

Anticipatory Action and Response Plan for Maharashtra

Managing Agricultural Risks from El Niño-Induced Below-Normal Conditions

Kharif 2026



Prepared by



In collaboration with



Supported by



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Preface

Managing variable climatic conditions remains a persistent challenge for millions of rainfed farmers in India. The high variability and inherent unpredictability of weather patterns makes it extremely difficult to plan and manage agricultural systems whose performance is closely tied to environmental conditions during the crop season. Extreme events, particularly droughts, have a profound impact on productivity and farm profitability. Historically, responses to such events have been largely reactive, focusing on relief and recovery rather than anticipatory planning and action. This limitation stems largely from the difficulty of reliably forecasting seasonal conditions in advance.

In recent years, meteorological science has made significant advances in understanding large-scale climate phenomena such as the El Niño–Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD), alongside improvements in predicting climatic conditions months ahead. In India, this progress has been further accelerated by the establishment of the Monsoon Mission (now Mission Mausam) under the Ministry of Earth Sciences, Government of India. The mission aims not only to enhance forecast accuracy but also to promote the effective use of climate information across weather-sensitive sectors, particularly agriculture.

In this context, ICRISAT, in collaboration with ICAR-CRIDA and ILRI, is implementing the project titled “AI-powered Context-Specific Agromet Advisory Services for Climate-Resilient Agriculture at Scale” with support from Mission Mausam. The project seeks to develop an automated system—the Intelligent Systems Advisory Tool (iSAT) that integrates climate and weather forecasts with context-specific agricultural knowledge drawn from a growing database compiled from multiple national and international research institutions. iSAT translates probabilistic climate forecasts into actionable, context-specific guidance, delivering both pre-season and in-season advisories tailored to user needs. The current phase of the project focuses on Maharashtra and aligns with the CGIAR Climate Action Science Program (AoW2), which aims to strengthen climate-informed decision-making in agriculture.

This report represents an early effort to test the tool and its capabilities in generating a state-level pre-season advisory based on the seasonal climate forecast issued by the India Meteorological Department (IMD) for the Kharif 2026 season. The forecast indicates below-normal rainfall at the national scale, consistent with the emergence of El Niño–like conditions in the Pacific Ocean. Accordingly, the advisory framework emphasizes anticipatory actions to manage agricultural risks associated with a potentially weak monsoon. As the project is still in its early stages of implementation, this report should be considered a work in progress. We expect its quality, precision, and relevance to improve as the underlying database is strengthened, and the AI/ML models are further refined. It is also important to note that a substantial portion of this report (approximately 80%) has been generated using AI-based methods.

This report is intended to support policymakers, extension systems, and field-level institutions in enabling timely, coordinated, and evidence-based responses to climate risks. We welcome feedback and suggestions from readers, which will be invaluable in improving future iterations.

Acknowledgement

The team acknowledges the support from the Ministry of Earth Sciences (MoES), Government of India through Mission Mausam for enabling this work. We thank the India Meteorological Department (IMD) for providing climate forecasts and the Indian Institute of Tropical Meteorology (IITM) for climate modelling inputs. We also acknowledge the support of the CGIAR Climate Action Science Program (AoW2) in strengthening climate-informed agricultural decision-making.

We also acknowledge the contributions of ICAR, State Agricultural Universities of Maharashtra, and collaborating institutions for their technical inputs in developing district-level advisories and contingency plans. Field-level insights and support from extension systems, partner organizations, and stakeholders have been critical in shaping the recommendations presented in this report.

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PART I

Anticipatory Action and Response Plan for Maharashtra

Managing Agricultural Risks from El Niño-Induced Below-Normal Conditions



Executive summary

- This report aims to support anticipatory planning to mitigate the impacts of potential below normal rainfall during the *Kharif* season 2026, as forecasted by the Indian Meteorological Department (IMD). The developing El Nino further reinforces this outlook.
- Analysis of past El Nino induced droughts shows that, of Maharashtra's 353 blocks, 181 blocks are highly vulnerable, 78 blocks are moderately vulnerable, and 94 have low vulnerability. The findings highlight that El Niño increase existing climatic disparities, disproportionately affecting inherently drier regions.
- NDVI analysis for normal versus El Nino years supports this pattern. A significant decline in vegetation index was observed in 2015 (a below normal year with El Nino), particularly across districts and blocks in the MH-6, MH-7, and parts of MH-8 agro-climatic zones.
- Crop production analysis indicates the reductions during El Nino years are driven primarily by a decline in cultivated area followed by yield losses.
- The crops most vulnerable during El Niño years are cotton, maize, and soybean. Rice and pulses show moderate resilience, while millets—especially jowar, bajra, and ragi—are the most resilient.
- Cultivation of water-intensive or long-duration crops in low-rainfall zones (MH-5 and MH-6) poses the highest risk, consistent with observed rainfall patterns.
- Drought tolerant crops such as jowar, bajra and ragi experienced relatively modest production declines (approximately 5-13%) compared to moisture intensive crops like cotton and soybean.
- The current outlook for *kharif* 2026 suggests a high probability of below-normal rainfall, particularly in Marathwada and central & western Maharashtra with peak impact expected during August–September.
- The proposed drought mitigation strategy is built on three interlinked pillars: accurate climate anticipation, robust contingency based planning and adaptive in-season management.
- Hindcast analysis from IITM indicates that while the skill of seasonal climate forecasts has improved, it remains below user expectation. To address this, it is recommended to use rainfall levels with 80% reliability as the planning threshold, as these closely resemble rainfall observed during past below-normal and El Niño years.
- As an initial step, it is recommended to establish or strengthen systems for generating and disseminating pre-season and in-season advisories with sufficient granularity for farm-level decision-making. iSAT is proposed as one such platform.
- Given the high likelihood of a below-normal monsoon, the following guiding principles are recommended:
 - ◇ Prioritize resilience over yield maximization
 - ◇ Shift from high-input, high-risk crops to low-input, drought-resilient systems
 - ◇ Promote diversified, short-duration cropping systems over monocropping
 - ◇ Most Reliable crops: Millets (bajra, jowar), Pulses (tur, gram, moong), Sesame
 - ◇ Moderate Risk crops: Maize, Soybean, Cotton (only in better rainfall zones)
 - ◇ High Risk crops: Sugarcane, Long-duration cotton, Water-intensive crops
- Agro-climatic zone specific strategies have been developed based on these principles and potential of each agro-climatic zone.
- Adaptive in-season management is the most critical component of the drought response. This requires continuous monitoring and timely interventions through soil, water and crop management practices.
- In addition to standard practices, the report identifies several high impact interventions for promotion by local administration:

- ◇ Plastic mulching to reduce evaporation and control weeds
 - ◇ Seed priming for faster germination and uniform crop establishment
 - ◇ Transplanting (e.g., millets and pigeonpea) for shortened season due to late onset of monsoon
 - ◇ Micro-irrigation, especially for high value crops
 - ◇ Rain guns for protective irrigation
 - ◇ Informed planting decisions based on advisories
 - ◇ Crop and livestock insurance to mitigate extreme losses
 - ◇ Fodder banks and fodder security measures
- Strengthening the capacity of farmers and supporting institutions is essential. Key areas include interpreting IMD seasonal forecasts at the local level, monitoring rainfall trends, issuing refined advisories, and conducting in-season reviews (June–July) to enable contingency actions. Equipping extension workers with digital tools is also critical.
 - A strengthened institutional coordination mechanism involving Agromet Field Units (AMFUs), Krishi Vigyan Kendras (KVKs), and district agriculture departments is recommended to track triggers and enable timely action.
 - Given the need to reach millions of smallholder farmers promptly, a multi-chain communication strategy including digital and social platforms is recommended.
 - The district-level advisories presented in Part II provide location-specific guidance including contingency measures for delayed monsoon onset and early, mid and end season drought scenarios.

Background

Historically, responses to extreme weather events have been largely reactive, focusing on relief and recovery rather than anticipatory planning and action. However, advances in climate science and forecasting are enabling a shift toward proactive, risk-informed decision-making. This transition presents a critical opportunity for policymakers to embed anticipatory action within development and sectoral planning frameworks.

Seasonal Climate Forecasts (SCFs), routinely produced by meteorological agencies worldwide, provide probabilistic projections of temperature and precipitation at lead times of one to six months. Progress in understanding the climate system—particularly through coupled ocean–atmosphere models—has significantly improved forecast reliability. In India, the India Meteorological Department (IMD) has operationalized the Monsoon Mission Coupled Forecast System version 1 (MMCFsV1) since 2011 to generate forecasts for the Southwest Monsoon (SWM), a key determinant of national food security and rural livelihoods.

Although the predictive skill of SCFs varies across space and time—generally higher in tropical regions and lower in extratropical areas—it is strongly influenced by large-scale climate drivers such as the El Niño–Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD). Continued scientific advancements have further enhanced forecast performance. Despite this progress, the integration of SCFs into policy frameworks and local-level decision-making remains limited, particularly in climate-sensitive sectors such as agriculture.

On 15 April 2026, the Ministry of Earth Sciences, Government of India, issued the Long Range Forecast (LRF) for the 2026 Southwest Monsoon. The forecast indicates a high likelihood of below-normal seasonal rainfall, estimated at approximately 92% of the Long Period Average (LPA) of 87 cm (1971–2020). Model projections also suggest the possible emergence of El Niño conditions, potentially accompanied by a positive phase of the Indian Ocean Dipole (IOD) during the monsoon season. Historically, this combination has been associated with weaker monsoon performance and an elevated risk of rainfall deficits.

