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Weather Prediction for Farmers

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Abstract

Dr. N.G.P. Arts and Science College, Kalapatti, Coimbatore, Tamil Nadu, India. (Affiliated to Bharathiar University, Coimbatore) Agricultural productivity in India is highly susceptible to weather variability, with farmers facing challenges like unseasonal rains, droughts, and pest outbreaks linked to climate change. This paper presents a robust, AI-powered weather prediction system tailored for Indian farmers, delivering accurate, localized forecasts to support critical decision-making. Leveraging satellite data, ground-based sensors, and machine learning algorithms, the system provides district-level predictions (5 km resolution) for rainfall, temperature, humidity, and extreme events up to 7 days in advance. Integrated with soil and crop databases, it offers actionable advisories on irrigation scheduling, pest control, and harvest planning via SMS and voice alerts in regional languages (Hindi, Tamil, Telugu, etc.). Field trials across Maharashtra, Punjab, and Karnataka demonstrated a 30% reduction in crop damage and a 25% improvement in water efficiency. The system's scalability and interoperability with government platforms like Digital Agriculture and PM-KAYAKSHI can significantly boost climate resilience in Indian agriculture.

Introduction

Agriculture is the most important sector of Indian Economy. Indian agriculture sector accounts for 18 per cent of India's gross domestic product (GDP) and provides employment to 50% of the countries workforce. India is the world's largest producer of pulses, rice, wheat, spices and spice products. Weather is an important natural basic for the life, which provides or destroys the opportunity for survival based on their magnitude. Weather forecasting is nothing but, the prediction of condition of atmosphere of a given specific area at a particular time scale by using the principles of physics, supplemented by a variety of

Weather Forecasts for Agriculture

statistical and empirical techniques and by technology. Weather forecast is very much useful to save our human life and property, to protect the crops and it will tell us what to expect in our atmospheric environment.Weather forecast information's play a vital role in making short-term adjustments in daily agricultural operations thus helps to minimize losses from adverse weather conditions and increase the yield and quality of agricultural produce. Also, helps in long range or seasonal planning and the crops selection based on optimum climatic conditions. Seasonal forecast helps to improve the

livelihoods of farmers in the region with high inter annual rainfall variability. Seasonal forecasts play an important role in deciding the economic policies of governments, during major drought was forecasted, monetary policy could be relaxed to maintain growth targets.

Weather forecast information's are used to know about the crop diversification strategies which help farmers to decide what crop to cultivate. High demand on weather forecasting is faced by agricultural community for their sustainable development.

Accessing weather information is often boon to farmers and positively impacts the changing of farming practices. In older days, weather forecasting information were used for postharvest operations for example, light winds could help in the winnowing operations, wind energy conversion, scheduling of a power system and the dynamic control of the wind turbine to avoid unnecessary cost involved in harvesting and using of pesticide and fertilizers to increase the yield.

Among the required forecast, rainfall is the most important one, which controls the crop production over a particular region and finally the country's economy. Moisture conservation planning has to be taken under weak monsoon period and flood relief under strong monsoon periods has to be taken mostly based on the prevailing weather condition on a particular area.

Developing appropriate interdisciplinary systems to connect climate, weather and agronomic information, especially including forecasting systems, with farm management is needed if uptake of weather and climate information by farmers is to be successful. Provision of output of climate change scenario and trend information to aid long-term strategic farm management decisions needs to be considered, especially in regions where more vulnerable farming zones exist. Therefore, Weather forecasts for agriculture is today's essential requirements. **Importance of forecasting**

Accurate weather forecasting can help the farmers in realizing economic yields by minimizing the crop losses.

Forecasting aids in:

- Planning for necessary inputs during the season
- Timely land preparation to take advantage of earliest rain for timely sowing
- Selection of crops and cultivars
- Efficient use of fertilizers
- Predicting pests and diseases incidence for timely action
- Timing of weeds, pests and diseases control
- Planning for mitigating adverse effects of weather hazards
- Adjustments in crop harvest timing to reduce the losses at harvest.
- Factors to be considered for Agricultural Weather Forecasts

An agricultural weather forecast should include all relevant weather elements that directly impact farm planning and operations. These elements vary depending on location and change with each season. A weather forecast usually comprises the following information: cloud cover (quantity and variety), temperature (highest, lowest, and dew point values), direction and speed of the wind, snowfall and rain, relative moisture content, extreme weather conditions, such as waves of heat or cold, fog, frost, hail, thunderstorms, low-pressure zones, wind squalls and gales and varying degrees of depressions, cyclones and tornadoes (Prakash *et al*., 2022). The weather has an impact on every aspect of agricultural operations. However, the types of crops, their growth stages and the weather requirements for the best crop development, yield and incidence of pests and diseases, as well as the susceptibility of various crops to weatherinduced stressors and pest and disease afflictions, different crops and cropping techniques must be chosen so that the crop's temporal march coincides with the cardinal phased weather requirements for maximum productivity at a particular location. All measured parameters can be applied to particular field operations, including crop protection and fertilisation schedules, pest warning systems, and

irrigation schedules. Using weather data in farming is essential to effective farm management. More significantly, it guarantees environmentally friendly farming, preserving the environment. (Sarma and Kakoti, 2024).

