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A Geometric Welfare-Sensitive Development Index for Indian States and Union Territories: Reassessing Spatial Inequality through Multidimensional Distributional Diagnostics

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Abstract:

Spatial inequality in India is frequently assessed using composite indices that conflate welfare achievements with settlement characteristics, thereby blurring the sources of inter-territorial disparity. This study constructs a three-dimensional Welfare-sensitive Development Index for all 36 Indian states and Union Territories using literacy rate, per capita Gross State Domestic Product, and sex ratio for 2011 and a modeled 2021 scenario. Population density is excluded on theoretical grounds because its welfare polarity is indeterminate without corroborating evidence on service quality and environmental burden. Each indicator is transformed into a ratio-to-mean coefficient and aggregated using a geometric mean to reduce perfect compensability across dimensions. Distributional structure is evaluated using the coefficient of variation, Gini coefficient, Theil index, and Atkinson index, complemented by dimensional balance and binding-constraint diagnostics and rank stability tests. Results show that per capita GSDP is the dominant source of inter-state inequality, with a 2021 coefficient of variation of 55.51 percent, Gini of 0.293, and Theil index of 0.137, whereas literacy and sex ratio display substantially lower dispersion. The composite index shows moderate inequality with a coefficient of variation of 19.72 percent, Gini of 0.110 and Theil index of 0.019. Goa, Delhi and Sikkim emerge as the top three in the 2021 ranking, whereas Bihar, Uttar Pradesh and Jharkhand are the bottom three. Per capita GSDP is the binding constraint for 19 of 36 units. The findings imply that addressing spatial inequality in India requires strengthening productive regional economies along with human capability formation rather than isolated improvements in social indicators.

Keywords: Spatial inequality; Multidimensional welfare measurement; Geometric composite index; Inter-state disparity; India

Introduction:

The principal structural challenge for large federal economies is spatial inequality in human development, a consequence of the territorially differentiated processes of capital accumulation, infrastructure provision, institutional capacity, agglomeration dynamics, and labour market segmentation. Development geography describes these disparities as multidimensional phenomena reflecting uneven access to economic opportunities,

educational attainment and demographic balance, rather than simply income variation (Perroux, 1955; Myrdal, 1957; Hirschman, 1958; Friedmann, 1966; Sen, 1985, 1999). Various theoretical perspectives, such as cumulative causation, growth-pole analysis, unbalanced growth and core-periphery models, indicate that spatial disparities tend to be self-reinforcing in the absence of deliberate redistributive intervention. Perroux (1955) showed that economic growth tends to concentrate through development poles and not to be spread evenly over territory. Myrdal (1957) formalized the cumulative backwash effects, showing that the mobility of factors increases, rather than reduces, the spatial disparity at the early stages of development, while Hirschman (1958) conceptualized unbalanced growth as an intrinsic property of development, and Friedmann (1966) placed regional inequality in the context of core-periphery structures driven by the spatial flows of labor and capital. Williamson (1965) proposed an inverted-U path for regional inequality over the stages of national development, first widening and then narrowing. The recent literature has well-documented the systematic challenge to the hypothesis of mechanical convergence by emphasizing the importance of public infrastructure investment, institutional quality, fiscal transfer mechanisms and governance capability for the reduction of spatial inequality (Barro & Sala-i-Martin, 1992; Kanbur & Venables, 2005; Lessmann, 2014). The conditions under which convergence occurs are therefore contingent rather than automatic, and territorial hierarchies of welfare achievement tend to exhibit structural persistence across extended time periods without targeted policy intervention.

India constitutes a critically important empirical setting for this inquiry. Its 36 states and Union Territories exhibit pronounced divergence in economic structure, demographic composition, historical institutions, administrative capacity, and human development outcomes. The spatial heterogeneity of the Indian federation is not merely a contemporary phenomenon but reflects historically accumulated differentials in agrarian systems, colonial infrastructure investment, post-independence public expenditure allocation, and institutional development trajectories. The post-reform growth following the liberalization of 1991 has not led to uniform territorial convergence, but the leading states have increased the pace of their growth vis-a-vis the laggard states, and inter-state disparities continue in income, infrastructure, social development and institutional indicators (Das & Barua, 1996; Ahluwalia, 2000; Sachs et al., 2002; Bhattacharya & Sakthivel, 2004; Shankar & Shah, 2003; Ohlan, 2013; Kumari et al., 2023). The persistence of these disparities across reform decades underscores the structural rather than transitional character of Indian spatial inequality.

A recurrent methodological limitation in the existing literature on Indian regional development is the conflation of welfare-relevant indicators with settlement characteristics of indeterminate welfare polarity. Population density, in particular, has been incorporated into composite development measures without adequate theoretical justification. High population density may reflect agglomeration

economies, service concentration, and labor market depth, but it may equally indicate land pressure, housing stress, environmental degradation, and urban congestion. Without corroborating evidence on the quality of services, adequacy of housing, transport infrastructure, and the burden of the environment, density cannot be defensibly treated as a direct welfare achievement (Fotheringham & Wong, 1991; Duranton & Puga, 2004; Glaeser & Gottlieb, 2009; World Bank, 2009). The inclusion of theoretically ambiguous variables in composite welfare indices introduces conceptual inconsistencies that undermine the interpretive validity of inter-territorial comparisons. The present study addresses this theoretical inconsistency by constructing a Welfare-sensitive Development Index restricted to three capability-relevant dimensions grounded in Sen's capability approach. Sen (1985, 1999) argued that development must be assessed through the substantive freedoms people have reason to value, extending the evaluative framework beyond income and commodity access. Literacy is a basic human capacity for political participation, economic opportunity and informed decision-making. Per capita GSDP is an indicator of the average economic output and control over resources which determine access to nutrition, health care and material well-being. Sex ratio is a demographic measure of gender balance reflecting the cumulative outcome of gender-specific mortality, migration and social practices affecting the welfare of females (Noorbakhsh, 1998; Sen, 1999; UNDP, 2010). Ratio-to-mean normalization and geometric aggregation are used to avoid full compensability across dimensions, ensuring that deficits on one dimension impose welfare costs which cannot be arithmetically compensated by surpluses on other dimensions (Nardo et al., 2005; OECD & European Commission Joint Research Centre, 2008; Ravallion, 2012; Decancq & Lugo, 2013; Greco et al., 2019). This aggregation procedure is consistent with the post-2010 Human Development Index methodology and accepted quality standards for composite indicators (UNDP, 2010). The study has four explicit objectives: first, to construct a theoretically robust and methodologically transparent state-level welfare index for all 36 Indian states and Union Territories; second, to test the distributional structure using diagnostics such as the coefficient of variation, Gini coefficient, Theil entropy index, and Atkinson index; third, to identify binding developmental constraints for lagging territorial units through dimensional balance and binding-constraint analyses; and fourth, to test rank stability between 2011 and a modeled 2021 scenario using Pearson, Spearman, and Kendall correlation measures. The 2021 values are treated strictly as modeled estimates based on specified projection assumptions and not as official Census observations, as Census 2021 was postponed due to the COVID-19 pandemic and the Government of India has officially notified Census 2027 as the next enumeration (Press Information Bureau, 2025). The paper contributes methodologically by integrating geometric aggregation with a comprehensive distributional diagnostic framework and binding-constraint identification, producing an analytical architecture that advances beyond conventional rank-based composite

exercises in the Indian regional development literature.

