



International Water
Management Institute



2nd Meeting of the Global Initiative on Resilience to Natural Hazards through AI Solutions

AI for Transforming Drought Preparedness and Decision-Making in India

Dr. Giriraj Amarnath

With inputs from Sanya Kapoor, Dhyey Bhatpuria

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Innovative water solutions for sustainable development

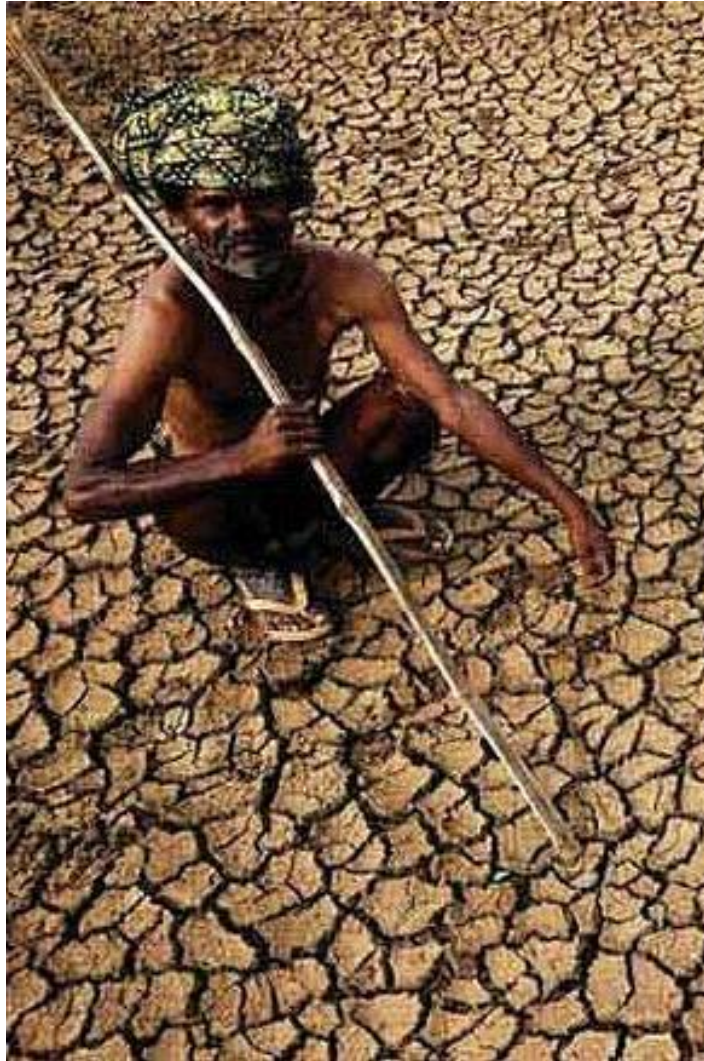
Food · Climate · Growth



The Challenge: Rising Drought Risks in India

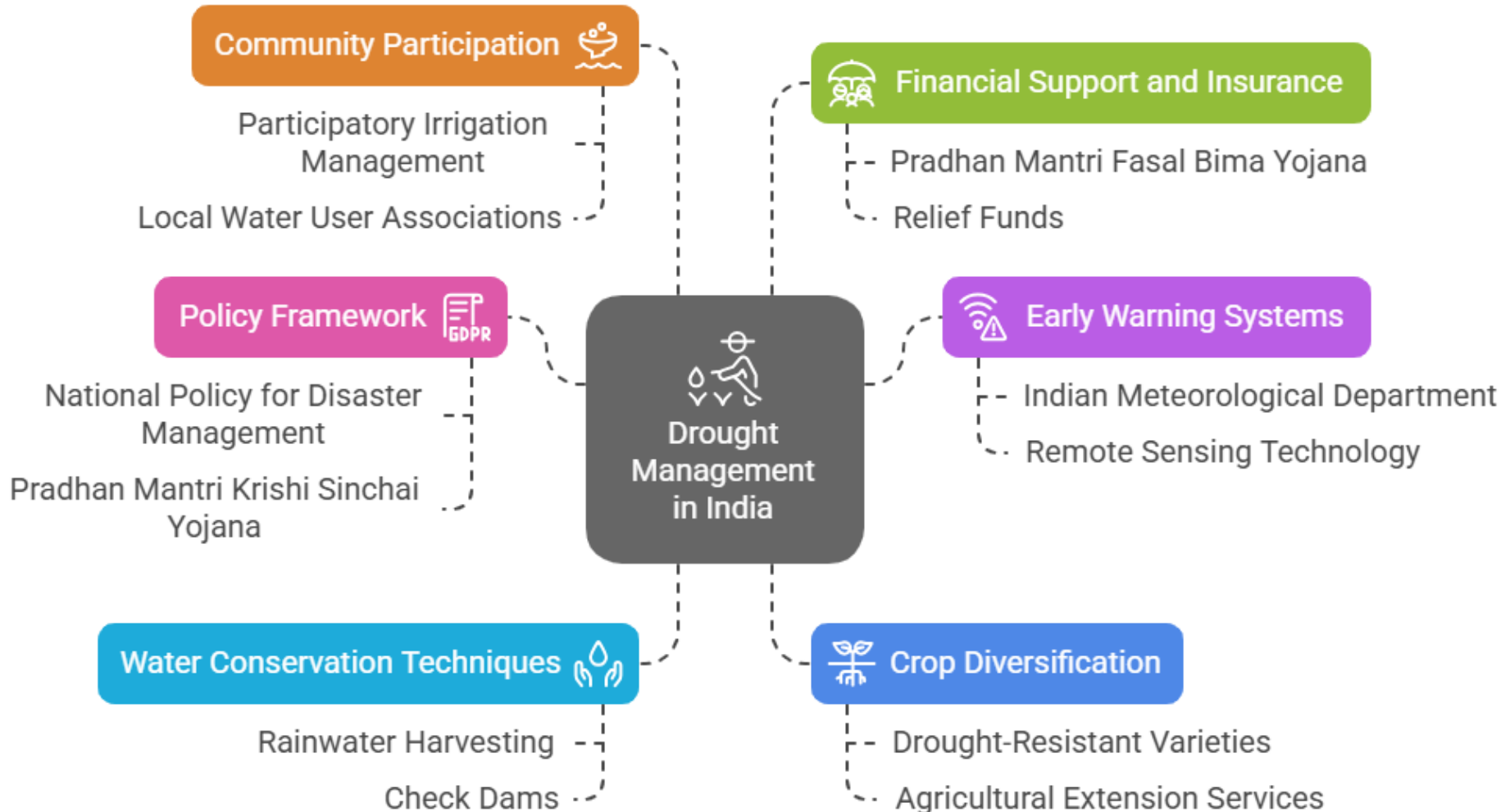
- Increasing frequency and severity of droughts
- Delayed, reactive responses lead to livelihood and crop losses
- Fragmented data systems and limited early warning capabilities