This outlook underscores the need for a coordinated, multi-sectoral response that translates climate information into timely and actionable interventions. In the context of Maharashtra's agriculture, this involves aligning cropping strategies, input planning, water management, and risk mitigation measures with anticipated seasonal conditions. While a wide range of agricultural technologies exists, most are optimized for average climatic conditions. Institutional mechanisms to systematically integrate seasonal forecasts into agricultural planning, extension services, and contingency frameworks remain underdeveloped.

Addressing this gap will require strengthening climate services, improving last-mile delivery of context-specific and locally relevant advisories, and fostering convergence between meteorological agencies, agricultural departments, and local governance institutions. Embedding forecast-based decision-making into policy and practice can significantly enhance the resilience of agricultural systems and reduce the economic and social costs associated with climate variability.

A key challenge in building climate resilience lies in bridging the gap between available technological solutions and real-time climate forecasts. There is a strong need to develop and scale location-specific, context-sensitive advisories that enable farmers to make data-driven decisions—minimizing risk during adverse conditions while capitalizing on favorable opportunities. This is the core objective of the current project led by ICRISAT in collaboration with CRIDA-ICAR, ILRI, State Agricultural Universities (SAUs), IITM, and IMD, supported by the MoES Monsoon Mission in Maharashtra.

This report builds on the initial work conducted under the project and provides a framework for anticipatory planning for the Kharif 2026 season. It is designed to guide implementation, facilitate in-season adaptive management, and strengthen recovery strategies in the face of extreme weather events. The report is structured in two parts: Part I outlines overarching strategic actions, while Part II provides granular district- and block-level plans.

Insights from the past

Understanding the impacts of El Niño on agriculture in Maharashtra requires examining how climate variability interacts with farm-level management systems. The 1972 drought remains the most severe in the state's history and serves as a benchmark for subsequent climate shocks. Nearly 80% of villages were affected, with rainfall far below normal across all agro-climatic zones. Estimates suggest that 15 to 30 million people were impacted, highlighting the scale of vulnerability to extreme climatic events.

More recent droughts in 2012–2013 and 2015–2016 were also significant, particularly due to their cumulative effects. The 2012–2013 drought, although not linked to El Niño, was widely regarded as the worst in four decades in terms of water scarcity, especially in districts such as Solapur and Ahmednagar. In contrast, the 2015–2016 drought—preceded by a weak monsoon in 2014—had compounding impacts, leading to acute water stress. The Marathwada region was particularly affected, recording some of the lowest rainfall levels in the state. These events highlight the need for resilient agricultural systems capable of withstanding both El Niño-related variability and other climatic stresses

Rainfall Dynamics

The primary driver of agricultural risk during El Niño years is reduced total seasonal rainfall combined with irregular monsoon distribution. Prolonged dry spells and extended gaps between rainfall events create significant abiotic stress, particularly during critical crop growth stages such as vegetative development and flowering

Maharashtra is divided into nine agro-climatic zones (Figure 1), each with distinct rainfall characteristics. Coastal zones (MH-1 and MH-2) receive very high rainfall (2800–3300 mm) with low variability (CV ~23–24%), making them relatively water-secure (Table 1). In contrast, the Western Ghats (MH-3) receive around 1372 mm of rainfall but with high variability, increasing risk.

The Western Maharashtra plains (MH-5) experience moderate rainfall (approximately 617 mm) but with high unreliability, making agriculture sensitive to rainfall distribution. The scarcity zone (MH-6), with an average rainfall of about 452 mm and a coefficient of variation of 39%, is the most drought-prone and vulnerable. The Central Maharashtra plateau (MH-7) receives around 695 mm and is moderately vulnerable, particularly in poor monsoon years. Central and eastern Vidarbha (MH-8 and MH-9) receive relatively higher and more stable rainfall, making them comparatively resilient.

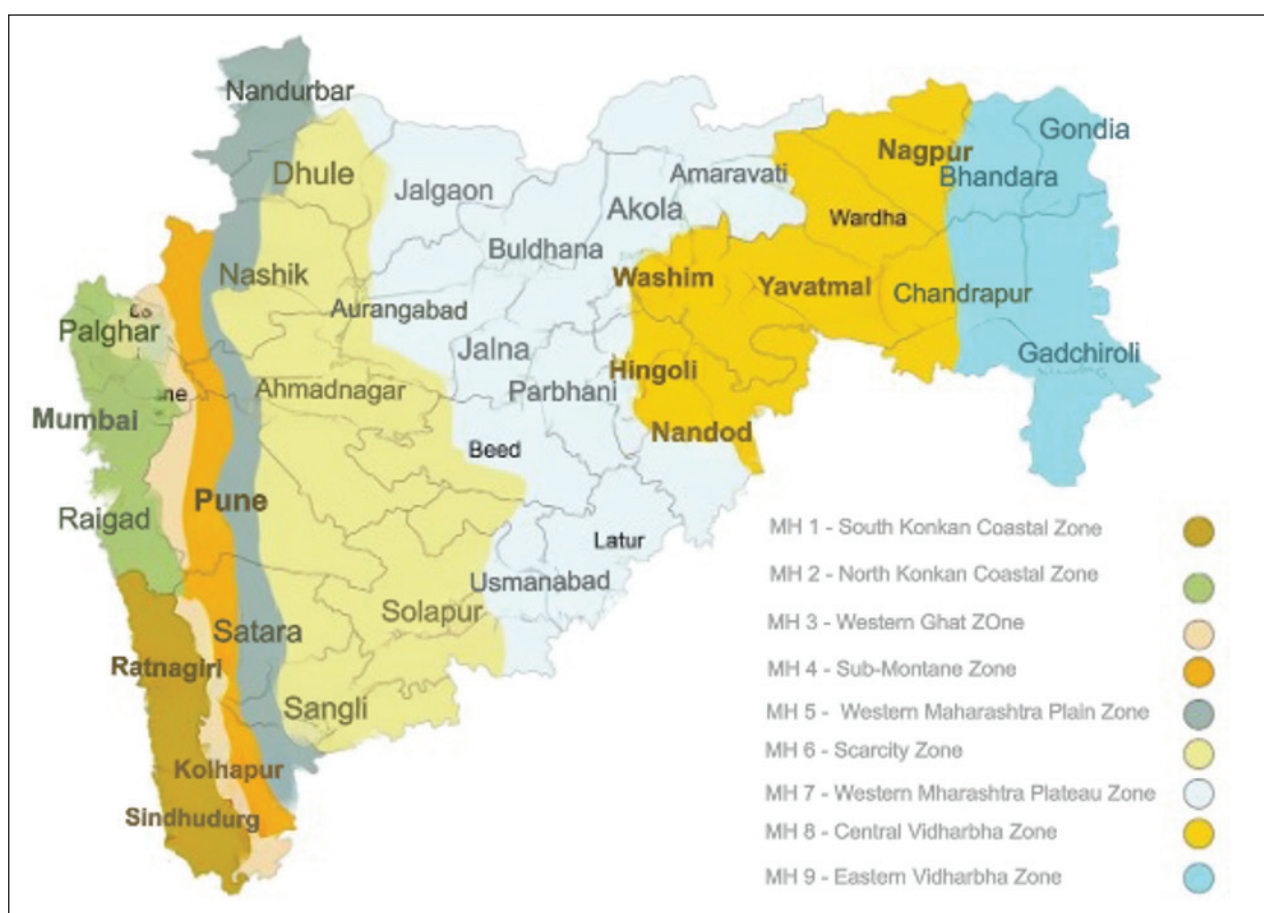


Figure 1: Agro-Climatic Zones of Maharashtra (Map Source: Yusuf Kabir)

Table 1: Agroclimatic zone wise distribution of districts and blocks and rainfall and coefficient of variation of rainfall (CV) in the districts.

Agro-climatic zone	District	No of blocks	Average Rainfall (mm)	CV (%)
South Konkan Coastal Zone (MH-1)	RATNAGIRI	9	3397	19.3
	SINDHUDURG	8	3255	28.7
	Total	17	3330	23.7
North Konkan Coastal Zone (MH-2)	MUMBAI	1	2248	22.4
	PALHGAR	8	2460	23.3
	RAIGAD	15	3192	23.8
	THANE	5	2386	27.6
	Total	29	2818	24.2
Western Ghat Zone (MH-3)	AHMEDNAGAR	1	577	45.2
	DHULE	1	518	29.8
	KOLHAPUR	5	1746	37.0
	NANDURBAR	3	888	38.3
	NASHIK	4	1502	40.7
	PUNE	7	1259	37.4
	SANGLI	1	958	31.7
	SATARA	3	2014	42.7
	Total	25	1372	38.4
Sub-Montane Zone (MH-4)	KOLHAPUR	7	1208	38.7
	Total	7	1208	38.7
Western Maharashtra Plain Zone (MH-5)	DHULE	3	575	28.4
	JALGAON	15	640	29.6
	NANDURBAR	3	696	37.2
	NASHIK	7	726	34.0
	PUNE	3	549	43.2
	SANGLI	6	464	37.2
	SATARA	5	600	36.8
Total	42	617	33.7	
Scarcity Zone (MH-6)	AHMEDNAGAR	13	465	40.5
	NASHIK	4	495	34.3
	PUNE	4	405	39.4
	SANGLI	3	375	40.4
	SATARA	3	401	38.6
	SOLAPUR	11	474	38.8
	Total	38	452	39.1

Continued...