Conceptual Framework and Literature Review:

1. Theoretical Foundations of Spatial Inequality:

The theoretical literature on spatial inequality is based on classical location theory, cumulative causation, growth-pole analysis, unbalanced growth and core-periphery models. Perroux (1955) argued that economic growth tends to be concentrated through poles of development, rather than distributed evenly across territory. Myrdal (1957) formalized the effects of cumulative causation and demonstrated that in the early stages of development factor mobility tends to reinforce rather than correct spatial disparities. Hirschman (1958) viewed unbalanced growth as an inherent feature of development, with trickling-down effects that will eventually reduce regional differentials under favourable institutional conditions. Friedmann (1966) placed regional inequality in a wider core-periphery perspective based on spatial flows of labour and capital. Williamson (1965) proposed that regional inequality follows an inverted-U path in stages of national development. However, later studies show that convergence depends heavily on public infrastructure investment, institutional quality and fiscal transfers, and governance capacity, and mechanical convergence cannot be taken for granted (Barro & Sala-i-Martin, 1992; Kanbur & Venables, 2005; Lessmann, 2014). In the Indian context, evidence has repeatedly shown that post-liberalization growth has been spatially uneven, with leading states pulling away from lagging counterparts rather than converging towards a common trajectory (Das & Barua, 1996; Ahluwalia, 2000; Sachs et al., 2002; Bhattacharya & Sakthivel, 2004; Ohlan, 2013).

2. The Capability Approach and Welfare-Relevant Indicators:

The welfare logic of the present index derives from Sen's capability approach. Sen (1985, 1999) argued that development should be assessed by the substantive freedoms that people have reason to value, not by income or commodity access alone. The conceptual foundation justifies the choice of literacy, per capita GSDP and sex ratio as the three dimensions of the WDI. Literacy is a basic human capacity that permits political participation, economic opportunity and informed decision-making. Per capita GSDP is a measure of average economic output and command over resources, which affects access to nutrition, health care and material well-being. Sex ratio provides a demographic signal of gender balance, reflecting the cumulative outcome of gender-specific mortality, migration, and social practices that affect female welfare (Sen, 1999; Noorbakhsh, 1998; UNDP, 2010).

These three indicators do not exhaust welfare, but they are theoretically more defensible than a mixture of welfare indicators and settlement-concentration statistics. The exclusion of population density follows from the theoretical ambiguity of its welfare polarity, which Fotheringham and Wong (1991), Duranton and Puga (2004), and Glaeser and Gottlieb

(2009) have documented in different empirical contexts.

3. Composite Index Construction: Methodological Standards:

Composite indicators require explicit decisions on normalization, weighting, aggregation, and sensitivity analysis (Nardo et al., 2005; OECD & European Commission Joint Research Centre, 2008). Additive linear aggregation allows full compensability: a high value in one dimension can arithmetically offset a serious deficit in another, obscuring the welfare costs of dimensional imbalance. Geometric aggregation reduces this problem by penalizing uneven achievement profiles, since the geometric mean of a set of values is always less than or equal to the arithmetic mean, with the difference increasing as dispersion among the values grows. This feature makes geometric aggregation theoretically consistent with the view that dimensional deficits entail welfare costs which cannot be fully compensated by surpluses elsewhere (Ravallion, 2012; Greco et al., 2019). On these grounds, the post-2010 Human Development Index adopted geometric aggregation (UNDP, 2010). Comprehensive reviews of weighting and aggregation choices in multidimensional welfare indices are provided by Decancq and Lugo (2013) and Booysen (2002).

The Indian empirical literature on regional disparities has used a variety of composite measures, including state-level HDI adaptations, poverty indices, and socioeconomic composite indicators (Dasgupta et al., 2000; Sachs et al., 2002; Ohlan, 2013; Kumari et al., 2023). The present contribution builds on this literature by combining geometric aggregation with an explicit distributional diagnostic framework involving CV, Gini, Theil and Atkinson measures, as well as dimensional balance and binding-constraint analysis.

Data and Methods:

1. Spatial Units and Temporal Scope:

The analysis covers all 36 Indian states and Union Territories. The 2011 values are derived from the project dataset of state-level socioeconomic indicators compiled from Census of India 2011 sources (Office of the Registrar General & Census Commissioner, India, 2011). The 2021 series is a modeled estimate generated through a specified projection methodology: literacy is projected by reducing the remaining gap to full literacy by a fixed proportional rate; per capita GSDP is adjusted for a COVID-19 contraction and partial recovery; and sex ratio is adjusted gradually toward parity. These estimates are used as an analytical scenario throughout the paper. They are not official Census 2021 observations. Census 2021 was postponed due to the COVID-19 pandemic, and the Government of India has notified Census 2027 as the next enumeration, with a reference date in 2027 (Press Information Bureau, 2025).

2. Indicator Selection and Rationale:

Three indicators are used: literacy rate (percentage of population aged seven years and above who can read and write), per capita GSDP (Indian Rupees at current prices), and sex ratio (females per 1000 males). These indicators are available at the state and Union Territory level for 2011 and are the basis for the modeled 2021 series. Population density is not included in the index for the theoretical reasons articulated in Section 2.2.

3. Coefficient Normalization:

Each indicator value is transformed into a ratio-to-mean coefficient:

$$C_{ij} = \left(\frac{x_{ij}}{\bar{x}_j}\right) \times 100 \quad (1)$$

Where C_{ij} is the coefficient for territorial unit i on indicator j, x_{ij} is the observed or estimated value, and $\bar{x}_j$ is the unweighted mean across all 36 units. A coefficient above 100 denotes above-mean performance; a coefficient below 100 denotes below-mean performance. This transformation preserves the relative structure of each distribution while placing all three dimensions on a common scale without imposing minimum-maximum normalization, which is sensitive to extreme values (Nardo et al., 2005).

4. Welfare-Sensitive Development Index:

The WDI is computed as the geometric mean of the three coefficients:

$$\mathrm{WDI}_i = (C_{Li} \times C_{Gi} \times C_{Si})^{\frac{1}{3}} \quad (2)$$

Where C_{Li} is the literacy coefficient, C_{Gi} is the per capita GSDP coefficient, and C_{Si} is the sex-ratio coefficient. Equal weights are applied because no independent empirical or normative weighting scheme is available for this framework, and unverified differential weights would introduce unjustified normative assumptions (Decancq & Lugo, 2013; Greco et al., 2019).

