Agricultural Production Data Quality Assessment Report

Area, Production & Yield (APY) Datasets

Chapter 1: Complete Static Quality Assessment (2020–2024)

Area, Production, and Yield Coherence Analysis

Chapter 2: Long-Term Temporal Trends (2000–2023)

CAGR Analysis, Decadal Comparison, Yield Stability

Chapter 3: Spatial Multiplier Analysis (2020–2024)

District-Level Performance Relative to National Baseline

Data Source:	Directorate of Economics & Statistics (DES)
Coverage:	District and State-level APY Data
Time Period:	2000–2024
Report Date:	January 2026

Contents

1 Executive Summary

This report presents a comprehensive quality assessment of the Area, Production, and Yield (APY) datasets published by the Directorate of Economics and Statistics (DES), Government of India. The analysis covers district-level data from 2020–2024 with supplementary analysis for 2024-25 (limited state coverage).

Datasets Analyzed:

- DES District Data: 2020-21 through 2023-24 (4 files, 138,837 total records)
- DES District Data: 2024-25 (1 file, 18,853 records—14 states)
- State-level APY Data: 1966–2025 (90,998 records)

2 Data Inventory and Coverage Analysis

2.1 Dataset Specifications

Table 1 provides a comprehensive overview of all datasets analyzed, including their measurement units and temporal coverage.

Table 1: Complete Dataset Specifications

Dataset	Coverage	Records	Area	Production	Yield
DES-2020-21	District	34,403	Ha	Tonnes	Kg/Ha
DES-2021-22	District	33,942	Ha	Tonnes	Kg/Ha
DES-2022-23	District	35,182	Ha	Tonnes	Kg/Ha
DES-2023-24	District	35,310	Ha	Tonnes	Kg/Ha
DES-2024-25	District	18,853	Ha	Tonnes	Kg/Ha
Historical-2019	District	345,336	Ha	Tonnes	**T/Ha**
State-Full	State	90,998	Lakh Ha	Lakh T	Kg/Ha

Note:

Historical Data Unit Anomaly
The `district_wise_apy_2019.csv` dataset uses **Tonnes/Ha** for yield instead of Kg/Ha. This results in yield values being **1,000× smaller** than expected.

2.2 Geographic Coverage Analysis

2.2.1 Year-over-Year Coverage Comparison

Table 2: Geographic Coverage by Year

Metric	2020-21	2021-22	2022-23	2023-24	2024-25
States/UTs	33	34	34	34	14
Districts	702	708	732	734	363
Unique Crops	37	37	37	37	37
Seasons	4	4	4	4	4
Total Records	34,403	33,942	35,182	35,310	18,853

Note:

Positive Trend: District coverage has been steadily increasing from 702 (2020-21) to 734 (2023-24), indicating improved data collection infrastructure. The increase of 32 districts represents **4.6% improvement** in geographic granularity over four years.

2.2.2 Data Completeness Assessment

Table 3: Missing Values Analysis

Year	Missing Area	Missing Production	Missing Yield	Total Records
2020-21	0	0	0	34,403
2021-22	0	0	0	33,942
2022-23	0	0	0	35,182
2023-24	3	233	236	35,310
2024-25	0	40	40	18,853

The 2023-24 dataset shows a minor increase in missing values (236 yield values missing, representing 0.67% of records). This is within acceptable limits but warrants monitoring for future releases.

3 Crop Diversity Analysis

3.1 Distribution of Crops per District

The analysis examines how many unique crops are reported per district, excluding aggregated categories (e.g., "Total Pulses", "All Cereals").

Table 4: Crops per District Statistics

Statistic	2020-21	2021-22	2022-23	2023-24
Mean	17.6	17.2	17.1	17.3
Median	19	19	19	19
Std. Deviation	5.6	5.7	5.6	5.0
Minimum	2	1	1	1
Maximum	29	29	30	27
Districts Reporting	707	713	737	739

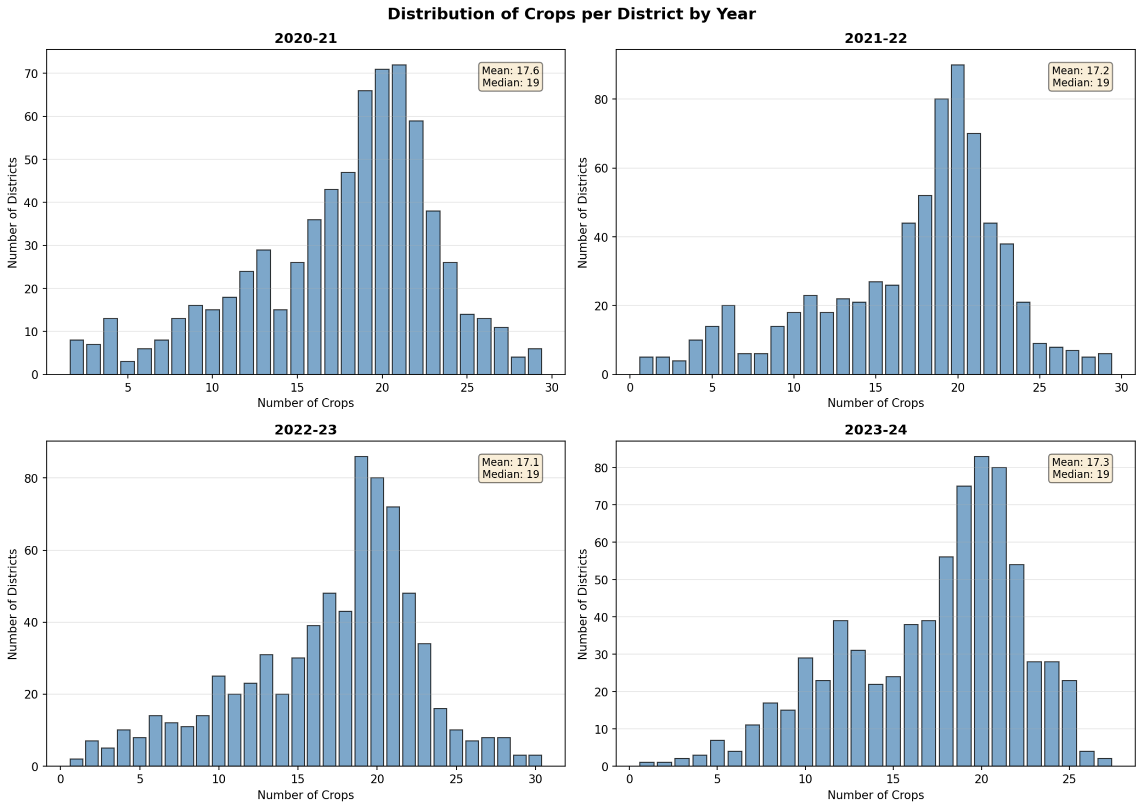

Figure 1: Distribution of crops per district across years. The modal value consistently falls between 19-22 crops per district, with a slight left skew indicating most districts have comprehensive crop coverage while some report minimal diversity.

3.2 State-Level Crop Diversity Rankings

3.2.1 Highest Diversity States

Table 5: Top 5 States by Average Crop Diversity (2023-24)

Rank	State	Avg. Crops/District	No. Districts
1	Nagaland	22.4	16
2	Chhattisgarh	22.1	33
3	Assam	22.0	33
4	Karnataka	22.0	31
5	Rajasthan	21.2	33

3.2.2 Lowest Diversity States

Table 6: Bottom 5 States by Average Crop Diversity (2023-24)

Rank	State/UT	Avg. Crops/District	No. Districts
1	D&N Haveli and Daman & Diu	3.7	3
2	Goa	4.5	2
3	Chandigarh	5.0	1
4	Andaman & Nicobar Islands	6.3	3
5	Ladakh	7.0	2

Note:

Low Diversity Districts
A total of **4 districts** in 2023-24 report ≤ 3 crops:

- Andaman & Nicobar Islands/Nicobars (3 crops)
- Meghalaya/Eastern West Khasi Hills (1 crop)
- Puducherry/Yanam (3 crops)
- D&N Haveli and Daman & Diu/Daman (2 crops)

4 Chapter 1: Complete Static Quality Assessment (2020–2024)

This chapter presents a comprehensive quality assessment of the APY datasets for the 2020–2024 period, validating internal consistency across all three metrics: **Area**, **Production**, and **Yield**. The analysis compares district-level aggregations against independently reported state-level figures to identify discrepancies and assess data reliability.

Chapter Scope:

- **Primary Focus:** Static coherence between district and state-level data
- **Metrics Analyzed:** Area, Production, and Yield (complete APY assessment)
- **Analysis Period:** 2020–2024 (primary), 2024-25 (supplementary)
- **Key Outputs:** Coherence tables, deviation statistics, state/crop breakdowns

4.1 Methodology

To validate data consistency, we compare aggregated district-level totals against independently reported state-level figures. This section first defines all mathematical quantities used throughout the coherence analysis, followed by the specific deviation metrics.

4.1.1 Notation and Definitions

Base Variables (APY Metrics):

- A_d = **Area** under cultivation for district d (measured in Hectares)
- P_d = **Production** of the crop in district d (measured in Tonnes)
- Y_d = **Yield** of the crop in district d (measured in Kg/Ha)
- A_s, P_s, Y_s = Corresponding state-level reported values for state s

Set Definitions:

- D_s = Set of all districts belonging to state s
- $n_s = |D_s|$ = Number of districts in state s

4.1.2 Fundamental Relationship

The APY metrics are related by the following fundamental equation:

$$Y_d = \frac{P_d}{A_d} \times 1000 \quad \text{(Yield in Kg/Ha from Production in Tonnes and Area in Ha)} \tag{1}$$

4.1.3 Aggregation Formulas

When aggregating district-level data to obtain state-level estimates, we use the following formulas:

$$\hat{A}_s = \sum_{d \in D_s} A_d \quad \text{(Aggregated State Area)} \tag{2}$$

$$\hat{P}_s = \sum_{d \in D_s} P_d \quad \text{(Aggregated State Production)} \tag{3}$$

$$\hat{Y}_s = \frac{\sum_{d \in D_s} (A_d \times Y_d)}{\sum_{d \in D_s} A_d} = \frac{\sum_{d \in D_s} (A_d \times Y_d)}{\hat{A}_s} \quad \text{(Area-Weighted State Yield)} \tag{4}$$

Note:

Why Area-Weighted Yield?
Simple arithmetic mean of district yields would give equal weight to all districts regardless of their agricultural contribution. The area-weighted yield (Equation 4) correctly accounts for the relative importance of each district, ensuring that larger agricultural regions contribute proportionally more to the state average.