Central Maharashtra Plateau Zone (MH-7)	AURANGABAD	9	586	30.1
	BEED	11	617	35.1
	HINGOLI	5	787	31.9
	JALNA	8	638	31.2
	LATUR	10	678	30.6
	NANDED	16	846	37.1
	OSMANABAD	8	587	33.7
	PARBHANI	9	743	34.5
	Total	76	695	33.5
Central Vidarbha Zone (MH-8)	AKOLA	7	693	26.4
	AMRAVATI	14	797	26.8
	BULDHANA	13	671	27.5
	NAGPUR	7	934	24.5
	WARDHA	8	873	27.8
	WASHIM	6	786	29.3
	YAVATMAL	16	850	30.0
		Total	71	797
Eastern Vidarbha Zone (MH-9)	BHANDARA	7	1145	25.9
	CHANDRAPUR	15	1115	28.5
	GADCHIROLI	12	1339	27.5
	GONDIA	8	1237	24.9
	NAGPUR	6	1028	24.7
		Total	48	1185
Grand Total		353	1106	31.3

Of the state's 353 blocks, 181—primarily in MH-3, MH-5, MH-6, and MH-7—are highly vulnerable to severe droughts and crop failures during low-rainfall years due to low and uneven rainfall. Another 78 blocks (MH-4 and MH-8) face moderate vulnerability, mainly due to intra-seasonal dry spells. The remaining 94 blocks (MH-1, MH-2, and MH-9) are relatively less vulnerable due to stronger natural buffering.

Block-wise rainfall analysis reveals that during El Niño years, the number of blocks receiving less than 600 mm of rainfall increases sharply—from 73 (21%) in normal years to 121 (34%). Meanwhile, blocks receiving more than 700 mm decline from 211 (60%) to 164 (46%). These findings indicate that El Niño amplifies existing climatic disparities, disproportionately increasing risk in already dry regions.

Table 2: Distribution of blocks under different rainfall classes during normal and El Niño Years.

Rainfall class (mm)	Average rainfall (mm)	Coefficient of Variation (%)	No of blocks (Total no of blocks are 353)	
			Normal seasons	El Niño seasons
<500	437	37.2	41	65
500-600	550	36.9	32	56
600-700	645	31.2	69	68
700-800	747	30.7	48	28
800-900	841	33.2	31	21
900-1000	950	28.0	21	14
>1000	2058	27.8	111	101

Regional vulnerability

A comparative assessment of vegetation dynamics using NDVI data highlights spatial variations in response to rainfall variability. NDVI maps from 2013 (a normal rainfall year) were compared with those from 2015 (an El Niño year with below-normal rainfall).

Low-rainfall zones—MH-6, MH-7, and parts of MH-8—showed a pronounced decline in NDVI values during the El Niño year (Figure 2). Across most of the state, NDVI anomalies were negative, indicating reduced vegetation health. A small region in eastern MH-9 was an exception, where vegetation remained relatively stable. These patterns reinforce the spatial concentration of vulnerability in low-rainfall zones.

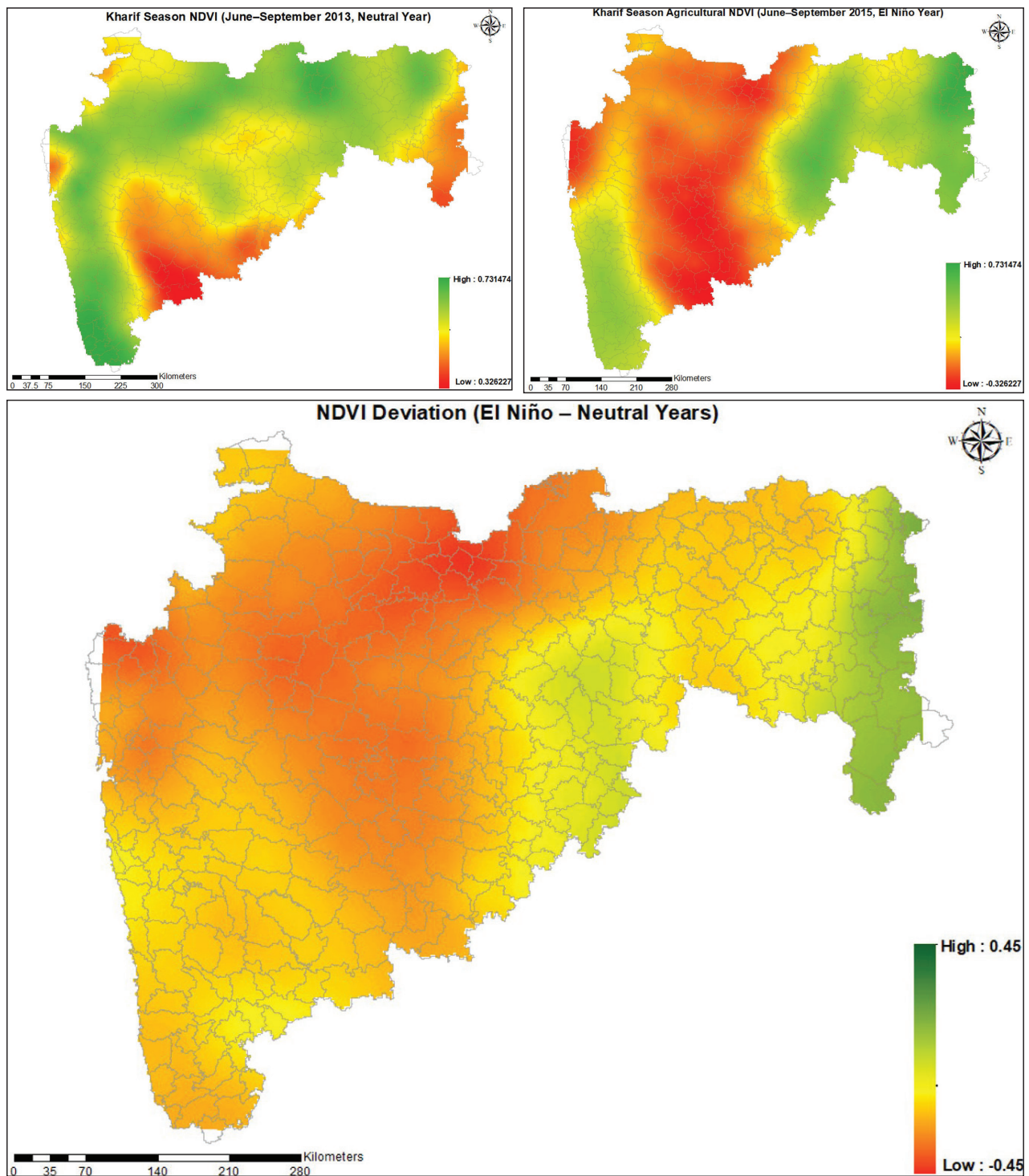


Figure 2: Maps showing NDVI during the year with normal rainfall (top left), below normal rainfall (top right) and the difference between the two seasons (bottom).

Agricultural impacts

An analysis of district-level crop production data (1997–2022) reveals that the primary impact of El Niño on agriculture is through reduced sown area, followed by declines in total production; yield reductions are comparatively modest (Table 3).

Significant reductions in cultivated area were observed for cotton (–24.6%), soybean (–20.3%), and wheat (–14.2%), followed by pigeon pea (–13.7%) and rice (–9.9%). This suggests that farmers tend to shift away from water-intensive or high-risk crops during El Niño years.

Maize exhibited the highest sensitivity to moisture stress, with yield declines exceeding 20%, followed by gram (a rabi crop). Drought-tolerant crops such as jowar, bajra, and ragi showed moderate production declines (5–13%), while crops like linseed, groundnut, and green gram showed minimal yield variation, indicating relative resilience.

Table 3: Decline in area, production and yield of major crops in El Niño years compared to normal years.

Crop	Area in ha		Production in tons		Yield in t/ha	
	Decline	%decline	Decline	% decline	Decline	%decline
Linseed	3242	3.1	1120	1.1	0.00	1.0
Green gram	80258	3.7	29013	1.3	0.00	-0.1
Jowar	1635767	5.6	1499573	5.2	0.00	0.3
Maize	639999	6.3	6596177	64.9	0.52	20.1
Bajra	1025420	7.2	1111103	7.8	0.02	3.3
Ragi	151019	8.9	221003	13.0	0.03	2.2
Rice	3559258	9.9	10637327	29.5	0.13	6.8
Pigeon pea	2875181	13.7	3399920	16.2	0.05	6.1
Wheat	1417279	14.2	2685840	27.0	0.05	2.9
groundnut	519061	17.1	646861	21.3	0.00	0.1
Urad	262575	19.6	138365	10.3	-0.01	-1.1
Soybean	13061550	20.3	18093363	28.2	0.06	5.5
Gram	5758507	22.0	6734180	25.7	0.09	10.2
Cotton	20276346	24.6	34002583	41.3	0.05	3.3
Sesamum	4182	33.4	1133	9.1	0.01	2.4

Source** Directorate of Economics and Statistics, DAFW, Govt. of India

Districts in MH-6, MH-7, and MH-8 experienced significant contractions in the area under cotton and soybean cultivation (Table 4). Cotton acreage declined by over 20% across producing districts, while soybean area declined similarly in 17 districts. Rabi gram also saw a notable reduction in sown area. However, yield declines generally remained below 10%, indicating that production losses were driven primarily by reduced sowing rather than poor crop performance. Hence, the challenge seems to be in increasing the planting area with appropriate crops. The decline in the area under rabi crops further indicates the importance of kharif rains on the performance of rabi crops.