Historical drought events in India

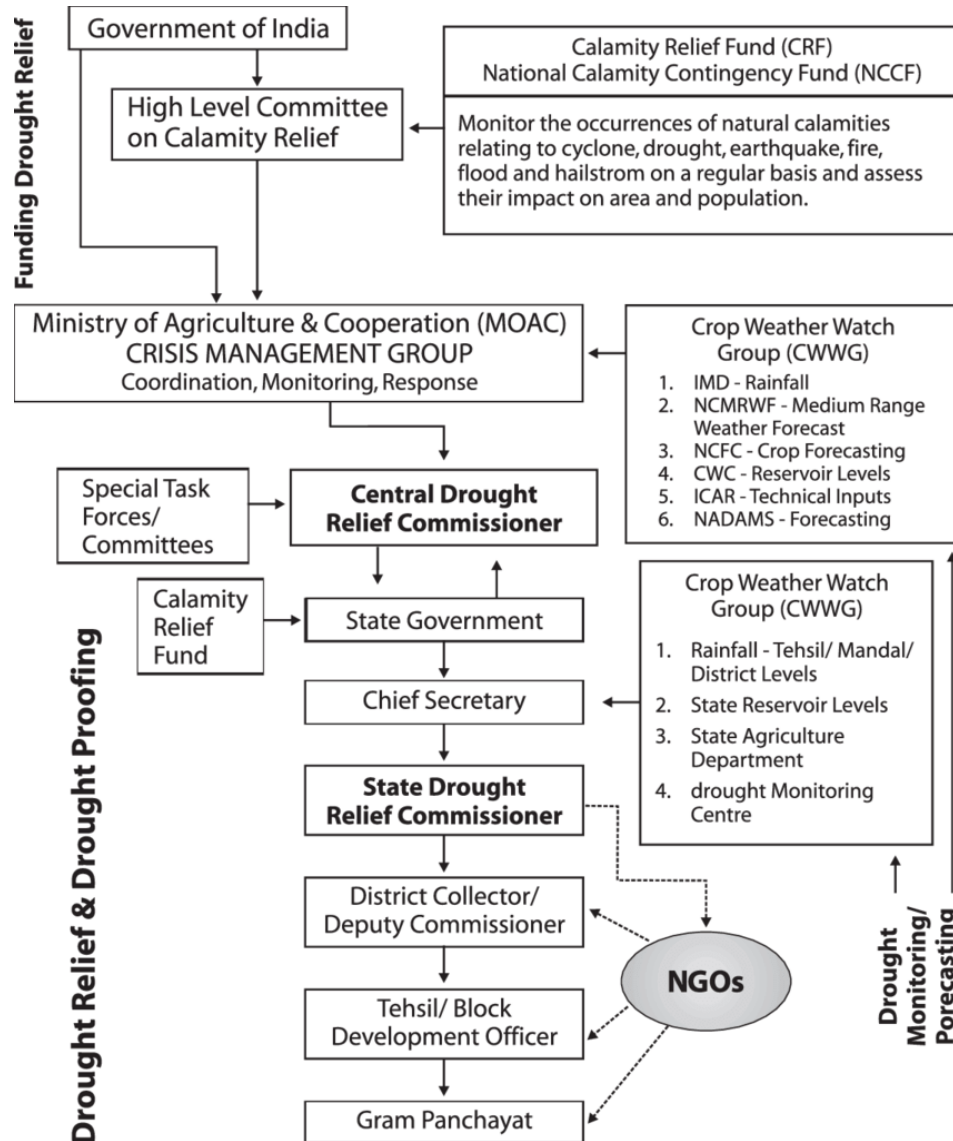


- 1876–1878** • Great Famine, affected southern and northeastern India causing death millions
- 1899–1900** • Drought devastated western India widespread crop failures
- 1918** • A drought affects nearly two-third of the country impacting agricultural
- 1965–1967** • Mid-1960s affecting large parts of the country food insecurity
- 1972** • A severe drought affects parts of Maharashtra and other states triggering a food crisis
- 1987** • One of India's worst droughts during 20th century, around 60% of the country impacted
- 2002** • A drought affects about a third of all districts, particularly in states of Rajasthan, Gujarat and Andhra Pradesh
- 2015** • Drought impacted nearly 17% of population, associated with weak monsoon rains

Drought Management in India



Institutional Framework for Drought Management



