Effective farmer-centred weather forecast information services

A deep-dive into design testing for AI-driven monsoon onset forecast messages in India

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Topics to cover

- **Background**: *farmer-facing weather information services*
- **Weather forecast use-case**: *monsoon-onset forecasts in India*
- **Deep-dive**: *design testing for monsoon-onset forecast messages*
- **Way forward**

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Background: farmer-facing weather information services

Challenge: Smallholders face high weather-related production risks

Climate change amplifies this variability; swings in rainfall and temperature driving floods, droughts, and heatwaves.

Solution: Accurate, timely forecasts help farmers decide when to plant, irrigate, fertilize, and harvest - boosting productivity and resilience.

Multiple RCTs shows farmers act on forecasts, improving yields, income, and climate resilience across contexts. (Rudder and Viviano, 2024, Fosu et al. 2018, Yegbemey et al. 2023, Camacho and Conover 2019, Jagnani and Pande, 2024)

Digital dissemination is highly cost-effective - PxD's digital service generates $13–21 in farmer profits per $1 invested. (Cole et al, 2025)

Current state: Farmers still lack access to relevant, timely, localised, accessible, comprehensible and actionable forecasts

PxD's role: Connecting farmers to cutting-edge innovations at scale

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Dissemination of AI-powered Weather Forecasts to ~39 million farmers in India

Generate relevant scientific information

Which are the right forecasts?
What are the right lead times?
How good are the forecasts?
Should we send forecasts, or forecast + dry spells?

forecasts

Human-centred Weather Forecasts Initiative (HCF) includes researchers from UChicago and UBerkeley

Translate into actionable messages

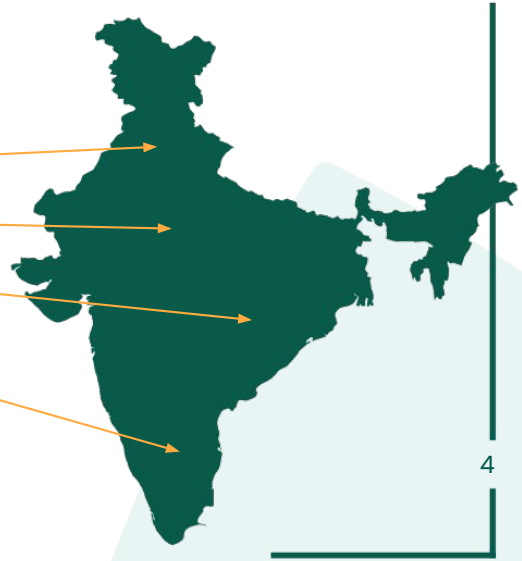
Transfer & disseminate

Do farmers comprehend? Are forecasts actionable?
What's the right message length?
How frequently should we send the messages?
What's the right channel for communication?
Do farmers prefer forecasts or forecast + advice?

Ministry of Agriculture and Farmer Welfare (MoAFW), India)
Department of Agriculture and Farmers' Empowerment (DAFE), Odisha (India)
Development Innovation Lab - India (DIL-India)

Use the information for relevant agricultural decisions

Improved resilience & farm outcomes



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Case: Monsoon-onset forecasts in India

Why monsoon-onset forecasts?

Monsoon season is the period of heavy rainfall in the Indian subcontinent (Jun-Sept)

- Associated with the main agriculture production season in the region (Kharif)

Arrival of monsoon rains is a critical piece of information for farmers

- Planting too early → germination fail; Planting too late → miss optimal growth/yield; seeds wash away
- Relevant for other key decisions on land use and planting

Longer-range (15-30 day lead time) forecasts can influence seasonal outcomes

- Non-marginal adjustments to key farm inputs (crop choice, seed variety, land use)
- Decide how much to invest in off-farm activities

Farmers are concerned with arrival of "continuous rains"

- Ag-relevant onset occurs when enough rain has fallen for sufficient topsoil moisture for planting
- Working definition (Moron & Robertson, 2014) - first wet-day succeeded by sufficient rainfall within a 5-day period, followed by no dry spell exceeding 10 days in the next 30 days

Case: Monsoon-onset forecasts in India

Study design - RCT in Telangana state (India)

