Chapter 16
Weather Based Information on Risk Management in Agriculture

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Abstract Weather and climate information plays a major role in the entire crop cycle right from selecting the most suitable crop/variety/ field preparation up to post harvest operations and marketing; and if provided in advance can be helpful in inspiring the farmer to organize and activate their own resources in order to reap the benefits by judicious application of costly inputs. It becomes more and more important to supply meteorological information blended with weather sensitive management operations before the start of cropping season in order to adapt the agricultural system to increased weather variability. India Meteorological Department (IMD), Ministry of Earth Sciences (MoES) in collaboration with Indian Council of Agricultural Research (ICAR) and State Agriculture Universities (SAUs) is rendering weather forecast based District level Agro meteorological Advisory Services (AAS) to the farmers in the country under the scheme "Gramin Krishi Mausam Sewa (GKMS)" since monsoon 2008. AAS provides advance weather information along with crop specific agromet advisories to the farming community by using state of the art instruments and technology through efficient delivering mechanism of the information which ultimately enables farmers to take appropriate actions at farm level. This present system of delivering the services at district level is underway to extend up to sub-district/ block level with dissemination up to village level to meet the end users' requirements in both the irrigated and rainfed systems and facilitate the agriculture risk management effectively.

Keywords Weather Forecast · Agromet advisory services · Gramin Krishi Mausam Sewa · Rainfed and irrigated system

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16.1 Introduction

Agriculture production is governed by various factors out of which weather is the only factor over which human has no control and hence it has an overwhelming dominance over the success or failure of agricultural enterprise. It is an accepted fact that food production is inextricably linked with climate and weather. It is also reported that weather induced variability of food production is more than 10 per cent. This variability can be as high as 50 per cent of the normal production in respect of smaller areas situated in arid and semi-arid regions. In order to reduce risks of loss in food production due to the vagaries of weather, weather per se, should be taken into account as one of the major inputs in agricultural planning. Hence forecast of weather parameters play a vital role in agricultural production. It also aids in minimizing crop losses to a considerable extent. Thus development and refinement of the art of weather prediction has been essential since time immemorial. Therefore prediction of weather systems in different spatial and temporal scale over the Indian region assumes considerable importance. The advent of new meteorological modeling capabilities provides opportunities for the meteorological community to develop better products and information to decision-makers in the various user sectors (i.e. energy, health, agriculture, water). Both post-processed General Circulation Model (GCM) output and forecasts made by Weather Research and Forecasting (WRF) models can be used in agricultural decision making. In the recent past, IMD has made enormous improvement in the accuracy and lead time of forecasts for various usage including tactical decisions at field level agricultural applications based on medium range forecast (e.g. frost protection, irrigation and fertilization) & for strategic decisions based on longer time scales, ranging from several weeks to months. This type of climate information is provided by GCMs and seasonal ensemble predictions. The potential value for agriculture of an accurate medium range forecast is enormous. If rainfall behavior were predicted with sufficient lead time and with a high degree of confidence, farmers could for example respond to forecasts by changing crop varieties, changing crop species, implementing soil and water conservation techniques, increasing or decreasing area planted, adjusting timing of land preparation, increasing or decreasing soil inputs and selling or purchasing livestock herds (Motha 2007).Weather aberrations may be nullified to a large extent by timely communication of adoptive measures disseminated through Agromet Advisory Services (AAS) to the farming community (Chattopadhyay and Lal 2007; Rathore et al. 2009; Chattopadhyay and Rathore 2013; Rathore et al. 2013). In the present paper it has been showed that how the National Meteorological Services like India Meteorological Department in collaboration with other organizations has geared up its activities to face the challenges of such weather aberrations, particularly in providing the risk management solution to the farmers of the country.

16.2   Weather Forecast and Agromet Information

India experiences large spectra of weather events having spatial scale of less than 1 km to more than 1000 km and temporal range of less than an hour to more than a week. Different parts of the country experience different kinds of weather conditions such as Winter season (Jan-Feb) is characterized by Western Disturbances, Cold Wave, Fog; Pre-Monsoon (Mar-May) by Cyclonic Disturbances, Heat Wave, Thunder Storms, Squalls, Hail Storm, Tornado; Monsoon (Jun-Sep) by Southwest Monsoon Circulation, Monsoon Disturbances; and Post-Monsoon (Oct-Dec) by Northeast Monsoon, Cyclonic Disturbances. All these weather systems individually or together affect the crop physiology and growth severely by means of inducing stress. Growth and development of crop depends upon all the weather variables therefore prediction of these weather systems in different spatial and temporal scale is of considerable importance to predict the weather induced stresses in crops.