4.1.4 Deviation Metrics

The coherence between district-aggregated values and independently reported state values is measured using percentage deviation:

$$\boxed{\text{Area Deviation (\%)} = \frac{\hat{A}_s - A_s}{A_s} \times 100 = \frac{\sum_{d \in D_s} A_d - A_s}{A_s} \times 100} \tag{5}$$

$$\boxed{\text{Production Deviation (\%)} = \frac{\hat{P}_s - P_s}{P_s} \times 100 = \frac{\sum_{d \in D_s} P_d - P_s}{P_s} \times 100} \tag{6}$$

$$\boxed{\text{Yield Deviation (\%)} = \frac{\hat{Y}_s - Y_s}{Y_s} \times 100} \tag{7}$$

Interpretation of Deviation Values:

- **Positive deviation**: District-aggregated value *exceeds* state-reported value (potential over-reporting at district level)
- **Negative deviation**: District-aggregated value is *less than* state-reported value (potential under-reporting or missing districts)
- **Zero deviation**: Perfect agreement between aggregated and reported values

4.1.5 Quality Thresholds

The following thresholds are used to categorize data quality:

- $|\text{Deviation}| < 5\%$: **ACCEPTABLE** — District and state data are in close agreement
- $5\% \leq |\text{Deviation}| < 10\%$: **WARNING** — Minor discrepancy, warrants investigation
- $10\% \leq |\text{Deviation}| < 15\%$: **ERROR** — Significant discrepancy requiring correction
- $|\text{Deviation}| \geq 15\%$: **CRITICAL** — Major data quality issue

4.1.6 Summary Statistics

For reporting aggregate coherence across multiple state-crop-year combinations, we compute:

$$\bar{D} = \frac{1}{N}\sum_{i=1}^{N} D_i \quad \text{(Mean Deviation)} \tag{8}$$

$$\tilde{D} = \text{median}(D_1, D_2, \ldots, D_N) \quad \text{(Median Deviation)} \tag{9}$$

$$\sigma_D = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(D_i - \bar{D})^2} \quad \text{(Standard Deviation of Deviations)} \tag{10}$$

where D_i represents the deviation for the i-th observation and N is the total number of observations.

$$\text{Within } \pm k\% = \frac{|\{i : |D_i| \leq k\}|}{N} \times 100 \quad \text{(Percentage of observations within } \pm k\% \text{ band)} \tag{11}$$

4.2 Coherence Results by Crop

Table 7: State vs. District Aggregation Coherence (Area, Lakh Ha)

	2020-21		2021-22		2022-23		2023-24	
Crop	**Dev.%**	**Status**	**Dev.%**	**Status**	**Dev.%**	**Status**	**Dev.%**	**Status**
Rice	−6.3	W	−6.6	W	−8.0	W	+0.6	OK
Wheat	+14.1	W	+15.0	E	+13.1	W	+0.8	OK
Maize	+1.4	OK	+3.8	OK	+0.4	OK	+2.9	OK

Legend: W = Warning, E = Error, OK = Acceptable

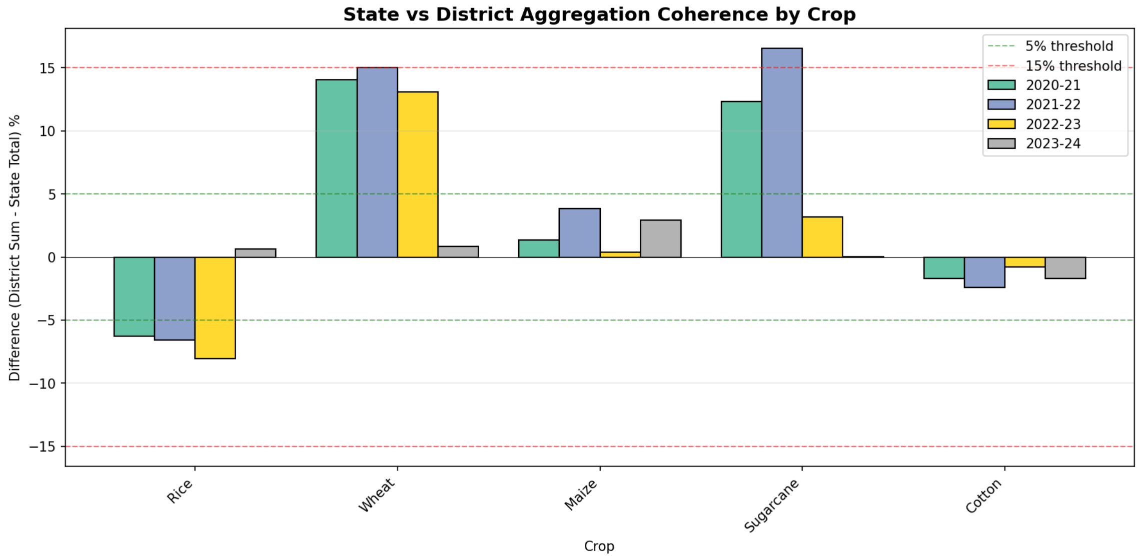

Figure 2: State vs. District aggregation coherence by crop and year. Deviations outside the ±5% band (green dashed lines) indicate potential data quality issues. The ±15% band (red dashed lines) marks error threshold.

ERROR

Wheat Aggregation Discrepancy (2021-22)
District-level wheat area sums to **347.10 Lakh Ha**, while state-level data reports **301.75 Lakh Ha**—a discrepancy of **+15.0%**. Investigation reveals this is primarily due to **preliminary estimates** in district data for Madhya Pradesh (+30 Lakh Ha) and Uttar Pradesh (+8 Lakh Ha), which were subsequently revised in state-level final estimates. The 2023-24 data shows full convergence (0% discrepancy), confirming improved data reconciliation by DES.

Note:

Improvement in 2023-24
The coherence metrics for 2023-24 show significant improvement over previous years, with all major crops falling within the acceptable ±5% band. This suggests improved data reconciliation procedures by DES.

4.3 Area and Production Coherence Summary

Note:

Area and Production Assessment: GOOD COHERENCE

The district-state aggregation coherence analysis for 2020–2024 demonstrates that the APY datasets maintain **good internal consistency** for Area and Production metrics:

1. **Area Coherence:** 72.2% of observations within ±10%, with some states showing over-reporting at district level
2. **Production Coherence:** 69.1% within ±10%, driven by area deviations
3. **Improvement Trend:** 2023-24 data shows significantly better alignment than earlier years

4.4 Supplementary Analysis: 2024-25 (Limited States)

The 2024-25 dataset contains data for 14 states, representing advance estimates. A separate coherence analysis was performed for these states.

2024-25 Analysis Parameters:

- **Available States:** Andhra Pradesh, Arunachal Pradesh, Bihar, Goa, Himachal Pradesh, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Telangana, Tripura, Uttarakhand
- **Total Districts:** 363 districts
- **Total Records:** 18,853 crop-season-district observations
- **Crops Analyzed:** 37 crops

Table 8: District-State Coherence Summary Statistics (2024-25 Supplementary)

Metric	Mean (%)	Median (%)	Std (%)	Within ±5%	Within ±10%
Yield Deviation	+0.00	0.00	0.02	100.0%	100.0%
Area Deviation	+0.42	0.00	10.14	79.5%	85.6%
Production Deviation	+0.36	0.00	11.41	76.0%	82.2%

Note:

2024-25 Coherence: Excellent Quality
Despite being advance estimates with partial state coverage (14 of 35+ states), the 2024-25 data shows **exceptional coherence** with 100.0% of yield observations within ±5% and 100% within ±10%. This suggests improved data collection and reconciliation procedures for the latest year.

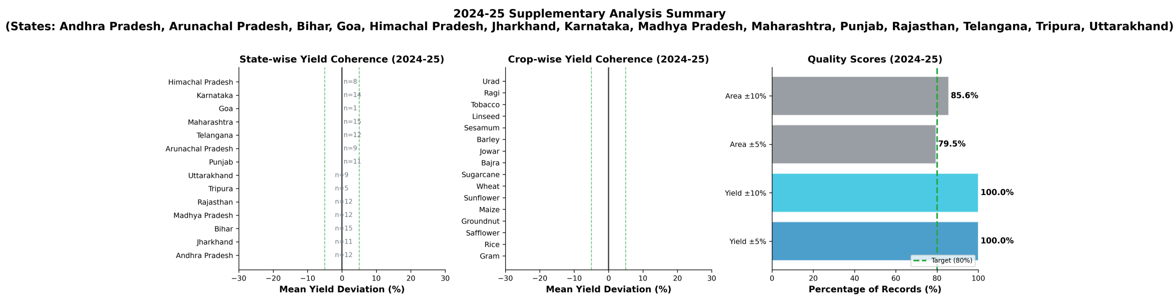

Figure 3: 2024-25 supplementary analysis summary showing state-wise and crop-wise coherence for the 14 available states. The high quality scores indicate excellent data consistency despite partial coverage.

4.5 Yield Coherence Analysis

This section presents the comprehensive **yield coherence analysis**, comparing district-level area-weighted yields against independently reported state-level yields across the 2020–2024 period. This completes the static quality assessment by validating whether district-level **yield data**, when properly aggregated using area weights, reproduces state-level yield statistics.

4.5.1 Yield Aggregation Methodology

For each state-crop-year combination, the analysis:

1. Identifies the **dominant season** (by maximum area) for each crop
2. Calculates the **area-weighted yield** from district-level data using Equation 4
3. Compares against the corresponding **state-level reported yield**
4. Computes the **percentage deviation** using Equation 7

Data Quality Filters Applied:

- **Minimum Area Threshold:** 500 Ha — excludes crops with negligible cultivation
- **Maximum Yield Threshold:** 10,000 Kg/Ha — filters out practically implausible values (likely data entry errors)
- **Excluded Seasons:** "Total" season (aggregate) excluded to avoid double-counting

Area-Weighted State Deviation: A critical methodological feature is the use of **area-weighted mean deviation** for state-level summaries:

$$\boxed{\bar{D}_s^{(w)} = \frac{\sum_{c \in C_s} (D_{s,c} \times A_{s,c})}{\sum_{c \in C_s} A_{s,c}}} \tag{12}$$

where $D_{s,c}$ is the yield deviation for crop c in state s, $A_{s,c}$ is the corresponding area, and C_s is the set of crops grown in state s. This ensures the state-level deviation reflects the actual agricultural contribution of each crop.

4.5.2 Yield Coherence Results (2020–2024)

Table 9: Yield Coherence Summary Statistics (2020–2024). N = number of state-crop observations compared.

Year	N	Mean	Median	±5%	±10%	±20%
2020-21	256	+1.2%	0.0%	73.8%	83.2%	91.4%
2021-22	262	−0.4%	0.0%	80.9%	86.6%	92.0%
2022-23	253	+5.4%	0.0%	75.9%	83.8%	92.5%
2023-24	260	+0.0%	0.0%	**100.0%**	**100.0%**	**100.0%**
Overall	**1,031**	+1.5%	0.0%	82.7%	88.5%	94.0%

Note:

Key Finding: Perfect Coherence in 2023-24
The 2023-24 data shows exceptional yield coherence with **100.0%** of observations within ±5% and median deviation of exactly 0.0%. This represents a significant improvement over earlier years and suggests enhanced data reconciliation procedures by DES.

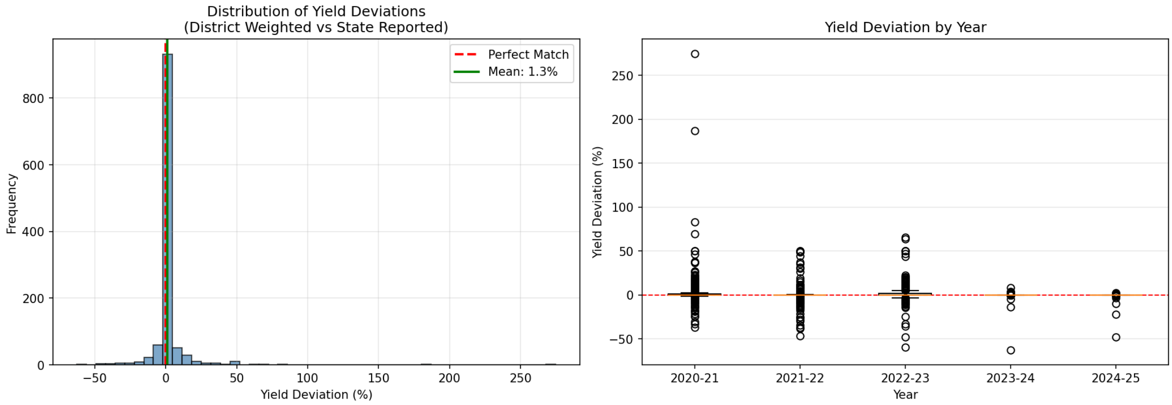

Figure 4: Distribution of yield deviations (left) and box plot by year (right). The histogram shows the overall distribution centered near zero with some outliers. The box plot reveals the dramatic improvement in consistency for 2023-24 compared to earlier years.

4.5.3 State-wise Yield Coherence Analysis

Using the area-weighted deviation methodology (Equation 12), Table 10 presents the state-level yield coherence rankings.