5. Inequality Diagnostics:

The distributional structure of each indicator and the WDI is assessed through four inequality measures:

5.1 Coefficient of variation (CV):

$$\mathrm{CV} = \frac{\sigma}{\mu} \times 100 \quad (3)$$

Measuring relative dispersion.

5.2 Gini coefficient:

$$G = \frac{1}{2n^2\mu}\sum_{i=1}^{n}\sum_{j=1}^{n}|x_i - x_j| \quad (4)$$

Summarizing average pairwise inequality (Gini, 1912; Milanovic, 1997).

5.3 Theil entropy index:

$$T = \frac{1}{n}\sum_{i=1}^{n}\frac{x_i}{\mu}\ln\left(\frac{x_i}{\mu}\right) \quad (5)$$

An entropy-based inequality measure with additive decomposability properties (Theil, 1967; Cowell, 2011).

5.4 Atkinson index:

$$A(\varepsilon) = 1 - \left[\frac{1}{n}\sum_{i=1}^{n}\left(\frac{x_i}{\mu}\right)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}, \quad \varepsilon = 0.5 \quad (6)$$

Expressing the proportional welfare loss attributable to inequality under a specified degree of inequality aversion (Atkinson, 1970).

6. Dimensional Balance and Binding-Constraint Analysis:

Dimensional balance ratio (DBR) for each unit is computed as:

$$\mathrm{DBR}_i = \frac{\min(C_{Li}, C_{Gi}, C_{Si})}{\max(C_{Li}, C_{Gi}, C_{Si})} \quad (7)$$

Values approaching 1 indicate even achievement across all three dimensions; lower values indicate that one dimension substantially outperforms another. The binding constraint for each unit is identified as the dimension with the minimum coefficient value, indicating the dimension most limiting overall welfare performance.

Binding constraint:

$$\mathrm{BC}_i = \arg\min(C_{Li}, C_{Gi}, C_{Si}) \quad (8)$$

7. Temporal Rank Stability:

Rank stability between 2011 and the 2021 estimate is assessed using Pearson correlation (r), Spearman rank correlation (ρ), and Kendall rank correlation (τ). These are reported as descriptive diagnostics only, given that the 2021 values are modeled estimates.

Table 1. Analytical framework, and interpretation.

Component	Interpretation
Literacy coefficient	Relative educational capability
Per capita GSDP coefficient	Relative economic output
Sex-ratio coefficient	Relative demographic gender balance
WDI	Three-dimensional welfare-sensitive composite score
Dimensional balance ratio	Balance of achievement across three dimensions
Binding constraint	Principal dimension constraining unit welfare performance

Results:

1. Indicator-Level Inequality:

The three indicator dimensions exhibit substantially different levels of inter-state dispersion in both 2011 and the 2021 estimate (Table 2). Per capita GSDP is consistently the most unequal dimension. In the 2021 estimate, it records a CV of 55.51%, Gini coefficient of 0.293, Theil index of 0.137, and Atkinson index of 0.067. These values indicate extreme economic heterogeneity across Indian states and Union Territories. Literacy is far less dispersed, with a CV of 9.32%, Gini of 0.053, Theil of 0.004, and Atkinson of 0.002 in 2021. Sex ratio is the least dispersed dimension, with a CV of 5.48%, Gini of 0.029, Theil of 0.001, and Atkinson of 0.001.

The WDI, as the geometric combination of a highly unequal economic dimension with two less dispersed social dimensions, produces a moderate composite inequality: CV of 19.72%, Gini of 0.110, Theil of 0.019, and Atkinson of 0.009 in the 2021 estimate. The compression of inequality from the dimensional to the composite level reflects the mathematical property of the geometric mean and confirms that the economic dimension is the dominant driver of inter-state WDI variation.

Between 2011 and the modeled 2021 series, literacy dispersion declined marginally (CV from 11.46% to 9.32%; Gini from 0.065 to 0.053), consistent with the convergence assumption embedded in the projection methodology. Sex-ratio dispersion also narrowed slightly. Per capita GSDP dispersion remained essentially unchanged, with Gini increasing marginally from 0.291 to 0.293, indicating that modeled economic growth did not reduce relative inter-state economic inequality.

Table 2. Inequality diagnostics for the three indicator dimensions and the WDI, 2011 and 2021 estimate (n = 36).

Dimension	Year	CV (%)	Gini	Theil	Atkinson (ε = 0.5)	Minimum	Maximum
Literacy coefficient	2011	11.46	0.065	0.006	0.003	80.12	121.87
Per capita GSDP coefficient	2011	55.38	0.291	0.136	0.066	27.09	271.72
Sex-ratio coefficient	2011	6.23	0.033	0.002	0.001	82.33	115.30
WDI	2011	20.04	0.111	0.019	0.010	59.62	147.88
Literacy coefficient	2021 estimate	9.32	0.053	0.004	0.002	83.82	117.80
Per capita GSDP coefficient	2021 estimate	55.51	0.293	0.137	0.067	26.80	266.29
Sex-ratio coefficient	2021 estimate	5.48	0.029	0.001	0.001	85.49	114.52
WDI	2021 estimate	19.72	0.110	0.019	0.009	60.31	145.49

Note: All coefficients are ratio-to-mean transformations (mean = 100). 2021 values are modeled estimates, not official Census observations.

2. WDI Ranking and Welfare Geography:

The 2021 WDI ranking reveals a distinct spatial stratification of welfare achievement across Indian states and Union Territories (Table 3; Appendix A). The leading group comprises Goa (WDI = 145.49), Delhi (130.24), Sikkim (127.39), Dadra and Nagar Haveli and Daman and Diu (121.15), Puducherry (118.40), Kerala (116.50), and Chandigarh (114.83). These seven units occupy the top seven positions in both 2011 and the 2021 estimate, confirming structural persistence in welfare geography at the upper end of the distribution.

However, dimensional profiles within the high-performing group differ substantially. Goa, Delhi, Sikkim, Dadra and Nagar Haveli and Daman and Diu, and Chandigarh have high WDI values largely due to high per capita GSDP coefficients (ranging from 155.12 to 266.29 in 2021) and relatively low sex-ratio coefficients (85.49 to 103.08). The units are described as high but uneven with balance ratios of 0.387 to 0.575. Kerala, on the other hand, presents a near-perfect balance ratio of 0.972 with literacy (117.80), per capita GSDP (117.22) and sex-ratio (114.52) coefficients all above the national mean and closely matched. Puducherry and Tamil Nadu also show high balance ratios (0.787 and 0.826 respectively), indicating that their welfare performance is broadly distributed across all three dimensions rather than driven by economic dominance.