Experimental study of 4-6 week ahead monsoon-onset forecasts
250 villages; 5-10 farmers per village sampled for the study
Learn more on the design (Burlig et al, 2024) here

Key findings

Engagement: Farmers update expectations by 26% toward predictions, indicating comprehension and trust

Usage: Farmer responses depend on whether predictions are more/less favorable than their prior expectations

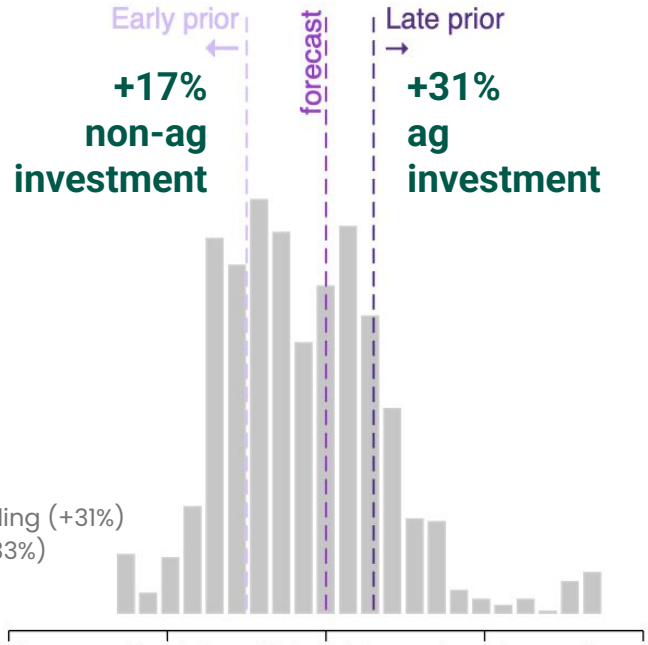
LESS FAVOURABLE FORECAST:

- cut land use (-22%) and spending (-10%)
- shifted to rice or non-farm work (+43%)
- lower agricultural outputs fell (-25%)

MORE FAVOURABLE FORECAST

- expanded land use (+21%) and spending (+31%)
- greater investment in cotton crop (+33%)
- higher agricultural outputs (-25%)

Outcomes: Welfare improved: +7% in food consumption



Prior vs. predicted rains arrival

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Case: AI-driven weather forecasts

Open-access models

Many open-access global weather models are available: Google, NVIDIA, European Centre for Mid-Range Weather Forecasts (ECMWF), FuXi.

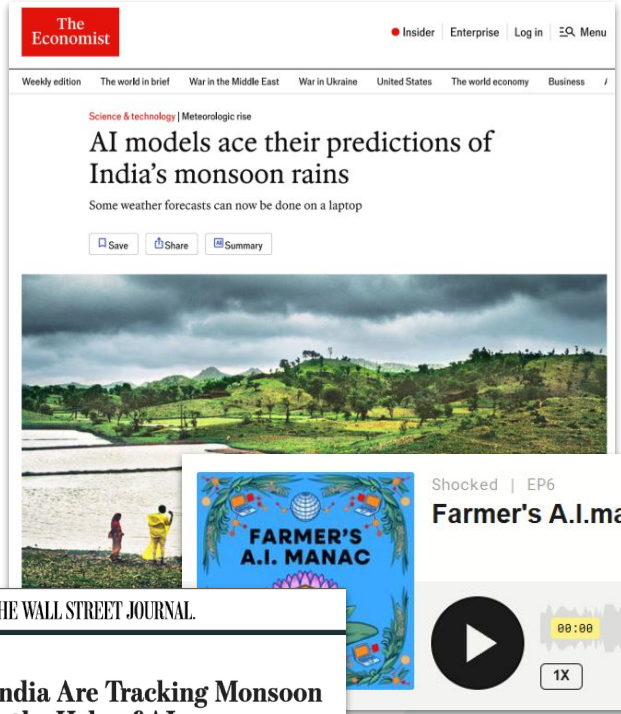
Benchmarking

Team from UChicago (HCF) benchmarked and identified best models to deliver agriculturally relevant forecasts on Indian monsoon:

- Outperforms historical average or ECMWF NWP forecasts.
  - 53% improvement over baseline for 2-week forecast
  - 20% improvement for 4-week forecasts
- Very inexpensive: AI models run 100,000 times faster and cheaper. Can be run on laptops instead of supercomputers.