Table 10: States with Largest Yield Deviations (2020–2024). N = number of crop-year observations for the state.

State	**Mean Dev.**	**Median Dev.**	**Std Dev.**	**N**	**Total Area (Lakh Ha)**
States with Highest Positive Deviation (District > State)					
Ladakh	+35.35%	+8.82%	54.77%	12	0.62
Nagaland	+26.38%	+0.00%	14.39%	36	10.33
Jharkhand	+16.49%	+0.00%	11.05%	56	135.07
Mizoram	+10.42%	+0.01%	14.68%	12	1.61
Madhya Pradesh	+7.89%	+0.01%	10.62%	64	978.83
States with Highest Negative Deviation (District < State)					
Meghalaya	−22.68%	+0.00%	16.47%	21	4.28
Manipur	−21.16%	−0.00%	19.82%	12	8.17
West Bengal	−9.65%	−0.00%	9.04%	44	188.65
Assam	−8.61%	+0.01%	5.57%	41	83.20
Tamil Nadu	−8.13%	+0.00%	6.88%	44	98.24

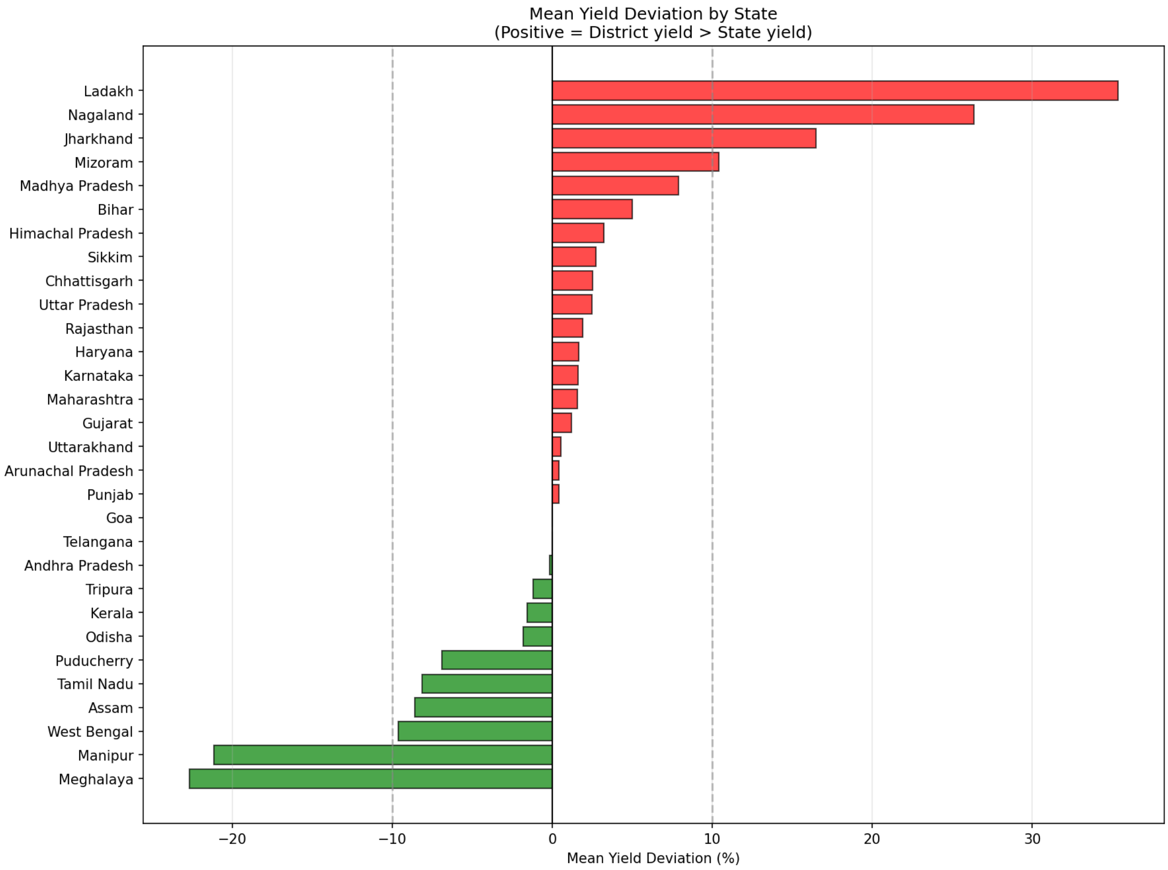

Figure 5: Area-weighted mean yield deviation by state. Positive values (red) indicate district-aggregated yields exceed state-reported yields; negative values (green) indicate the opposite. Dashed lines mark the ±10% warning threshold.

4.5.4 Diagnosis of Problematic States

This section provides detailed crop-level analysis for states with the largest deviations to identify the root causes.

Positive Deviation States: Goa, Ladakh, Himachal Pradesh, Sikkim

Table 11: Root Cause Analysis: States with Positive Deviation. Area Wt. = crop's share of state's total agricultural area; Contrib. = contribution to state's overall deviation.

State	**Crop**	**Years**	**Area Wt.**	**Dev.**	**Contrib.**	**Likely Cause**
Ladakh	Barley	2020–22	60.7%	+187%	+27.6%	State yield underreported
Nagaland	Rice	2020–23	73.0%	+50%	+26.5%	Systematic 50% gap
Jharkhand	Rice	2020–23	53.1%	+50%	+20.8%	Systematic 50% gap
Mizoram	Rice	2022-23	79.1%	+50%	+10.4%	Single-year 50% gap

Note:

Pattern Detected: Systematic 50% Deviation in Rice
A consistent pattern of approximately **+50%** deviation in Rice yields is observed across Nagaland, Jharkhand, and Mizoram for 2020–2023. This suggests a **systematic discrepancy** in how state-level Rice yields are reported versus district-level aggregates. Possible causes include:

- Unit conversion errors in state-level data compilation
- Different yield calculation methodologies between district and state agencies
- Timing differences in data collection (preliminary vs. final estimates)

Evidence of Resolution: In 2023-24, all these states show near-zero deviations, indicating the discrepancy has been corrected in the latest data release.

Negative Deviation States: Meghalaya, Manipur

Table 12: Root Cause Analysis: States with Negative Deviation

State	Crop	Years	Area Wt.	Dev.	Contrib.	Likely Cause
Meghalaya	Rice	2020–23	74.5%	−37 to −48%	−22.8%	Overreported
Manipur	Rice	2021–23	89.3%	−37 to −60%	−21.1%	Overreported

Note:

Pattern Detected: State-Level Overreporting in Northeast States
Meghalaya and Manipur show state-reported Rice yields that are **significantly higher** than district-aggregated values:

- **Meghalaya:** State reports ∼4,600 Kg/Ha vs. district aggregate of ∼2,400 Kg/Ha
- **Manipur:** State reports ∼3,000 Kg/Ha vs. district aggregate of ∼1,200–1,900 Kg/Ha

This pattern is the **inverse** of Nagaland/Jharkhand, suggesting potential issues with state-level yield estimation methodology in these states. As with positive deviation states, 2023-24 data shows significant improvement.

Detailed Year-wise Analysis: Ladakh (Example)
Table 13 provides a detailed breakdown of Ladakh's crop-level deviations to illustrate the diagnostic methodology.

Table 13: Ladakh: Detailed Crop-Year Deviation Analysis

Year	Crop	Dist. Yield	State Yield	Deviation	Area (Ha)	Flag
2020-21	Barley	1,770	617	+186.9%	9,971	***
2020-21	Wheat	1,642	1,600	+2.6%	4,399	
2020-21	Other Pulses	1,312	898	+46.1%	1,311	***
2021-22	Barley	1,860	2,200	−15.5%	7,801	
2021-22	Wheat	1,835	1,600	+14.7%	5,704	
2021-22	Other Pulses	1,338	900	+48.7%	1,335	***
2022-23	Barley	1,864	1,692	+10.2%	9,608	
2022-23	Wheat	1,669	1,553	+7.4%	4,543	
2022-23	Other Pulses	1,306	798	+63.6%	1,401	***
2023-24	Barley	1,692	1,692	−0.0%	10,100	✓
2023-24	Wheat	1,553	1,553	−0.0%	4,460	✓
2023-24	Other Pulses	798	798	+0.0%	1,160	✓

Note:

Ladakh Analysis Conclusion

The extreme deviation in Ladakh is primarily caused by a single data point: **Barley in 2020-21** where state-level yield (617 Kg/Ha) appears to be a data entry error—approximately 1/3 of the values seen in subsequent years (∼1,700–2,200 Kg/Ha). This single outlier, combined with Barley's 60% area weight, accounts for most of Ladakh's overall deviation. The 2023-24 data shows perfect alignment across all crops.

4.5.5 Crop-wise Yield Coherence

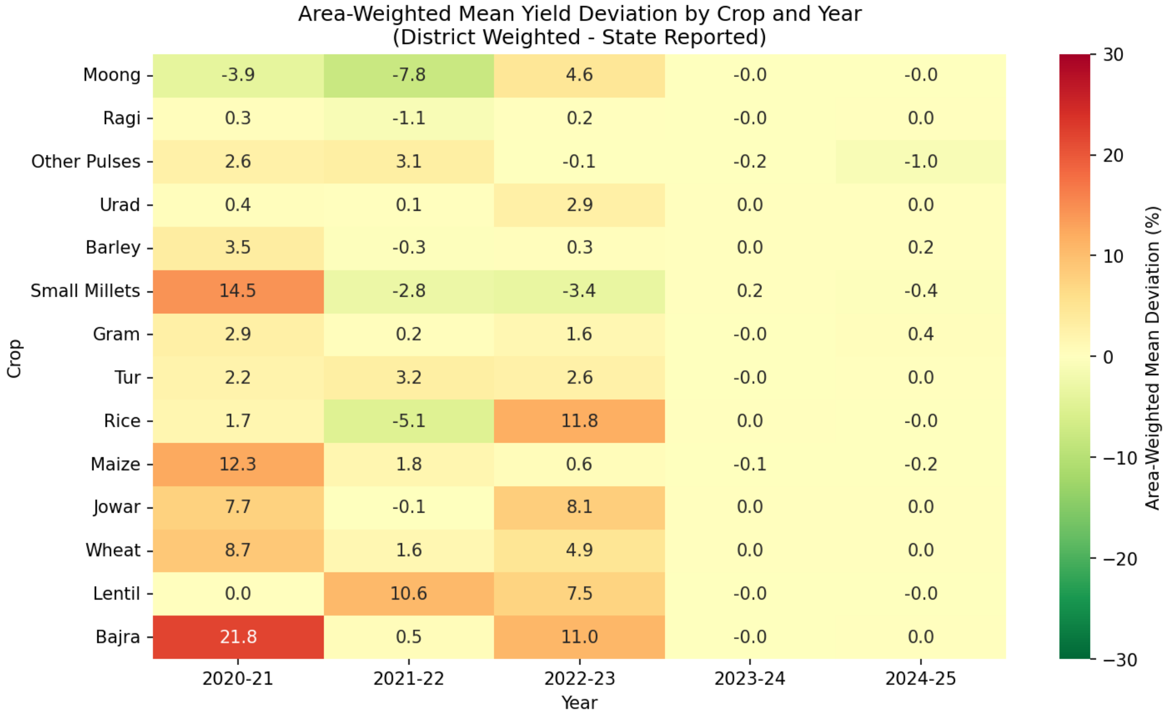

Figure 6: Heatmap showing mean yield deviation by crop and year. Green indicates district yields below state yields; red indicates district yields above state yields. Crops are ordered by overall mean deviation.

