI/ML Technologies for Enhancing Crop Prediction

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Abstract

In the face of unpredictable global economic conditions, urban populations in developing countries are experiencing heightened challenges compared to their rural counterparts. Recognizing the importance of agriculture as a resilient support system during economic downturns, particularly in the wake of climate-related uncertainties such as heat waves, our team, embarked on a mission to identify root causes and viable solutions. Through extensive field visits and analysis, we identified that urban middle-class populations are particularly vulnerable, lacking the resilience afforded by rural agriculture. To address this, we propose the implementation of artificial intelligence (AI) to optimize crop related data, thereby enhancing crop production predictability. Focusing our efforts in Bangladesh, where recent heat waves have exacerbated food security concerns, we seek to leverage AI to develop and maintain accurate crop data prediction as well as crop calendars, ensuring sufficient food reserves for urban and rural populations alike. By sharing our experiences and proven solutions, we aim to contribute to addressing the challenges posed by economic volatility and climate change, safeguarding food security for all.

Keywords

Crop Management, Artificial Intelligence (AI), Agricultural Big Data, Smart Agriculture, Crop Prediction, Agricultural Forecasting, AI/ML Models

1. Introduction

The AI powered crop mobile application/web application gives farmers a customized schedule for each crop, guiding them from land preparation to harvest. Using AI, this tool will help farmers to enhance their crop yield. Agriculture is one of the world's oldest and most vital industries. As the world's population grows, so does demand

for food and work. Traditional farming methods cannot keep up, necessitating the development of new automated approaches. AI in crop production makes agricultural goods smarter and more linked, resulting in higher quality and quantity.

Technology is transforming agriculture, boosting resilience, sustainability, and productivity in the face of challenges such as population growth and climate change. Integrating AI/ML into crop calendars is a critical part of this change. These technologies can analyze enormous amounts of data to produce accurate forecasts and insights. AI methods are being used to meet requirements of foods. Cause AI methods are not only used to meet the field requirements but also creating opportunities for huge employment opportunities for huge amount of people all over the world [1] [2].

To put it briefly, agricultural cooperatives in developing countries depend heavily on technological innovation to maintain their competitive edge and long-term viability. Agriculture now needs to adopt a more dynamic and data-driven approach due to factors including changing soil conditions, unpredictable weather patterns, and the introduction of new pests and diseases. This approach further benefits farmers with Risk Mitigation and Early Detection, Improved Production Predictions, and Resource Management. All these combined wills eventually enable farmers to boost profit.

The objective of this research is to understand the need of AI in crop field, we are focusing to build an app/web portal in our next project, in this paper, we have added the flow chart as well the prototype of our assuming app/web portal where we want to take data from satellite as well as the sensor. In this way, AI will help us to get the relevant data for evaluating data and will help us to detect Favorable Weather Conditions, Congenial Weather Conditions for Pests, Diseases, and Weather Warning. Through the app, we are planning to get proper guidelines for the farming, as well as getting notification/alerts for different warning situations for different stages [3] [4].

AI can transform crop management and output, particularly in places with different climates such as Bangladesh. The goal is to create an AI-powered system that leverages satellite meteorological data to deliver exact suggestions for the optimal growth of rice, mustard, and potato [5] [6].

Rice, potato, and mustard are very important for Bangladesh, as these are the staple crops. Each of these crops has unique characteristics that require unique climatic conditions. For example, rice grows well in warm, wet conditions, therefore, areas having high rainfall and temperature will be good for rice production, on the other hand, mustard grows well at temperature 15˚C to 29˚C and soil temperature 13˚C to 27˚C, while potatoes need a cooler climate. Our AI system will analyze weather data, such as temperature, precipitation, and soil moisture, from satellites to identify the best areas and times for cultivating each crop [7] [8].

The system will be trained with various weather data from satellites and several Machine Learning and Artificial Intelligence algorithms will be used and the models will be updated with real-time data from time to time so that it can predict and give recommendations to farmers regarding which crops to grow in which

weather conditions. For example, depending on the rainfall, it will suggest a crop that is most suitable for that level of rainfall.

2. Methodology

The study proposes a comprehensive methodology involving data collection, preprocessing, model development, and deployment. Key stages include:

Data Collection: Gathering weather, soil, crop yield, and GIS data from reliable sources.

Data Preprocessing: Cleaning, normalizing, and integrating data for effective analysis.

Model Development: Employing machine learning models (e.g., LSTM, ARIMA, SVM) for weather prediction, crop suitability classification, and yield estimation.

