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DROUGHTS AND FLOODS ARE TWO SIDES OF THE SAME CLIMATE COIN

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Introduction

Indian agriculture is increasingly influenced by the hydroclimatic extremes like droughts and floods which is acting as major constraints on crop growth and productivity. These atmospheric aberrations are inherent to the climatic system and often affect the yield and stability of the cropping system management. Even though the agronomic inputs raise yield potential but actual production largely depends on weather and climate variability. Small and marginal farmers face high exposure to rainfall fluctuations and recurrent yield losses across regions ranging from flood prone eastern rice areas to the semi-arid Deccan Plateau. Reliable weather forecasts help farmers make timely decisions on sowing, irrigation, and risk management, offering benefits that input intensification alone cannot provide. Climate model projections indicate that future climate conditions are likely to become more variable rather than changing uniformly. It emphasizes the need for agriculture to be directed by climate information.

Hydro climatic Extremes in the Climate System

Drought and flood represent the natural rhythm of climatic variability. It formed by large scale oscillations such as ENSO and increasingly intensified warming by anthropogenic actions. In India, nearly three quarters of the annual rainfall is concentrated within the monsoon season. Hydro climatic risk generates alternating periods of water scarcity and surplus. These extremes are not rare events but inherent features of the climate system. Droughts persisting over months and floods develop rapidly damage over short periods. In rice growing regions such as West Bengal, this variability directly affects the crop performance where as dry spells reduce tillering and prolonged flooding damages root system. Crop simulation model such as DSSAT show that monsoon deficits can cause severe yield reductions, while excessive rainfall also leads to substantial losses. Weather and climate forecasts help to break down this variability by adaptive decisions such as adjusting sowing dates and alternate cropping system. Global level assessments by the Intergovernmental Panel on Climate Change (IPCC) indicate that increasing climate extremes are linked to changes in atmospheric circulation, reinforcing the critical role of prediction in managing agricultural risk.

Linkages between Drought-Flood Processes

Droughts and floods are physically linked through land and atmospheric processes and should not be viewed as independent hazards. Extended dry periods modify the soil structure and reduce infiltration capacity, so when the rainfall occurs, runoff increases rapidly and raises the risk of flash floods. Such sequences have been reported across several parts of India, where drought conditions prior to rainfall events have intensified the impacts of subsequent floods and landslides in hilly regions. Crops are highly sensitive to these rapid shifts in hydrological event as the roots already weakened by moisture stress often fail under sudden waterlogging. Nutrient losses further exacerbate the problem, because fertilizers applied during dry periods are easily leached or washed away during heavy rains. Forecasting systems that combinedly consider drought and flood occurrences are more effective than approaches that treat them as separate hazards. Studies show that many flood events in India occur after drought periods. It highlights the need for integrated weather and climate information to better manage agricultural risk.

Atmospheric and Oceanic Drivers

Large scale atmospheric and oceanic circulations play a crucial role in droughts and floods events by regulating moisture is transported into the Indian sub-continent. Madden–Julian Oscillation (MJO), Indian Ocean Dipole (IOD), monsoon wind shear and oceanic patterns influence whether rainfall is enhanced or suppressed. For example, a negative Indian Ocean Dipole is often associated with weaker monsoon rainfall, while La Niña conditions tend to increase flood risk over the Gangetic plains. Moisture carried by low level jets can concentrate rainfall over limited areas, leaving other regions dry. Downscaling studies linking global climate model to district level scales. It shows shifts in the wind circulation systems which can intensify drought conditions in regions such as Bihar. Weather forecasts capture these circulation patterns in real time, allowing farmers to adjust practices and improve yields.

Rainfall Variability Changes

Rainfall patterns are increasingly shifting toward extremes with fewer rainy days but more intense rainfall events. It reduces the effectiveness of crop water uptake. India Meteorological Department (IMD) study shows 10% increase in heavy rainfall events exceeding 100 mm per day since 1980, along with 15% increase in the duration of dry spells. It increases surface runoff and limits soil moisture availability during critical crop growth stages. Pulses and wheat often experience moisture stress during mid-season dry periods despite adequate fertilizer application. Climate model projections suggest that this shift in rainfall distribution could intensify 20% by mid-century in eastern India. Weather forecasts that resolve changes in rainfall intensity and frequency which allows better timing of irrigation and field operations.