Overall, the crops most at risk during El Niño years are cotton, maize, and soybean. Rice and pulses are moderately resilient, while millets—particularly jowar, bajra, and ragi—are the most resilient, especially in low-rainfall zones. Cultivating water-intensive or long-duration crops in low-rainfall zones (MH-5 and MH-6) poses the highest risk. These trends closely align with observed rainfall patterns.

Table 4: Districtwide decline (in percentage) in the area, production and yield of important crops during El Nino years

ACZ	District	Cotton			Soybean			Gram			Pigeon pea			Rice			wheat			
		A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y	
MH-8	Akola	9.9	14.5	41.6	20.7	24.6	56.3	18.1	23.0	48.8	11.4	16.2	34.12							
MH-7	Latur	11.5	22.0	85.1	23.6	26.8	85.2	31.1	36.4	83.8	12.6	11.2	80.5							
MH-8	Buldhan	11.6	19.6	65.4	21.1	27.9	68.9	30.7	43.8	30							15.9	21.6		
MH-7	Hingoli	12.5	11.4	-180	21.9	21.7	-135.4				18.0	14.2	-175.8				11.2	12.9	-90.1	
MH-5	Jalgaon	13.5	16.9	51.3				18.8	21.6	18.1							20.2	18.6	41.4	
MH-7	Jalna	15.5	20.7	77.1	31.1	41.8	71.1				12.9	21.2	79.4							
MH-7	Beed	16.1	26.2	81.36	33.9	49.5	91.4	0.0	0.0	0.0										
MH-9	Chandrapur	19.1	25.6	31.2	8.0	9.2	17.74	-592.4	51.9	-25	16.7	25.5	21.8	11.9	14.9	37.8				
MH-3/ MH-5	Dhule	20.4	24.7	-43.1				21.6	22.7	33.3										
MH-7	Parbhani	21.3	20.8	80.9	25.4	27.8	-251.6	28.4	-86.9	-35.4	9.3	18.3	81.4							
MH-3/ MH-5	Nandurbar	23.3	28.1	-109.4	19.3	19.6					16.8	17.3	-77.4							
MH-8/ MH-9	Nagpur	25.9	33.5	21.4	7.3	5.6	9.3	15.1	26.0	-20.6				17.3	24.2	10.3				
MH-7	Nanded	25.9	33.5	21.4	7.3	5.6	9.3	15.1	26.0	-20.6				17.3	24.2	10.3				
MH-3/ MH-6	Ahilyanagar	27.2	35.3	75	26.4	35.8	57.5	23.8	43.9	48										
MH-9	Gadchiroli	28.0	29.5	-9.8	0.1	0.1	41.05				16.1	22.2	38.1	13.4	16.9	42.8				25.7
MH-8	Yavatmal	29.7	23.2	65.4	21.7	30.44	33.4				12.8	10.1	29.7							
MH-8	Washim	-31.1	28.3	-4.0	21.8	30.4	11.1	23.1	29.7	8.7	25.0	61.8	8.4							
MH-8	Amaravati	35.4	27.2	38.3				16.3	79.9	31.3	12.7	10.9	61.8							
MH-6	Chatrapati Sivajinagar	63.9	73.0	75.9				16.0	15.8	51.3										

Continued...

Preparing and managing the impacts

Effective drought mitigation rests on three interlinked pillars: accurate anticipation of climate conditions, robust planning with built-in contingencies, and adaptive in-season management. These pillars function not in isolation but as components of an integrated Drought Cycle Management framework. Without reliable anticipation, planning lacks direction; without a sound plan, in-season management becomes reactive and disorganized. The success of any drought management strategy ultimately depends on how effectively data and scientific insights are applied at each stage—and, crucially, how well these insights are translated into clear, actionable guidance. When done well, this enables farmers to make informed decisions throughout the agricultural cycle, from pre-sowing to harvest, and to respond proactively as conditions evolve.

Under the Mission Monsoon-supported project, partners are developing an Intelligent Systems Advisory Tool (iSAT), an automated platform designed to operationalize this process. Leveraging advances in data analytics, including artificial intelligence (AI), iSAT integrates climate data with agricultural information to generate actionable advisories. These advisories are sufficiently granular to capture variability at the district and block levels, with the potential to extend to the village level as more detailed data become available.

This pre-season advisory report for the state of Maharashtra represents the first comprehensive output from the tool. It will undergo thorough evaluation, and the findings are expected to inform further refinement and improvement. Feedback from all recipients of this report is highly valued and will play a critical role in strengthening the system.

Anticipating the seasonal conditions

The effectiveness of mitigation efforts depends largely on how accurately an event—and its impacts on target systems—can be predicted. Such predictions form the foundation for effective planning. Since agriculture is predominantly weather-driven, our ability to anticipate agricultural performance is closely tied to how well we can forecast seasonal conditions and their progression at weekly or shorter time scales. The India Meteorological Department (IMD) provides a suite of forecasts, ranging from nowcasts to seasonal outlooks, which serve as the primary source of information for anticipating future conditions and enable structured, anticipatory decision-making.

A key challenge, however, lies in the varying skill of these forecasts. It is well established that forecast accuracy declines with increasing lead time, making short-range forecasts generally more reliable than seasonal ones. Despite their lower precision, long-range forecasts remain highly valuable as early triggers for action. Recognizing both the strengths and limitations of current forecast products which are developed using the best available science, this project undertook a critical evaluation of forecast skill to identify the types of decisions that can be supported with forecasts issued for different lead times and to translate probabilistic forecasts into actionable, risk-informed insights for farm-level planning. A crucial first step in this process is bridging the gap between forecast skill and the requirements of the decision makers.

Bridging the forecast skill gap

The evaluation of seasonal climate forecasts aims to identify insights that can be derived with high confidence and to assess how these insights can support planning. For this purpose, we analysed hindcasts generated by IITM using MMCFSv2 for the state of Maharashtra. The evaluation involved two steps:

- A hit-and-miss analysis, in which each season was classified as below normal or above normal based on the hindcast and observed rainfall and
- Estimation of rainfall amounts that can be expected with 80% probability during below-normal and above-normal seasons

Overall, the forecasts correctly identified the below- and above-normal seasons 63% of the time (Table 5). However, forecast skill varied across districts and agroclimatic zones. The MH-6 and MH-7 agroclimatic zones showed relatively higher skill compared to other regions. Similarly, the districts of Osmanabad, Nashik, and Solapur—located within these zones—demonstrated better performance.

Despite this, the overall skill remains below user expectations. Users typically expect forecast accuracy of around 80% (i.e., correct outcomes in four out of five cases). To address this gap, we derived rainfall thresholds that are met 80% of the time when forecasts indicate above- or below-normal conditions. These values, presented in Table 5, can be interpreted as low-risk thresholds to identify “best-bet” planning options for a given season.

It is also important to note that our analysis has indicated that the forecast skill is higher when the season corresponds with strong El Niño or La Niña type conditions. While no relation was found between Indian Ocean Dipole (IOD) and forecast skill, it is reported that IOD can partially offset El Niño impacts by contributing late-season rainfall, which may support Kharif crops or improve soil moisture for Rabi planting.

Table 5: Agroclimatic wise and district wise reliability of forecast and the amount of rainfall that can be expected with 80% probability.

ACZ	District	AN Hits (%)	Rainfall with		
			p=0.8	BN Hits (%)	
			p=0.8		p=0.8
Central Maharashtra Plateau Zone (MH-7)	AURANGABAD	72.8	642	62.6	374
	BEED	76.7	661	72.7	359
	HINGOLI	66.4	830	64.0	532
	JALNA	66.1	686	61.9	402
	LATUR	69.3	814	80.4	420
	NANDED	62.9	845	68.4	537
	OSMANABAD	80.8	673	76.2	356
	PARBHANI	71.1	795	72.7	461
	Total	70.3	748	70.3	434
Central Vidarbha Zone (MH-8)	AKOLA	61.6	740	60.8	523
	AMRAVATI	70.1	819	64.3	591
	BULDHANA	64.4	740	64.2	476
	NAGPUR	54.4	986	62.6	719
	WARDHA	57.2	911	66.0	632
	WASHIM	67.4	845	60.1	559
	YAVATMAL	60.2	852	62.2	580
		Total	62.8	833	63.1
Eastern Vidarbha Zone (MH-9)	BHANDARA	65.3	1131	65.1	892
	CHANDRAPUR	63.7	1129	69.7	810
	GADCHIROLI	64.0	1353	57.0	1054
	GONDIA	64.7	1239	56.1	1013
	NAGPUR	44.3	1081	52.4	799
		Total	59.5	1198	63.7