System Integration: Developing a user-friendly interface and deploying models on a cloud-based platform. Testing and Validation: Conducting field tests and performance monitoring to refine the system.

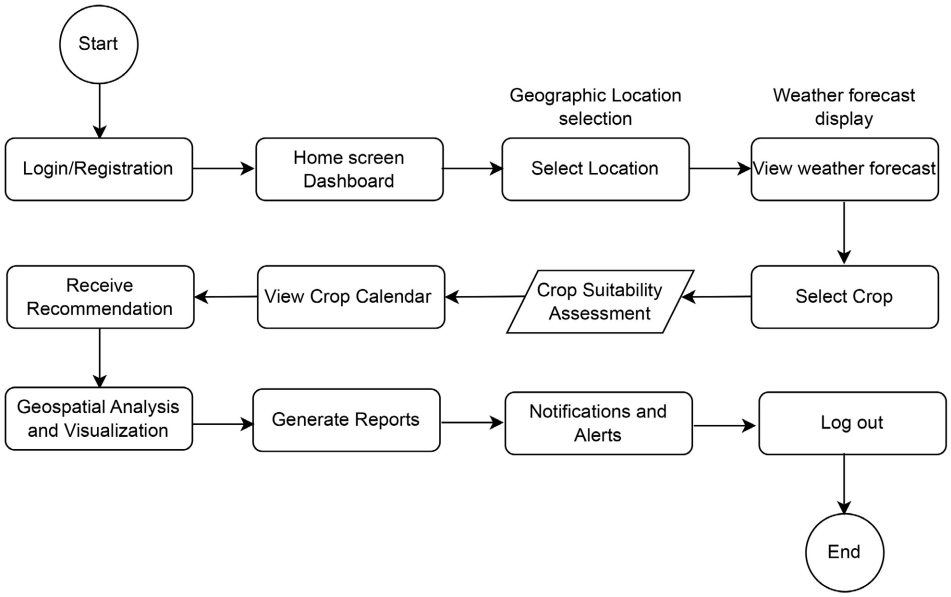

Figure 1. The flow diagram for crop calendar application. **Note:** This is the flow diagram of mobile application or web application of crop calendar.

Figures/Flow

In the flow diagram, we tried to say how we think mobile application/web a process flow of crop mobile application or web application (Figure 1). This process will help us to understand how the variables will relate with the flow. In our proposed system the new users need to registration first. As well as the existing user can login with their registered user credentials. Then the user can see the dashboard as well as selecting the geographic location where they want to predict the climate condition for particular-lar crops. In the dashboard, the user can also experience the weather forecasting for different crops. Through the dashboard the user can select the crop. They can do crop suitability assessment. Also using crop

calendar view user can easily assess the crop suitability for that particular crop. Through this process, the user will receive recommendations for particular crop in a suitable location. This recommendation helps the user to analysis as well as visualize the crop progress on that particular location. The system will also have the facilities to generate the reports for further uses. The system also generates notification and alerts that help user for any bad situation detection for crop production. In short, the whole system (mobile application/web application) will help the end user to predict the crop assessment for any particular location, to predict the weather forecasting. This will help to get the recommendation, get the notifications and alerts. Also, it will help to generate a report for the details description of the system. The below image reflected on the article:

2.1. Algorithm

We have taken three crops for analysis and optimizing the growth. Three crops are: Rice, Mustard and Potato. Our proposed AI-driven crop system includes algorithms which will process satellite data for weather and other information to provide the exact recommendations. The algorithms involved the below process:

1) Normalize soil and weather data for input into random machine learning models through prepossessing and cleaning algorithms. In most cases, the median is utilized to handle meteorological data and missing soil.

2) Long short-term memory networks are models used in weather prediction that use satellite data to estimate temperature and humidity. The baseline forecast is derived from short-term weather prediction models.

3) Acceptability Crop classification: this facilitates the grouping of crops by geographical areas. The soil type, weather, and weather patterns are taken into account while classifying using this model. The resulting data is then sent into a web-based portal or application. Much like SVN useful for binary classification jobs to determine the precise area that will be appropriate for a given crop.

4) Different types of input features such as temperature, rainfall, soil moisture, and historical data will use multiple Linear regression models to estimate crop yields.

5) To optimize planting schedules and resource allocation by simulating and selecting various scenarios and strategies used to optimize the planting schedules.