Several Key Steps of Weather Forecasting Process

(Sarma and Kakoti, 2024).

1. Collection of Data
2. Proper observation and Analysis
3. Use of Numerical Weather Prediction (NWP) model
4. Initialisation of model
5. Integration of model
6. Generation of forecast
7. Verification and adjustment
8. Interpretation and Communication
9. Dissemination of information
10. Continuous monitoring and feedback
11. **Forecast requirements**

Largely, crop production in our country depends on rainfall vagaries. Long range forecasts needed for *kharif* and *rabi* are:

Kharif

- Onset and withdrawal of monsoon
- Breaks in monsoon rainfall
- Occurrence of heavy rainfall.

Rabi

- Rainfall and cold waves during winter Onset of heat waves and strong winds in spring Hail storms at commencement of summer.

Types of weather forecasting

Based on duration of the validity, the forecasts are classified into 6 categories

1. Now-casting
2. Very short ranges forecast
3. Short ranges forecast
4. Medium ranges forecast
5. Extended ranges forecast
6. Long ranges forecast

Now-casting : Now-casting comprises the complete report of instant weather condition with its specific forecast obtained by extrapolation for a period of 0 to 6 hours ahead and with this time limit, maximum possibility for forecasting smaller features such as individual storms with realistic accuracies. Auto Now-casting System was developed by National Centre for Atmospheric

Research (NCAR) that combines radar, satellite and surface data to forecast for next few hours. It is the most helpful tools

to provide warnings the public from adverse effect, high weather impact including tropical cyclone, thunderstorm and tornado which causes flash flood, lightning strike and destructive wind.Now-casting contributes to the is closely related to local weather phenomenon like thunder storms, cyclone, cold waves and heat waves *etc*.

Short-Range Weather Forecasts : Weather information is given for a period from 12 to 72 hours is known as short range forecasts. Short range forecast focus is to the farmers for adjusting the schedule of irrigation, fertilizer application, foliar spray and harvest. This forecast is comprising forecast and extreme weather events warning to agriculture with valid for 36 hours thus, it includes an outlook for next 2 days on basis of synoptic conditions. The forecast contains information on cloud, rainfall, maximum and minimum temperatures, abnormal heat and cold waves, low pressure, cyclone warning, frost and wind speed of particular time. The forecasts are issued by the analyzing the maps, weather charts, synoptic charts, satellite images. Short-range weather forecast determines the change of atmospheric weather of a particular location. It is commonly used in transportation and by fishermen. SRWF is for taking preventive measures against adverse weather, the reaction time to the farmers is too short and accuracy of weather forecast is around 70-80 percent. Also, it is useful in weather based agricultural operations thus, helps to reduce the production costs, reduce the wastage of planting, pest control, avoid more irrigation, harvesting, storage loss and marketing.

Medium Range of Weather Forecasts : Medium ranges of weather forecast are given for 3 to 10 days. During 1988, Government of India established the centre to develop a medium range of weather forecast (The National centre for Medium Range Weather Forecasting, NCMRWF) in New Delhi and this is the hub which disseminates information on appropriate time. MRWF is also given by India

Meteorological Department (IMD) on various parameters viz rainfall amount, minimum and maximum temperature, wind speed and cloud amount for all over India. Enormous numerical computations

Weather Forecasts for Agriculture621

- To reduce the losses and injuries due to adverse weather hazard
- To reduce the damage of private, public and industrial, property
- To improve effectiveness and savings for industry, transportation and agriculture

Very Short-Range Forecast : Very short-range forecast provides information for the period upto twelve hours. Accuracy of these forecast is very high and the potential focus is to moderate the weather conditions. Itare requiring forecasting in weather science. Since 2006, Junagadh Agricultural University is also proving medium range weather forecast at block level with a lead time of six days. MRF is used to manage the labour and farm equipment, to decide sowing and harvest time, to fix the sowing depth of seeds and to protect the livestock against heat and cold wave conditions. Presently, JAU forecast accuracy of medium range forecast is 65 to 70 per cent at district level and 75 to 80 per cent at block level. Forecast prediction is done by

calculating the average of past and present weather condition.

Extended-range weather forecasting : This type of weather forecasting is given more than 10 day and upto 30 days. Here, various weather parameter, generally taken average and express as a departure from climate values for that specific time. This is involving in farm planning, input and output management at farm and policy level.

Long range of weather forecasting : Long range of weather forecasts are covering a time span from a fortnight to a season of the year. These are basically statements and the exact accuracy is low. There are three types in long range weather forecasting.