North Konkan Coastal Zone (MH-2)	MUMBAI	76.9	2427	41.7	1747
	PALHGAR	63.2	2662	65.8	2201
	RAIGAD	60.8	3139	67.0	2533
	THANE	46.0	2743	54.9	2147
	Total	61.7	2915	61.4	2348
Scarcity Zone (MH-6)	AHMEDNAGAR	70.9	537	62.8	261
	NASHIK	80.9	551	73.6	280
	PUNE	69.6	452	53.0	219
	SANGLI	61.5	402	58.3	222
	SATARA	58.6	441	56.4	252
	SOLAPUR	76.5	503	70.3	263
	Total	71.7	502	64.2	256
South Konkan Coastal Zone (MH-1)	RATNAGIRI	53.9	3609	60.3	2879
	SINDHUDURG	46.7	3328	57.0	2595
	Total	60.4	1568	61.8	1118
Sub-Montane Zone (MH-4)	KOLHAPUR	60.4	1568	61.8	1118
	Total	50.5	3477	58.8	2746
Western Ghat Zone (MH-3)	AHMEDNAGAR	46.2	794	50.0	560
	DHULE	50.0	622	69.2	300
	KOLHAPUR	60.3	2141	65.3	1622
	NANDURBAR	50.0	1059	60.0	671
	NASHIK	56.4	1750	61.7	1367
	PUNE	51.6	1304	54.2	967
	SANGLI	50.0	1059	53.3	706
	SATARA	45.2	2824	57.9	2074
	Total	52.8	1638	59.2	1206
Western Maharashtra Plain Zone (MH-5)	DHULE	46.7	702	63.9	367
	JALGAON	52.2	747	60.3	423
	NANDURBAR	56.0	794	63.3	497
	NASHIK	55.0	816	53.9	575
	PUNE	65.8	589	55.1	372
	SANGLI	62.8	478	61.8	285
	SATARA	59.2	711	59.9	459
	Total	55.9	704	59.5	431
Grand Total		62.8	1183	63.6	845

Agro-advisories based on seasonal and short-range forecasts

Among the various forecast products developed and disseminated by IMD, seasonal climate forecasts and five-day short-range forecasts are particularly important for agricultural planning. Seasonal forecasts support strategic decisions such as crop and variety selection, land allocation, and input planning. In contrast, short-range forecasts inform tactical decisions, including the timing of sowing, fertilizer application, intercultural operations, and harvesting. Accordingly, the core output is designed to deliver two tiers of advisories:

- Pre-season advisories: Developed by integrating seasonal climate forecasts with soil and water resource information, these advisories guide cropping choices, land allocation, and input planning.
- In-season advisories: Based on short-range forecasts, these provide timely, operational guidance for field activities such as sowing, nutrient management, irrigation, and harvesting.

Pre-season advisories are issued twice, in line with the two-stage process used by IMD for Long-Range Forecasts (LRFs) of the Southwest Monsoon. The first stage, released in mid-April, provides a national-level quantitative and probabilistic outlook. The second stage, issued in mid-May, presents an updated forecast with regional detail for four homogeneous regions and the Monsoon Core Zone. Rainfall thresholds derived from these forecasts underpin district- and block-level strategies for identifying suitable crops, cropping systems, and climate-resilient varieties. Detailed district-wise advisories are presented in Part II of this report, which provides location-specific information.

In-season advisories follow the framework adopted by IMD for agro-advisory services in collaboration with AMFUs, SAUs, and KVKs. Given the relatively high reliability and deterministic nature of short-range forecasts, these advisories can be readily interpreted to provide actionable weekly guidance. The iSAT system is designed to generate such advisories by incorporating rainfall received since monsoon onset, short-range weather forecasts, crop growth stages, and the type of field operations to be undertaken. This enables the delivery of precise, real-time advisories tailored to local conditions, as reflected in district-level plans. In addition to short-range forecasts, the system also incorporates intra-seasonal updates issued monthly (June–August), along with a specialized forecast for the latter half of the monsoon.

Robust Planning with Contingencies

Planning for the forthcoming season is guided by anticipated climatic conditions across different lead times. The long-range forecast issued by the Ministry of Earth Sciences, Government of India, for the 2026 Southwest Monsoon indicates a high probability of below-normal seasonal rainfall, projected at approximately 92% of the Long Period Average (LPA) of 87 cm (1971–2020).

Current projections also point to the potential development of El Niño conditions, possibly accompanied by a positive phase of the Indian Ocean Dipole (IOD) during the monsoon season. Historically, this combination has been associated with weaker monsoon performance and an increased risk of rainfall deficits. Forecasts from international agencies, including NASA, IRI, and ECMWF, broadly align with this outlook for the Asia region.

Given the strong likelihood of a below-normal monsoon in 2026, seasonal planning should prioritize strategies that reduce water demand, shorten crop duration, and minimize exposure to risk during critical growth stages. The following guiding principles are recommended:

- Prioritize resilience over yield maximization
- Shift from high-input, high-risk crops to low-input, drought-resilient systems
- Promote diversified and short-duration cropping systems over monocropping
- Most Reliable crops: Millets (bajra, jowar), Pulses (tur, gram, moong), Sesame

- Moderate Risk crops: Maize, Soybean, Cotton (only in better rainfall zones)
- High Risk crops: Sugarcane, Long-duration cotton, Water-intensive crops

Based on these principles, the following strategies are proposed, taking into account the potential of each agro-climatic zone and associated crop risks. Since rainfall patterns vary significantly across zones, they play a critical role in determining what can realistically withstand a poor monsoon year. A zone-wise crop risk interpretation is presented below, while more detailed, district-level contingency plans are provided separately.

Zone-wise Risk-Based Strategies

- Very high-risk zones (MH-5, MH-6 – scarcity and western plains):
 - ◊ Promote drought-tolerant crops (millets, pulses, oilseeds)
 - ◊ Avoid or reduce area under cotton, soybean, and sugarcane
 - ◊ Emphasize short-duration varieties and intercropping (e.g., millet + pulse)
 - ◊ Prefer dual purpose crops or varieties that provide both grain and quality fodder, to utilize water efficiently and meet fodder requirements
 - ◊ Promote moisture conservation practices including plastic mulching
 - ◊ Promote seed priming and transplanting for quick and uniform establishment of crop
- High-risk zones (MH-3, MH-7 – transitional regions):
 - ◊ Promote millets, pigeon pea, and short-duration maize
 - ◊ Adopt mixed cropping (e.g., cotton + tur)
 - ◊ Avoid long-duration crops without irrigation
 - ◊ Focus on diversification
 - ◊ Adopt dual purpose crops/varieties for improved water use efficiency and better resilience
 - ◊ Promote moisture conservation practices including plastic mulching
 - ◊ Promote seed priming and transplanting for quick and uniform establishment of crop
- Moderate-risk zones (MH-4, MH-8):
 - ◊ Soybean and cotton remain viable with caution
 - ◊ Prepare for protective irrigation
 - ◊ Maintain contingency options (crop switching)
 - ◊ Strengthen soil moisture conservation
- Low-risk zones (MH-9 – eastern Vidarbha):
 - ◊ Normal cropping largely viable
 - ◊ Maintain contingency plans for mid-season dry spells
- Very low-risk zones (MH-1, MH-2 – Konkan):
 - ◊ Rice and horticulture systems remain stable
 - ◊ Focus shifts from drought to drainage and flood management

Dynamic Management

The third and most critical pillar is adaptive in-season management. This is a highly dynamic process that requires continuous monitoring of monsoon progress and timely responses based on evolving conditions. Implementation will rely on weekly assessments using short-range weather forecasts to guide decision-making.

El Niño-associated below-normal rainfall years are typically marked by delayed monsoon onset and frequent dry spells. Accordingly, management must remain responsive to emerging risks, with timely and context-specific interventions to mitigate potential impacts.

The district-level advisories presented in Part II of this report provide location-specific guidance. In addition, the following cross-cutting principles and practices are recommended to strengthen resilience.

Capture and storage of excess rainfall

The main approach to prepare for the expected erratic behavior in rainfall during El Niño–linked dry seasons, it is essential to adopt an integrated approach that combines soil moisture conservation, water harvesting, and strategic cropping practices. The primary objective here is to capture and store every drop of rainfall before it is lost. A number of options are available to capture the rain water either to increase the in situ available moisture or ex situ storage into a water body for later use or minimize water loss especially through evaporation. While the options vary from one location to the other, the following steps will ensure efficient use of rain water.

A. Water storage structures: Much of the dryland areas are covered by watershed management programs and a number of water conservation structures like check dams, farm ponds, percolation tanks, and other rainwater harvesting were constructed to store runoff water. Repairing and strengthening these structures to reduce runoff, capture and store the excess water must be taken up in all the blocks.

B. In situ conservation of rain water: Enhancing amount of moisture stored in the soil is another intervention which can extend the moisture availability to the crop and reduce the moisture stress period. Some options that are proven for their effectiveness include the following.

- ◇ Early land preparation during summer period improves infiltration and kills pests
- ◇ Addition of soil amendments such as compost, manure improves organic matter content, increases infiltration and boosts water retention. Healthy, organic-rich soil stores more water and releases it slowly during dry spells
- ◇ Minimizing or avoiding tillage during the season prevents moisture loss since undisturbed surface soil serves as mulch
- ◇ Land shaping techniques will contribute to improve water capture and storage by slowing down water flow and increasing infiltration. Broad Bed and Furrow (BBF) system, raised beds with channels and ridge and furrow system improve moisture retention and proven useful in Marathwada & Vidarbha regions for dry spells
- ◇ Micro-catchments, small pits or basins to trap rain near plants are recommended for horticultural crops
- ◇ Contour bunding small earthen bunds along slope to slow runoff. This practice is also promoted under climate resilient agricultural program
- ◇ Promote micro-irrigation where possible (drip/sprinkler)

C. Mulching for Soil Moisture Conservation: Mulching is the practice of covering the soil surface to reduce direct evaporation, moderate soil temperature, and suppress weed growth. It is commonly done using materials such as crop residues, while plastic mulching has gained increasing popularity in recent years.

