

Agromet advisory services for managing extreme weather events in dryland regions

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Dryland regions, characterized by low rainfall and high evaporation rates, cover approximately 41% of the Earth's land surface and are home to more than two billion people. The vulnerable dryland regions are also exposed to extreme weather events, including droughts, heatwaves, and erratic rainfall, affecting agricultural productivity severely. The increasing frequency and intensity of these events due to climate change have underscored the need for robust systems that can assist farmers in adapting to these challenges. Agrometeorological (agromet) advisory services are critical in mitigating the effects of these weather extremes by providing farmers with timely, location-specific information and recommendations. This article explores the importance of agromet advisory services in managing extreme weather events in dryland areas, highlights the integration of climate data with farming practices, and discusses strategies to enhance resilience in agricultural systems. The article also highlights the need to develop agromet advisories based on nowcasting.

Keywords: Agromet advisory, Drylands, Extreme weather events

AGROMETEOROLOGICAL advisory services play a crucial role in mitigating the adverse impacts of extreme weather events on agriculture and allied sectors by providing timely and location-specific weather information and guidance to farmers. These services integrate meteorological data, and field-based observations to issue advisories that help farmers make informed decisions about sowing, irrigation, fertilizer application, pest management, and harvest timing. By anticipating weather extremes such as droughts, floods, heatwaves, and unseasonal rains, agromet advisories empower farmers to adopt adaptive and resilient farming practices, reducing crop losses and safeguarding livelihoods.

Extreme weather events and their impact on dryland agriculture

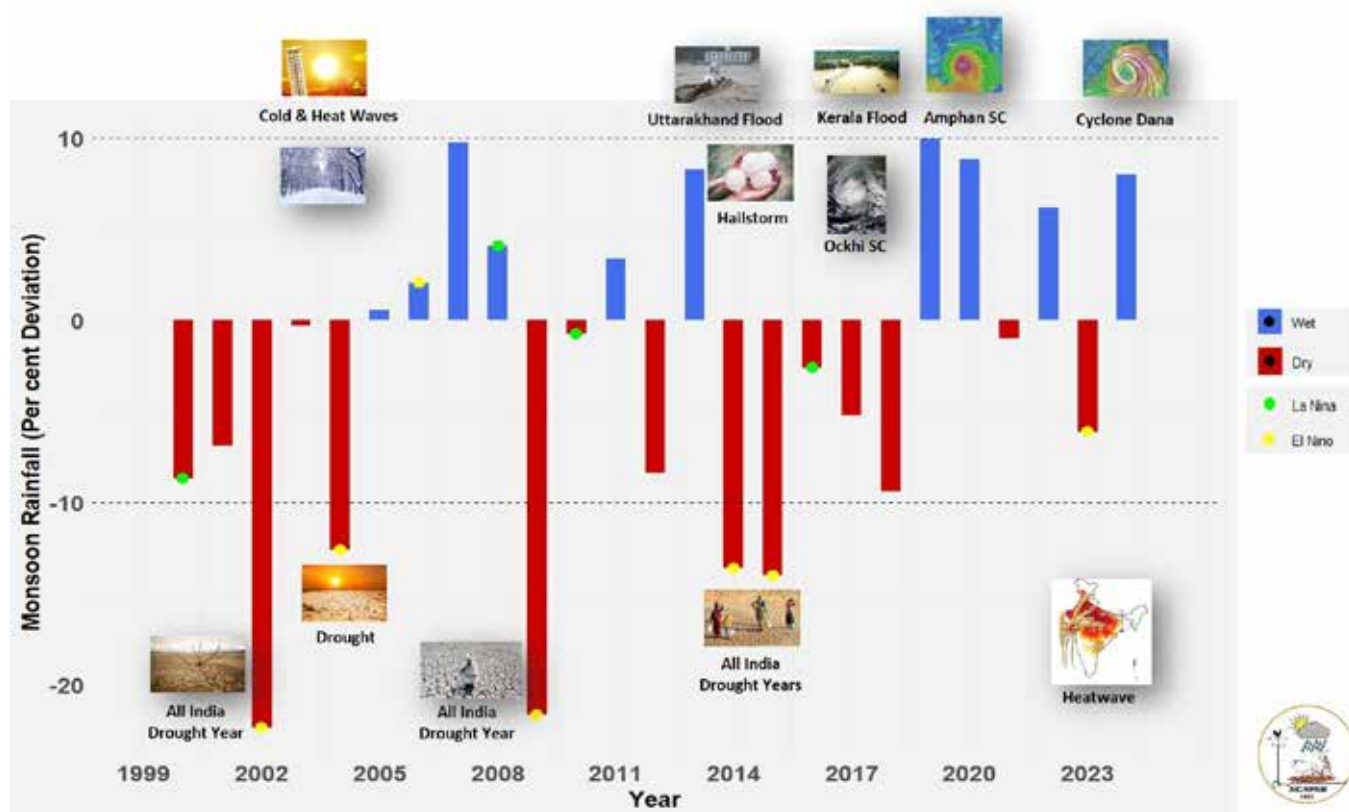
Drought: The immediate consequence of drought is a shortage of water for agriculture and drinking water; resulting in crop failures, negatively affecting individual and community livelihoods as well as negatively impacting the country's economy. The extent of crop losses due to drought depends upon its type (chronic or contingent), duration, frequency etc. Severe effects due to drought occurred in 1877, 1899, 1901, 1918, 1972, 1987, and 2009 affecting greater than 50% of the country's geographical area.