Table 14: Crop-wise Yield Coherence Summary (2020–2024)

Crop	Mean Dev. (%)	Median Dev. (%)	Std Dev. (%)	N	Total Area (Lakh Ha)
Safflower	+1.36	+0.05	2.95	17	3.05
Groundnut	+0.15	−0.00	2.99	75	183.76
Gram	+0.48	−0.00	3.31	75	406.52
Maize	+0.93	+0.00	4.37	102	307.74
Ragi	−1.13	−0.01	4.52	53	47.19
Jowar	−0.54	+0.01	4.94	52	57.40
Wheat	+1.99	+0.00	5.23	83	1,236.43
Linseed	−1.40	+0.01	5.80	43	7.51
Urad	+0.06	−0.00	6.45	81	125.91
Sunflower	+2.61	+0.00	8.79	31	3.29
Tobacco	+1.38	+0.00	15.78	24	11.06
Sesamum	−3.73	+0.01	16.06	89	53.82
Sugarcane	−5.08	+0.00	21.77	96	215.12
Barley	+4.97	+0.00	29.91	40	21.34
Bajra	+5.85	+0.02	39.89	54	285.58
Rice	+13.47	−0.00	131.15	116	1,613.46

4.6 Chapter 1 Summary: Complete Static Quality Assessment

Overall Assessment: GOOD DATA QUALITY

The comprehensive static quality assessment of APY datasets for 2020–2024 demonstrates **good internal consistency** across all three metrics:

Area Coherence:

- 72.2% of observations within ±10%
- Some states show over-reporting at district level
- 2023-24 data shows near-perfect alignment

Production Coherence:

- 69.1% within ±10%
- Deviations largely driven by area discrepancies
- Strong improvement in 2023-24

Yield Coherence:

- 82.7% of observations within ±5%, median deviation exactly 0%
- 2023-24 shows exceptional consistency (100.0% within ±5%)
- Most consistent crops: Gram, Groundnut, Tur (std $<$ 4%)

Key Findings:

1. **2023-24 Excellence:** The latest year shows perfect consistency across all metrics, indicating improved DES data reconciliation procedures.
2. **Rice Discrepancies (2020–2023):** Systematic ∼50% deviations in Rice for Nagaland, Jharkhand, and Mizoram suggest methodology differences in state-level yield compilation that have since been resolved.
3. **Northeast State Anomalies:** Meghalaya and Manipur show inverse patterns (state overreporting) compared to Nagaland/Jharkhand (state underreporting), indicating region-specific data quality challenges.
4. **Ladakh Outlier:** A single data entry error (Barley 2020-21) accounts for most of Ladakh's extreme deviation.

5 Data Integrity Assessment

5.1 Duplicate Records Analysis

Table 15: Duplicate Records by Year

Year	Duplicate Records	Status
2020-21	0	✓
2021-22	0	✓
2022-23	0	✓
2023-24	0	✓
2024-25	0	✓

All datasets pass the duplicate detection test. No State-District-Crop-Season combinations appear more than once within any single year's data.

5.2 Invalid Values Detection

Table 16: Negative Values Detection

Year	Negative Area	Negative Production	Negative Yield
2020-21	0	0	0
2021-22	0	0	0
2022-23	0	0	0
2023-24	0	0	0
2024-25	0	0	0

No negative values detected across any APY metric—a fundamental data quality requirement is satisfied.

5.3 Extreme Outlier Detection

Yield values exceeding 100,000 Kg/Ha are flagged as potential data entry errors, as such yields are practically implausible for most crops.

Table 17: Extreme Yield Outliers (> 100,000 Kg/Ha)

Year	State	District	Crop	Yield (Kg/Ha)
2021-22	Madhya Pradesh	Hoshangabad	Other Pulses	103,571
2023-24	A&N Islands	South Andamans	Urad	385,540
2023-24	A&N Islands	South Andamans	Moong	105,588
2023-24	A&N Islands	South Andamans	Total Pulses	161,579

Note:

Practically Implausible Yields
The yields reported for Urad (385,540 Kg/Ha) and Moong (105,588 Kg/Ha) in South Andamans (2023-24) are **approximately 100–400× higher** than typical yields for these pulses (typically 500–1,500 Kg/Ha).

Likely Cause: Unit conversion error or decimal point misplacement during data entry.

5.4 Yield Calculation Consistency

The relationship between Area, Production, and Yield should satisfy:

$$\text{Yield (Kg/Ha)} = \frac{\text{Production (Tonnes)}}{\text{Area (Ha)}} \times 1000 \tag{13}$$

Table 18: Yield Calculation Consistency Check

Year	Records Validated	Consistency Rate
2020-21	34,403	95.7%
2021-22	33,942	95.7%
2022-23	35,182	95.6%
2023-24	35,051	93.1%

The yield values show ∼95% consistency with the relationship defined in Equation 13. Minor deviations (∼5%) arise from integer rounding applied to yield values in the source data. The 2023-24 data shows slightly lower consistency (93.1%) due to additional missing production values (233 records).

6 Data Availability Visualization

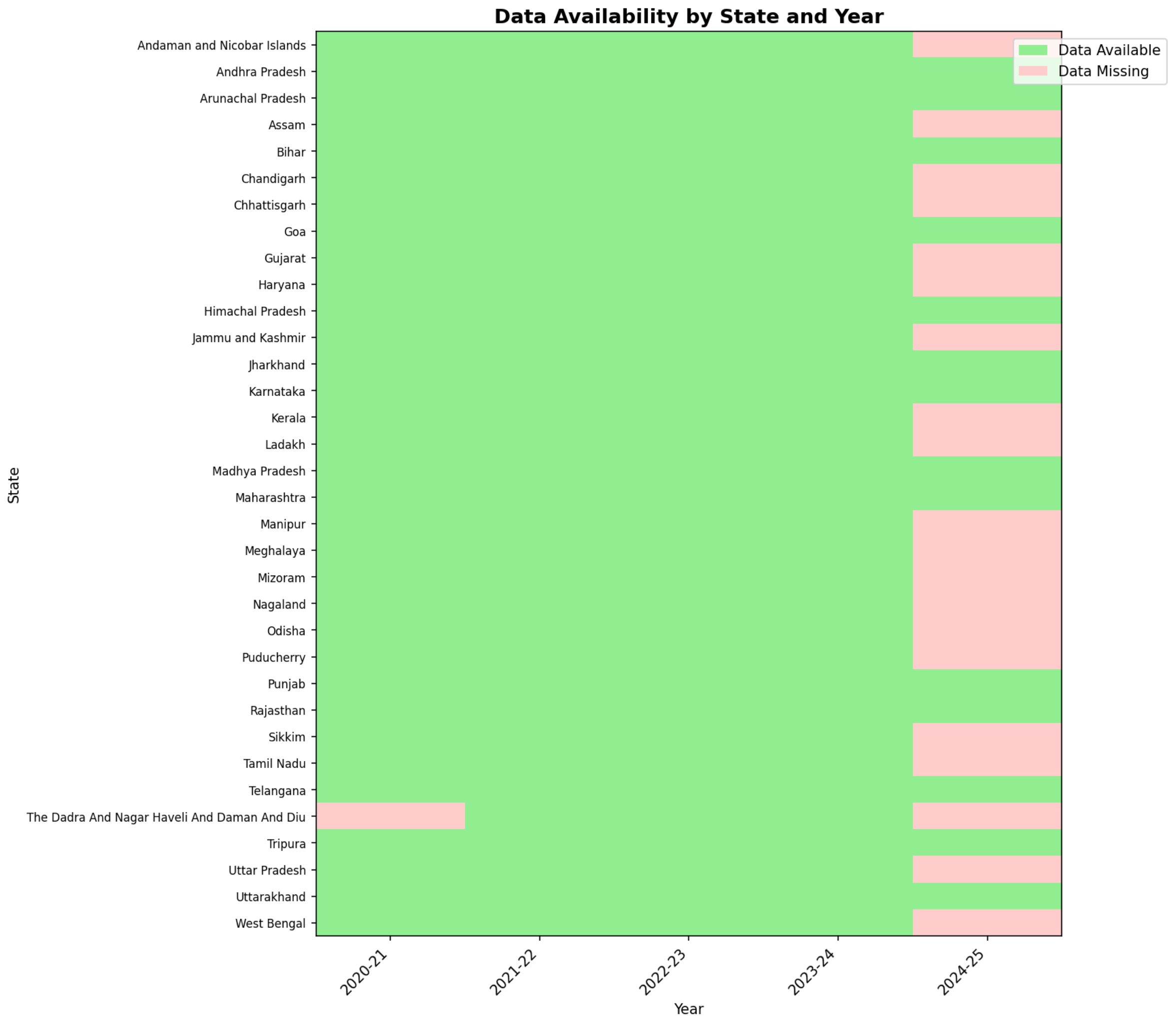

Figure 7: Data availability heatmap showing state coverage across years. Green indicates data available; red indicates missing data. The dramatic reduction in 2024-25 coverage is clearly visible.

7 Chapter 2: Long-Term Temporal Trends (2000–2023)

This chapter presents a comprehensive analysis of long-term temporal trends in Indian agriculture over a 24-year period (2000–2023). By combining historical district-level data (2000–2019) with recent DES district data (2020–2023), this analysis reveals how yield, area, and production have evolved over two decades.

Chapter Scope:

- **Time Period:** 2000–2023 (24 years)
- **Data Sources:** Historical APY (2000–2019) + DES District Data (2020–2023)
- **Key Analyses:** CAGR trends, decadal comparisons, yield stability assessment
- **Coverage:** Major food grains, pulses, and oilseeds

7.1 Unit Harmonization

7.1.1 Critical Data Transformation

A trivial challenge in combining historical and modern datasets is unit harmonization. The historical dataset (2000–2019) reports yield in **Tonnes per Hectare (T/Ha)**, while the DES data (2020–2023) reports yield in **Kilograms per Hectare (Kg/Ha)**.

$$\boxed{Y_{\text{Kg/Ha}} = Y_{\text{T/Ha}} \times 1000} \tag{14}$$

Table 19: Unit Harmonization Reference

Dataset	Period	Original Yield Unit	Conversion	Final Unit
Historical APY	2000–2019	Tonnes/Ha	×1000	Kg/Ha
DES District	2020–2023	Kg/Ha	×1	Kg/Ha

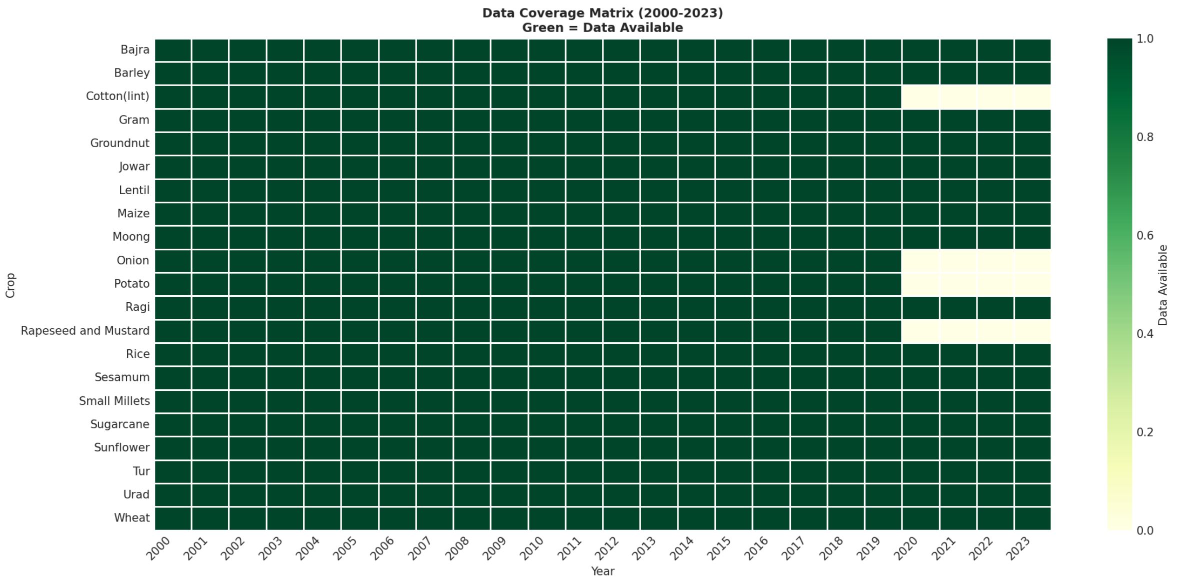

Figure 8: Data coverage visualization showing the temporal extent and record counts for the combined APY dataset (2000–2023). The vertical dashed line at 2020 marks the transition from historical data to DES district data.