Mulching with plastic films

Plastic films made from recycled HDPE or LLDPE materials are commonly used for mulching. The films of 15–20-micron thickness are suitable for short-duration crops, while 25–30-micron films are commonly used for vegetables such as tomato, chilli, cucumber, and watermelon. For orchards and long-duration crops, 50–100-micron films are preferred. Black mulch is widely used for weed suppression, while silver-black mulch is useful in hot climates because it reflects sunlight and helps repel sucking pests such as aphids and thrips. The total cost of mulching, including material and installation, is generally around ₹8,000–₹15,000 per acre depending on thickness of the material and the type of crop. Mulch is most effective when combined with drip irrigation and properly prepared beds.

Plastic mulching has been shown to reduce irrigation water requirements by approximately 30–50% and suppress weed growth by 70–90%. These benefits not only improve water-use efficiency but also reduce labour costs associated with weeding. The practice is particularly effective for high-value crops such as vegetables, cotton, maize, chilli, turmeric, banana, and other horticultural crops.

Studies indicate that mulching can increase marketable yields by about 15–30%, with potentially greater benefits under below-normal rainfall conditions. Additional advantages include reduced soil erosion, prevention of soil crusting, and minimization of nutrient losses.

Given these benefits, mulching can be promoted as a practical moisture conservation strategy in drought-prone areas with limited irrigation, especially for high-value cropping systems.

Raised Beds with Plastic Mulching



Figure 3: Field treated with raised beds and plastic mulch

D. Micro irrigation: Micro-irrigation is a water-efficient irrigation method that delivers water directly to the plant root zone in small, precise quantities through systems such as drip and sprinkler irrigation. By minimizing conveyance and application losses, it significantly improves water-use efficiency compared to conventional flood irrigation.

This method can reduce water use by 30–60% while maintaining or even enhancing crop yields. It also enables better nutrient management through fertigation, reduces weed growth by limiting water application to targeted areas, and lowers energy and labour requirements.

Micro-irrigation is particularly suitable for high-value crops such as fruits, vegetables, cotton, sugarcane, and plantation crops, as well as for regions facing water scarcity. In drought-prone conditions and below-normal rainfall years, it serves as a critical strategy for conserving water, stabilizing yields, and improving farm resilience.

Since these are expensive to establish, many state and central governments including government of Maharashtra are supporting the adoption of these techniques by providing subsidies and other support.

E. Rain Gun for Protective Irrigation: During the season, many blocks may experience prolonged dry spells, delayed monsoon onset, or extended gaps between rainfall events, particularly during critical crop stages. Under such conditions, even a single protective irrigation can play a crucial role in reducing crop stress and preventing yield losses. In this context, the use of rain gun systems has proven to be highly effective. These systems are especially useful for mitigating water stress during sensitive growth stages such as germination, flowering, and grain filling. They are also well suited for high-value crops including sugarcane, maize, vegetables, fodder crops, banana, turmeric, and plantation crops. Compared to conventional flood irrigation, rain guns can reduce water use by more than 50% while ensuring more uniform water application and minimizing conveyance and deep percolation losses. They are particularly suitable in areas where water is available from farm ponds, borewells, tanks, check dams, or community irrigation structures. An additional advantage is their flexibility—they can be deployed without extensive land levelling or permanent pipeline installations. Depending on crop stage and soil moisture status, one or two lifesaving irrigations during dry spells exceeding three weeks can help sustain crops until the next rainfall event. Promoting the use of rain guns through community-based models can significantly enhance accessibility. These systems can be managed by custom hiring centres, Farmer Producer Organizations (FPOs), watershed committees, village organizations, Primary Agricultural Credit Societies (PACS), or youth-led rural enterprises under an “irrigation-as-a-service” approach.

Rain Gun for protective irrigation

Rain guns are high-pressure, large-volume sprinkler systems that simulate rainfall and are capable of irrigating relatively large areas within a short duration. A standard agricultural rain gun generally covers around 0.5 to 1 acre from a single position, with a wetting radius of 25 to 60 metres depending on nozzle size, operating pressure, and pump capacity. In practical field conditions, one rain gun can irrigate approximately 0.25 to 0.5 acres per hour, while a full acre may require around 2 to 3 hours of operation. Most rain guns discharge between 10,000 and 32,000 litres of water per hour, although larger models may discharge up to 100,000 litres per hour. They generally operate efficiently at 2.0 to 7.5 kg/cm² pressure and require at least a 5 HP motor, while larger units may require 7.5–10 HP pumps.



A standard rain gun system—including stand, riser, pipes, and fittings—typically costs between ₹15,000 and ₹25,000, which may be prohibitive for smallholders. Under a shared service model, one or two units can be maintained at the community level and deployed across farms based on need. Farmers can then pay for irrigation services on an hourly or per-acre basis.

Operational costs generally range from ₹150 to ₹400 per acre per irrigation, while service charges may vary between ₹300 and ₹800 per acre, depending on factors such as distance, water source, labour, and pumping costs. This approach reduces the financial burden on individual farmers, ensures timely access to protective irrigation, and creates livelihood opportunities for rural youth and agri-entrepreneurs in drought-prone and rainfed regions.

Optimizing planting time

Since production losses during most dry seasons are largely caused by crop establishment failure, identifying the optimal planting time and ensuring timely sowing are critical interventions. Timely planting promotes better germination, uniform establishment, and healthy growth, while also reducing exposure to weather-related risks, pests, and diseases.

Under dryland conditions, farmers often initiate sowing immediately after receiving a significant rainfall event. However, this can lead to poor crop establishment if subsequent rainfall does not occur and the soil profile has not accumulated sufficient moisture to support emerging seedlings. As a result, early sowing without adequate follow-up moisture can increase the risk of crop failure.

The ideal planting time depends on several factors, including the crop-specific sowing window, soil type, cumulative rainfall since the onset of the season, and short-term weather forecasts. The iSAT system developed under this project integrates these parameters to identify optimal planting windows, as illustrated in the decision framework (Figure 4).

When sowing is aligned with these optimal conditions, the probability of successful crop establishment is significantly enhanced. If suitable planting conditions do not occur within the defined window, the system recommends alternative crops and/or varieties, as outlined in the contingency plans.

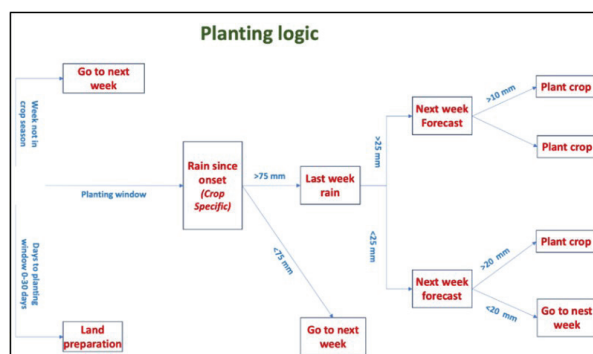


Figure 4: Planting logic used in iSAT to identify optimal planting time

Seed Priming: A Pre-Sowing Technique to Enhance Germination and Crop Performance

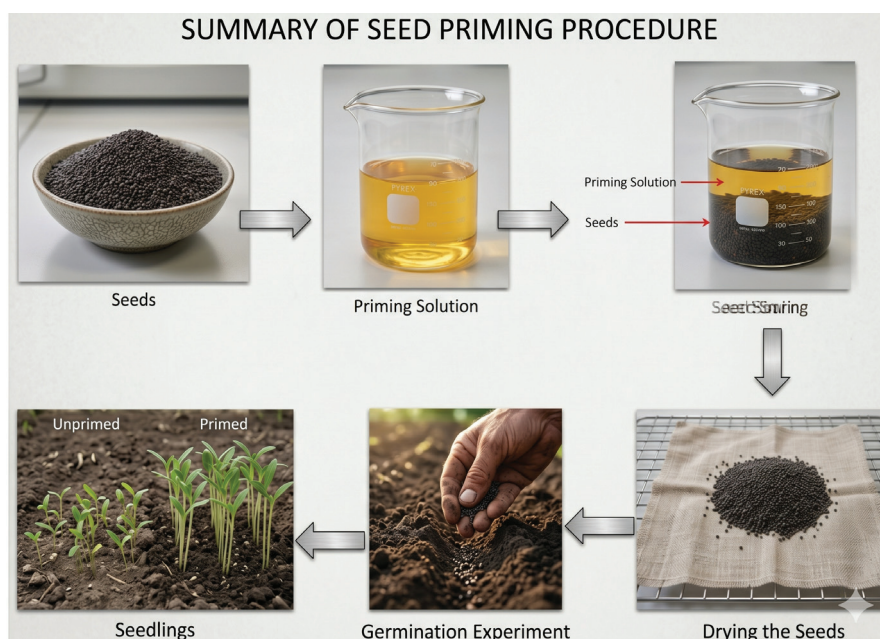


Figure 5: Procedure of seed priming to initiate germination

Seed priming is a pre-sowing treatment in which seeds are partially hydrated to initiate early physiological processes of germination without allowing the radicle (embryonic root) to emerge. This prepares the seeds to germinate faster once sown. After priming, seeds are dried back to their original moisture content, making them suitable for normal handling and storage. This technique has gained importance in modern agriculture for improving seed performance, especially under stress conditions through faster and more uniform germination, improved seedling growth and vigor, better tolerance to abiotic stresses such as drought, salinity, and temperature extremes and increased crop yield and productivity

The main objectives of seed priming are to enhance germination rate, uniform establishment of crop, improved seedling vigor and reduce time required for germination. Though there are several types of seed priming techniques, the simplest and most cost-effective one is hydropriming in which seeds are soaked in water for a specific duration and then dried. Soaking seeds in solutions containing plant growth regulators such as gibberellins, auxins, or cytokinin's and micronutrients are also common. Note that primed seeds will have reduced storage life. Hence, they should be planted soon after priming. The soaking time requires careful control and there are differences between the seeds in their response to priming treatments.