Heatwaves: Heatwave conditions are generally

experienced from February to June in India. High-pressure systems, late monsoon onset, and climate change-induced temperature rise are some causes of heat waves. Heatwaves during February–March in north India resulted in losses of wheat production estimated at 6 MT in 2002–03 and 4 MT in 2021–22. The direct effect is through the damage to the crop's reproductive development thus, reduced production potential. Indirectly heatwaves increase the plant water stress, resulting in cessation of photosynthesis and subsequently possibly death.

Cold waves: Though less common, cold waves can affect dryland regions in northern India, such as Rajasthan and parts of Gujarat. The damage also extends to northern parts of Maharashtra. Sudden drops in temperature during the winter months can damage crops like wheat and mustard, especially if they are in the flowering or fruiting stages. Cold winds from the Himalayan region descending into the northern plains are the major cause. Frost damage to crops, livestock health issues, and reduced agricultural output are some of the negative effects on Indian agriculture due to cold waves.

Hailstorms: In recent years, India experienced widespread hailstorm events from February to May in the northern, central, and southern parts of India. Among the extreme weather events, hailstorm damage



Major extreme weather events experienced in India since 2000

to crops severely affected within a short time interval. More than 61% of the districts in India experienced at least one hail event in 38 years (1972–2011) with a gap of two other years in between.

Cyclones and flash floods: While cyclones are more frequent along India's coastlines, their impact on dryland regions, particularly in southern and western India (e.g., Gujarat, Andhra Pradesh), can still be profound. Cyclones bring heavy rainfall and strong winds, often causing flash floods in areas that are otherwise arid. They cause extensive damage to crops, infrastructure, soil erosion, and loss of livestock. Flash floods are also common in regions like Rajasthan and parts of Gujarat. Intense monsoon rains, cyclonic events, or localized cloudbursts are the major causes of flash floods. Loss of crops, livestock, and human lives, destruction of infrastructure, and soil erosion are the major impacts of flash floods on agriculture.

Dust storms: Dust storms are frequent in the dryland areas of north-western India, particularly in Rajasthan and Haryana, during the pre-monsoon season. These storms reduce air quality, damage crops, and contribute to soil erosion. Strong winds and loose, dry soil from deforested or overgrazed lands cause dust storms. Their major impact includes crop loss, reduced soil fertility, respiratory problems in humans and animals, damage to infrastructure.

Agromet advisory services in India

Agromet Advisory Service (AAS) is a part of extension agrometeorology and is defined as 'Agrometeorological and agro-climatological information that can be directly

applied to improve and/or protect the livelihood of farmers'. Agrometeorological advisory services provide critical support to farmers by delivering weather-based agricultural advisories, which help in making informed decisions about cropping practices, irrigation scheduling, pest and disease management, and soil conservation. These services leverage weather forecasts, satellite data, and climate models to predict and manage risks associated with extreme weather events, thereby enhancing agricultural productivity and resilience.

In 1976, the India Meteorological Department (IMD) launched AAS in partnership with state agricultural departments from its state meteorological centres. Since 1991, the National Centre for Medium-Range Weather Forecast (NCMRWF) has been providing quantitative weather forecasts for a total of 5 agrometeorological field units (AMFUs) with a spatial resolution of 250 Km in the medium range (3 days). AAS is currently a multi-institutional and multi-disciplinary endeavour. It includes the Indian Council of Agricultural Research (ICAR), State agricultural institutions, State agricultural departments, Non-governmental organizations, the media, and others, in addition to IMD.