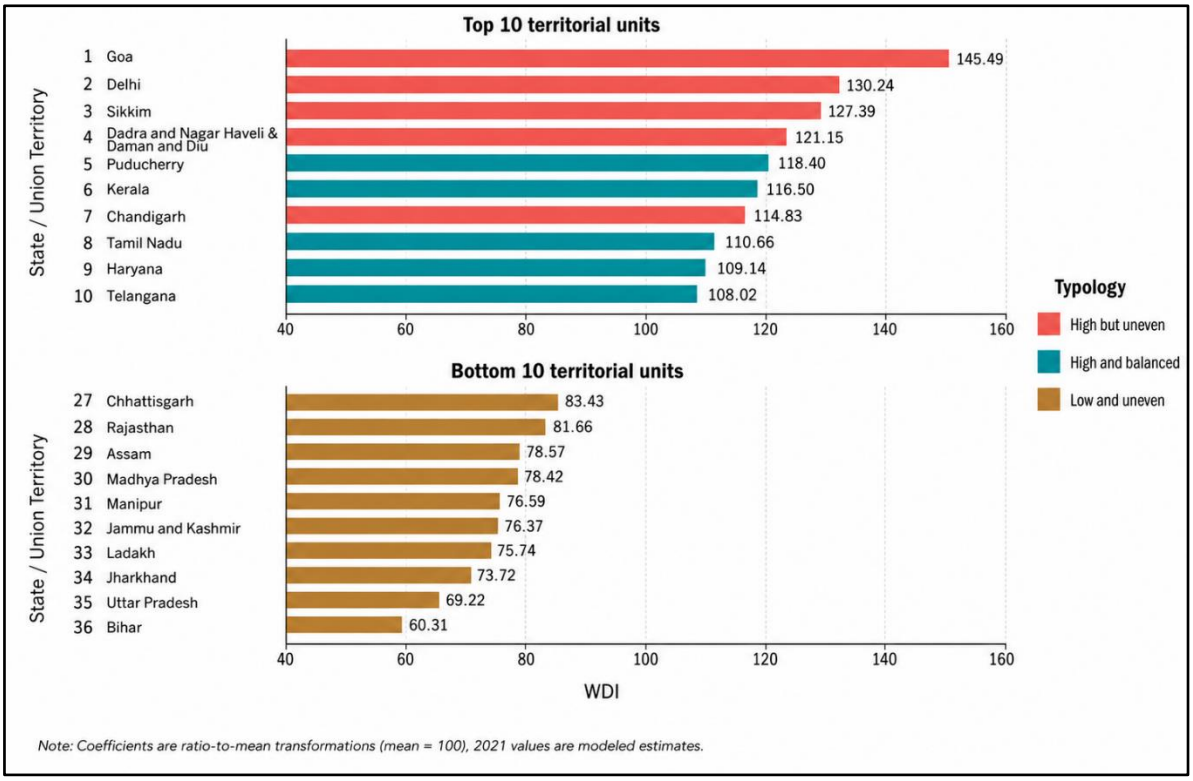

Figure 1. WDI Top 10 and bottom 10 ranking, India

At the lower end of the WDI distribution, Bihar records the lowest score (60.31), followed by Uttar Pradesh (69.22), Jharkhand (73.72), Ladakh (75.74), Jammu and Kashmir (76.37), Manipur (76.59), Madhya Pradesh (78.42), Assam (78.57), Rajasthan (81.66), and Chhattisgarh (83.43). These units share a common structural characteristic: their per capita GSDP coefficients are severely depressed (ranging from 26.80 in Bihar to 62.55 in Rajasthan), while their literacy and sex-ratio coefficients are substantially less deficient. Bihar's per capita GSDP coefficient of 26.80 is the lowest in the entire distribution, at less than one-quarter of the national mean, and this single dimension drives its last-place WDI ranking despite a sex-ratio coefficient of 97.66 that is close to the national mean.

The WDI range in the 2021 estimate spans from 60.31 to 145.49, a ratio of 2.41:1. The top-quintile to bottom-quintile mean WDI ratio is 1.71:1. These metrics confirm substantial but not extreme composite welfare inequality, a result consistent with the moderating effect of the geometric aggregation when one dimension (literacy) has already converged substantially across states.

Table 3. WDI ranking, dimensional coefficients, balance ratio, and binding constraint: top 10 and bottom 10 territorial units, 2021 estimate.

Group	State/UT	WDI Rank	WDI	Literacy Coeff.	GSDP Coeff.	Sex-Ratio Coeff.	Balance Ratio	Binding Constraint	Typology
Top 10	Goa	1	145.49	112.20	266.29	103.08	0.387	Sex-ratio	High but uneven
Top 10	Delhi	2	130.24	109.58	215.76	93.43	0.433	Sex-ratio	High but uneven

Top 10	Sikkim	3	127.39	104.52	207.56	95.29	0.459	Sex-ratio	High but uneven
Top 10	Dadra and Nagar Haveli and Daman and Diu	4	121.15	107.45	193.61	85.49	0.442	Sex-ratio	High but uneven
Top 10	Puducherry	5	118.40	109.20	138.74	109.56	0.787	Literacy	High and balanced
Top 10	Kerala	6	116.50	117.80	117.22	114.52	0.972	Sex-ratio	High and balanced
Top 10	Chandigarh	7	114.83	109.41	155.12	89.21	0.575	Sex-ratio	High but uneven
Top 10	Tamil Nadu	8	110.66	103.12	124.83	105.27	0.826	Literacy	High and balanced
Top 10	Haryana	9	109.14	98.33	140.12	94.36	0.673	Sex-ratio	High and balanced
Top 10	Telangana	10	108.02	88.74	135.92	104.51	0.653	Literacy	High and balanced
Bottom 10	Chhattisgarh	27	83.43	92.77	59.73	104.79	0.570	GSDP	Low and uneven
Bottom 10	Rajasthan	28	81.66	88.37	62.55	98.51	0.635	GSDP	Low and uneven
Bottom 10	Assam	29	78.57	94.78	50.33	101.65	0.495	GSDP	Low and uneven
Bottom 10	Madhya Pradesh	30	78.42	91.76	53.23	98.76	0.539	GSDP	Low and uneven
Bottom 10	Manipur	31	76.59	99.80	43.20	104.22	0.415	GSDP	Low and uneven
Bottom 10	Jammu and Kashmir	32	76.37	89.48	52.28	95.21	0.549	GSDP	Low and uneven
Bottom 10	Ladakh	33	75.74	87.20	52.28	95.29	0.549	GSDP	Low and uneven
Bottom 10	Jharkhand	34	73.72	88.69	45.08	100.20	0.450	GSDP	Low and uneven
Bottom 10	Uttar Pradesh	35	69.22	90.03	37.93	97.15	0.390	GSDP	Low and uneven
Bottom 10	Bihar	36	60.31	83.82	26.80	97.66	0.274	GSDP	Low and uneven