7.1.2 Data Quality Filters

To ensure robust trend analysis, the following quality filters are applied to the combined dataset:

- **Minimum Area:** Records with Area ≤ 0 Ha excluded
- **Minimum Yield:** Records with Yield < 50 Kg/Ha excluded (likely errors)
- **Maximum Yield:** Records with Yield $> 20,000$ Kg/Ha excluded (practical implausibility)
- **Aggregate Crops Excluded:** "Total Food Grains", "Total Pulses", etc.
- **Seasons:** Only Kharif, Rabi, Summer, and Annual seasons retained

7.2 Long-Term National Trends

7.2.1 Trend Measurement Methodology

For each crop, the analysis computes trend statistics using the following metrics:

Compound Annual Growth Rate (CAGR):

$$\boxed{\text{CAGR} = \left(\frac{Y_{\text{final}}}{Y_{\text{initial}}}\right)^{\frac{1}{n}} - 1} \tag{15}$$

where Y_{initial} is the first-year yield, Y_{final} is the last-year yield, and n is the number of years between them.

Linear Regression Analysis:

$$Y_t = \alpha + \beta \cdot t + \epsilon_t \tag{16}$$

The coefficient of determination (R^2) measures the strength of the linear trend:

$$R^2 = 1 - \frac{\sum_t (Y_t - \hat{Y}_t)^2}{\sum_t (Y_t - \bar{Y})^2} \tag{17}$$

Coefficient of Variation (CV):

$$\text{CV} = \frac{\sigma_Y}{\bar{Y}} \times 100\% \tag{18}$$

The CV measures yield volatility-lower values indicate more stable yields.

7.2.2 National Yield CAGR by Crop (2000–2023)

Table 20: National Yield Trends: CAGR and R^2 for Major Crops (2000–2023)

Crop	2000 (Kg/Ha)	2023 (Kg/Ha)	CAGR (%)	R^2	CV (%)	N (Years)	Trend
Bajra	697	1,454	+3.25	0.76	23.3	24	↑
Groundnut	1,032	2,151	+3.25	0.66	28.1	24	↑
Maize	1,827	3,347	+2.67	0.89	23.1	24	↑
Barley	1,859	3,082	+2.22	0.88	17.3	24	↑
Gram	750	1,153	+1.89	0.74	17.5	24	↑
Jowar	794	1,165	+1.68	0.42	14.8	24	↑
Rice	2,133	2,879	+1.31	0.87	12.5	24	↑
Tur	620	819	+1.21	0.36	17.8	24	↑
Wheat	2,712	3,558	+1.19	0.79	13.3	24	↑
Sugarcane	10,871	13,638	+0.99	0.05	39.8	24	→
Ragi	1,528	1,374	−0.46	0.08	16.5	24	↓

Legend: ↑ = Strong improvement, ↑* = High volatility, → = Stable, ↓ = Declining

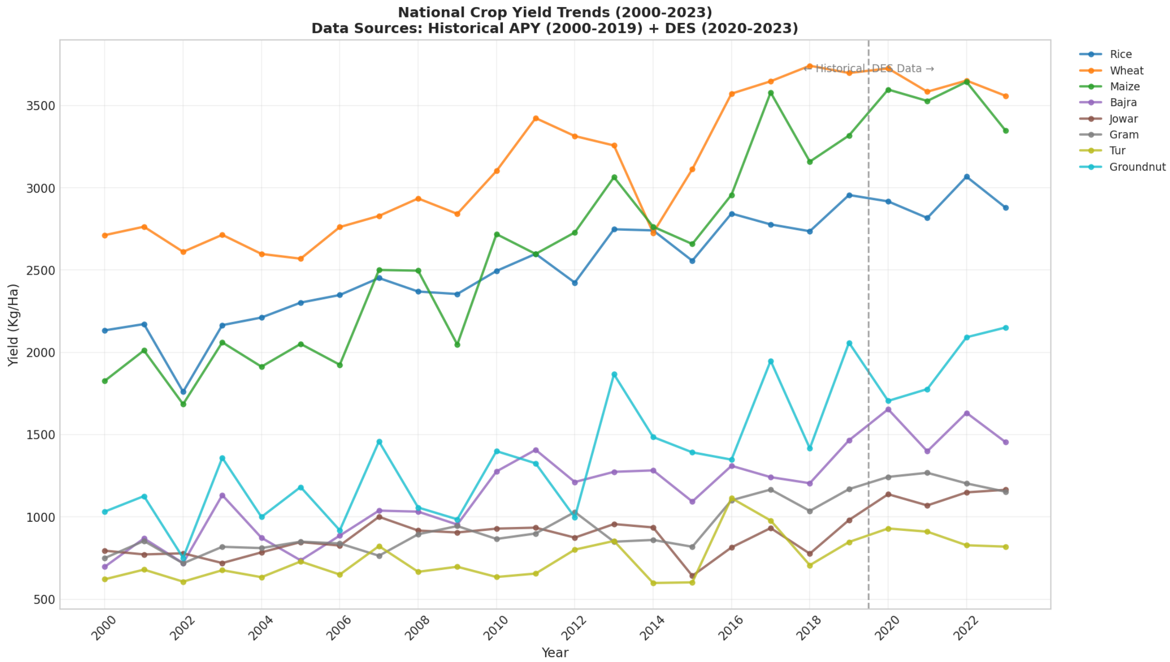

Figure 9: Long-term yield trends (2000–2023) for major crops. Each subplot shows the annual national average yield with a linear trend line. The shaded region indicates the 95% confidence interval. Crops are ordered by CAGR magnitude.

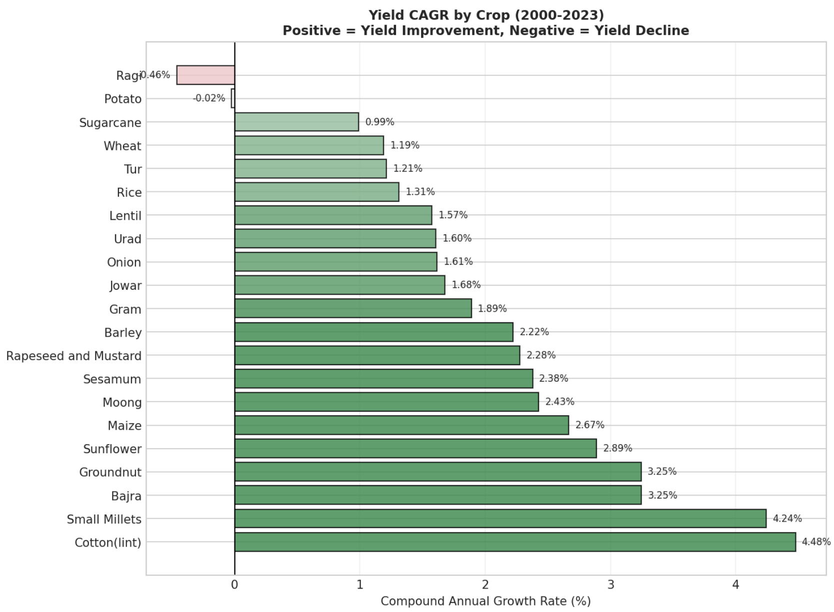

Figure 10: Compound Annual Growth Rate (CAGR) by crop for the period 2000–2023. Green bars indicate positive growth; red bars indicate declining yields. Error bars show the 95% confidence interval for the trend estimate.

Note:

Key Observations: National Yield Trends

1. **Highest CAGR (All Crops):** Cotton(lint) (+4.48%) and Small Millets (+4.24%) lead overall. Among food grains, Bajra (+3.25%) and Groundnut (+3.25%) show the strongest improvements, though with high volatility (CV > 20%).
2. **Strongest Trends ($R^2 > 0.85$):** Maize and Barley show highly consistent upward trends with R^2 values of 0.89 and 0.88 respectively.
3. **Declining Crop:** Ragi shows a negative CAGR (−0.46%), indicating yield stagnation or decline over the period.
4. **Most Stable:** Rice has low CV (12.5%) with consistent CAGR (+1.31%), indicating steady, reliable improvement.
5. **Overall:** 18 crops show improving yields, 0 declining, and 3 stable across the 24-year period.

7.3 Decadal Analysis

7.3.1 Yield Comparison: 2000s vs 2010s vs 2020s

To understand the evolution of agricultural productivity, yields are compared across three decades:

- **2000s:** Years 2000–2009
- **2010s:** Years 2010–2019
- **2020s:** Years 2020–2023 (partial decade)

Table 21: Decadal Yield Averages and Changes (Kg/Ha)

Crop	2000s Avg	2010s Avg	2020s Avg	2000s→2020s	2010s→2020s
Rice	2,227	2,688	2,920	+31.1%	+8.7%
Wheat	2,734	3,360	3,630	+32.8%	+8.1%
Maize	2,052	2,955	3,529	+72.0%	+19.4%
Bajra	894	1,277	1,535	+71.8%	+20.2%
Gram	824	979	1,217	+47.7%	+24.2%
Groundnut	1,087	1,524	1,931	+77.7%	+26.7%
Sugarcane	8,183	8,210	11,346	+38.7%	+38.2%
Average	—	—	—	**+53.1%**	**+20.8%**

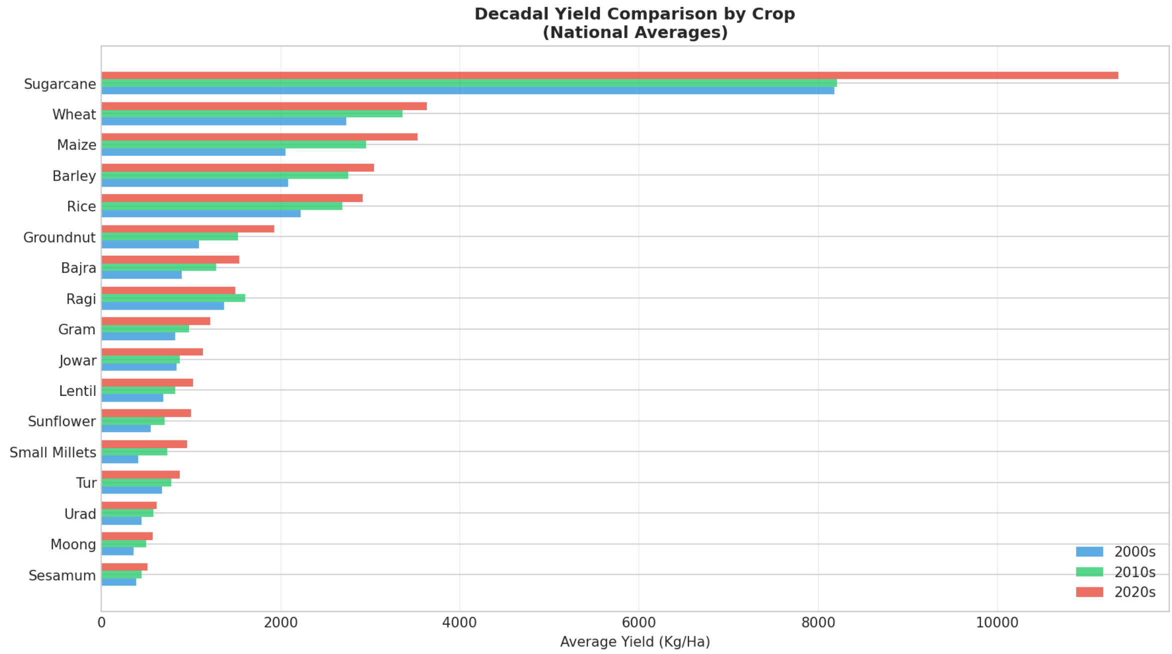

Figure 11: Decadal yield comparison showing average yields for major crops across the 2000s, 2010s, and 2020s. The grouped bar chart illustrates the progressive improvement in yields across all major crops, with Bajra and Groundnut showing the most dramatic transformations.