6) Techniques of Geographic Information System will be used to yield predictions geographic locations, also will help to map crop suitability and visual insights and spatial analysis.

7) LSTMs and CNNs are used for image as well as time data processing and help us with deep data learning for further training.

2.2. Table and Analysis

We have tried to display the data according to crop stages. For analysis, we have chosen various variables. Our goal is to obtain input for these variables from many sources, such as satellites and other sensors. Next, we are organizing a web-based and AI-based application for three crops: Rice, Mustard and Potato. We have col-

lected information from the below web portal link: Bangladesh crop calendar.

Climate Variables are:

Temperature: T

Soil Temperature: ST

Bright Sunshine (hrs): S

Relative Humidity (%): RH

Rainfall (mm): R

Normal Phase wise Water requirement (mm): W

Plant Diseases Variables are:

Late Blight: LB

Alternaria leaf blight: ALB

Bacterial wilt: BW

Fusarium wilt: FW

Potato Leaf Roll Virus: LV

Termite: TM

Potato Wire Worm: PWW

Stem rot: SR

Meteorological Variables are:

Duration of wet spell: WP

Cloudy Weather: CW

Light Intensity: LI

Drought: D

High Winds: HW

Hailstorm: HS

A1) Favorable Weather Conditions for Different growth stages of Potato:

- **Spouting and seeding:**

T 18˚C - 21˚C

S At least 6 - 9 hr

H 65% - 80%

ST 15˚C - 18˚C

R 400 - 600 mm

W 400 - 450 mm

- **Vegetative growth of potato:**

T 10˚C - 18˚C

S At least 6 - 9

H 65 - 80 percent

ST 15˚C - 18˚C

R 400 - 600 mm

W 400 - 450 mm

- **Tuber set/initiation and bulking/development of potato:**

T Day temperature 18˚C - 20˚C and night temperature 15˚C

S At least 6 - 9

H 65 - 80 percent

ST 15˚C - 18˚C

R 400 - 600 mm
W 400 - 450 mm

- **Maturity of potato:**

T 15˚C - 18˚C
S At least 6 - 9
H 65 - 80 percent
ST 15˚C - 18˚C
R 400 - 600 mm
W 400 - 450 mm

For Favorable Weather Conditions spouting and seeding of potato need (T 8˚C - 21˚C, S At least 6 - 9, H 65 - 80 percent, ST 15˚C - 18˚C, R 400 - 600 mm, W 400 - 450 mm). For Favorable Weather Conditions vegetative growth of potato need (T 10˚C - 18˚C, S At least 6 - 9, H 65 - 80 percent, ST 15˚C - 18˚C, R 400 - 600 mm, W 400 - 450 mm). As shown in (Table 1), for Favorable Weather Conditions Tuber set/initiation and bulking/development of potato need (T Day temperature 18˚C - 20˚C and night temperature 15˚C, S At least 6 - 9, H 65 - 80 percent, ST 15˚C - 18˚C, R 400 - 600 mm, W 400 - 450 mm). For Favorable Weather Conditions Maturity of potato need (T 15˚C - 18˚C, S At least 6 - 9, H 65 - 80 percent, ST 15˚C - 18˚C, R 400 - 600 mm, W 400 - 450 mm), as shown in (Table 1).

Table 1. Different growth stages of Potato (In the favorable weather).

Weather Condition / Growth Stages	Temperature (T)	SS hr (hrs)	RH(%)	Soil temperature (ST)	Rainfall (mm) (R)	Normal Phase wise water requirement (mm) (W)
Spouting	18˚C - 21˚C	At least 6 - 9	65% - 80%	15˚C - 18˚C	400 - 450 mm	
Seeding	18˚C - 21˚C	At least 6 - 9	65% - 80%	15˚C - 18˚C	400 - 450 mm	
vegetative growth	10˚C - 18˚C	At least 6 - 9				
Tuber set/initiation	Day temperature 18˚C - 20˚C and night temperature < 15˚C	At least 6 - 9		15˚C - 18˚C	400 - 450 mm	
Tuber bulking/development	Day temperature 18˚C - 20˚C and night temperature <15˚C	At least 6 - 9		15˚C - 18˚C	400 - 450 mm	
Maturity		At least 6 - 9		15˚C - 18˚C	400 - 450 mm	
Harvesting						

Note: This table indicated the favorable weather indicator for different growth stages of Potato.

A2) Favorable Weather Condition responsible for Potato:

LB Temperature 16˚C - 20˚C. Cold and humid weather is congenial for spreading the disease.