Note: Coefficients are ratio-to-mean transformations (mean = 100). 2021 values are modeled estimates

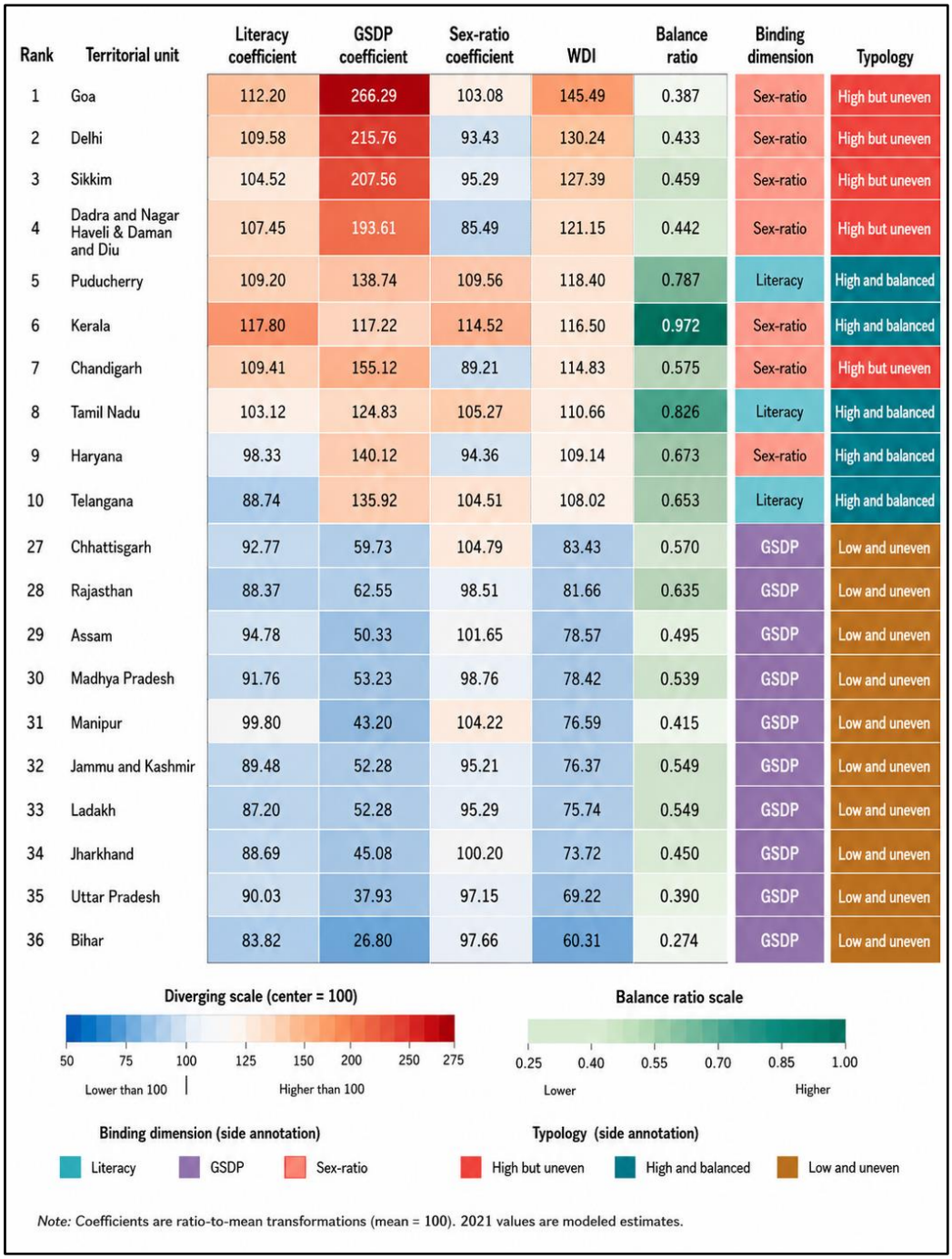

Figure 2. Coefficient Heat Map, India

3. Temporal Rank Stability:

The temporal rank stability between 2011 and the modeled estimate for 2021 is very high across all three correlation measures: Pearson r = 0.999, Spearman ρ = 0.994, and Kendall τ = 0.962. This suggests that the hierarchy of state-level welfare development has not been substantially altered by the modeled decade, which is consistent with the structural persistence of inter-state inequality documented in the Indian regional development literature (Das & Barua, 1996; Sachs et al., 2002; Ohlan, 2013).

Table 4 reports the twelve states and Union Territories with the largest positive and negative WDI changes between 2011 and the 2021 estimate. Telangana records the largest absolute WDI gain (1.764 points), advancing four rank positions. Dadra and Nagar Haveli and Daman and Diu, Haryana, and Rajasthan also

show positive changes while retaining their 2011 rank positions. At the other end, Goa experiences the largest absolute decline (-2.384 points), although it retains its first-place rank. Kerala, Lakshadweep, Mizoram, and Puducherry also show negative WDI changes in the estimate. These declines reflect the coefficient system's relative measurement logic: if a unit's absolute values improve more slowly than the cross-state mean, its coefficient and WDI may decline even when absolute values rise.

Table 4. WDI values and rank changes between 2011 and the 2021 estimate: units with the largest absolute changes.

State/UT	WDI 2011	WDI 2021	Change	Rank 2011	Rank 2021	Rank Change
Telangana	106.26	108.02	+1.764	14	10	+4
Arunachal Pradesh	89.00	90.35	+1.352	22	21	+1
Dadra and Nagar Haveli and Daman and Diu	119.97	121.15	+1.184	4	4	0
Andhra Pradesh	96.47	97.41	+0.941	17	17	0
Haryana	108.39	109.14	+0.748	10	9	+1
Rajasthan	80.93	81.66	+0.728	28	28	0
Goa	147.88	145.49	-2.384	1	1	0
Kerala	118.53	116.50	-2.022	6	6	0
Lakshadweep	88.55	86.63	-1.920	23	24	-1
Mizoram	108.82	107.22	-1.605	9	13	-4
Puducherry	119.86	118.40	-1.459	5	5	0
Andaman and Nicobar Islands	95.71	94.76	-0.956	18	19	-1

Note: Positive rank change indicates improvement; negative indicates decline. 2021 values are modeled estimates.

4. Dimensional Balance and Binding Constraints:

Binding-constraint analysis identifies per capita GSDP as the lowest-scoring dimension for 19 of the 36 territorial units in the 2021 estimate, sex ratio for 11 units, and literacy for 6 units (Table 5). This finding confirms that the economic dimension is the most frequent structural weakness in the development profile of Indian states and Union Territories. Notably, all 10 bottom-ranked units are constrained by the per capita GSDP coefficient, and in several cases (Bihar, Uttar Pradesh, Jharkhand, Manipur) the GSDP coefficient is less than half the national mean while literacy and sex-ratio coefficients are in the range of 83 to 100, close to the national average.