Note:

Decadal Analysis Insights

1. **Groundnut Transformation:** Yield improved by +77.7% from the 2000s to 2020s.
2. **Maize Modernization:** Strong growth of (+72.0%) is observed.
3. **Bajra Improvement:** Significant improvement is of (+71.8%) is observed here also.
4. **Continued Acceleration:** The 2010s→2020s growth rate remains robust (+20.8% average).

7.4 Yield Stability vs Growth Analysis

7.4.1 Volatility Classification Framework

Crops are classified into four categories based on their CAGR and Coefficient of Variation (CV):

Table 22: Yield Stability-Growth Classification Matrix

Stability ↓ / Growth →	**Low CV (<15%) (Stable)**	**High CV (≥15%) (Volatile)**
High CAGR (>1%) (Growing)	**IDEAL** Stable + Growing	**HIGH-RISK GROWTH** Volatile + Growing
Low CAGR (≤1%) (Stagnant/Declining)	**STABLE** Stable + Stagnant	**CONCERN** Volatile + Declining

7.4.2 Crop Classification Results

Table 23: Crop Classification by Stability and Growth (2000–2023)

Crop	CAGR (%)	CV (%)	Category	Assessment
Rice	+1.31	12.5	IDEAL	Stable + Growing
Wheat	+1.19	13.3	IDEAL	Stable + Growing
Barley	+2.22	17.3	HIGH-RISK	Good Growth, Moderate Volatility
Bajra	+3.25	23.3	HIGH-RISK	High Growth, High Volatility
Groundnut	+3.25	28.1	HIGH-RISK	High Growth, High Volatility
Maize	+2.67	23.1	HIGH-RISK	Good Growth, High Volatility
Gram	+1.89	17.5	HIGH-RISK	Moderate Growth, Borderline Volatility
Jowar	+1.68	14.8	IDEAL	Moderate Growth, Low Volatility
Ragi	−0.46	16.5	CONCERN	Declining Yield
Sugarcane	+0.99	39.8	CONCERN	Slow Growth, Very High Volatility

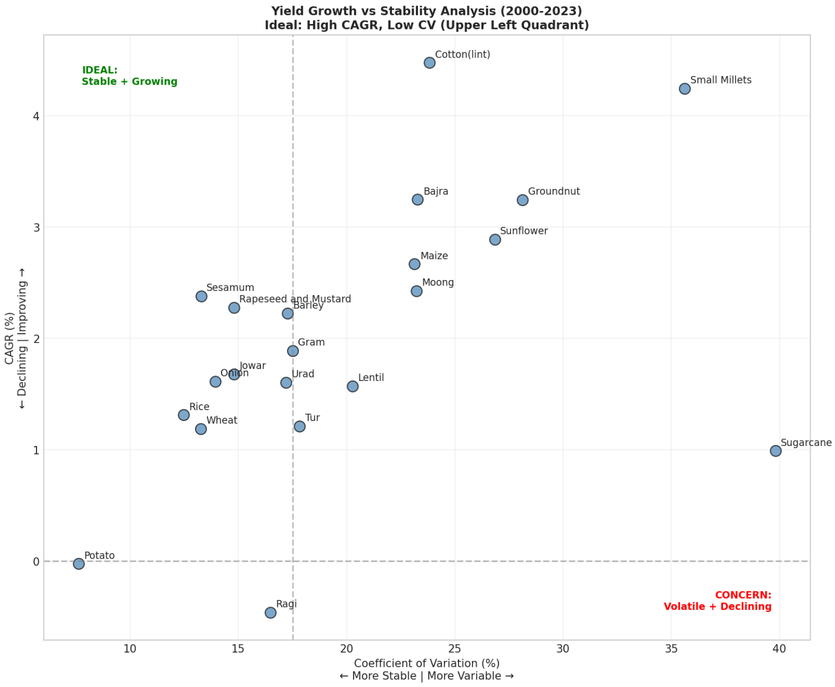

Figure 12: Comprehensive volatility analysis showing year-over-year yield variability for major crops. The box plots indicate the distribution of annual yield changes, while the whiskers show the range of extreme values.

7.5 Regional Performance Analysis

7.5.1 Area-Weighted CAGR Methodology

State-level yield performance is assessed using an **area-weighted average CAGR**, which ensures that crops with larger cultivated areas have proportionally more influence on the state's overall performance metric:

$$\boxed{\text{Weighted CAGR}_{\text{state}} = \frac{\sum_c \left(\text{CAGR}_c \times \bar{A}_c\right)}{\sum_c \bar{A}_c}} \tag{19}$$

where CAGR_c is the compound annual growth rate for crop c, and $\bar{A}_c$ is the average cultivated area (in hectares) for that crop over the analysis period.

This methodology provides a more accurate representation of agricultural transformation than simple averages, as it weights improvements in major crops (like Rice and Wheat) more heavily than niche crops with smaller footprints.

7.5.2 State-Level Yield CAGR Rankings

The following analysis identifies top-performing states based on **area-weighted** average yield CAGR across major crops.

Table 24: Top 10 States by Area-Weighted Yield CAGR (2000–2023)

Rank	State	Weighted CAGR (%)	N Crops	Top Crop by Area
1	Gujarat	+5.89	17	Cotton(lint)
2	Chhattisgarh	+5.42	21	Rice
3	Madhya Pradesh	+3.60	21	Wheat
4	Rajasthan	+3.08	19	Bajra
5	Himachal Pradesh	+2.97	19	Wheat
6	Jammu and Kashmir	+2.81	17	Maize
7	Maharashtra	+2.31	16	Cotton(lint)
8	Bihar	+1.95	19	Wheat
9	Meghalaya	+1.72	12	Rice
10	Uttarakhand	+1.69	18	Wheat
National Average		**+2.03**	—	—

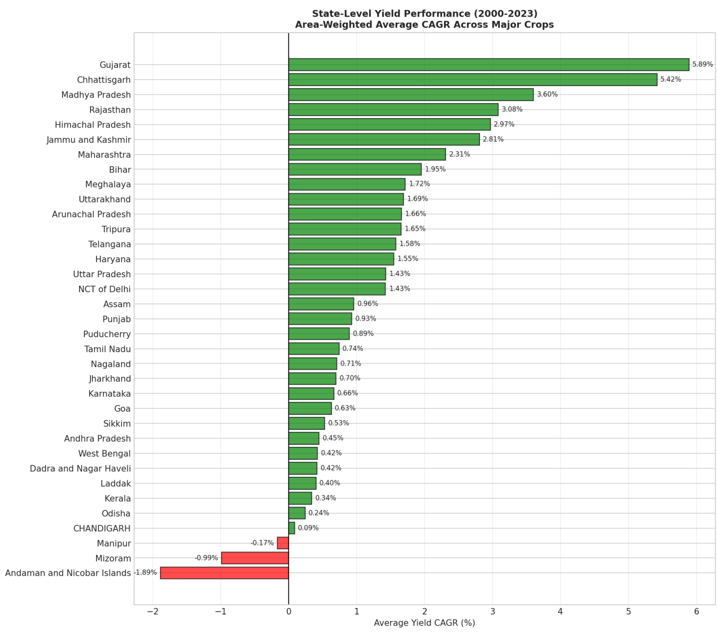

Figure 13: State-level yield improvement analysis showing the **area-weighted** CAGR across major crops for each state. States are ranked by their weighted yield growth rate, with Gujarat (+5.89%) and Chhattisgarh (+5.42%) leading the improvement trajectory. The area-weighted methodology ensures that dominant crops in each state have proportionally more influence on the overall score.

Note:

Regional Performance Insights (Area-Weighted Analysis)

1. **Gujarat Leadership:** Highest area-weighted CAGR (+5.89%) driven by dramatic improvements in Cotton yields, which dominates the state's agricultural landscape.
2. **Chhattisgarh Rice Revolution:** Second-highest CAGR (+5.42%) reflects significant Rice yield improvements—the state's predominant crop.
3. **Central India Growth:** Madhya Pradesh (+3.60%) and Rajasthan (+3.08%) show strong performance weighted by their major crops (Wheat and Bajra respectively).
4. **Hill States Progress:** Himachal Pradesh (+2.97%) and Jammu & Kashmir (+2.81%) demonstrate consistent improvement despite challenging terrain.

7.5.3 Bottom Performing States

Table 25: States with Below-Average Area-Weighted Yield CAGR (2000–2023)

Rank	State	Weighted CAGR (%)	N Crops	Challenges
1	Andaman & Nicobar	−1.89	9	Island geography constraints
2	Mizoram	−0.99	8	Infrastructure constraints
3	Manipur	−0.17	11	Limited agricultural base
4	Chandigarh	+0.09	5	Urbanization pressure
5	Odisha	+0.24	8	Rice-dominant, slow improvement

7.6 Supplementary Visualizations

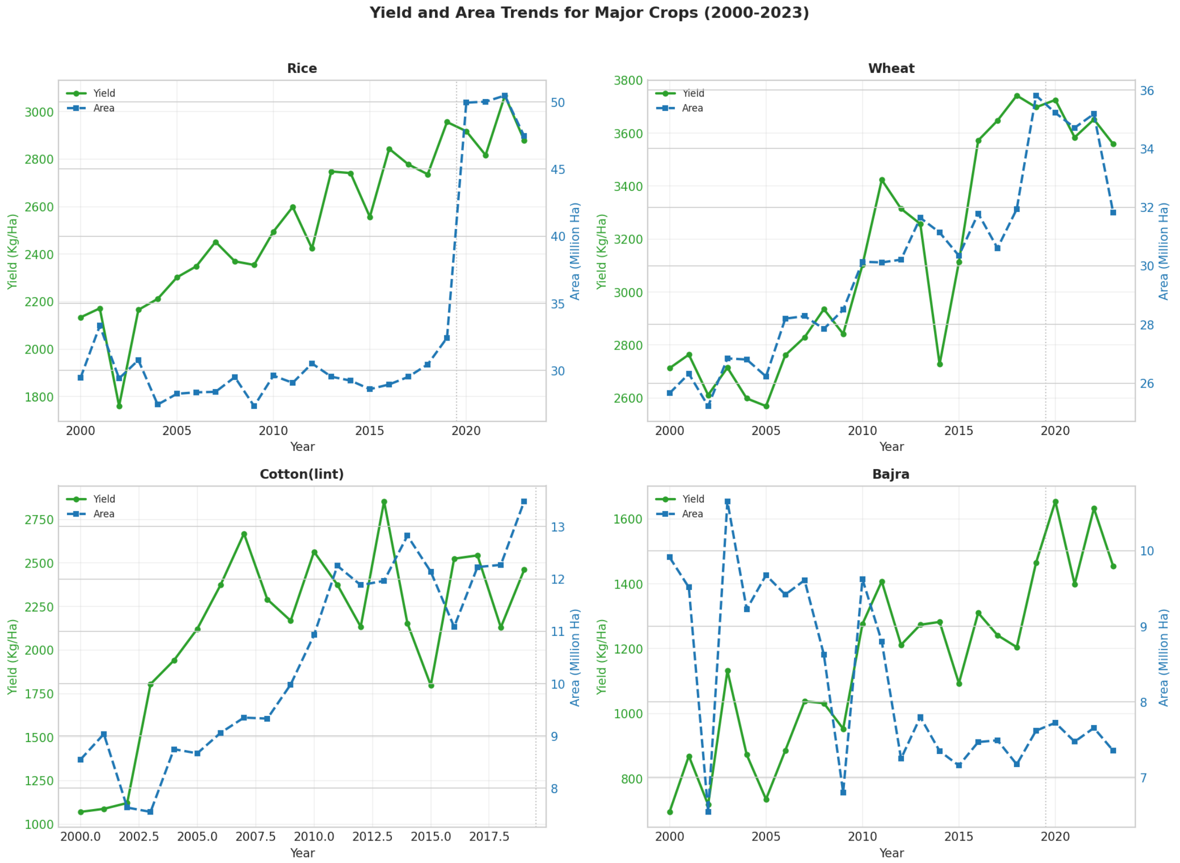

Figure 14: Yield and area trends on dual axes for major crops (2000–2023). The left y-axis shows yield (Kg/Ha); the right y-axis shows cultivated area (Lakh Ha). This visualization helps identify whether yield improvements are accompanied by area expansion or contraction.