BW and FW High Night Temperature (28˚C - 30˚C) and Relative Humidity (RH) 80% - 90% is also responsible for this condition. LV Average temperature 18˚C - 20˚C and Relative Humidity (RH) 70% (for Vector), PWW Soil tempera-

ture 10˚C - 27˚C indicate the favorable weather for worm, as shown in (Table 2).

Table 2. The weather indicator for Pest and Diseases of Potato.

Pest & Disease / Growth Stages	Late Blight	Potato Leaf Roll Virus	Termite	Potato Wire Worm
Spouting Seeding vegetative growth Tuber set/initiation Tuber bulking/development Maturity Harvesting	1. 16˚C - 20˚C. Cold and humidity -spread the disease. 2. Low night temperature and high humidity - the disease becomes epidemic.	18˚C - 20˚C and Relative Humidity (RH) 70%	Fogy, Cloudiness, abnormal high temperature	Soil temperature 10˚C - 27˚C

Note: The weather indicator for Pest and Diseases of Potato on mobile application or web application.

A3) Adverse Weather for different Growth Stages of Potato:

Seedling and vegetative growth stage: when rainfall is greater than 25 mm/day, duration of Wet Spell is greater than 25 mm for 2 days, drought remains greater than 10 days. As shown in (Table 3), Tuber set/initiation and Tuber bulking/Development stage: Hailstorm creates weather warning for potato if (R is greater than 100 mm/day, WP is greater than 50 mm for 3 days, CW and D is greater than 15 days. HW is greater than 30 km/hr, HS Hail storm, T Min temp will be less than 10˚C and Max. Temp will be greater than 30˚C, creates weather warning for potato growth stage. Harvesting and Maturity stage: when R is greater than 50 mm/day, WP is greater than 25 mm for 3 days, CW and D are greater than 15 days, HW is greater than 30 km/hr, HS: Hail storm as shown in (Table 3).

Table 3. Adverse weather condition for different growth stages of potato.

Weather Condition / Growth Stages	Rainfall	Duration of wet spell	Cloudy Weather	Drought	High Winds	Hailstorm	Temperature
Spouting Seeding vegetative growth	>25 mm/day	>25 mm for 2 days		>10 days		Hailstorm	
Tuber set/initiation	>100 mm/day	>50 mm for 3 days	Cloudy Weather		>30 km/hr	Hailstorm	Min temp < 10˚C and Max. Temp >3 0˚C
Tuber bulking/development	>100 mm/day						
Maturity Harvesting	>25 mm/day	>25 mm for 3 days	Cloudy Weather				

Note: Adverse weather condition for Different Growth Stages of Potato on mobile application or web application.

B1) Favorable Weather Conditions for Different growth stages of Mustard:

Germination, Vegetative, Flowering, Pod initiation, Maturity to Harvesting stages:

T 15˚C - 27˚C

S 6.0 - 7.5 hr with bright sunshine

H 65% - 74%

ST 13˚C - 25˚C

H 65% - 74%

ST 13˚C - 25˚C

For Favorable Weather Conditions of (Germination Vegetative Flowering Pod Initiation Maturity to Harvesting stages) for Mustard: (T 15˚C - 27˚C, S 6.0-7.5 hr with bright sunshine, H 65 - 74 percent, ST 13˚C - 25˚C), For Favorable Weather Conditions of (Germination Vegetative Flowering Pod Initiation Maturity to Harvesting stages) for Mustard: H 65 - 74 percent, ST 13˚C - 25˚C, as shown in (Table 4).

Table 4. Favorable weather conditions for different growth stages of mustard.

Growth Stages \ Weather Condition	Temperature	SS (hrs.)	RH (%)	Soil temp (˚C)
Germination				
Vegetative				
Flowering	15˚C - 27˚C	6.0 - 7.5 hr. with bright sunshine	70% - 75%	13˚C - 25˚C
Pod initiation				
Maturity to Harvesting				

Note: Favorable Weather indicator for Different Growth Stages of Mustard on mobile or web application.

B2) Favorable Weather Condition for Pests and Diseases for Mustard:

ALB: 25˚C - 28˚C temp with heavy dew during vegetative, flowering stage and Pod initiation stage.

SR: 27˚C - 35˚C temp with humid condition and low pH (7.0) during vegetative, flowering stage and Pod initiation stage. **Aphids:** T 16˚C - 30˚C and H 50% - 85% with CW vegetative, flowering stage and Pod initiation stage, as shown in (Table 5).