IMD having mandate to issue weather forecast for different time scale in advance, it provides opportunity to efficiently minimize the loss from adverse weather and took the benefit from benevolent weather.

16.2.1   Nowcast and Special Weather Forecast for Extreme Events

Nowcast having temporal resolution of 3 h to 6 h, derived products of Doppler weather Radar form a very important guiding tool for improving the nowcasting system. IMD has implemented nowcasting of thunderstorms, squalls and hailstorms for the areas covered by DWRs. Agriculture sector are also benefitted by nowcast/forecast of severe weather as time of rain fall occurrence and quantum of rain may enable farmers to plan the agriculture activities which in turn may reduce/protect from the loss of inputs, enhance its use efficiency like pesticide spray, fertilizer application and thus yield more production. Special weather forecast for agriculture provides the necessary meteorological input to assist farmers in making decisions. The requirements for these special forecasts will vary from season to season and crop to crop. Special forecast issued are as follows:

- Tropical storms (cyclones, hurricanes, typhoons, etc.) associated with high winds, flooding and storm surges.
- Floods (other than those related to tropical storms) heavy rains due to monsoons, water logging and landslides.
- Severe thunderstorms, hail storms, tornadoes and squalls.
- Drought and heat waves.
- Cold spells, low temperature, frost, snow and ice-storms.
- Dust storms and sand storms.

16.2.2   Medium Range Weather Forecast

IMD is issuing quantitative district level (646 districts) weather forecast up to 5 days
and the products comprise of quantitative forecasts for 8 weather parameters viz.,
rainfall, maximum temperature, minimum temperatures, wind speed, wind direc-
tion, relative humidity I,II and cloudiness. This weather forecast is generally valid
for a period of 5 days and prepared using the GFS-1534 at 12.5 km spatial resolu-
tion. This Medium Range Weather Forecast has been generated on Every Tuesday
and Friday by NWP division of IMD and sent to RMC/MC for value addition in
forecast by local expertise. Value added districtwise forecast further disseminated to
130 AgoMeteorological Field Units of IMD for Agroadvisory generation. Group of
experts in agriculture discipline issues the advisory for next five days based on the
forecast. Medium Range Weather forecast is of prime importance for farmers in
order to take the tactical decisions. Farmers are using these advisories for sowing
and transplantation of crops, fertilizer application, predictions regarding pests and
diseases and measures to control them, weeding/thinning, irrigation (quantities and
timing), and harvest of crops.

16.2.3   Extended Range Forecast

Long breaks in critical growth periods of agricultural crops lead to substantially
reduced yield. Thus, the forecast of this active/break cycle of monsoon, commonly
known as the Extended Range Forecasts (ERF) is very useful. The forecasts of pre-
cipitation on this intermediate timescale are critical for the optimization of planting
and harvesting. Prediction of monsoon break 2 to 4 weeks in advance, therefore, is
of great importance for agricultural planning (sowing, harvesting, etc.) and yield
forecasting, which can enable tactical adjustments to the strategic decisions that are
made based on the longer-lead seasonal forecasts, and also will help in timely
review of the ongoing monsoon conditions for providing outlooks to farmers.

   IMD has been issuing experimental extended range forecast since 2009 using
available products from statistical as well as multi-model ensemble (MME) based
on outputs available from dynamical models (NCEP_CFS, IITM_CFS, JMA,
ECMWF etc) from various centers in India and abroad. The MME forecast is being
prepared once in a week with the validity for subsequent four weeks. However
model runs is made for 45 days every week. The latest generation coupled models
are found to be very useful in providing skillful guidance on extended range fore-
cast. The performance of extended range forecasts for the southwest monsoon sea-
sons clearly captured the delay/early onset of monsoon over Kerala, active/break
spells of monsoon and also withdrawal of monsoon in the real time in providing
guidance for various applications. On experimental basis the MME forecast on
meteorological subdivision level up to two weeks are also being used in providing
the agromet advisory for farming community. During the other season the MME
based ERF also provides encouraging results in case of northeast monsoon rainfall

over southern peninsula and tropical cyclo-genesis over the north Indian Ocean during the post monsoon season from October to December (OND). In addition, the MME based ERF forecast also provides useful guidance pertaining to rainfall associated with Western Disturbances (WD) over northwest India during winter. The ERF forecast for minimum and maximum temperatures during winter and summer seasons are also found to be very useful.