Transplanting under delayed onset conditions

Transplanting of dryland crops is an adaptive strategy used to improve crop establishment under erratic rainfall conditions. Instead of direct sowing in the field, seedlings are first raised in nurseries using limited and controlled water, and later transplanted into the main field once sufficient soil moisture is available.

This approach helps overcome the risks associated with delayed monsoon onset and early-season dry spells, which often lead to poor germination and uneven crop stands in dryland areas. By ensuring uniform plant population and better early growth, transplanting can enhance crop survival and yield stability.

Transplanting is particularly useful for crops such as millets, pulses, and certain oilseeds, as well as for crops like cotton and chilli in specific regions. It also allows efficient use of early rainfall events and provides flexibility in adjusting planting time based on actual field conditions.

However, transplanting requires additional labour, nursery management, and careful handling of seedlings to avoid transplant shock. When implemented properly, it serves as an effective climate-resilient practice for stabilizing production in drought-prone and rainfed systems.

Transplanting pigeonpea

Transplanting of pigeonpea is recommended as a contingency measure to ensure timely crop establishment. Seedlings should be raised in a nursery for 3–4 weeks using trays or seedbeds and transplanted in the main field upon receipt of sufficient rainfall. Transplanting helps overcome sowing delays, ensures uniform plant population, and improves crop survival under early-season moisture stress. Medium- to long-duration varieties are preferred, and transplanting should be done in well-prepared fields with appropriate spacing. This practice is particularly suitable for blocks prone to delayed onset and can be integrated with moisture conservation measures to improve yield stability under below-normal rainfall conditions.



Figure 6: Transplanting of pigeonpea.

Crop and livestock insurance

Though the forecast indicates that the forthcoming season is going to get below normal rainfall, it is difficult to forecast the severity of the same and potential financial and other losses farmers can incur. Crop and livestock insurance can protect the farmers against such losses from extreme events and in enhancing the resilience.

The Pradhan Mantri Fasal Bima Yojana (PMFBY) is one program that provides comprehensive coverage for yield losses due to non-preventable risks, including adverse weather conditions. Farmers may be encouraged to enrol in this scheme by paying subsidized premium. Crop insurance operates primarily on an “area approach,” where payouts are triggered based on average yield losses in a defined unit (such as a block or village), rather than individual farm losses. Yield estimation is done through crop cutting experiments (CCEs), which remain a key operational component. Increasingly, efforts are being made to integrate remote sensing, weather data, and digital tools to improve the accuracy and timeliness of loss assessment.

Beyond PMFBY, the Weather Based Crop Insurance Scheme (WBCIS) provides insurance linked to weather parameters such as rainfall, temperature, and humidity. This allows for faster claim settlement, as payouts are triggered by deviations from predefined weather thresholds rather than measured yield loss.

Despite its potential, crop insurance faces several challenges. Efforts should be made to improve the effectiveness of this program by enhancing awareness and transparency so that farmers clearly understand coverage, claim processes, and timelines, strengthening last-mile delivery through banks, extension systems, and Farmer Producer Organizations (FPOs), customizing products to local risks and ensuring timely and faster claim settlement. The crop insurance can complement early warning systems and climate advisories by providing a financial safety net and by enabling farmers to take calculated risks, adopt improved practices, and recover more quickly from climate shocks—making it a key pillar of climate-resilient agriculture.

Compared to crop insurance, livestock insurance is more operational and is supported under schemes such as the Department of Animal Husbandry and Dairying livestock insurance initiatives, state-level livestock insurance programs and insurance companies such as New India Assurance, United India Insurance and National Insurance Company Limited. Many schemes that provide premium subsidies for small and marginal farmers are also available.

Fodder banks

A major lesson from past droughts is meeting the fodder demands of livestock and fodder security should be treated as a core preparedness priority in the preparation for projected below normal seasonal conditions especially in Maharashtra which is considered as a fodder deficit state. The state experiences deficits of 31.3% in dry fodder, 59.4% in green fodder, and 32.3% in concentrates. Since crop residues contribute nearly 60% of total fodder resources, below-normal rainfall can reduce both grain yield and residue availability, directly affecting livestock feed supply. This risk is especially critical in rainfed and drought-prone regions where livestock acts as an income buffer during crop stress.

Fodder banks is one option that was found to be effective in mitigating the fodder problem. Fodder banks are community- or farm-level systems for the collection, storage, and timely distribution of fodder to livestock, especially during periods of scarcity such as droughts, delayed monsoons, or prolonged dry spells. They play a critical role in ensuring feed security, stabilizing livestock productivity, and reducing distress sale of animals during adverse seasons.

Fodder banks typically store crop residues (such as straw and stover), cultivated fodder, and conserved feed in the form of hay or silage. Surplus fodder produced during good rainfall years or peak production periods is collected and preserved for use during lean periods. Proper storage methods are essential to maintain fodder quality and minimize losses.

These systems can be managed by village institutions, self-help groups, Farmer Producer Organizations (FPOs), or cooperatives. In addition to improving resilience, fodder banks help in better utilization of local biomass, reduce dependence on external feed sources, and support sustainable livestock management.

A decentralized fodder bank system should therefore be established at village-cluster, tehsil/block, and district levels, with priority to high livestock-density and fodder-deficit areas. The fodder banks should not be limited to storing dry fodder; they should include enriched crop residues, chaffed sorghum stover, hay, silage, fodder bales, and feed blocks. The Maharashtra fodder plan specifically highlights fodder conservation technologies such as hay, bales, silage, and feed blocks to reduce storage and transport constraints and support fodder supply during calamities and lean periods.

Strengthening fodder security

Fodder banks alone cannot meet the fodder demands during the below normal seasons. The strategy should combine fodder production, conservation, processing, and distribution. In surplus or potential fodder-producing districts, fodder cultivation and residue collection should be promoted before the stress period. In deficit districts, fodder warehouses and transport linkages should be planned in advance. Priority interventions should include promoting dual purpose crops and varieties, chaffing of sorghum stover to reduce wastage, urea enrichment of poor-quality crop residues where appropriate, silage preparation from maize/sorghum/Bajra Napier/guinea grass, and baling or densification of dry fodder for easier transport and storage.

For long-term preparedness, the state should also expand fodder production beyond conventional cultivated land. The Maharashtra fodder plan recommends using field bunds, pond embankments, waterways, common lands, fallows, orchards, and pasturelands for fodder production. Horti-pasture and silvi-pasture systems, grassland rejuvenation, and fodder production in fruit orchards are particularly relevant because they increase fodder availability without competing strongly with food crops.

For planning fodder bank capacity, district livestock population should be converted into Adult Cattle Units (ACU), and dry matter demand estimated using standard livestock feeding norms. A simple planning formula can be used:

$$\text{Annual Fodder Requirement (tonnes)} = \text{Total ACU} \times 10 \times 365 / 1000$$

This indicative estimate should be compared with available crop residues, cultivated fodder, grazing resources, and conserved fodder stocks to identify district-level fodder gaps. Institutional responsibility should be anchored with the State Animal Husbandry Department, in coordination with the Agriculture Department, KVKs, FPOs, milk unions, local bodies, and private feed/fodder actors. The IGFR plan also emphasizes networking across ICAR institutions, state departments, milk federations, dairy owners, feed manufacturers, NGOs and private actors under a coordinated implementation mechanism.

Capacity Building and Extension Strengthening

Preparing for drought requires strengthening the capacity of both farmers and the institutions that support them, across technical and community dimensions. Technical expertise underpins effective Early Warning Systems, enabling informed decisions before a crisis unfolds. While climate information and advisory services are increasingly available, their value ultimately depends on the ability of frontline extension systems to interpret and translate them into clear, actionable guidance. In practice, the key gap is not the availability of advisories, but their timely conversion into field-level decisions—especially during the onset phase of the monsoon, when sowing choices are highly sensitive to rainfall variability.

Capacity-building efforts should be closely aligned with critical agricultural decision points. In the pre-monsoon period (May–June), targeted orientation programs can equip Agromet Field Units (AMFUs),

Krishi Vigyan Kendras (KVKs), and district- and block-level agriculture staff to interpret seasonal forecasts from IMD, assess recent rainfall trends, and refine sowing advisories accordingly. These efforts should be followed by short, in-season reviews (June–July) to recalibrate advisories based on actual rainfall progression, delayed onset scenarios, and emerging dry spells.