Blending

HCF used a blend of open-access models to generate long-range ag-relevant monsoon onset forecasts at 200 × 200 km resolution, with a 2–4 week lead time.



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Case: Dissemination of AI-based monsoon onset forecasts to 39M farmers in India

Program overview: First-of-its-kind AI-based weather forecast dissemination program at scale led by government

Partnership between PxD, DIL-India, HCWF, central and Odisha state ag-ministries

Dissemination via two delivery channels

SMS (~38M farmers across 13 states)
IVRS in (~1M in Odisha).

Five rounds of promotional and forecast messages sent in May-June 2025.

Promotional messages also circulated through **WhatsApp** groups.
5 languages: Bangla, Hindi, Marathi, Odia, Punjabi

Ultra cost-effective: only ₹0.40 (<1 cent) per farmer for the SMS dissemination cycle.

Govt. paid for dissemination, with PxD and DIL-India teams providing technical assistance.

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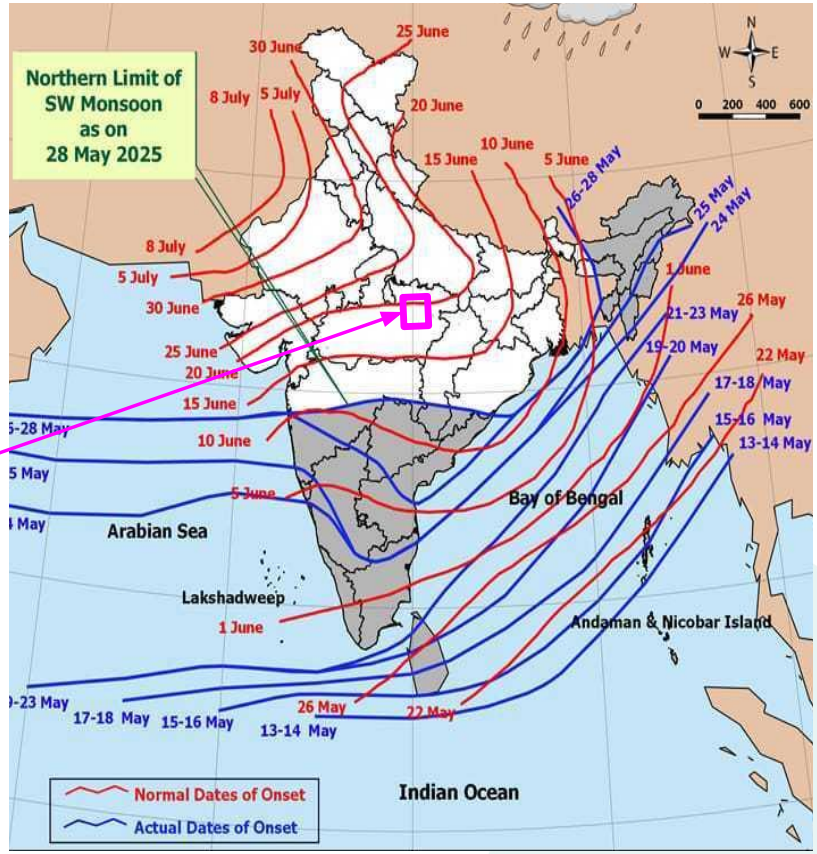
Successfully predicted pause in monsoon progress after early onset over Kerala

- **From IMD:** Monsoon set in over Kerala on the 24th May against the normal date of 1st June.
- Isochrones of actual onset dates indicate rapid advancement; consistent with rule of thumb
- AI-forecasts predicted ~20 day pause in northward monsoon progression
- Example forecasts for eastern Madhya Pradesh (onset occurred June 18):
  - May 28: onset most likely after June 17
  - June 4: onset most likely June 10-24
  - June 11: onset most likely before June 24
- Accuracy increased as onset date neared.