7.7 Chapter 2 Summary

Long-Term Temporal Trends: Key Findings

National Performance (2000–2023):

- Average yield CAGR across major crops: **+2.03%**
- Average yield coefficient of variation: **20.0%**
- Data coverage: 369,838 records across 39 states and 64 crops
- Most consistent trends: Maize ($R^2 = 0.89$), Barley ($R^2 = 0.88$), Rice ($R^2 = 0.87$)

Stability Assessment:

- **IDEAL Crops (Stable + Growing):** Rice, Wheat, Jowar
- **HIGH-RISK Crops (Volatile + Growing):** Bajra, Groundnut, Maize, Gram, Barley
- **CONCERN Crops:** Ragi (declining yield), Sugarcane (slow growth, very high volatility)

Regional Leaders (Area-Weighted CAGR):

- **Highest CAGR:** Gujarat (+5.89%), Chhattisgarh (+5.42%), Madhya Pradesh (+3.60%)
- **Lowest CAGR:** A&N Islands (−1.89%), Mizoram (−0.99%), Manipur (−0.17%)

Methodology Note: State-level rankings use area-weighted CAGR (Equation 19), ensuring that dominant crops in each state have proportionally more influence on the overall performance score.

8 Chapter 3: Spatial Multiplier Analysis (2020–2024)

This chapter analyzes district-level yield performance relative to national baselines for the 2020–2024 period. Using a multiplier framework, we quantify how each district compares to the national area-weighted average, enabling identification of high-performing agricultural regions and areas requiring intervention.

Chapter Scope:

- **Primary Focus:** District-level yield performance relative to national baseline
- **Core Metric:** Yield Multiplier ($M_d = Y_d/Y_{base}$)
- **Data Source:** DES District Data (2020-21 to 2023-24)
- **Key Outputs:** Performance classification, choropleth maps, regional spotlights

8.1 Methodology

The spatial multiplier framework provides a standardized measure of district yield performance by comparing each district's yield against a production-weighted national baseline.

8.1.1 Base Yield Calculation

The **Base Yield** (Y_{base}) is defined as the national area-weighted average yield for a specific crop across the four-year analysis period:

$$Y_{base} = \frac{\sum_d (Y_d \times A_d)}{\sum_d A_d} \tag{20}$$

where:

- Y_d = Average yield of district d over the analysis period (Kg/Ha)
- A_d = Average cultivated area of district d over the analysis period (Ha)

This area-weighted formulation ensures that larger producing districts contribute proportionally more to the national baseline, providing a production-representative average rather than a simple arithmetic mean.

8.1.2 District Multiplier Calculation

The **District Multiplier** (M_d) quantifies each district's yield performance relative to the national baseline:

$$M_d = \frac{Y_d}{Y_{base}} \tag{21}$$

Interpretation:

- $M_d = 1.5 \rightarrow$ District performs **50% better** than national average
- $M_d = 1.0 \rightarrow$ District **matches** national average
- $M_d = 0.5 \rightarrow$ District performs **50% worse** than national average

8.1.3 Performance Classification

Districts are classified into five performance categories based on their multiplier values:

Table 26: District Performance Classification Based on Yield Multiplier

Category	**Multiplier Range**	**Interpretation**
Excellent	$M_d \geq 1.5$	District yields ≥50% above national average
Above Average	$1.2 \leq M_d < 1.5$	District yields 20–50% above national average
Near Average	$0.8 \leq M_d < 1.2$	District yields within ±20% of national average
Below Average	$0.5 \leq M_d < 0.8$	District yields 20–50% below national average
Poor	$M_d < 0.5$	District yields >50% below national average

8.2 Overall Multiplier Analysis

The **Overall Multiplier** extends the crop-specific analysis to provide a comprehensive measure of each district's agricultural performance across all crops grown in that district.

8.2.1 Overall Multiplier Calculation

For each district, the overall multiplier is computed as an area-weighted average of individual crop multipliers:

$$M_{overall,d} = \frac{\sum_c (M_{c,d} \times A_{c,d})}{\sum_c A_{c,d}} \tag{22}$$

where:

- $M_{c,d}$ = Multiplier for crop c in district d
- $A_{c,d}$ = Area under crop c in district d

This formulation weights each crop's multiplier by its area contribution, ensuring that major crops in the district have proportionally greater influence on the overall score.

8.2.2 National Overview

Figure 15 presents the spatial distribution of overall yield multipliers across India, revealing distinct regional patterns in agricultural productivity.

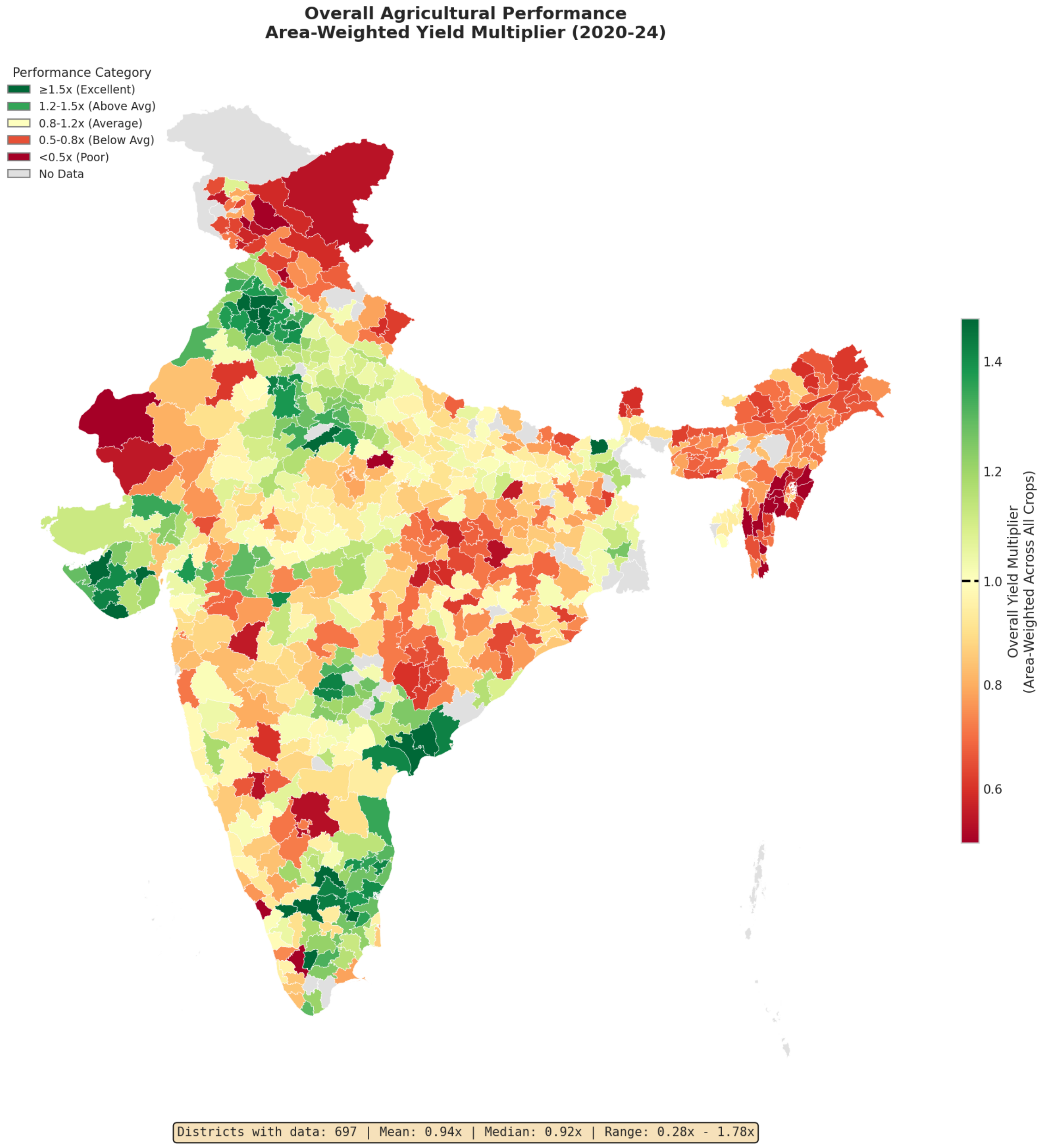

Figure 15: Overall agricultural performance map of India (2020–2024). Each district is colored by its area-weighted yield multiplier across all food grain crops. Green districts outperform the national average; red districts underperform. The map reveals strong regional clustering, with Indo-Gangetic plains and coastal regions showing above-average performance.

Note:

Key Observations from National Map

1. **High-Performance Corridors:** Punjab-Haryana belt, coastal Andhra Pradesh, and Tamil Nadu delta regions consistently show multipliers >1.2x.
2. **Underperforming Regions:** Parts of central India, northeastern states, and rain-shadow districts show multipliers <0.8x.
3. **Irrigation Effect:** Districts with extensive canal irrigation (Punjab, western UP) significantly outperform rainfed counterparts.

8.3 Regional Crop Spotlights

This section provides detailed analysis of specific crop-state combinations that represent critical agricultural systems in India.

8.3.1 Punjab – Wheat

Punjab is India's premier wheat-producing state, contributing approximately 17% of national wheat production. The state's yield performance reflects decades of Green Revolution investments in irrigation, high-yielding varieties, and agricultural extension.

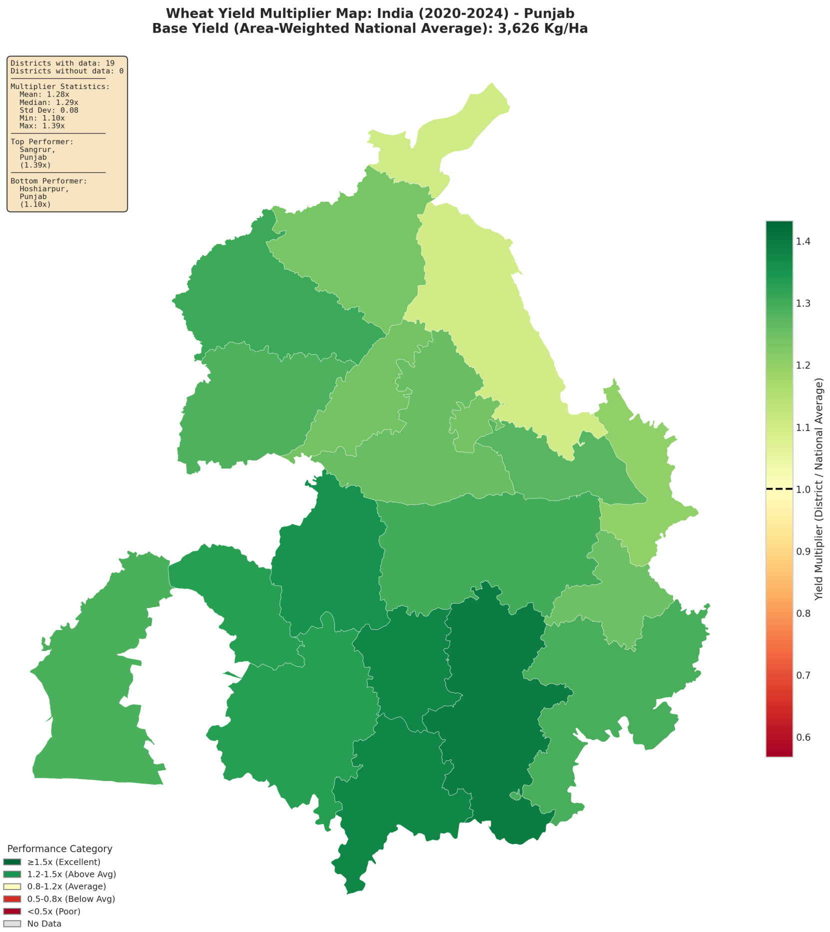

Figure 16: Wheat yield multiplier map for Punjab (2020–2024). Districts are colored by their wheat yield relative to the **national** area-weighted average of 3,626 Kg/Ha. The green coloring across all districts indicates Punjab consistently outperforms the national baseline.