- **Top-down structure:** Involves central to local levels, from the Government of India to Gram Panchayat.
- **State-level implementation:** Led by State Drought Relief Commissioner, working through district and local officials.
- **Multi-agency coordination:** Crop Weather Watch Groups bring together IMD, ICAR, CWC, and others for forecasting and technical input.
- **Diverse data sources:** Inputs include rainfall, reservoir levels, crop forecasts, and technical assessments.
- **Information asymmetry:** Different users (national, state, district, local) require tailored data and responses
- **Need for improved coordination:** Cross-sector and inter-agency cooperation is essential for timely drought action.

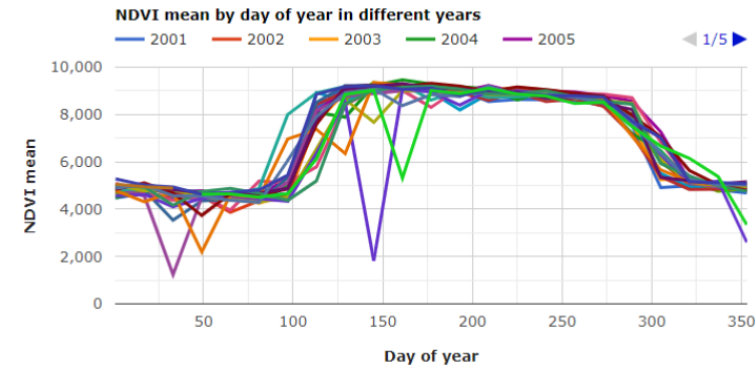
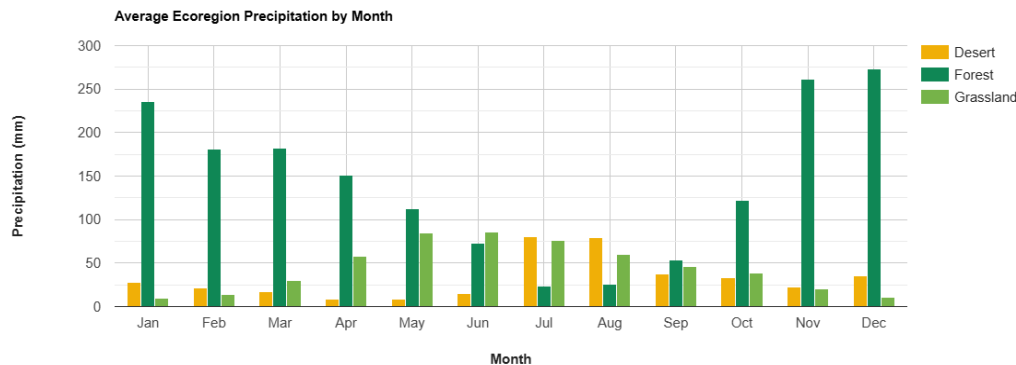
Introduction

Our main objective of this presentation is to create a LLM focusing on Drought Mitigation. An example of a query sent to such a chatbot with it's response can be seen below.