AICRPAM centres as part of the GKMS program publish AAS bulletins twice a week in local languages across the nation. The dynamic web portal 'Crop Weather Outlook' hosted by AICRPAM-CRIDA updates daily as well as weekly weather & crop information besides Agromet advisories of the 20 states, where the AICRPAM centres are located (<http://www.cropweatheroutlook.in/>). Looking at the shortcomings of district-level Agromet advisory services, AICRPAM

conceptualized and implemented a Micro-level Agromet Advisory Services (MAAS) in pilot mode in 50 selected villages across 20 states of the country in 2011. Further, several research outputs from AICRPAM's research themes are incorporated and enriched in the Agromet Advisory bulletins. These scientific inputs and improved preparation processes attracted the country's leading weather provider IMD to collaborate with the AICRPAM unit to develop the National Agromet Advisory Services bulletin every week and also conceptualized and developed Dynamic Crop Weather Calendar, a DSS system for generating very precise information on the sowing time of the crop, crop water requirements, LGP, irrigation water requirements etc.

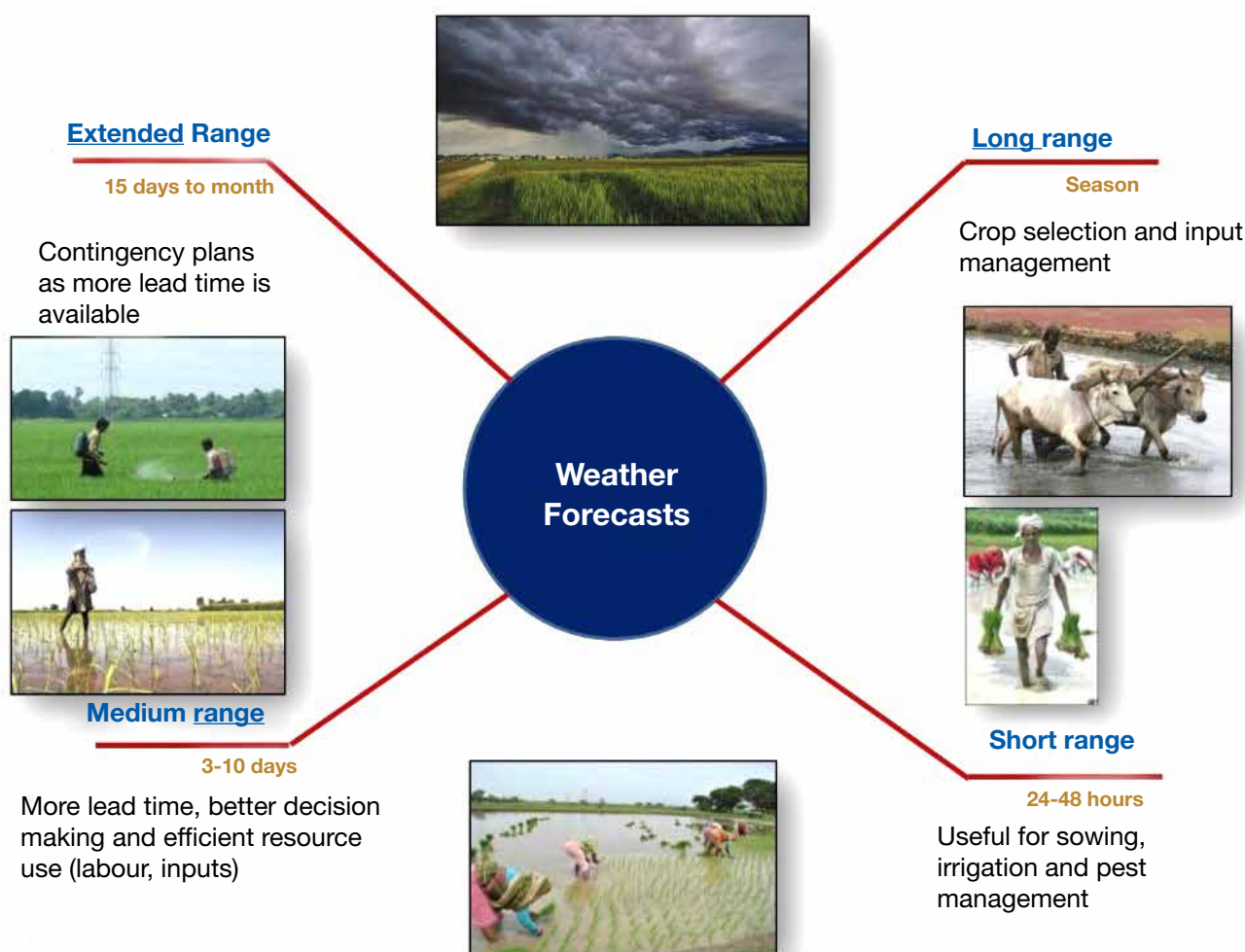
District agriculture contingency plans

District-level contingency plans are technical documents containing integrated information on agriculture and allied sectors (i.e., field crops, horticulture, livestock, poultry, fisheries) and technological solutions for all the major weather-related aberrations including extreme events viz., droughts, floods, heat waves, cold wave, untimely and high-intensity rainfall, frost, hailstorms, pest and disease outbreaks and are aimed to be utilized by district authorities. These contingency plans contain information