16.2.4   Long Range Forecast

IMD has been issuing long-range forecasts (LRF/Seasonal forecast) for monsoon based on statistical methods for the southwest monsoon rainfall over India (ISMR) for more than 100 years. The forecast for the South-West monsoon rainfall is issued in two stages. The first stage forecast for the seasonal (June to September) rainfall over the country as a whole is issued in April and the update of the April forecast is issued in June. Along with the update forecast, forecast for seasonal rainfall over four broad geographical regions of India and July rainfall over country as a whole are also issued. Rainfall induced stress associated with amount and date of occurrence viz. early, mid and late drought is predicted by long range forecast. Long range forecast provides lead time for starategic planning in agriculture.

16.2.5   Customized Agromet Products for Advisory Preparation

Various products has been derived from weather forecast, satellite observation, remote sensing data, gridded product of IMD for monitoring and forecasting of soil moisture, drought and crop health. Aridity anomaly maps gives information about the moisture stress experienced by growing plant. The crop water stress condition during the monsoon anomalies are helpful for early warning of crop stress occurrence. Standard precipitation Index (SPI) (Guhathakurta et al. 2011) used for monitoring rainfall departure status from the normal and helps in monitoring of rainfall status. NOAA/AVHRR Satellite derived state wise weekly Normalized Difference Vegetation Index (NDVI) monitors the crop condition. These entire derived products guide in irrigation give advisory for irrigation and other farm activities such as mulching (Fig. 16.1).

16.2.6   Gramin Krishi Mausam Sewa

Weather and climate information plays a vital role in agriculture production to render the need of weather information to farming community efforts has been made since 1945 with the initiation of Farmers Weather Bulletin. Since then with the
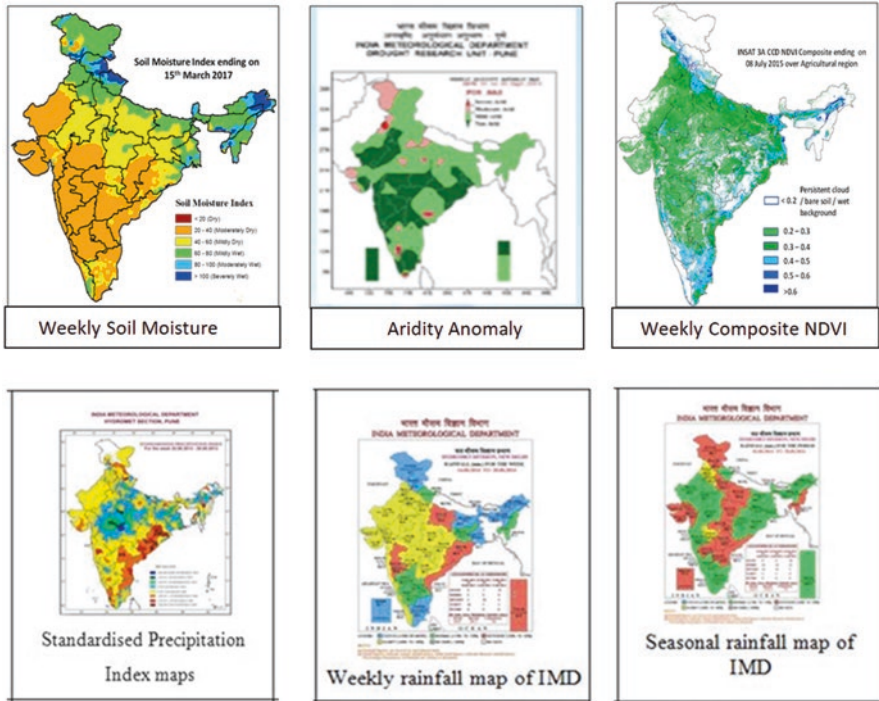
Fig. 16.1 Derived Agromet product facilitate in Agro Advisory preperation