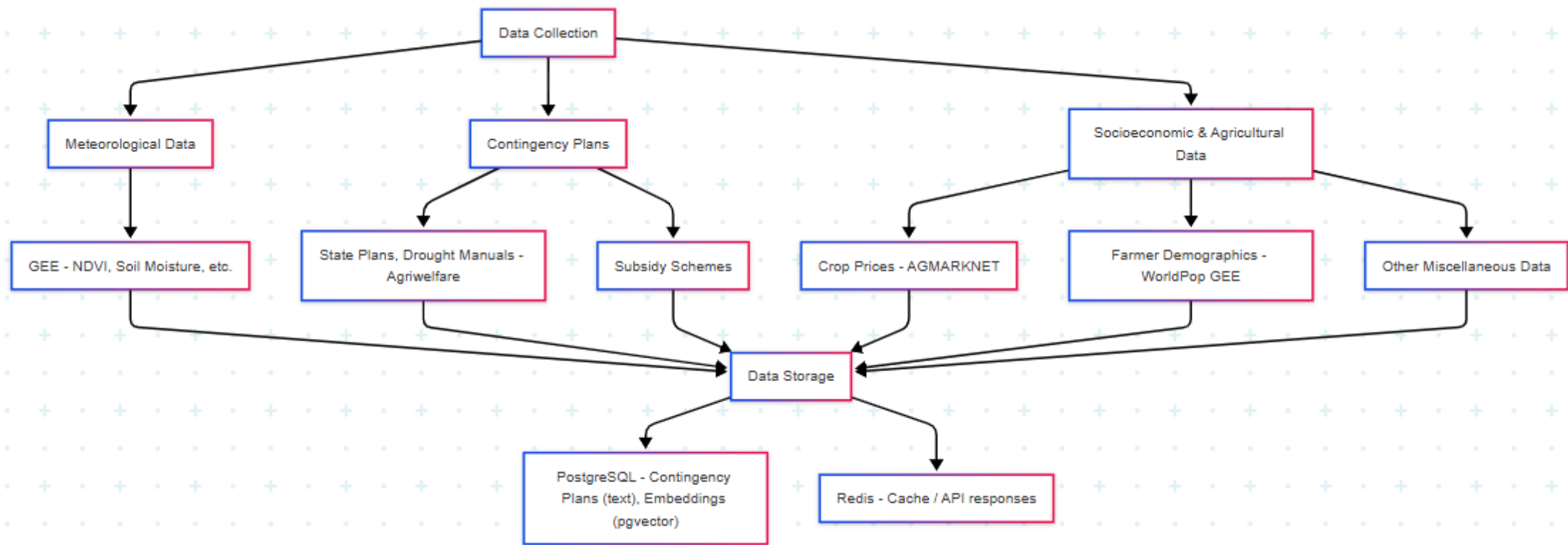
Query : What is the drought level in Punjab and what are it's impacts?

An expected response on this query would detail:

- Weather forecast in Punjab & adjoining states (cloud cover etc.)
- Expected drought possibilities
- Analyse the agriculture contingency plan & meteorological data to provide insights (eg. NDVI, soil moisture)
- Possible measures related to drought & agriculture from drought contingency plan
- Show interactive graphs along with text explaining possible impact in economy, people affected, rainfall levels etc.