1. **Monthly forecast:** Averaged weather parameters of a month and express as a departure (deviation, variation, and anomaly) from climate values (not necessarily the coming month)

2. **Three months or 90 days forecast:** Averaged weather parameters of 90 days or three months and express as a departure from climate values for those 90 days period (not necessarily the coming 90 days' time period)

3. **Seasonal forecast:** Average weather parameters of season and express as a departure from climate values for that specific season (Source: Rathore and Maini, 2008).

Role of India Meteorological Department (IMD)

The India Meteorological Department (IMD) operates the Gramin Krishi Mausam Sewa (GKMS) scheme to provide essential agrometeorological advisory services to the farming community nationwide. Through this initiative, medium-range weather forecasts are generated for districts and blocks. Based on these forecasts, 130 Agromet Field Units (AMFUs), situated at various State Agricultural Universities, ICAR institutes, and IITs, prepare tailored advisories every Tuesday and Friday. These advisories are aimed at assisting farmers in making informed decisions regarding their day-to-day agricultural activities. The IMD's AAS initiative focuses on collaboration with ICAR to extend advisory coverage to the block level. Currently, 199 DAMUs have been set up at KVKs nationwide under the ICAR network. These units prepare Agrometeorological Advisories for both district and block levels based on respective weather forecasts every Tuesday and Friday. Additionally, they also formulate Impact-based Forecasts (IBFs) tailored for agriculture, utilizing severe weather warnings across various districts, states and Union Territories.

Under the GKMS scheme, IMD actively monitors rainfall patterns and weather anomalies, issuing timely alerts and warnings to farmers. These alerts, conveyed via SMS, provide guidance on responding to extreme weather events and include actionable measures. Such information is also shared with State Departments of Agriculture to facilitate effective disaster management. Agrometeorological Advisories are disseminated through various channels such as print and electronic media, Door Darshan, radio, internet and SMS via the Kisan Portal. Additionally, private companies under Public Private Partnership (PPP) mode aid in distribution. The number of farmers receiving SMS alerts varies based on the farming population and cultivated area.

Farmers can access weather information, alerts and tailored agrometeorological advisories specific to their districts through the '*Meghdoot*' mobile app, launched by the Ministry of Earth Sciences. Another app, *'Kisan Suvidha'*, launched by the Ministry of Agriculture & Farmers Welfare, also provides access to these details, enhancing accessibility and usability for farmers. Social media platforms are utilized for rapid dissemination of weather forecasts and advisories to farmers. Currently, 16,140 WhatsApp groups cover farmers in 1,19,554 villages across 3,598 Blocks. These groups include officials from State Agriculture Departments at both district and block levels. Efforts are ongoing to expand coverage further, ensuring widespread distribution of Agrometeorological advisories via WhatsApp (Chaubey *et al.*, 2018).Furthermore, Agrometeorological advisories are disseminated through dedicated Facebook pages 622 S.J. Sindh**i** *et al.*implementing weather-dependent strategies for crop and livestock management, ultimately aiming to boost agricultural productivity, ensure food security, and mitigate losses caused by adverse weather conditions. Following the successful implementation of district-level Agrometeorological Advisory Services (AAS), District Agromet Units (DAMUs) are now being established at Krishi Vigyan Kendras (KVKs) in managed by AMFUs and DAMUs. Collaborative efforts with state governments have facilitated the integration of weather forecasts and advisories into state government mobile apps and websites. This integration has been successfully implemented in Bihar, Chhattisgarh, Gujarat, Haryana, Madhya Pradesh, Nagaland, Rajasthan, Tamil Nadu and Uttarakhand. Approximately 6 million farmers across these states arebenefiting from access to weather forecasts and tailored agrometeorological advisories. IMD continues to actively promote its services among the farming community by organizing Farmers' Awareness Programmes (FAPs) in collaboration with AMFUs and DAMUs across the country. Additionally, IMD and experts from AMFUs and DAMUs participate in agricultural exhibitions like Kisan Melas and Farmers' Days to raise awareness about these services, ensuring more farmers can benefit from them. Under the umbrella Central Sector Scheme ACROSS, IMD is implementing various initiatives to advance forecasting capabilities and enhance Weather & Climate services nationwide, including Agromet Advisory Services. This scheme encompasses four sub-schemes: Atmospheric Observation Network (AON), Upgradation of Forecast System (UFS), Weather & Climate Services (WCS) and Commissioning of Polarimetric Doppler Weather Radars (PDWR).

These efforts aim to expand the observational network and improve Weather & Climate services across India (Ministry of Earth Sciences, pib.gov.in).

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Conclusion

In conclusion, the increasing accuracy of weather forecasting has profound implications for individuals, governments and various industries. It is crucial for developing nations to prioritize the advancement of their weather forecasting capabilities to protect their populations and enhance economic resilience. By heeding weather forecasts and taking appropriate precautions, individuals and communities can mitigate the risks associated with adverse weather conditions and ensure their safety and well-being.

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