advent of technology, extension of weather observation network and weather fore-
cast the customized weather information in the form of advisory also follows era of
evolution. In the year 1976 Agro advisory Services initiated at state level followed
by Agroclimatic Zone level AAS using medium range weather forecast in the year
1991. In the year 2008 District Level agro advisories has been initiated by IMD,
MoES in collaboration with ICAR and State Agriculture Universities. The main
emphasis of the existing AAS system is to collect and organize climate/weather, soil
and crop information, and to amalgamate them with weather forecast to assist farm-
ers in taking management decisions. This has helped to develop and apply opera-
tional tools to manage weather related uncertainties through agro-meteorological
applications for efficient agriculture in rapidly changing environments. Being a
multidisciplinary and multi-institutional project, AAS project is being implemented
through tiered structure to set up different components of the service spectrum. It
include meteorological (weather observation & forecasting), agricultural (identify-
ing weather sensitive stress & preparing suitable advisory using weather forecast),
extension (two way communication with user viz. farmers and planners) and infor-
mation dissemination (Media, Information Technology, Telecom) agencies. Under
GKMS scheme weather based crop and locale-specific agro-advisories for 633 rural
districts are prepared and disseminated to farmers deploying various modes of

information dissemination e.g. radio, television, print media, internet, Kisan Call Centres and mobile phones. Presently 20.6 million farmers receive abridged advisories through SMS on their mobile phone.

The services at its current spatial resolution made significant contribution to reduce risk and improve agricultural productivity farm income, despite local climate variations. It also focuses on environment friendly integrated solutions that are within the farmers' capabilities. It was observed that there has been substantial increase in productivity for cereals, oilseeds and vegetable. National Council of Applied Economic Research (NCAER), an independent agency, during 2015 estimated that the economic benefit from the use of weather information as the product of the percentage of farmers receiving information, scenario-wise, times the percentage of farmers benefiting from the information times average profit, crop-wise, attributable to weather information times the total national production of crops. Conversion factors, crop-wise, were used to convert farmers' financial profits to economic profits (NCAER 2015). At present only 24 percent of the farmers are benefitting from the SMS services. The economic profit estimates Rs. 42,000 crore. Service has the potential of generating net economic benefit up to Rs. 3.3 lakh crores on the 22-principal crops when AAS is utilized by 95.4 million farming households.

Further to improve the relevance of this service at block level, high –resolution weather forecast will be utilized to develop the services. As a part of Gramin Krishi Mausam Sewa it is planned to establish 660 District Agromet Units (DAMUs) in the premises of Farm Science Centre, called Krishi Vigyan Kendra (KVKs), in each district in a phase manner. Efforts are being made to automize the process of farm advisory preparation and dissemination through Kisan portal. Service delivery at village level will be established using all the dissemination channels including DD Kisan, Kisan portal, the Ministry of IT and the Department of Electronics and IT (DeitY), the Department of Post, CSC etc. and other initiatives under Digital India Movement.

16.3 Structuring a Weather Risk Management Tools/ Solution

The emerging weather and climate risk clearly offers new risk management tools and opportunities for agriculture. Identifying the location wise risk to weather, time period during which risk is prevalent and further quantifying and designing a weather risk management strategy based on an index is more pertinent to neutralize the risk in agriculture. Following are the ingredients of a typical Agromet Advisory Bulletin to reap benefits of benevolent weather and minimize or mitigate the impacts of adverse weather;

(i) District specific weather forecast, in quantitative terms, for next 5 days for rainfall, cloud, max/min temperature, wind speed/direction and relative

humidity, including forewarning of hazardous weather event likely to cause stress on standing crop and suggestions to protect the crop from them.

 (ii) Weather forecast based information on soil moisture status and guidance for application of irrigation, fertilizer and herbicides etc.

(iii) The advisories on dates of sowing/planting and suitability of carrying out intercultural operations covering the entire crop spectrum from pre-sowing to post harvest to guide farmer in his day–today cultural operations.

 (iv) Weather forecast based forewarning system for major pests and diseases of principal crops and advises on plant protection measures.

 (v) Advisory for extreme events suggest the measures under Drought/Dry spell, extreme cold, Heat wave, hailstorm, cyclone, intense rainfall and flood.

 (vi) Propagation of techniques for manipulation of crop's microclimate e.g. shading, mulching, other surface modification, shelter belt, frost protection etc. to protect crops under stressed conditions.

(vii) Advisory on contingency plan under extreme weather situations.