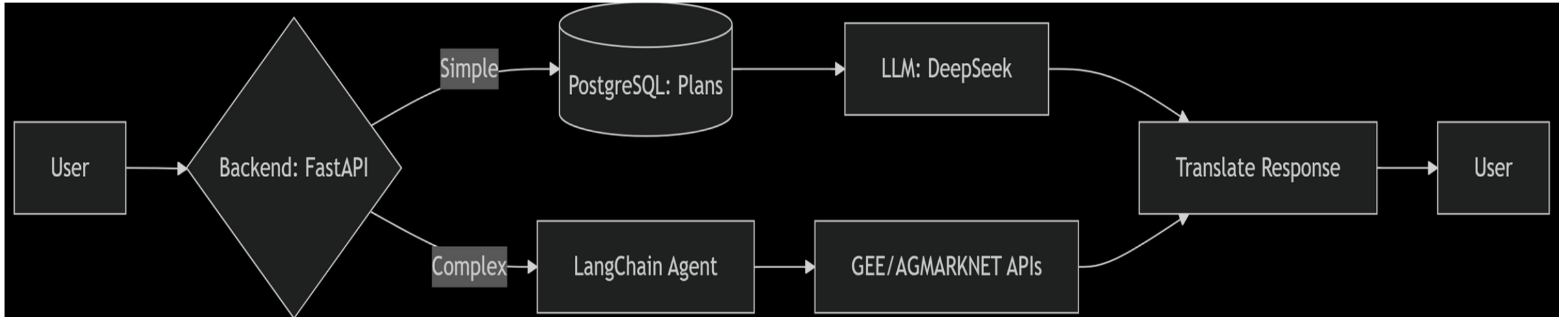


Data Flow for AI enabled Drought Management Innovation



- Data used for RAG like contingency plans are stored in PostgreSQL meanwhile Redis caches commonly accessed data like rainfall for a certain week.

Workflow for Drought Mitigation ChatBot



How the pipeline works:

- The user's query is first translated to English using AI4Bharat models.
- A DeepSeek V3 AI model determines if the query is simple or complex, using FastAPI (Python).
- The system fetches data from external sources like GEE, IMD, and other third-party datasets.
- PostgreSQL + pgvector (RAG) is used for storing backup data and enabling fast retrieval.

Model Training

Training	Done To	Example
Instruction Tuning	Deepseek	Fine-tuning DeepSeek to follow structured commands related to Drought & build a knowledge base (e.g. "Analyze NDVI → Generate drought risk score").
Fine Tuning	AI4Bharat	Adapting Indic NLP models to agricultural jargon (e.g., "drought-tolerant" → "सुखा-सहिष्णु") to improve translation accuracy.
RAG	Deepseek	RAG allows us to improve the factual accuracy of our model by retrieving information from an external knowledge source (database or documents).

What data do we need?

Achieving our objective requires access to meteorological information, contingency planning resources, a robust analytical knowledge base, and relevant socioeconomic and agricultural datasets.

Meteorological Data:

DATA	SOURCE	USE	EXAMPLE
Rainfall Anomaly	CHIRPS (GEE)	Rainfall Trends (Drought trigger)	Rainfall in Odisha is 30% below average (May 2024). Drought risk: HIGH.
NDVI	MODIS (GEE)	Crop stress levels (low NDVI = poor growth)	NDVI in Punjab shows 20% crop stress in wheat fields.
Reservoir Levels	WRIS India	Water storage status for irrigation	Bhakra Dam is at 40% capacity (critical for Punjab).
Groundwater	GRACE (GEE)	Long-term groundwater depletion trends	Groundwater in Haryana dropped 2m YoY.
Soil Moisture	SMAP (GEE)	Crucial for plant growth	
Weather Forecasts	IMD	Weekly rainfall etc.	

Other than these factors like EVI, LST etc. from Google Earth Engine can be included.

Contingency Plans:

DATA	SOURCE	USE	EXAMPLE
Crop Advisories	agriwelfare.gov.in	Govt-recommended drought actions	For low rainfall in Odisha, switch to millets.
Drought Manual	nidm.gov.in/pdf/manuals/drought_manual.pdf	Drought detection and actions related to it	
Drought Mitigation Plans	sdma.cg.gov.in/CMP2017.pdf	Ways to detect and mitigate drought	Delay of south-west monsoon can lead to drought in Kharif season.

Additional such plans can be incorporated to help the model analyse meteorological data for drought indicators.

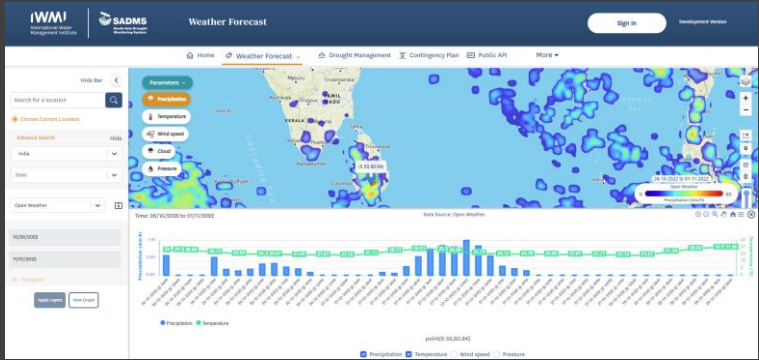
Socioeconomic & Agricultural data:

DATA	SOURCE	USE
District census data	Census 2011, NOSS	Agriculture related statistics
Schemes	PMKSY, MGNREGA etc.	Irrigation, Drought relief works
Farmer income & yield	https://desagri.gov.in/dashboard/	Crop yield, loss metrics, land use