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Impact pathway: from forecast to farmer

SERVICE PROVIDER

What | **How**

Generate relevant scientific information

Translate into actionable messages

Disseminate via digital tools

FARMERS

Use the information for agricultural decisions

Improved resilience & farm outcomes

to USE pipeline

FARMERS

Access	Engage	Recall / Comprehend	Trust / update beliefs
Farmers receive messages	Access, Usability, Timeliness	Salience, Relevance, Completeness	Persuasiveness, Credibility

Intermediate outcomes

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Iterative design testing: Test→Learn→Adapt

Generate relevant scientific information

Translate into actionable messages

Disseminate via digital tools

Use the information for agricultural decisions

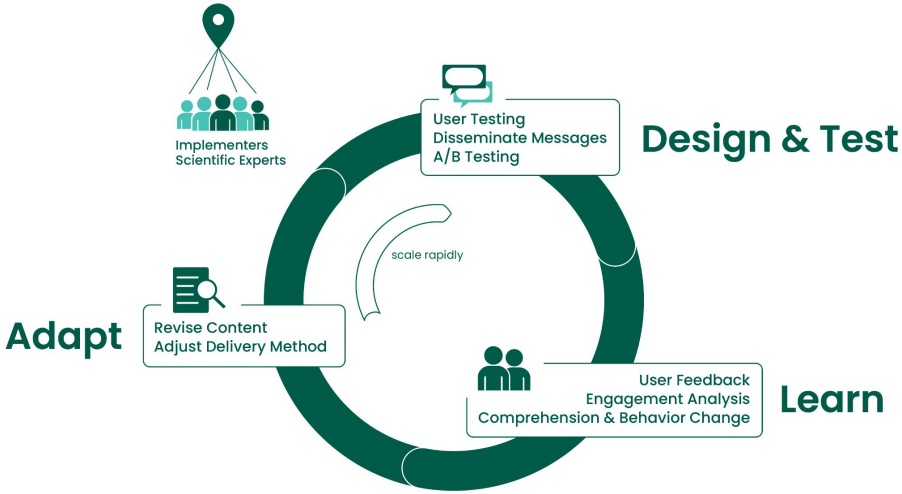
Improved resilience & farm outcomes

Why design testing?

01 Agricultural or climate information is technical

02 Farmer reactions are context-specific

03 Small design tweaks matter



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Setting The Base for Iterative Testing

Forecast Details

- Probabilistic forecasts
- Agriculturally relevant monsoon onset
- Available 15–30 days in advance

Formative Research with Farmers

- Farmers' perceptions of monsoon onset
- Terminologies and local expressions used by farmers
- Agricultural decision-making related to monsoon onset

Key Questions Identified for Testing

1. How to convey **location relevance** to farmers?
2. How to convey **temporal information** clearly?
3. How to convey **probabilistic information** meaningfully?
4. How to convey **agriculturally relevant monsoon-onset**?

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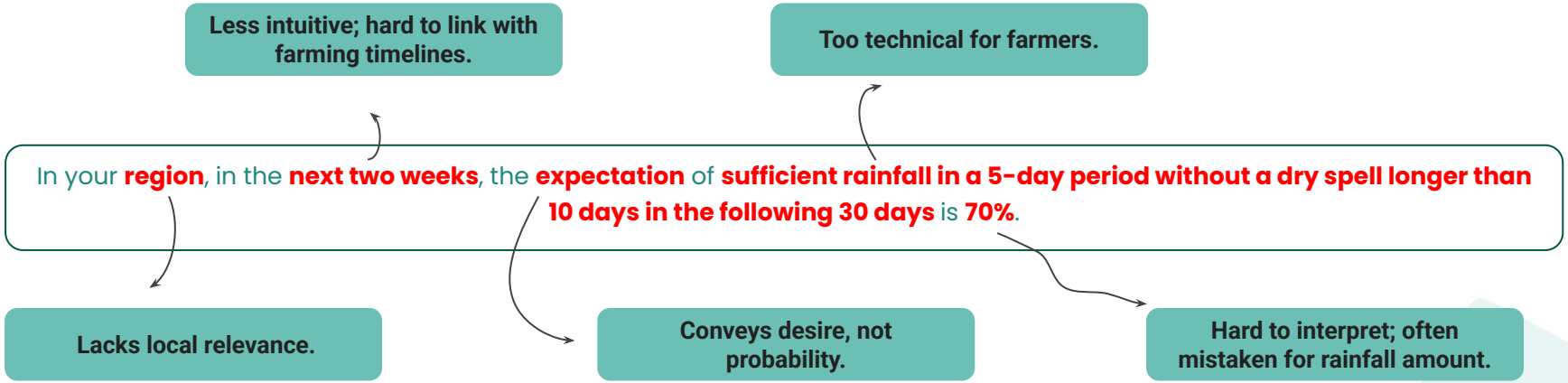
Why Iterative Testing Matters

