Assessing Long-Term Ecological Resilience in Punjab's Paddy-Dominated Agroecosystems through Integrated Geospatial Analysis (2001-2023)

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1 Background & Aim

- Punjab's paddy-wheat systems have intensified, increasing pressure on soils, groundwater, and ecosystem services.
- Multi-decadal remote sensing enables consistent monitoring of vegetation productivity, moisture, land cover change, and water storage.
- Aim: synthesize 2001-2023 geospatial evidence to interpret resilience trajectories and guide digital decision support.

2 Data Streams & Indicators

- Vegetation: NDVI/EVI trends, seasonal productivity, crop vigor anomalies.
- Water: groundwater proxy trends (gravimetry + wells), irrigation intensity signals, surface water dynamics.
- Soil: salinity risk mapping, moisture indices, land degradation proxies, residue/burning footprints.
- Land use: paddy extent shifts, cropping intensity, fragmentation and edge effects.

3 Integrated Workflow

- Step 1: Satellite Time Series (2001-2023) $\rightarrow$ Pre-processing & Harmonization
- Step 2: Ancillary Data (climate, wells) $\rightarrow$ Indicators (NDVI, moisture, salinity)
- Step 3: Integrated Analysis: trends, thresholds, hotspots, resilience scoring and policy-relevant maps
- Outputs: Maps, Dashboards, and Risk Alerts

4 Key Findings from 2001-2023 Evidence

- Vegetation productivity signals show spatially uneven greenness change, with stress hotspots aligned to intensive paddy zones and climate variability.
- Groundwater indicators show sustained decline across canal-command and tubewell-dependent areas, increasing vulnerability in dry years.
- Remote-sensed soil proxies indicate rising salinity risk and degradation signatures in parts of the central and southern plains.
- Evidence integration is constrained by inconsistent methods and limited field validation in several studies.

5 Research Priorities & Digital Tools

- Standardize multi-sensor workflows (Landsat/Sentinel) with uncertainty reporting.
- Link remote sensing indicators to field bio-physical measurements and pest/disease risk layers.
- Detect ecological thresholds using change-point analytics and drought-response metrics.
- Build decision-ready dashboards for irrigation scheduling, residue management, and salinity mitigation.
- Adopt open geospatial pipelines for reproducible monitoring and policy evaluation.

6 Flow to Insight Graphs