Comparison of LLMs

Model	DeepSeek-V2	Mistral / Mixtral	LLaMA 2 / 3	Gemma (Google)	GPT-4 / 3.5	Claude / Command-R+	Falcon LLM
Open Source	Yes	Yes	Yes	Yes	No	No	Yes
Context Window	32k-148k	32k (Mixtral)	4k–64k (3)	8k	128k (GPT-4-Turbo)	200k (Claude 3)	2k–4k (Falcon 40B++)
Accuracy (Reasoning)	High	Good	High (v3)	Moderate	Excellent	Excellent	Moderate
Indian Language Support	Basic (via English)	Poor	Moderate	Weak	Strong (via APIs)	Moderate	Basic (via English)
RAG Integration	Easy	Easy	Easy	Easy	via API	via API	Moderate
Multimodal	Text only	Text only	Text only	Text only	GPT-4-Vision	Claude 3 Vision	Text only
Deployment Ease (Cloud)	Moderate (HuggingFace, GCP)	Easy (vLLM, LM Studio)	Moderate (LLM Foundry)	Easy (Vertex AI)	Only via OpenAI API	Only via Anthropic API	Moderate (HuggingFace, AWS)
Cost (Inference)	Free/Self-hosted	Free/Self-hosted	Free/Self-hosted	Free (limited)	Paid API (\$\$)	Paid API (\$\$)	Free/Self-hosted
On-Prem/Offline Ready?	Yes	Yes	Yes	Yes	No	No	Yes
Model Size Options	7B, 67B	7B (Mistral), 12.9B (Mixtral)	7B, 13B, 70B	2B, 7B	API only	API only	1.3B, 7.5B, 40B

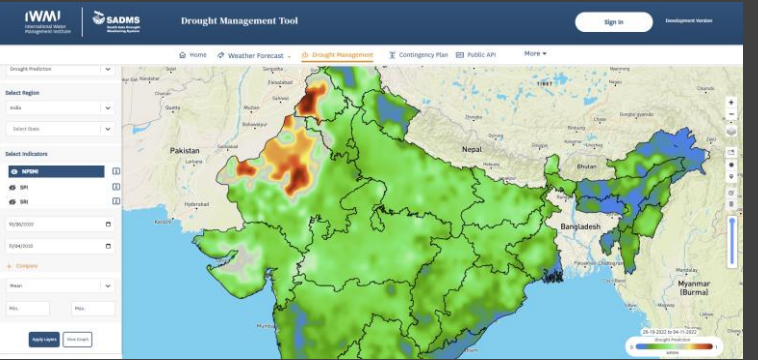
Weather and Climate Monitor



Products: (Sub)seasonal, short-term forecast
Source: IMD, IRI, ECMWF, NOAA

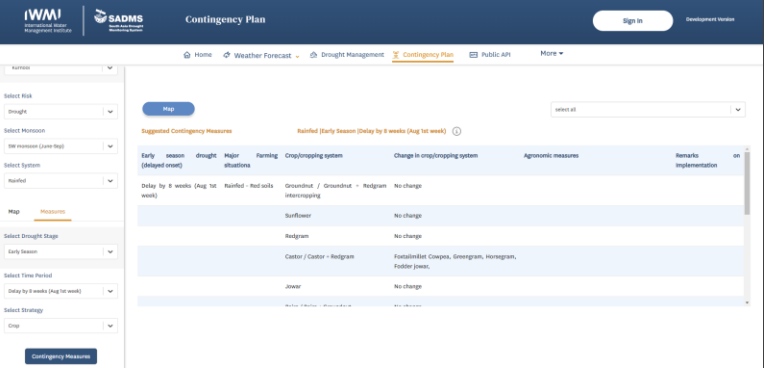


Drought Prediction



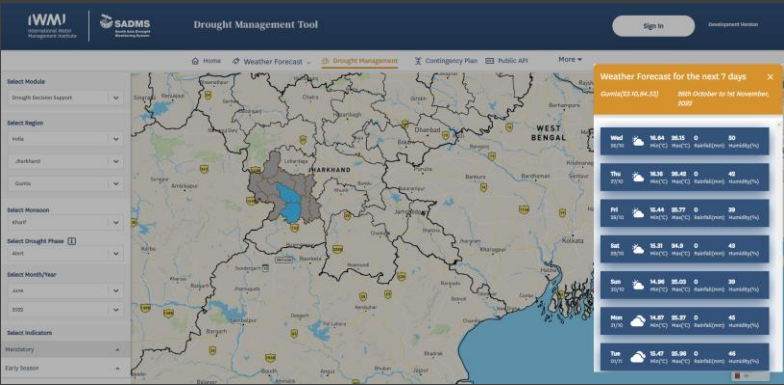
Products: Drought prediction using VIC model
Source: NOAA GEFS, GPM, ERA-5, IMD