on alternate crop varieties/ crops to be chosen in case of delay in the onset of monsoon or early-season drought, and also on agronomic measures for mid and terminal-season droughts. Further, strategies for contingency situations in livestock, poultry, and fisheries have also been included. Various interventions need to be taken during a delay in canal water release and its later release in irrigated regions and related aspects are also dealt with. The district-based contingency plans are prepared for 650 districts of the country and hosted on ICAR / DAC websites (<http://agricoop.nic.in/acp.html>, <http://icar-crida.res.in/>) and circulated to all state agriculture departments.

Augmenting crop contingency plans with weather forecasts

Once crop contingency plans are prepared based on agro-ecological region, information on soil type, rainfall pattern, type and frequency of extreme weather events, crops/cropping systems prevalent in the area, sowing/planting window, acreage under rainfed/ irrigated agriculture, etc., its implementation is mainly dependent on the weather forecast and agromet advisory. The preparation for operationalization of crop contingency plans begins with the long-range weather forecast (LRF) issued by IMD, which provides



Weather forecasts and their applications in developing agromet advisories in India

an overall idea of whether the southwest monsoon will be above normal/normal/below normal. If the forecast is below normal, steps to implement crop contingency plans are taken. The events of mid-season drought can be identified using an extended-range weather forecast issued by IMD, which is valid for two weeks. Regular agricultural operations can be planned according to the medium-range weather forecast. Nowcast is the latest forecast issued by IMD in the event of hail storms, cloud bursts, lightning, etc. which can be used by farmers to protect the livestock and high-value crops.

Farmers require timely and accurate weather forecasts and advisories information to plan the operations and remedial measures to reduce the losses in farm produce due to aberrant weather conditions. Inputs (seeds, fertilizer, plant protection chemicals), as well as the entire crop, can be saved when agromet advisories are delivered in a timely way (especially at the maturity stage). Key information that can address extreme weather events in India's agriculture context through agromet advisories are described below.

Drought management advisories

- *Early drought warnings:* Advisories that provide long-range weather forecasts and monitor drought onset to help farmers plan for water scarcity.
- *Crop diversification recommendations:* Farmers are advised to plant drought-tolerant crop varieties (e.g., millets, pulses) and use short-duration crop varieties to reduce water demand during drought periods.
- *Water conservation techniques:* Recommendations on water-saving practices such as mulching, micro-irrigation, rainwater harvesting, and the use of moisture retention techniques to cope with limited water availability.
- *Irrigation scheduling:* Precise advisories on when and how much to irrigate based on weather forecasts and soil moisture levels, ensuring efficient use of scarce water resources.

Heatwave management advisories

- *Heatwave alerts:* Early warning of impending heatwaves allows farmers to take measures to protect crops and livestock from heat stress.
- *Crop protection measures:* Advisories may recommend covering crops with shade nets or using organic mulches to reduce soil temperature. In addition, adjusting planting dates to avoid critical crop growth stages coinciding with heatwaves is suggested.
- *Livestock care:* Recommendations for providing adequate water and shade to livestock, adjusting feeding times, and taking steps to prevent heat-induced illnesses.
- *Soil moisture retention:* Techniques like deep ploughing and using organic matter to retain moisture in the soil and prevent rapid evaporation during high temperatures.

Advisories for managing erratic rainfall

- *Rainfall forecasting:* Short- and medium-term rainfall

forecasts enable farmers to adjust their sowing times, optimize water usage, and plan for irrigation or drainage systems.

- *Contingency crop planning:* In regions with unpredictable rainfall patterns, advisories can provide alternative crop plans, such as switching to crops that are more tolerant to delayed or excessive rain.
- *Drainage management:* Recommendations for constructing drainage systems or raised beds to avoid waterlogging during heavy rains, which can damage crops, particularly in areas that face erratic rainfall.

Flood management advisories

- *Flood warnings:* The issuance of real-time flood forecasts and alerts allows farmers to safeguard their livestock, store agricultural inputs, and harvest mature crops early.
- *Soil erosion control:* Advisories may suggest planting cover crops or constructing bunds and check dams to prevent soil erosion caused by floods or heavy rains.
- *Post-flood crop management:* Recommendations for replanting fast-growing or flood-tolerant crops after floodwaters recede, as well as guidance on restoring soil health.