Without Iterative Testing:



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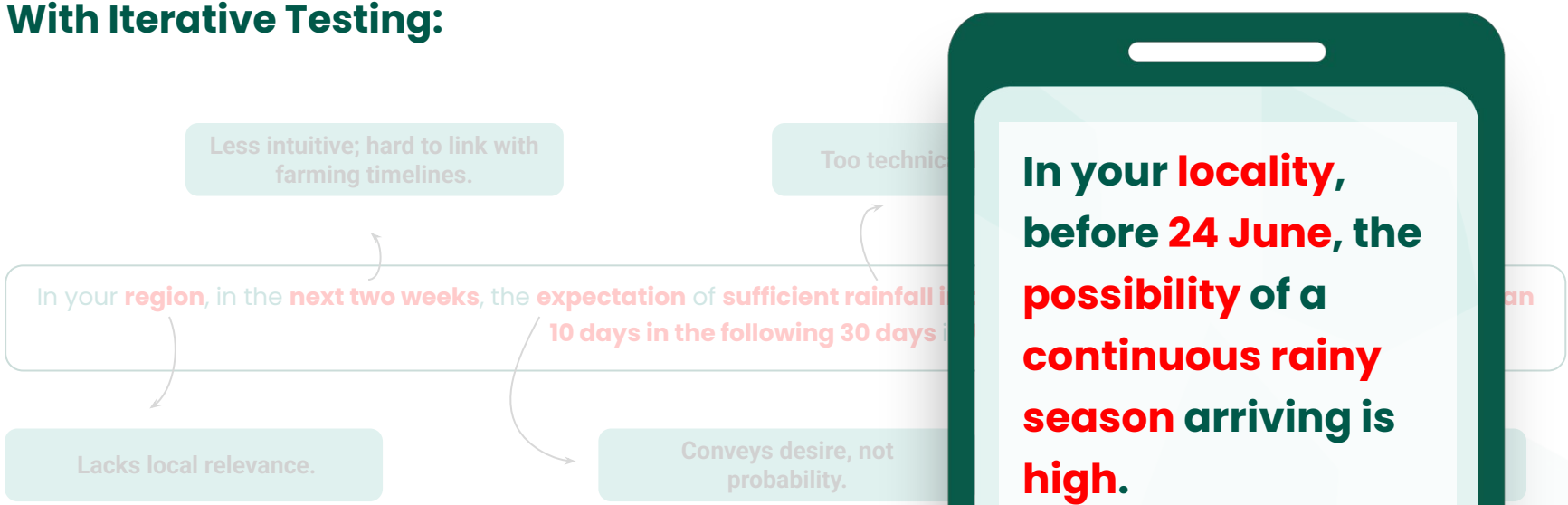
Why Iterative Testing Matters

With Iterative Testing:



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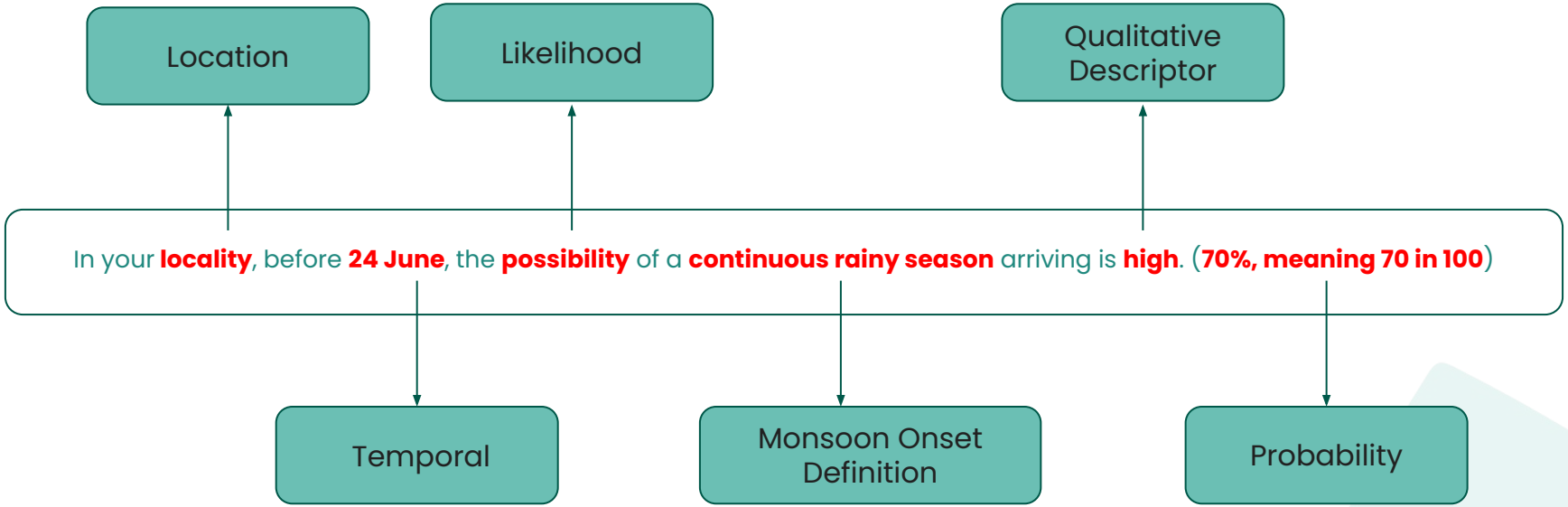
Farmer-Centric Forecast: Key Elements



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Designing Farmer-Centric Forecasts: **Monsoon Onset Definition**

In your locality, before 24 June, the possibility of a **continuous rainy season** arriving is high. (70%, meaning 70 in 100)

Context

- Monsoon onset was defined as sufficient rainfall within a 5-day period, followed by no dry spell exceeding 10 days in the next 30 days.
- Needed a simple way to convey this technical definition to farmers.

Approach

Iterative testing with farmers was conducted to identify which descriptions of monsoon onset were best understood and conveyed the intended meaning accurately.

Insight

"Continuous rainy season" aligns with farmers' natural understanding of steady, useful rainfall for farming and with the technical definition of agriculturally relevant monsoon onset.

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Designing Farmer-Centric Forecasts: **Qualitative Descriptor**

In your locality, before 24 June, the possibility of a continuous rainy season arriving is **high**. (70%, meaning 70 in 100)

Context

- The forecast communicated probabilistic information in numeric terms.
- Varying literacy levels made interpretation challenging and could hinder informed decision-making.

Approach

- In-person surveys were conducted with farmers to test variations in how probabilistic information was communicated.
- Variations tested: With and without qualitative descriptors.

Insight

Adding a qualitative descriptor improved comprehension by up to 25% compared to the non-descriptor version, helping farmers interpret probabilities in more relatable terms.

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Designing Farmer-Centric Forecasts: **Probability**

In your locality, before 24 June, the possibility of a continuous rainy season arriving is high. (**70%, meaning 70 in 100**)

Context

- Probabilistic forecasts included a numeric element essential for informed decision-making.
- Needed a simple and intuitive way to communicate this information to farmers.

Approach

- In-person surveys and FGDs were conducted with farmers to test different ways of expressing probabilities
- Variations tested: Percentages, ratios, or both.

Insight

Percentages were familiar but often misinterpreted as rainfall amount rather than likelihood, while ratios were less intuitive, especially those based on 10, 20, or 25. Combining percentages with ratios using a base of 100 improved comprehension.