Table 5. Favorable weather condition for pests and diseases for mustard.

Growth Stages \ Pest & Diseases	Alternaria leaf blight	Stem rot	Cut warm	Aphids
Germination			Dry sandy loam soil	
Vegetative	25˚C - 28˚C temp with heavy dew	27˚C - 35˚C temp with humid condition and low pH (<7.0)		Temperature 16˚C - 30˚C and RH 50% - 85% with cloudy weather
Flowering				
Pod initiation				
Maturity to Harvesting				

Note: Favorable Weather indicator for Pests and Diseases for Mustard on mobile or web application.

B3) Adverse Weather Condition for Different Growth Stages of Mustard:

Germination Stage: when D is greater than 10 days, HS is greater than 25 - 40 km and HW is greater than 25 - 40 km, max temp 30˚C and min temp 10˚C. As shown in (Table 6).

Table 6. Adverse weather condition for different growth stages of mustard.

Weather Condition / Growth Stages	Rainfall	Cloudy Weather	Drought	Hailstorm	High wind	Temperature
Germination	>50 mm/day	Cloudy weather	>10 days	Hailstorm	>25 - 40 km/h	Max Temp > 32˚C, min temp < 10˚C
Vegetative	>50 mm/day					
Flowering	>50 mm/day		>20 days	Hailstorm	>25 - 40 km/h	
Pod initiation						
Maturity to Harvesting	>50 mm/day		>30 days	Hailstorm	>25 - 40 km/h	

Note: Adverse Weather Condition for Different Growth Stages of Mustard on mobile or web application.

Vegetative Stage: when R is greater than 50 mm/day. **Flowering and Pod initiation Stage:** when R is greater than 50 mm/day with cloudy weather. Also, D is greater than 20 days, HS is greater than 25 - 40 km, HW is greater than 25 - 40 km, max temp is greater than 30˚C and min temp is less than 10˚C, as shown in (Table 6).

C1) Favorable Weather Conditions for Different growth stages of Rice:

- **Seedbed:**
  T < 10˚C
  W < 76 mm
- **Transplanting and Tillering:**
  LI: 200% of normal
  H: High
  ST: <160˚C
  W: 76 mm
- **Heading, Flowering, Grain Formation and Maturity to Harvesting:**
  W 190 mm, 145 mm, 100 mm respectively
  T 22˚C - 25˚C

For Favorable Weather Conditions Seedbed for rice need (T will be greater than 10˚C, W will be greater than 76 mm). As shown in (Table 7), for Favorable Weather Conditions Transplanting and Tillering for rice need (LI 200 percent of normal, H High, ST Above 160 C, W 120 mm). For Favorable Weather Conditions Heading, Flowering, Grain Formation and Maturity to Harvesting for rice need (W 190 mm, 145 mm, 100 mm, T 22˚C - 25˚C, 22˚C - 25˚C), as shown in (Table 7).

C2) Adverse Weather Condition for Different Growth Stages of Rice:

For Transplanting Tillering, Heading, Flowering and Grain Formation Stages:

R 50 mm/day, 100 mm/day, 50 mm/day respectively

Table 7. Favorable weather conditions for different growth stages of rice.

Weather Condition / Growth Stages	Temperature	Light Intensity	Relative Humidity	Soil Temperature	Normal phase wise water requirement (mm)
Seedbed	At least 10˚C for germination				76
Transplanting					
Tillering		≤200% of normal	High	Above 160˚C	76
Heading					
Flowering					190
Grain Formation					145
Maturity to Harvesting					100

Note: Favorable Weather Conditions for Different Growth Stages of Rice on mobile or web application.

WP-25 mm for 3 days, 50 mm for 4 days, 20 mm for 4 days
High wind 50 km/hr, 40 km/hr, 30 km/hr
T Min Temperature 10˚C with cloudy weather

Weather Warning for Transplanting Tillering Heading Flowering Grain Formation for rice when (R 50 mm/day, 100 mm/day, 50 mm/day, And WP-25 mm for 3 days, 50 mm for 4 days, 20 mm for 4 days, CW Cloudy weather, High wind: 50 km/hr, 40 km/hr, 30 km/hr, T: Minimum Temperature 10˚C as shown in (Table 8).

Table 8. Adverse weather condition for different growth stages of rice.