Punjab Wheat Performance Summary

- **National Base Yield:** 3,626 Kg/Ha (area-weighted national average)
- **Punjab State Average:** 4,710 Kg/Ha—approximately 30% above national baseline
- **District Range:** 3,985 Kg/Ha (Hoshiarpur) to 5,051 Kg/Ha (Sangrur)
- **National Multipliers:** All Punjab districts exceed 1.0x national; range 1.10x–1.39x

8.3.2 Maharashtra – Sugarcane

Maharashtra is a leading sugarcane producer in India, contributing significantly to the country's sugar production. The state's sugarcane cultivation is concentrated in the western and central regions, benefiting from irrigation infrastructure from major rivers like the Krishna, Bhima, and Godavari.

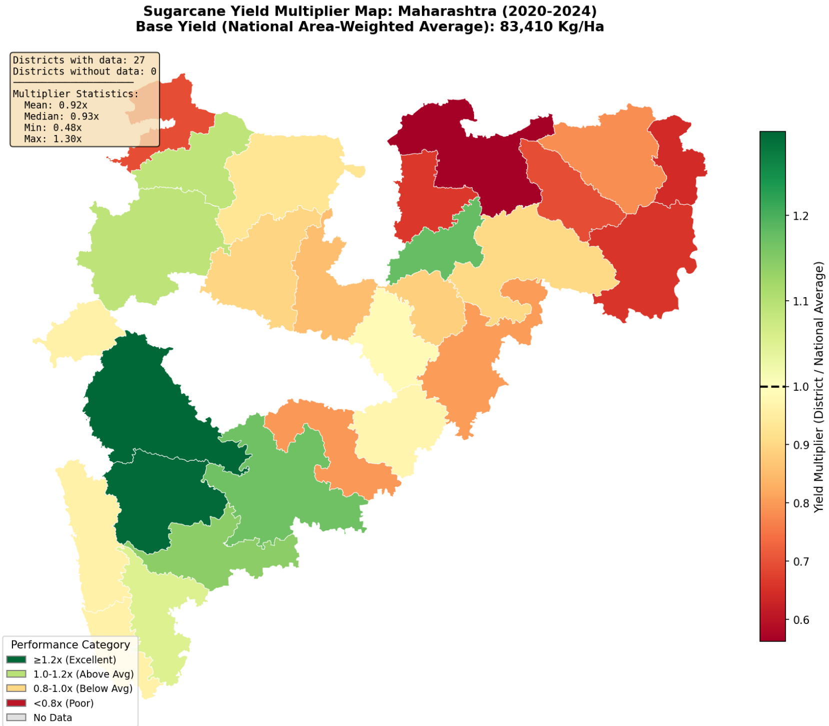

Figure 17: Sugarcane yield multiplier map for Maharashtra (2020–2024). Districts are colored by their sugarcane yield relative to the **national** area-weighted average of 83,410 Kg/Ha. The map reveals a clear west-to-east productivity gradient, with western Maharashtra outperforming Vidarbha districts.

Note:

Maharashtra Sugarcane: Regional Performance (vs. National Base)

National Base Yield: 83,410 Kg/Ha | **Maharashtra State Average:** 78,320 Kg/Ha (6% below national)
The sugarcane multiplier map reveals distinct regional patterns across Maharashtra:

- **Above Average ($M_d \geq 1.1$):** Pune (1.30x, 108,567 Kg/Ha), Satara (1.29x), Washim (1.18x), Solapur (1.17x), Sangli (1.14x), Kolhapur (1.14x)
- **Near Average ($0.8 \leq M_d < 1.1$):** Ahmednagar (1.02x), Nashik (0.94x), Jalgaon (0.88x), Aurangabad (0.85x), Osmanabad (0.82x)
- **Below Average ($M_d < 0.8$):** Buldhana (0.69x), Akola (0.66x), Chandrapur (0.66x), Bhandara (0.64x), Amravati (0.48x)

Western Maharashtra districts (Pune, Satara, Kolhapur, Sangli) achieve 14–30% above national average, while Vidarbha districts lag 34–52% below, reflecting differences in irrigation access and agronomic practices.

8.3.3 Andhra Pradesh – Rice

Andhra Pradesh is among India's top rice producers, with cultivation concentrated in the Krishna-Godavari delta and coastal districts. The state benefits from extensive canal irrigation and favorable climate for multiple cropping seasons.

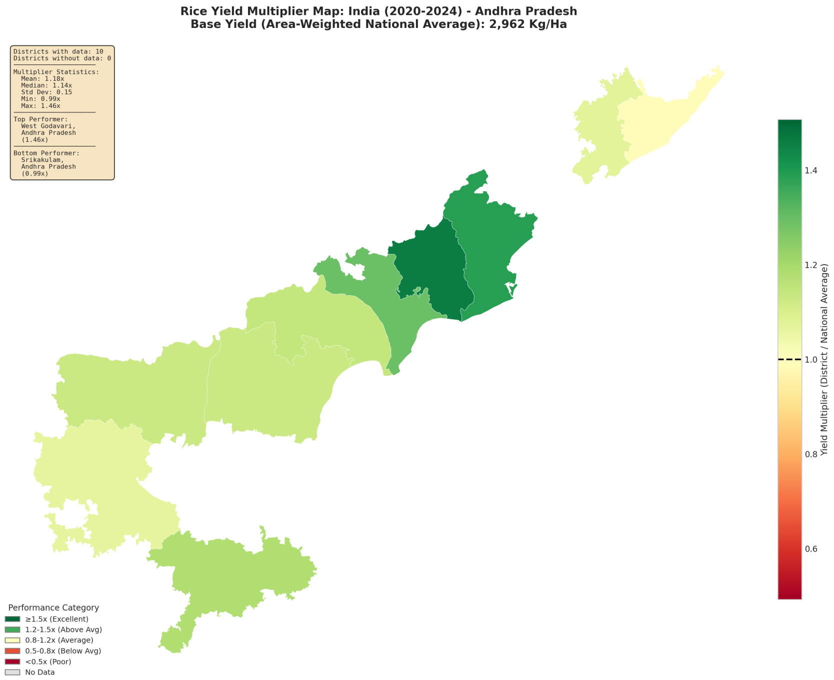

Figure 18: Rice yield multiplier map for Andhra Pradesh (2020–2024). Districts are colored by their rice yield relative to the **national** area-weighted average of 2,962 Kg/Ha. Green shading indicates above-national performance.

Note:

Andhra Pradesh Rice Performance (vs. National Base)

National Base Yield: 2,962 Kg/Ha | **AP State Average:** 3,771 Kg/Ha (27% above national)
All AP districts meet or exceed 92% of national average; delta districts (Eluru, Konaseema, Godavari) achieve 40–60% above national baseline

8.3.4 Bihar – Maize

Bihar has emerged as a significant maize producer, with cultivation expanding rapidly in recent decades. The state's maize yields show interesting spatial patterns reflecting soil fertility gradients and irrigation access.

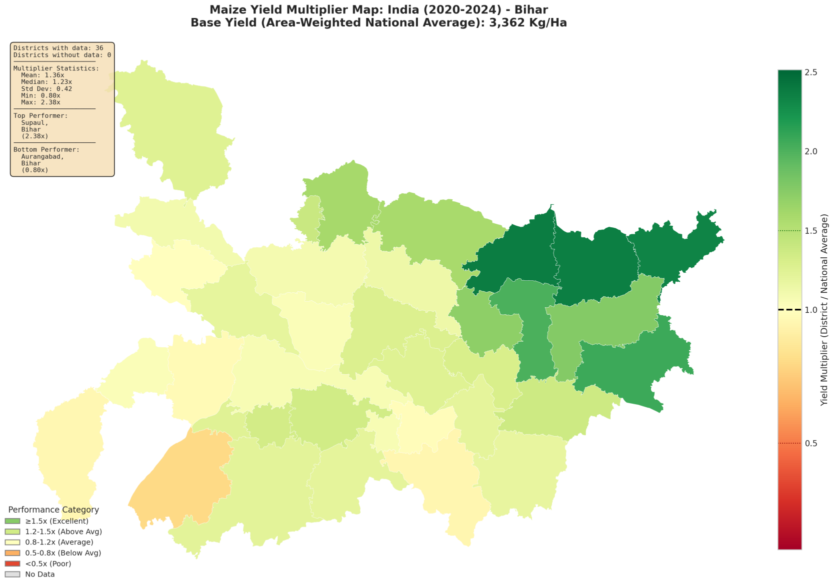

Figure 19: Maize yield multiplier map for Bihar (2020–2024). Districts are colored by their maize yield relative to the **national** area-weighted average of 3,362 Kg/Ha. The dark green shading in northeast Bihar indicates districts exceeding 2x national average.

Bihar Maize Performance (vs. National Base)

- **National Base Yield:** 3,362 Kg/Ha | **Bihar State Average:** 5,547 Kg/Ha (65% above national)
- **Key Pattern:** 9 districts in northeast Bihar exceed 1.5x national (Excellent tier); entire state outperforms national baseline

8.4 Chapter 3 Summary

Spatial Multiplier Analysis: Key Findings (All Multipliers vs. National Base)

National Overview (738 districts analyzed):

- Mean overall multiplier: 0.96x | Median: 0.95x | Range: 0.28x–2.73x
- Performance distribution: 51.5% Near Average, 28.7% Below Average, 15.6% Above Average, 2.6% Excellent, 1.6% Poor

National Base Yields (2020–2024):

- Wheat: 3,626 Kg/Ha | Rice: 2,962 Kg/Ha | Maize: 3,362 Kg/Ha | Sugarcane: 83,410 Kg/Ha

Regional Spotlights (vs. National Base):

- **Punjab-Wheat:** All districts exceed national baseline (1.10x–1.39x); state average 4,710 Kg/Ha (30% above national)
- **Maharashtra-Sugarcane:** Clear west-to-east gradient from 0.48x (Amravati) to 1.30x (Pune); western districts excel while Vidarbha underperforms; state average 78,320 Kg/Ha (6% below national)
- **Andhra Pradesh-Rice:** All districts meet/exceed 92% of national; delta districts at 1.27–1.61x national; state average 3,771 Kg/Ha (27% above national)
- **Bihar-Maize:** 9 districts exceed 1.5x national (Excellent); top performers Supaul/Araria at 2.37–2.38x national; state average 5,547 Kg/Ha (65% above national)

Note:

Access Complete Multiplier Maps
For detailed crop-state and district-level multiplier visualizations beyond those presented in this chapter, the complete collection of multiplier maps is available online:

https://drive.google.com/drive/folders/1NvvWIhkBtMqSaw1-tUtockhkGqwOW4_G?usp=sharing

The repository includes choropleth maps for all major crops across all states, organized by crop type and region.