Table 5. Binding dimension counts, 2021 estimate (n = 36).

Binding dimension	Number of territorial units
Per capita GSDP coefficient	19
Sex-ratio coefficient	11
Literacy coefficient	6

The four-cell WDI-balance typology (Table 6) further differentiates the welfare geography. Eleven units classified as high and balanced achieve WDI values above the national mean with balance ratios above 0.750, representing the most equitable welfare profiles. Five units classified as high but uneven include Goa, Delhi, Sikkim, Dadra and Nagar Haveli

and Daman and Diu, and Chandigarh, where economic dominance drives WDI performance while sex-ratio coefficients are comparatively depressed. Thirteen units defined as low and uneven have WDI values below the national mean and balance ratios below 0.700, with economic weakness as the structural constraint. Seven units defined as moderate or low but balanced have modest WDI values with relatively even dimensional profiles, indicating broad underperformance rather than a single extreme deficiency.

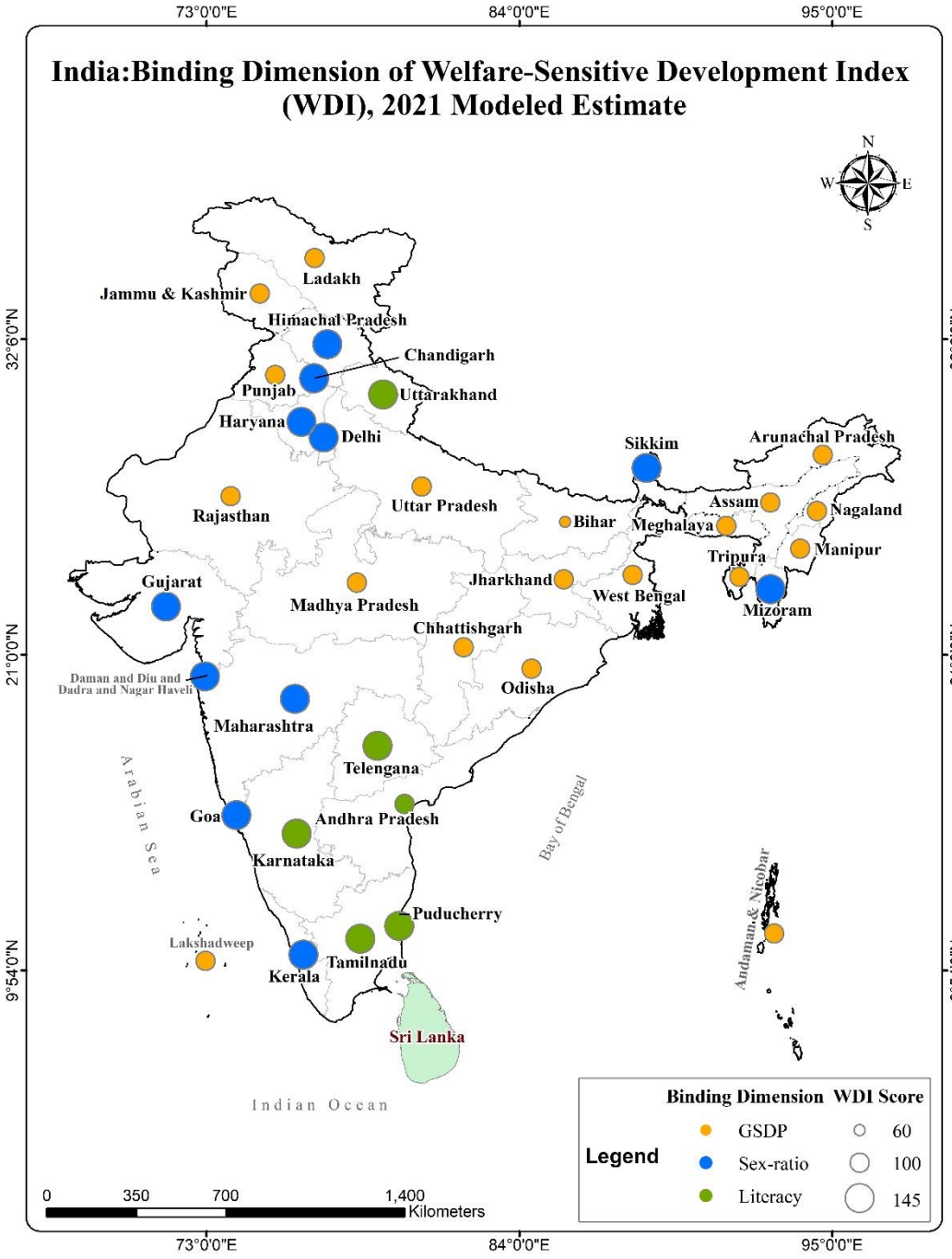

Figure 3. Binding dimensions of welfare-sensitive development index (WDI), 2021 modeled estimate, India

Table 6. WDI-balance typology, 2021 estimate.

Typology	Number of units	Mean WDI	Mean balance ratio
High and balanced	11	109.18	0.830
High but uneven	5	127.82	0.459
Low and uneven	13	78.46	0.500
Moderate or low but balanced	7	90.69	0.762

Discussion:

1. Economic Disparity as the Principal Axis of Spatial Inequality:

The central finding of this analysis is unambiguous: inter-state spatial inequality in welfare achievement in India is driven predominantly by economic disparity. The per capita GSDP coefficient displays a Gini coefficient of 0.293 and a Theil index of 0.137 in the 2021 estimate, values that are four to five times larger than those for literacy and substantially larger than those for sex ratio. Binding-constraint analysis reinforces this finding, with 19 of 36 units constrained by the economic dimension and all 10 bottom-ranked states constrained by depressed GSDP coefficients. This pattern is consistent with the findings of Das and Barua (1996), Sachs et al. (2002), Bhattacharya and Sakthivel (2004) and Kumari et al. (2023) on the persistence of economic disparities across Indian states in the post-reform period. The finding that the dispersion in literacy has reduced more than the dispersion in economics between 2011 and the modelled estimate for 2021 is consistent with the argument of Williamson (1965) and the Indian fiscal federalism literature that central transfers, midday meal schemes, right-to-education legislation, and state-level welfare programmes have reduced disparities in education, even as disparities in income have widened or stagnated (Shankar & Shah, 2003; Lessmann, 2014). The narrowing of literacy dispersion is, however, a modeled outcome in the 2021 series and should be confirmed with verified data when Census 2027 results become available.