Pest & Diseases / Growth Stages	Sheath rot	Blast	Stem borer	Leaf roller	Rice bug	Brown plant hopper	Rat
Seedbed							Cloudy weather with high humidity and high temperature
Transplanting							
Tillering	Temperature 25˚C - 28˚C High Relative Humidity > 90%, Cloudy weather	Night temperature 16˚C - 200˚C, for 7.30 hrs., Day temperature 25˚C - 300˚C, for 7.30 hrs., Day night temperature > 100˚C, RH > 90%, Cloudy weather	Min Temp > 20.30˚C, Max Temp: 29.5˚C - 34.70˚C, optimum Temp: 24˚C - 290˚C, Morning RH > 84%, Afternoon RH 38.7%, Dry weather	Max Temp: 32˚C - 330˚C, RH 92% - 95%	Max Temp: 31.90˚C Morning Bright Sunshine Hours > 5.9 hrs., Min temp > 22.10˚C Afternoon RH > 66.4% Dry, or intermittent rain	High temperature > 320˚C, high RH: 80% - 90%, drizzle, wet spell, rainfall > 75 mm	
Heading							
Flowering							
Grain Formation							
Maturity to Harvesting							

Note: Adverse Weather Condition for Different Growth Stages of Rice on mobile or web application.

2.3. System Workflow (UI) of Desired Application

The AI-driven crop recommendation system follows a detailed workflow from data collection to recommendation generation. This includes stages such as weather forecasting, crop suitability assessment, yield prediction, and optimization of planting schedules. The Crop Calendar UI is designed to be intuitive and user-friendly, providing farmers and agricultural stakeholders with easy access to critical information and recommendations for optimal crop management. The interface is structured to display relevant data, visual insights, and actionable suggestions clearly and effectively (Figure 2).

