

Towards Weather Information Fusion Framework for Climate-Resilient Smallholder Agriculture

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Climate change has intensified rainfall variability in timing, duration, and intensity, making smallholder farmers in developing countries increasingly vulnerable to weather-related crop losses. While contemporary adaptation discourse advocates integrating traditional ecological knowledge with modern meteorological systems, existing approaches lack systematic frameworks for meaningful integration.

This study addresses the “Smallholder Weather Information Paradox”—the inverse relationship between meteorological system sophistication and practical utility for farm-level decisions. Modern systems operate on 1-25 kilometer grids while smallholder farms span 0.5-2 hectares, creating a 3-4 order magnitude scale mismatch. Current integration attempts fail due to incompatible information architectures rather than technological limitations.

We propose a “Weather Information Fusion Protocol” analogous to remote sensing pansharpening, where coarse-resolution regional forecasts are enhanced through fine-resolution traditional indicators. Modern meteorology provides regional scope and temporal depth, while traditional knowledge offers spatial precision and local calibration—creating complementary information layers addressing different decision-making scales.

Two domains offer systematic integration pathways: rain prediction and rainmaking. Both traditional and modern systems observe identical atmospheric phenomena through different frameworks—traditional cloud assessment converges with atmospheric pressure analysis. Remarkably, traditional rain ceremonies using coordinated fires parallel modern cloud seeding through shared mechanisms: both target pre-existing clouds during optimal atmospheric windows and introduce artificial nucleation sites via aerosol particles.

The study introduces a “Mechanistic Bridge Model” transforming traditional practices into scientifically-validated measurement methodologies. This enables systematic integration based on atmospheric physics rather than cultural accommodation, directly enhancing climate resilience for vulnerable smallholder farming systems facing unprecedented weather variability.

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October 25, 2025

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Organized Session Details

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