2. Diversity of Development Pathways among Leading Units:

The top-ranked group does not represent a single development model. Goa, Delhi, Sikkim, Dadra and Nagar Haveli and Daman and Diu, and Chandigarh achieve high WDI values principally through large economic coefficients, with balance ratios below 0.580 indicating dimensional dependence on economic performance. These units combine strong economic positions with comparatively weaker sex-ratio coefficients, reflecting demographic pressures associated with male-dominated migration streams in industrial, service, and urban-concentrated economies (Duranton & Puga, 2004; World Bank, 2009).

Kerala offers a contrast, and a theoretically salient development profile. Kerala's balance ratio of 0.972 in the 2021 estimate is associated with near-equal coefficients for the three dimensions: literacy (117.80), per capita GSDP (117.22), and sex-ratio (114.52). This profile is consistent with Kerala's well-documented commitment to female education, public health, gender equity, and remittance-supported household incomes, which has produced widely distributed welfare gains without extreme economic concentration (Noorbakhsh, 1998; Sen, 1999). Tamil Nadu and Puducherry also have relatively high balance ratios (0.826 and 0.787), with balanced performance across literacy, economic output, and demographic gender balance.

This typological diversity has important analytical implications. Ranking exercises alone, reporting WDI values without dimensional structure, cannot distinguish between Kerala-type balanced development and Goa-type economically concentrated development. The balance ratio and binding-constraint analysis provide information that is invisible in rank tables and is essential for policy interpretation.

3. Structural Consistency among Lagging Units:

The bottom-ranked group is structurally more consistent than the top group. Bihar, Uttar Pradesh, Jharkhand, Jammu and Kashmir, Ladakh, and Manipur are all constrained by weak economic coefficients, despite literacy and sex-ratio coefficients that are relatively closer to the national mean. Bihar's per capita GSDP coefficient of 26.80 in the 2021 estimate places it at less than one-quarter of the national mean economic output per capita. Uttar Pradesh and Jharkhand are only marginally stronger economically, at 37.93 and 45.08 respectively.

This structural pattern has a direct policy implication: literacy improvements in these states, while valuable for individual welfare and for closing the educational gap, will not close the composite WDI gap unless accompanied by productivity-enhancing investment, regional economic diversification, labor-market deepening, and stronger linkages between educational attainment and employment opportunity. The decoupling of literacy gains from economic gains, which the binding-constraint analysis reveals, echoes the findings of Sachs et al. (2002) and Ohlan (2013) on the multidimensional character of regional underdevelopment in India.

4. Methodological Contribution:

The methodological contribution of this paper is threefold. First, the explicit exclusion of population density from the welfare index, on theoretically grounded polarity grounds, strengthens the conceptual coherence of the composite measure relative to indices that mix welfare achievements with settlement characteristics (Fotheringham & Wong, 1991; Duranton & Puga, 2004). Second, arithmetic aggregation is replaced by geometric aggregation, which reduces full compensability across dimensions and makes dimensional deficits welfare-relevant instead of arithmetically erasable (Ravallion, 2012; Greco et al., 2019; UNDP, 2010). Third, the combination of the composite index with CV, Gini, Theil, Atkinson, balance ratio and binding-constraint diagnostics yields a richer analytical output than rank tables, consistent with the standards recommended by Nardo et al. (2005) and Saisana et al. (2005) for composite indicator quality assessment.

Policy Implications:

The findings generate four policy-relevant conclusions for reducing spatial inequality in India. Economic capability formation in lagging states is the priority intervention. The binding-constraint analysis identifies economic weakness as the most frequent and most severe dimensional deficit. For Bihar, Uttar Pradesh, Jharkhand, and other economically constrained states, the policy priority should be productivity-enhancing investment encompassing industrial diversification, logistics infrastructure, agro-processing, MSME development, digital connectivity, and skill systems linked to local employment markets. Literacy improvements and welfare delivery programs, while necessary, are insufficient to close WDI gaps when economic coefficients remain at 26 to 50% of the national mean. Literacy policy must be connected to labor-market absorption. Where literacy coefficients

have already converged toward the national mean while per capita GSDP coefficients remain severely depressed, there is an implicit disconnection between educational attainment and economic opportunity. State policies need to strengthen vocational training, entrepreneurship ecosystems and institutions that translate educational capability into productive employment, especially in Manipur, Jharkhand and Jammu and Kashmir where literacy is near the national mean but per capita GSDP is below 55% of the mean.

Gender balance must be addressed as a substantive welfare dimension, not a residual concern. Sex-ratio coefficients are comparatively less dispersed than economic coefficients, but several high-income states and Union Territories (Delhi, Dadra and Nagar Haveli and Daman and Diu, Chandigarh, Haryana) record sex-ratio coefficients well below the national mean, reflecting gender imbalances associated with male-dominated migration and persisting social practices. Welfare sensitive regional planning should include female education, healthcare, labour force participation and social protection as core elements of development strategy. Policy transfer across leading states should be conditioned by dimensional profiles. There is typological diversity across top ranked units so Goa's economic model and Kerala's balanced human development model are not interchangeable. State governments and planning bodies should analyse dimensional structure rather than overall WDI rank when identifying peer comparators for policy learning.

Limitations and Directions for Future Research:

Several limitations constrain the interpretation of results. The 2021 series consists of modeled estimates derived from projection assumptions, not official enumeration. All findings relating to 2021 should be treated as scenario analysis pending the publication of Census 2027 data. The reliability of the modeled 2021 series depends on the validity of convergence and growth assumptions that cannot be independently verified at this stage.

The analysis is limited to three indicators. Health outcomes, poverty rates, employment levels, infrastructure access, urbanization, environmental stress, and service quality are not incorporated because verified state-level values consistent with the analytical framework were not available in the project dataset. The omission of these dimensions means that the WDI captures only a subset of welfare-relevant variation and should not be interpreted as a comprehensive development measure.

The analysis is conducted at the state and Union Territory scale and cannot detect intra-state inequality between districts, tribal regions, agrarian interiors, and metropolitan cores. There is a good deal of evidence of socioeconomic disparities across districts within Indian states (Ohlan, 2013; Kumari et al., 2023) and the state-level WDI might be masking policy-relevant internal heterogeneities. Future research should apply the same analytical framework at district scale using verified official data and a reproducible GIS boundary layer.

Spatial autocorrelation and hotspot analysis are not reported in this paper because they require a verified spatial weights matrix and geographic boundary layer. Future work should add Moran's I global spatial autocorrelation, Local Indicators of Spatial Association, Getis-Ord Gi* hotspot analysis, and spatial regression to examine whether territorial clusters of high and low WDI values exist beyond what the rank table reveals.

Sensitivity analysis of aggregation rules and indicator weights, following the Monte Carlo approach recommended by Saisana et al. (2005), should be conducted when the framework is applied to verified official data, to assess the robustness of WDI rankings to alternative weighting schemes and normalization choices.