Dynamic Drought contingency plan



Products: Drought phase wise indices to activate contingency plans
Source: NASA MODIS, GPM, SMAP

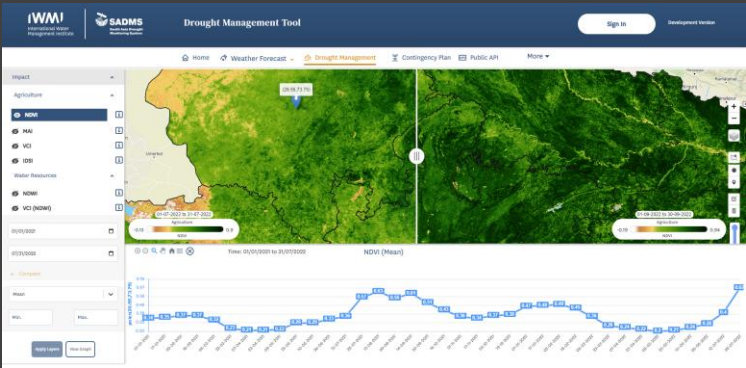
Drought Decision Support tool



Products: Drought alert and active phase
Source: NASA MODIS, GPM, SMAP



Drought Monitor



Products: Drought indices mandatory and impact indicators e.g. SPI, VCI, VHI, IDIS
Source: NASA MODIS, GPM, SMAP

Agriculture Contingency Plan

Select Risk

Drought

Select Monsoon

SW monsoon (June-September)

Select System

Rainfed

Map

Measures

Select Drought Stage

Early Season

Select Time Period

Delay by 8 weeks (September 1st week)

Select Strategy

Crop

Contingency Measures

Map

select all

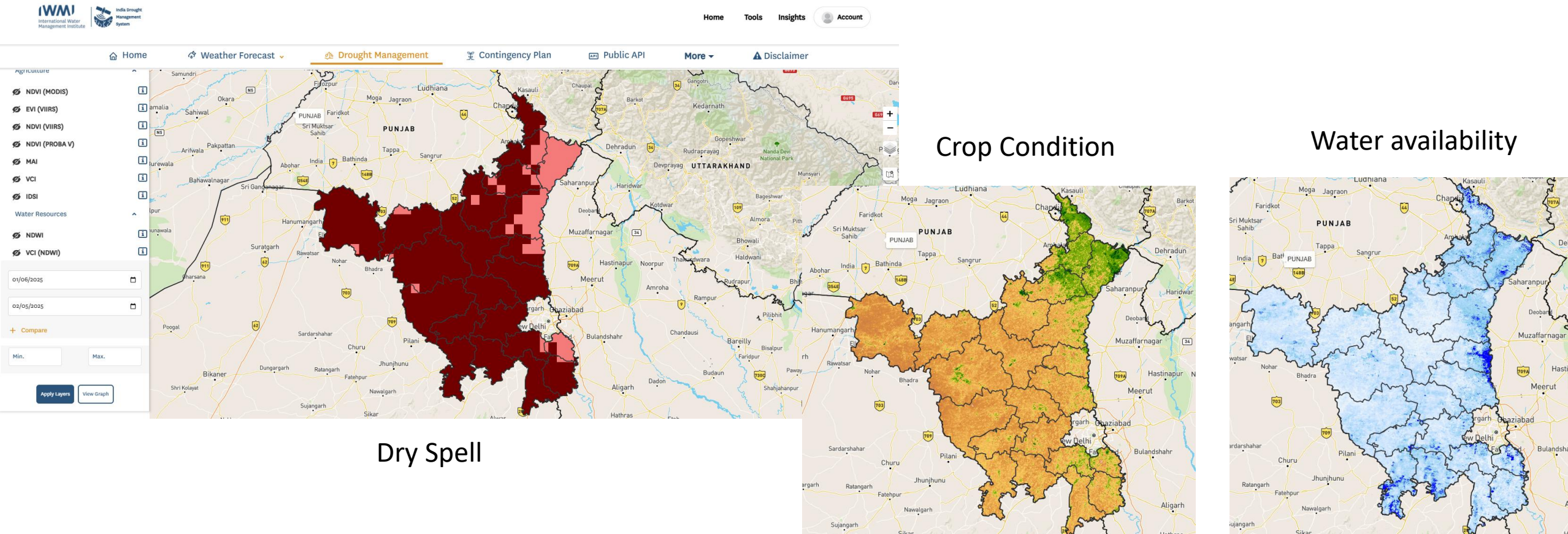
Suggested Contingency Measures

Rainfed | Early Season | Delay by 8 weeks (September 1st week)