Equipping extension workers with digital tools for real-time agrometeorological advisories is another priority. Such tools enable a shift from generic warnings to context-specific recommendations. For instance, the iSAT platform, combined with an LLM-enabled chatbot trained on regional datasets from Maharashtra, can serve as an on-demand knowledge resource. It allows users to access historical climate data, interpret forecasts across different lead times, monitor evolving conditions, and generate localized advisories. With appropriate training and access support from the project team, such tools can significantly enhance advisory quality and responsiveness.

At the farmer level, the focus should be on strengthening practical decision-making under uncertainty. Training should cover response strategies for different drought scenarios, including delayed onset and early-, mid-, and late-season dry spells. Delivering this knowledge through KVKs and cluster-based platforms—such as those in POCRA areas—can improve adoption rates more effectively than stand-alone advisory messages.

Strengthening last-mile dissemination is equally critical. Although advisories from IMD and ICAR are available, their reach remains uneven, particularly in rainfed regions. Greater convergence with Farmer Producer Organizations (FPOs), village-level institutions, and input dealer networks can improve both coverage and timeliness. Mobile-based communication channels, including SMS and WhatsApp groups, should be systematically leveraged—especially during sowing and early crop establishment stages. Priority attention should be given to rainfed and drought-prone blocks, where dependence on timely advisories is highest.

Overall, the approach should emphasize a clear continuum from forecast to decision to advisory to field action. Distinct roles can be defined: AMFUs for forecast interpretation, KVKs for training and demonstrations, and line departments for dissemination and follow-up. This integrated framework helps ensure that advisories are grounded in real-time field conditions rather than issued as isolated messages.

Ultimately, preparedness for below-normal monsoon conditions in Maharashtra will depend not just on the availability of forecasts, but on how effectively climate information is translated into location-specific decisions and coordinated action across the agricultural system.

Institutional Setup

A strengthened pre-season institutional coordination mechanism is essential to manage below-normal monsoon risks, with clearly defined roles across agrometeorology, extension systems, and local administration. Agromet Field Units (AMFUs) should anchor climate analysis and early warning generation, while Krishi Vigyan Kendras (KVKs) and district agriculture departments operationalize block-level contingency planning and farmer advisories. State agricultural universities should support crop-specific decision frameworks and validation. It is recommended to establish a block-level convergence platform prior to the monsoon season to align climate information, crop planning, and field-level interventions, supported by digital advisory systems for timely translation of forecasts into actionable decisions.

Monitoring Dashboard:

Coordination with IMD for regular updates on forecasts, Track weekly the rainfall deviation (%), reservoir storage, crop condition tanker trips and MGNREGA person-days

Early Warning & Trigger Framework

Indicator	Threshold	Action
Rainfall deviation	>10% deficit	Alert
Activate contingency	Dry spell	>15 days
Reservoir storage	<50%	Water rationing
Crop advisories	Soil moisture	Very high deficit

Implementation Timeline

Phase	Timeline	Key Activities
Preparedness	Apr–Jun	Water works, seed distribution
Early Warning	Jun–Jul	Monitoring, advisories
Response	Aug–Oct	Tankers, relief, cattle camps
Recovery	Nov–Mar	Recharge, rabi support

Monitoring Framework (Key Indicators)

- Rainfall deviation (%)
- Reservoir levels (%)
- Tanker supply (villages covered)
- Crop condition index
- Institutional Preparedness: Form district drought task forces integrating departments of Agriculture, Water Resources, Rural Development
- Activate real-time monitoring dashboards
- Strengthen early warning dissemination
- Community-Level Preparedness
- Awareness campaigns on Water conservation, Crop advisories, Promote community water management committees, Capacity building for Panchayats

Communication Strategy

In Maharashtra, climate advisories are disseminated through multiple government channels, including IMD–ICAR Agromet Advisory Services (GKMS), mKisan SMS services, Krishi Vigyan Kendras (KVKs), and the State Agriculture Department. In addition, initiatives such as PoCRA (Project on Climate Resilient Agriculture) provide a strong field-level platform for climate-resilient interventions in drought-prone regions. However, the reach and effective utilization of advisories at the last-mile farmer level remain a key challenge, particularly in remote and rainfed areas.

To enhance preparedness under below-normal monsoon conditions, it is recommended to strengthen convergence across these platforms and ensure block-level localization of advisories aligned with crop stages and seasonal scenarios. A multi-channel communication approach should be adopted, integrating digital dissemination (SMS, mobile applications, WhatsApp groups, and social media platforms such as YouTube) with traditional and local communication channels, including village-level meetings, local television and radio, and farmer networks. Leveraging POCRA clusters, extension workers, and community-based institutions can significantly improve last-mile delivery and awareness. Establishing structured feedback mechanisms and promoting awareness on the use of seasonal forecasts will further enhance the timeliness, relevance, and adoption of climate-informed decisions.

District agricultural preparedness plan with contingencies for Kharif 2026

Available forecasts indicate that the kharif 2026 is expected to receive below normal rainfall. The reliability of this forecast is expected to be very high due to the strong signal from other influencing factors such as El Nino Southern Oscillation phenomenon and Indian Ocean Dipole condition. The project on “AI-powered Context-Specific Agromet Advisory Services for Climate-Resilient Agriculture at Scale” under Mission Monsoon program has developed the following pre-season advisories for the districts/blocks in the state of Maharashtra. Click on the link next to the district of your interest to access the district specific report.

Agro-climatic zone	District	Access to report
Central Maharashtra Plateau Zone (MH-7)	AURANGABAD	District agricultural preparedness for AURANGABAD
	BEED	District agricultural preparedness for BEED
	HINGOLI	District agricultural preparedness for HINGOLI
	JALNA	District agricultural preparedness for JALNA
	LATUR	District agricultural preparedness for LATUR
	NANDED	District agricultural preparedness for NANDED
	OSMANABAD	District agricultural preparedness for OSMANABAD
Central Vidarbha Zone (MH-8)	PARBHANI	District agricultural preparedness for PARBHANI
	AKOLA	District agricultural preparedness for AKOLA
	AMRAVATI	District agricultural preparedness for AMRAVATI
	BULDHANA	District agricultural preparedness for BULDHANA
	NAGPUR	District agricultural preparedness for NAGPUR
	WARDHA	District agricultural preparedness for WARDHA
	WASHIM	District agricultural preparedness for WASHIM
Eastern Vidarbha Zone (MH-9)	YAVATMAL	District agricultural preparedness for YAVATMAL
	BHANDARA	District agricultural preparedness for BHANDARA
	CHANDRAPUR	District agricultural preparedness for CHANDRAPUR
	GADCHIROLI	District agricultural preparedness for GADCHIROLI
	GONDIA	District agricultural preparedness for GONDIA
NAGPUR	District agricultural preparedness for NAGPUR	

Continued...

Agro-climatic zone	District	Access to report
North Konkan Coastal Zone (MH-2)	MUMBAI	
	PALHGAR	District agricultural preparedness for PALHGAR
	RAIGAD	District agricultural preparedness for RAIGAD
	THANE	District agricultural preparedness for THANE
Scarcity Zone (MH-6)	AHMEDNAGAR	District agricultural preparedness for AHMEDNAGAR
	NASHIK	District agricultural preparedness for NASHIK
	PUNE	District agricultural preparedness for PUNE
	SANGLI	District agricultural preparedness for SANGLI
	SATARA	District agricultural preparedness for SATARA
	SOLAPUR	District agricultural preparedness for SOLAPUR
South Konkan Coastal Zone (MH-1)	RATNAGIRI	District agricultural preparedness for RATNAGIRI
	SINDHUDURG	District agricultural preparedness for SINDHUDURG
Western Ghat Zone (MH-3)	AHMEDNAGAR	District agricultural preparedness for AHMEDNAGAR
	DHULE	District agricultural preparedness for DHULE
	KOLHAPUR	District agricultural preparedness for KOLHAPUR
	NANDURBAR	District agricultural preparedness for NANDURBAR
	NASHIK	District agricultural preparedness for NASHIK
	PUNE	District agricultural preparedness for PUNE
	SANGLI	District agricultural preparedness for SANGLI
	SATARA	District agricultural preparedness for SATARA
Western Maharashtra Plain Zone (MH-5)	DHULE	District agricultural preparedness for DHULE
	JALGAON	District agricultural preparedness for JALGAON
	NANDURBAR	District agricultural preparedness for NANDURBAR
	NASHIK	District agricultural preparedness for NASHIK
	PUNE	District agricultural preparedness for PUNE
	SANGLI	District agricultural preparedness for SANGLI
	SATARA	District agricultural preparedness for SATARA
Sub-Montane Zone (MH-4)	KOLHAPUR	District agricultural preparedness for KOLHAPUR



About



The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a pioneering International Organization committed to developing and improving dryland farming and agri-food systems to address the challenges of hunger, malnutrition, poverty, and environmental degradation affecting the 2.1 billion people residing in the drylands of Asia, Sub-Saharan Africa, and beyond.

ICRISAT was established under a Memorandum of Agreement between the Government of India and the CGIAR on the 28 March 1972. In accordance with the Headquarters Agreement, the Government of India has extended the status of a specified "International Organisation" to ICRISAT under section 3 of the United Nations (Privileges and Immunities) Act, 1947 of the Republic of India through Extraordinary Gazette Notification No. UI/222(66)/71, dated 28 October 1972, issued by the Ministry of External Affairs, Government of India.

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