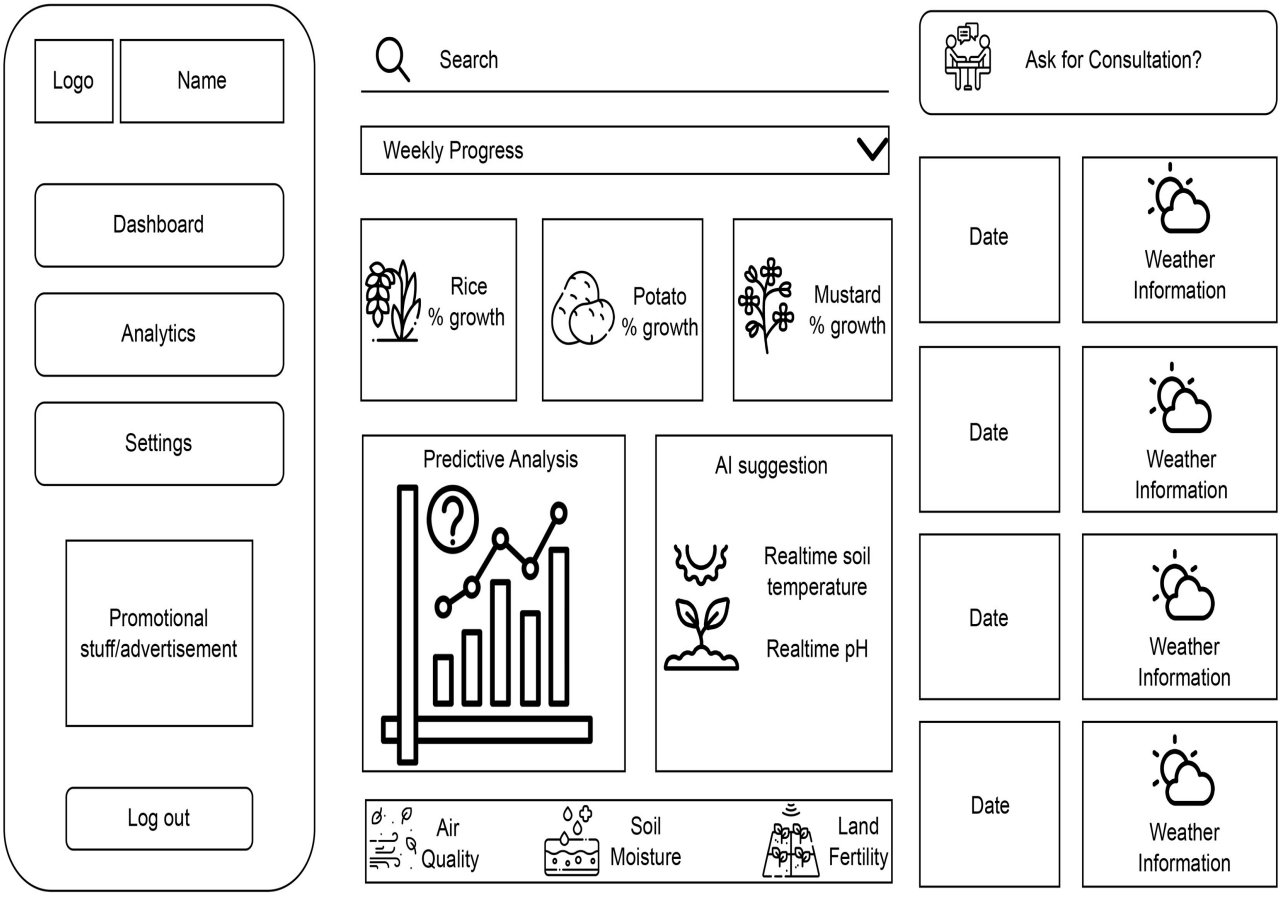

Figure 2. System workflow (UI) of desired application. **Note:** This is the Dashboard (UI) of desired Application which is showing the system workflow.

Dashboard: Overview of weather conditions, forecasts, and crop recommendations.

Geographic Map View: GIS-based map highlighting crop suitability by region.

Crop Selection and Details: Detailed information on each crop, including optimal growing conditions and pest management tips.

Calendar View: Displays recommended planting, growing, and harvesting schedules. Weather Forecast and Analysis: Graphical representation of weather trends. Resource Management Tools: Features for irrigation scheduling, fertiliza-

tion planning, and more.

3. Artificial Intelligence Applications for Smart Agriculture

3.1. Weather Prediction

The different agricultural conditions such as quality of land, different crop cycle, detection of plant disease, means for all critical issues AI technology provide significant prediction. Through satellites or drones the multispectral photos can be taken as well as sensors of soil and plant are used for crop health monitoring. For prevent the harmful activities of wild animals, birds or unexpected person, security cameras or drone can help in this regard [9]-[12].

3.2. Diseases Prediction

Artificial intelligence is capable of weed identification and removal, plant disease detection and forecasting, and the recommendation of effective pest management strategies. AI helps determine the optimal timing for nutrient application, optimal irrigation schedules, and product combinations for agronomy. Artificial intelligence (AI) can be used to automate harvesting and even forecast when it should be done. Industries could fundamentally change because of predictive analytics use. Farmers can process and collect more data with AI than they could in the past. Artificial intelligence (AI) can help farmers with common problems including pricing forecasts, market demand assessments, and agricultural planting and harvesting schedules. This helps growers sort the fruit before putting it on the market into stacks of different levels of readiness. Using top-notch field management techniques, real-time forecasts are feasible [13]-[18].

3.3. Crop and Soil Monitoring

AI is frequently used in soil and crop monitoring. Field satellite photos, the Internet of Things, and drones may all be used to gather data, which AI-based apps can then track and analyze to find the best solutions. Artificial intelligence (AI) applications help with the understanding of diseases, plant pests, and poor soil. Machine learning algorithms facilitate quick and easy data analysis. Farmers' irrigation may be aided by mobile agricultural applications. To increase efficiency, this labor-intensive procedure can be mechanized. Machine learning can provide important insights into how to improve overall production by learning past weather patterns and soil quality [19]-[24].

3.4. Decision Making Improvement

The use of AI technologies to improve judgment is expanding. More and more data are being analyzed and applied to agricultural decision-making. Industry advances that have made this possible for irrigation include the increased use of sensors, faster access to satellite photographs, cheaper data loggers, increased use of drones, and simpler access to data archives. It is possible to automate this labor-intensive procedure to increase productivity. Automated systems possess the abil-

ity to comprehend past weather trends and soil composition, offering significant perspectives on optimizing total crop productivity. Precision farming is a method that uses automated steering systems, high precision positioning systems, geo-mapping, sensor and remote sensing, and integrated electronic communication to replace labor-intensive and repetitive components of agriculture with more controlled and exact methods [25]-[27].