Conclusion:

This paper constructs a three-dimensional Welfare-sensitive Development Index for all 36 Indian states and Union Territories using literacy, per capita GSDP, and sex ratio coefficients for 2011 and a modeled 2021 scenario. By excluding population density on theoretical grounds and adopting geometric aggregation to reduce perfect compensability across dimensions, the index provides a more defensible welfare-oriented measure of spatial inequality than additive composite indices incorporating settlement-concentration variables.

The distributional analysis demonstrates that per capita GSDP is the dominant source of inter-state welfare inequality, with inequality diagnostics four to five times larger than those for literacy and sex ratio in both time periods. The composite WDI shows moderate inequality that reflects the moderating effect of combining a highly unequal economic dimension with less dispersed social dimensions. Binding-constraint analysis confirms that economic weakness is the most frequent limiting dimension, constraining 19 of 36 territorial units and all 10 bottom-ranked states in the 2021 estimate.

The WDI ranking identifies Goa, Delhi, Sikkim, Dadra and Nagar Haveli and Daman and Diu, Puducherry, Kerala, and Chandigarh as leading units, while Bihar, Uttar Pradesh, Jharkhand, Ladakh, Jammu and Kashmir, and Manipur remain at the lower end of the welfare distribution. The typological analysis reveals that high WDI can arise through dimensional concentration, as in Goa and Delhi, or through balanced multidimensional achievement, as in Kerala, and that these pathways have different implications for development policy. Rank stability between 2011 and the 2021 estimate is very high across all three correlation measures, indicating structural persistence in the territorial hierarchy of welfare development.

The central policy message is that reducing spatial inequality in India requires linking human capability formation with productive regional economies, gender-sensitive development, and stronger territorial investment. Literacy improvements in lagging states are necessary but insufficient when economic coefficients remain at one-quarter to one-half of the national mean. Closing the WDI gap requires prioritizing economic capability formation as the binding constraint that currently limits welfare achievement across the majority of India's lagging territorial units.

Data Availability Statement:

No additional numerical indicator values beyond those provided in the resaerch material were introduced. A data appendix should specify the exact official tables from Census of India 2011 and the GSDP series used for the indicator values and the projection methodology for the 2021 estimates.

Ethics Statement:

The study uses aggregate state and Union Territory level data. It does not involve human-subject microdata, individual-level records, or personally identifiable information, and therefore does not require ethical approval.

Conflict of Interest Statement:

The authors declare no conflict of interest.

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Appendix A. Complete State and Union Territory WDI Scores and Typology, 2021 Estimate

Table A1. Three-indicator WDI scores, dimensional coefficients, balance ratio, binding constraint, and typology for all 36 Indian states and Union Territories, 2021 estimate.

State/UT	Literacy Coeff.	GSDP Coeff.	Sex-Ratio Coeff.	WDI	Rank	Balance Ratio	Binding Constraint	Typology
Goa	112.20	266.29	103.08	145.49	1	0.387	Sex-ratio	High but uneven
Delhi	109.58	215.76	93.43	130.24	2	0.433	Sex-ratio	High but uneven
Sikkim	104.52	207.56	95.29	127.39	3	0.459	Sex-ratio	High but uneven
Dadra and Nagar Haveli and Daman and Diu	107.45	193.61	85.49	121.15	4	0.442	Sex-ratio	High but uneven
Puducherry	109.20	138.74	109.56	118.40	5	0.787	Literacy	High and balanced
Kerala	117.80	117.22	114.52	116.50	6	0.972	Sex-ratio	High and balanced
Chandigarh	109.41	155.12	89.21	114.83	7	0.575	Sex-ratio	High but uneven
Tamil Nadu	103.12	124.83	105.27	110.66	8	0.826	Literacy	High and balanced
Haryana	98.33	140.12	94.36	109.14	9	0.673	Sex-ratio	High and balanced
Telangana	88.74	135.92	104.51	108.02	10	0.653	Literacy	High and balanced
Gujarat	100.95	126.95	97.75	107.80	11	0.770	Sex-ratio	High and balanced
Karnataka	98.13	122.22	103.08	107.33	12	0.803	Literacy	High and balanced
Mizoram	114.98	103.70	103.36	107.22	13	0.899	Sex-ratio	High and balanced
Maharashtra	105.49	117.16	98.59	106.81	14	0.842	Sex-ratio	High and balanced
Himachal Pradesh	105.98	106.13	102.98	105.02	15	0.970	Sex-ratio	High and balanced
Uttarakhand	101.78	108.45	102.13	104.08	16	0.938	Literacy	High and balanced
Andhra Pradesh	89.33	98.55	104.98	97.41	17	0.851	Literacy	Moderate or low but balanced
Punjab	98.64	90.28	95.72	94.81	18	0.915	GSDP	Moderate or low but balanced
Andaman and Nicobar Islands	109.64	82.45	94.11	94.76	19	0.752	GSDP	Moderate or low but balanced
Tripura	110.64	67.59	101.84	91.32	20	0.611	GSDP	Low and uneven
Arunachal Pradesh	87.60	84.74	99.35	90.35	21	0.853	GSDP	Moderate or low but balanced
Nagaland	102.55	68.06	98.76	88.33	22	0.664	GSDP	Moderate or low but balanced
West Bengal	99.08	67.09	100.89	87.53	23	0.665	GSDP	Moderate or low but balanced
Lakshadweep	115.53	56.27	100.03	86.63	24	0.487	GSDP	Low and uneven
Odisha	95.50	64.16	103.65	85.96	25	0.619	GSDP	Low and uneven
Meghalaya	97.15	57.63	104.60	83.67	26	0.551	GSDP	Low and uneven
Chhattisgarh	92.77	59.73	104.79	83.43	27	0.570	GSDP	Low and uneven
Rajasthan	88.37	62.55	98.51	81.66	28	0.635	GSDP	Low and uneven
Assam	94.78	50.33	101.65	78.57	29	0.495	GSDP	Low and uneven
Madhya Pradesh	91.76	53.23	98.76	78.42	30	0.539	GSDP	Low and uneven
Manipur	99.80	43.20	104.22	76.59	31	0.415	GSDP	Low and uneven
Jammu and Kashmir	89.48	52.28	95.21	76.37	32	0.549	GSDP	Low and uneven
Ladakh	87.20	52.28	95.29	75.74	33	0.549	GSDP	Low and uneven
Jharkhand	88.69	45.08	100.20	73.72	34	0.450	GSDP	Low and uneven
Uttar Pradesh	90.03	37.93	97.15	69.22	35	0.390	GSDP	Low and uneven
Bihar	83.82	26.80	97.66	60.31	36	0.274	GSDP	Low and uneven

Note: All coefficients are ratio-to-mean transformations where the national mean equals 100. WDI is the geometric mean of the three coefficients. 2021 values are modeled estimates, not official Census 2021 observations. Census 2027 will provide the next verified enumeration (Press Information Bureau, 2025).