(viii) Reducing contribution of agricultural production system to global warming and environment degradation through judicious management of land, water and farm inputs, particularly pesticides, herbicides and fertilizers.

 (ix) Advisory for livestock on health, shelter and nutrition.

Under GKMS Scheme IMD in collaboration with ICAR, State Department of Agriculture and other agencies is planning to establish an automated system of agro
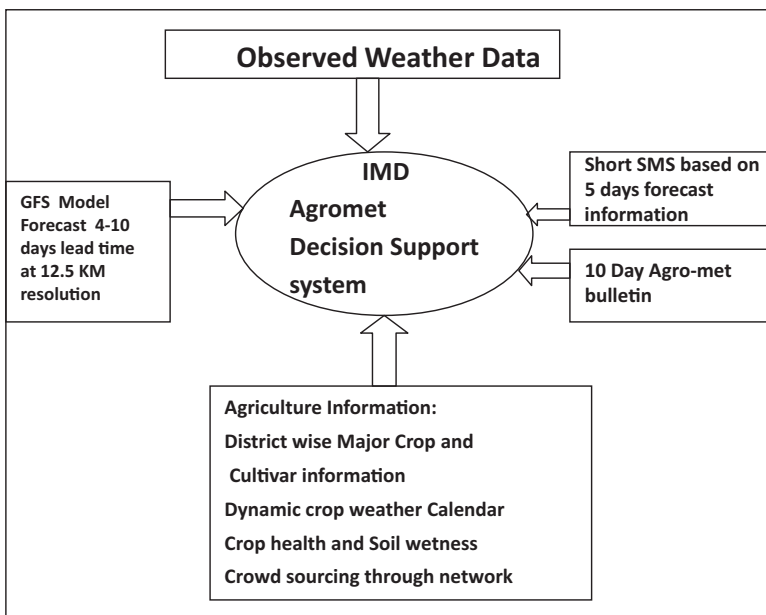

Fig. 16.2 System Overview of Agromet-Decision Support System

advisory generation at district level. An advanced system with detailed location specific information of agriculture, a dynamic crop weather calendar for major crop of the area, remote sensing and ground information based crop health and water balance based soil moisture information along with the high resolution weather forecast will make the system exhaustive and capable to generate the customized advisory for rainfed and irrigated farming system. Knowledge of field experts and the State agriculture officers will train the system for automation (Fig. 16.2).

16.4   Dissemination of Information

Dissemination of information under the aberrant weather condition plays a vital role in minimizing crop loss. The information Dissemination Process are broadly divided into three channels viz. Mass and electronic media, Group methods and Individual contacts. Presently AAS disseminated to the farmers regularly and also in case of extreme weather through Short Message Service (SMS) messaging and Interactive Voice Response Technology (IVR) in regional/English language. In a public-private partnership (PPP) arrangement, AMFUs are preparing and sending district AAS bulletins twice weekly to private companies including IFFCO Kisan Sanchar Limited (IKSL), NOKIA, Reuter Market Light (RML), Handygo, Mahindra Samriddhi comprising of weather forecasts and advisories on extreme events along with crop, pest, disease, seed and fertilizer information all over the country. AMFUs are also uploading the agromet advisories in the form of SMS in regional languages in Kisan Portal started by Ministry of Agriculture, Govt. of India and their respective web sites of Universities or National Institutes.

In general, the use of more than one channel gives a greater chance of reaching the client or user. The Agromet Advisory Services provided by IMD/MoES through various channels have resulted in significant increases in farm productivity, resulting in increased availability of food and higher income generation. There is a need for dissemination of AAS information to farmers on a wider scale and convincing them about its positive impacts on a sustainable basis.

16.5   Conclusion

The risks confronting with agriculture production are very high due to weather variability. Weather forecast translated in agro advisory helps in taking the decision at field level in advance and avoids the associated risk. Increasing number of observatories, use of advance tools and techniques, expansion of existing Agromet Field Unit network, customized Decision Support System for advisory generation and advance dissemination tools & techniques are highly efficient to support the weather smart agriculture under existing scenario. Though useful services are being

provided to the farmers through the Agromet Advisory Services by using the latest state of art technology, there is an urgent need for a better understanding of the changing climate patterns and how they affect agriculture, better weather forecasting at small scale and awareness of information provided to the farmers.

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