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Challenges and Learnings

01 **Low Literacy and Numeracy Levels**

02 **Historical Weather Priors**

03 **Digital Dissemination Constraints**

04 **Time and Resources**

05 **Collaboration at Scale**

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Way forward

Expand AI-powered weather forecast services to farmers

- Existing use-case to more geographies (India, Ethiopia)
- New use-cases (dry-spell, heat)
- Additional delivery channels (whatsapp, chatbots, apps)
- More farmer-centered iterative testing for design and delivery

Institutionalisation for sustainability

- Leverage AI-based open-source weather forecasting models
- Build government (Ag and Met departments) capacity to:
    - Identify locally-relevant and farmer-focussed use cases
    - Produce and benchmark associated forecasts
    - Transform to comprehensible and actionable messages
    - Timely and accessible dissemination to the end-user

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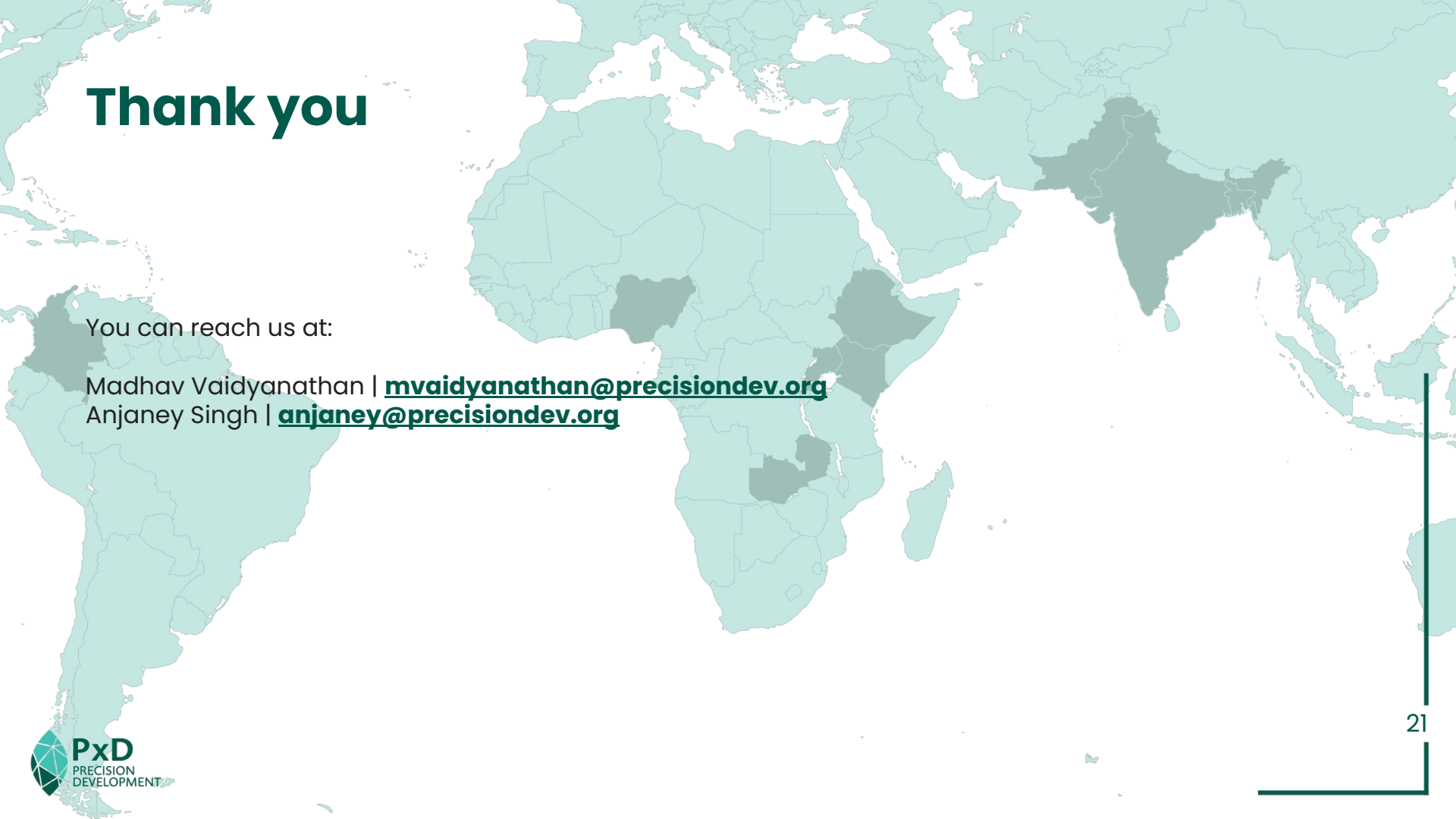
Thank you



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