Soil Moisture Dynamics and Feedbacks

Soil conditions prior to rainfall play a critical role in both drought and flood impacts. When soils remain dry, their infiltration capacity declines which causing even moderate rainfall to generate rapid surface runoff and flooding through Hortonian overland flow. These dry soils also heat the near-surface atmosphere, which suppresses cloud development and prolongs drought through land-atmosphere feedbacks. As crops experience moisture stress, root systems weaken and lose their ability to store and transmit water which is further reducing the soil moisture retention. Satellite observations from SMAP reveals that 30% contrast between dry and wet soil moisture states, contributing to the intensification of both droughts and floods. Forecasting systems that incorporate these soil–atmosphere interactions can guide adaptive practices such as mulching and residue management.

Rising Temperature Influence

Warmer air increases evapotranspiration by 7% for every 1°C rise in temperature. It intensifies drought conditions also the warmer air can hold nearly 7% more moisture which leads to heavier rainfall events and stronger floods. India has warmed by 1.2°C since 1970. It sharply increased the vapour pressure deficit and caused greater moisture stress on crops. Warmer oceans also evaporate more water which supplying additional moisture to storms and increasing flood intensity. High temperatures dry out soils and prevent crops from absorbing applied fertilizers, leaving nutrient unused. Occurrence of heavy they are often leach the nutrients. Climate projections from CMIP6 indicate a further temperature rise of 2–4°C by mid-century, which is expected to amplify both droughts and floods. Improved weather and climate forecasting can reduce these impacts by helping farmers to timely irrigation, fertilizer application and other interventions more effectively. Overall, rising temperature links drought and flood intensification also reducing the effectiveness of farm inputs.

Drought-to-Flood Transitions

Dry soils often fail to absorb sudden heavy rainfall which causes rapid flood development. This pattern is commonly observed in peninsular India. At terminal drought, atmospheric river systems can deliver 200–500 mm of rainfall within a short time, which overwhelm the rivers and drainage channels. These rapid transitions are especially damaging during the flowering stage of crops, which washout the pollens lead to sterility and lesser grain filling. Early warning system allow farmers and planners to prepare in advance.

Compound Extremes on Agriculture

Combined effect of drought and flood events are a major driver of yield stability. These sequences accelerate soil erosion and increase pest and disease pressure under physiological stress. In India, more than 50% of annual crop losses are associated with such hydroclimatic extremes, with long-term consequences for soil fertility and land productivity. Crop simulation studies of rice shows yield reductions of approximately 40–60% when drought conditions are followed by intense rainfall. Extreme weather events affecting large number of smallholder farmers which cause billion-dollar annual losses. Integrating weather forecasts with agronomic decision-making can reduce these impacts by 20–50% (Table 1).

Table 1. Timely informed forecast and yield improvement on extreme weather events

Extreme Type	Key Driver	Yield Impact	Forecast Gain
Drought	ET Rise	-40 to -60%	+30% Timing
Flood	Intensity Burst	-30 to -50%	+25% Warning
Combined	Transitions	-50 to -70%	+40% Adaptation

Spatial-Temporal Water Asymmetry

Off-season extreme rainfall events inundate fallow or non-cropped land which is not useful for the agricultural operations. Agroecosystems function optimally under sustained and temporally distributed moisture supply. However, hydroclimatic extremes deliver water in shortage or surplus. Across the Gangetic Plains, spatial heterogeneity in rainfall leaves nearly 40% of districts under moisture deficit while adjacent districts experience flooding. Due to these temporal discrepancies, crop growth and yield is affected. Reservoir operation and delayed release strategies further exacerbate this spatial–temporal asymmetry. Forecast informed water management, including dynamic storage and release advisories, can better synchronize water availability with crop demand and improve water-use efficiency by approximately 30%.

Conclusion

Drought and flood extremes are increasingly monitored using standardized precipitation indices (e.g., SPI), satellite-derived soil moisture observations (e.g., SMOS) and Doppler weather radar, with integrated early warning systems which provides 7–10-day lead time. Recent forecasting upgrades by the India Meteorological Department have reduced the false-alarm rates by 20%. It enhancing the reliability of district-level agrometeorological advisories delivered through unified decision-support dashboards. Crop and hydrological models are validated against observed extremes to support forecast information. Evidence shows that hazard-specific responses are inadequate, while integrated strategies like linking reservoir operations, climate-resilient cropping systems, agroforestry buffers and insurance mechanisms are more effective. Policy frameworks are shifting towards resilience-based planning, as demonstrated by India's NAMAMI project. It embeds with weather and climate forecasts across governance scales. Climate-resilient agro-hydrological systems are increasingly depended on predictive hydroclimatic capacity, which is supported by downscaled CMIP6 projections. Weather forecast based adaptation enables timely deployment of tolerant crop varieties and management interventions. It documented yielding ~7% increase in crop productivity. Securing food systems under climate change thus requires prioritizing anticipatory, decision-making over reactive, input-centric approaches.

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