Early season drought (delayed onset)	Major Farming situation	Normal Crop/cropping system	Change in crop/ cropping system	Agronomic measures	Remarks Implementation	on
Delay by 8 weeks (September 1st week)	Light textured sandy soils susceptible to wind erosion	Pearl millet	Fallow	Conserve soil moisture for rabi sowing.		
		Pearl millet + Greengram / Mothbean (Intercropping 84/63)	Fallow	-do-		
		Clusterbean Cowpea Castor Sesame	Fallow	-do-		

Plan shared by Ministry of Agriculture, GOI
Data source: SADMS/IWMI

Q: What are the Drought Conditions in Haryana in April?



Chatbot Results (Sample)

AGRICULTURAL OFFICER

Drought Situation in April:

Haryana experienced a rainfall deficit in April, receiving only 6.6mm of rainfall, which is 31% below the average of 9.5mm. Furthermore, low NDVI values (0.2-0.4) suggest reduced vegetation health. This situation indicates the onset of possible agricultural drought conditions, particularly as April falls within the pre-monsoon season, making crops heavily reliant on irrigation.

Recommendations:

Given the present conditions, here are some important considerations:

1. **Promote Water Conservation Techniques:** Advocate for and implement water-saving irrigation methods like drip irrigation and sprinkler systems. Educate farmers on efficient water use practices, aligning with the principles of "More Crop Per Drop."
2. **Crop Diversification Strategies:** Encourage farmers to adopt less water-intensive crops wherever feasible. Provide information on alternative crops that can withstand drier conditions and offer market support for these crops.
3. **Timely Crop Advisories:** Issue detailed crop advisories through various channels, like SMS, radio, and agricultural extension services. These advisories should include information on irrigation scheduling based on evapotranspiration rates, nutrient management strategies, and pest and disease control measures that are crucial under water stress.
4. **Input Support and Subsidies:** Ensure the availability of quality seeds, fertilizers, and pesticides at subsidized rates. Special attention should be given to providing drought-resistant varieties of seeds for crops that are commonly grown in the region.
5. **Promote Research and Development:** Prioritize need-based research to develop crop varieties that can tolerate drought conditions and require less water. Ensure that research data reaches farmers in a timely manner. Also, explore rescue arrangements such as 2-4-D/GA (20 ppm) based on research data.

By taking proactive measures and offering targeted support, we can mitigate the adverse effects of drought on agriculture in Haryana.

General Public

Here's a breakdown of what the situation looked like in April:

- **Low Rainfall:** Haryana experienced significantly less rainfall than usual in April. Only 6.6mm of rain fell, which is about 31% lower than the average of 9.5mm for the month.
- **Low Vegetation Health:** NDVI values were recorded as 0.2-0.4. NDVI or Normalized Difference Vegetation Index is an index which indicates the health of the vegetation. The value usually varies from -1 to +1. Higher values indicate dense and green vegetation and vice versa.

What does this mean for you?

- **Water Availability:** Low rainfall during April can affect the water availability for irrigation, drinking, and other daily needs in the coming months, especially if the monsoon season is delayed or yields less rainfall than expected.
- **Food Prices:** If the drought conditions continue, it could impact crop yields, leading to potential increases in the prices of vegetables, grains, and other food items in the market.

Chatbot Results (Sample)

Farmers

Namaste Kisan Bhail

April has been a bit dry in Haryana this year. We received only 6.6mm of rainfall, which is about 31% less than the usual 9.5mm we expect in April. This is a pre-monsoon season, so the low rainfall itself isn't a major cause for alarm just yet, but it's something to keep an eye on.

Also, the NDVI (a measure of how green and healthy plants are) is around 0.2-0.4. This indicates that our crops and vegetation might be a little stressed due to the lack of moisture.

What does this mean for you?

- **Be mindful of irrigation:** If you have irrigation facilities, use them judiciously to make sure your crops don't suffer from water stress. Focus on critical growth stages.
- **Water Conservation:** Now is the time to adopt water conservation techniques like mulching, drip irrigation if possible, and avoiding over-watering.
- **Monitor your crops closely:** Watch your crops carefully for any signs of wilting, yellowing, or stunted growth. If you see any of these symptoms, consult with your local agriculture officer for advice.
- **Consider drought-resistant crops for the next season:** When planning for the next season, think about planting crops that are more tolerant of dry conditions. Pearl millet is a good option for Haryana.

Keep an eye on weather forecasts and advisories from the agriculture department. Stay informed, and let's work together to manage this situation!

Scaling Drought Intelligence Together





International Water
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Thank you

a.giriraj@cgiar.org

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