4. Discussion

Artificial intelligence tech helps agricultural business to overcome long-standing issues as well as obstacles. The AI function helps to analyze the bid dataset with the help of deep learning which is similar like brain activities of human being. For decision making the produced patterns that will be used. To solve large volume of problems of agriculture deep learning process and methods are being used. For analyze the big volume of dada, different companies use application-based solutions as well as the deep learning technique and algorithms. When executing the Artificial intelligent technology, we have to remember that the resources and land the farmers own very little

Integration of AI system (proposed) with the current agricultural systems in Bangladesh needs perfect design and systematic execution. The AI system should be able to improve the current system.

Integrating the proposed AI system with Bangladesh's existing agricultural process needs to confirm the alignment with current platforms, layout offline solutions, local stakeholders' collaboration, and simple design. The AI system can use the resources effectively by integrating with existing systems as well as ensure support for local languages.

The current prototype layout the basic but important features such as forecasting of weather, assessment crop suitability, user management, and detection of pest. The primary feedback would likely check on usability, effectiveness of feature, and accessibility, especially in rural area with limited internet connection. As the application will improve, farmers ongoing feedback, and experts of agricultural sector will play important role to meet end user needs and also help to improve the productivity agricultural field.

In India, AI applied in AgNext Technologies. This company focused on the use of AI technology to quality assessment of crop, detection of pest, predictions of crop yield. In Bangladesh AI also used for crop management and weather prediction as well. Bangladesh agricultural Research Institute which is called (BARI) used AI as well as ML to improve management of crop, predict the patterns of weather and also used for detect pests as Bangladesh is highly impacted country for climate change like irregular patterns of weather, heatwaves and also floods in several area.

We have engaged in collaboration with climatologist and discussed about weather data integration as well as impact of climate changes. Also, we tried to collaboration with farmers and also with local communities. This collaboration

helped us to plan to develop such type of application.

For continuous improvement of the AI-driven crop recommendation system as well as to maintain its relevance for farmers and end users, it will be crucial to integrate farmer feedback. We can maintain some strategies for this.

Mechanisms (collection) of User Feedback:

- Feedback Surveys through App: Periodically these surveys could be sent within the app.
- Groups and Interviews focusing: To provide valuable qualitative insights.
- Community (Online/Forum): Platform to discuss farmers experiences, asking questions, provide suggestions, share updates, and offer advice.

To fulfills users' ever-changing requirements, the application can develop and enhance through constant evaluation, gathering, and integration of input from farmers.

We can propose some strategy to handle situation where there is insufficient data to make reliable predictions. In this situation where the data is limited, expert knowledge can provide input on weather conditions. Expert rules and knowledge, crowdsourced data, data augmentation ensuring more reliable information even with limited data. By continuously gathering more data and improving the model with farmer feedback, our application system will be more effective in long term use.

Especially in developing regions, farmers may face challenges to use digital tools as well as internet connectivity, it's necessary to develop the AI-driven crop system which can support farmers when they will have limited access to technology.

We have plan to develop a version of application which will work offline with limited connectivity and which will support key feature like forecasts of weather as well as farming guidelines will be stored in application/device. In this way user could able to get access the data when device will get internal connectivity. We will add SMS-bases feature as well. In this way farmers will get basic service like weather updates, alert for pest based on their location along with crop type.

So, the main reason to use AI is to encourage the farmers to do Agri business to increases the profits. Farmers need proper idea about agribusiness as well as they need Agri business related training. In this way the real problem can be solved. Through this technology it is possible to monitoring crops problems and progress. Also, it is capable to address labor shortages in agriculture [28]-[31].

5. Limitations

Now a days most of applications are complicated. Most of farmers have less access to internet as well as they have less time and technological knowledge or skill to maintain and operate the AI application. Also, AI applications are not able to give decision outside of programming, so AI application system needs a large volume of data analysis to rich their database and in this way, they will be able to give more proper decision. Our aim is to develop such an application which will give result base on the huge volume of data set. In this paper we only could be able to

show the visual impacts of that application. In our upcoming paper/project we will present the application which will give more appropriate data for farmers of their Agriculture business.

6. Conclusion

AI-related applications use information such as wind speed, temperature, solar radiation, and precipitation, along with machine learning algorithms and images to forecast weather, assess crop sustainability, identify pests and diseases, and monitor plant nutrition. Farmers will receive an AI-driven strategy if they have access to internet-based AI applications. AI-related program will provide accurate results and by using natural resources responsibly, farmers will profit from a source of revenue. Additionally, farmers will be able to meet everyone's demands globally. Productivity of agricultural items will be increased. With the help if AI, picking and packing are also easier nowadays. AI associated application will play a vital role in agriculture field to enhance the whole agriculture system.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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