Cyclone risk mitigation

- *Cyclone alerts:* Early warnings of impending cyclones allow farmers in nearby dryland regions to take preventive actions, such as securing greenhouses, shifting livestock to safer areas, and harvesting mature crops.
- *Crop protection measures:* Advice on how to minimize cyclone damage through the use of windbreaks, sturdy staking for horticultural crops, and protection of nurseries.
- *Post-cyclone recovery:* Guidance on replanting and rehabilitating damaged fields after cyclones, as well as measures to restore soil fertility by incorporating organic matter.

Cold wave management advisories

- *Cold wave forecasts:* Timely forecasts of cold spells help farmers prepare for frost or low temperatures, particularly in northern India's dryland regions.
- *Frost protection:* Advisories recommend techniques like covering sensitive crops with plastic sheets or using smoke to reduce frost impact. Farmers are also advised to irrigate fields before cold waves, as moist soil retains heat and can help protect crops.
- *Crop selection:* Suggestions for cold-tolerant crop varieties and adjusting planting schedules to avoid sensitive growth stages during periods of extreme cold.

Pest and disease management under extreme weather

- *Weather-pest forecast integration:* Advisories based on the relationship between weather conditions and pest/disease outbreaks. For example, drought or erratic rainfall can lead to increased pest pressure,

and advisories can recommend pest management strategies such as timely application of biopesticides or integrated pest management (IPM) techniques.

Soil and nutrient management advisories

- *Soil health monitoring:* Continuous weather monitoring, combined with soil moisture sensors, can provide advisory services on the optimal time for fertilizer application to avoid nutrient leaching during heavy rains or maximize absorption during dry spells.
- *Nutrient management under drought:* Recommendations on applying nutrient solutions that help plants cope with drought stress and maintain productivity under water-limited conditions.

Livestock management in extreme weather

- *Heat stress alerts:* Advisories for protecting livestock during heatwaves, such as increasing water intake, providing shade, and altering feeding schedules to reduce heat-related stress.
- *Flood and cold wave protection:* Guidance on shelter management for livestock during extreme weather events, with specific advice on maintaining health and nutrition in stressful conditions.

Training and capacity building

- *Farmer awareness programs:* Regular workshops, farmer field schools, and training sessions to enhance farmers' understanding of weather patterns, interpretation of advisories, and adoption of climate-resilient practices.

- *SMS and Mobile app-based advisories:* Use of digital platforms to disseminate agromet advisories, allowing farmers to receive real-time, location-specific advice on extreme weather events and appropriate responses.

SUMMARY

In India, climate variability and extreme weather events affect the agricultural livelihood systems negatively. In our country, the National Agricultural Research Service is actively involved in research and extension services to improve the livelihood of the farming community. State-level policymakers and officials of the line department are using the crop contingency measures prescribed by ICAR-Central Research Institute for Dryland Agriculture for giving advisory and actions. Timely and accurate agromet advisories can be a game changer if they can reach all the farmers of the country. Leveraging nowcasting to develop short-term agromet advisories for events like cloudbursts, hailstorms, and flash floods has the potential to be a transformative approach for agriculture in India over the coming decade. With the giant leap in computing power and the advent of artificial intelligence, it is envisaged that the accuracy of weather forecasts will improve shortly, which will further aid in agromet advisories based on nowcasting and help in reducing the negative impacts due to extreme weather events.

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Fisheries is a sunrise sector with varied resources and potentials. The sector engages 14 million people at the primary level and is earning over ₹10,000 crore annually through exports. Fish consumption has shown a continuous increasing trend assuming greater importance in the context of 'Health Foods'. It is expected that the fish requirement by 2025 would be of the order of 16 million tonnes, of which at least 12 million tonnes would need to come from the inland sector and aquaculture is expected to provide over 10 million tonnes. The domestic market for fish and fishery products is also growing rapidly and necessary models and quality control protocols in this regard need to be developed.



In 2006, the Indian Council of Agricultural Research, brought out the First Edition of 'Handbook of Fisheries and Aquaculture'. The present revised edition comprises 42 updated and six new chapters, viz. Fish physiology; Aquaculture engineering, Fisheries development in India; Fisheries cooperatives; Demand and supply of fish; and Climate change - impact and mitigation. The Handbook would be of great value to students, researchers, planners, farmers, young entrepreneurs and all stakeholders in fisheries and aquaculture.

TECHNICAL SPECIFICATIONS

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