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Urban-Rural Literacy Gaps in India: A Comprehensive Spatio-Temporal Study

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Abstract:- The article examines urban-rural literacy disparities across fifteen Indian states between 1981 and 2011, focusing on key factors that contribute to reducing educational inequality. Using Sopher's index, it analyzes spatial and temporal shifts in literacy disparities over time. Despite an overall decline, the index shows that states like Andhra Pradesh, Madhya Pradesh, Gujarat, and Karnataka still faced significant disparities in 2011. The study applies the Least Square Dummy Variable (LSDV) technique to identify determinants influencing these disparities. It finds that lower rural fertility rates, a higher percentage of women marrying after age 21, increased female educational attainment (as mothers' education), and higher male labour force participation (as fathers' income) play significant roles in narrowing the urban-rural literacy gap.

Keywords:- *Least Square Dummy Variable (LSDV) Model, Spatio-Temporal Analysis, Sopher's Index, Urban-Rural Literacy.*

I. INTRODUCTION

Education is a transformative force for social change, and its equitable distribution between urban and rural population is crucial for enhancing a country's social welfare (Dreze & Sen, 1999). Literacy, as defined by UNESCO (1946), not only involves the ability to read, write, and understand language but also encompasses essential civic knowledge, personal hygiene, political engagement, and occupational skills, enabling individuals to fully participate in their communities. Despite numerous efforts, including the National Adult Education Programme (NAEP) launched in 1978, India continues to struggle with widespread illiteracy, particularly in rural areas. By 2011, while the literacy gap had narrowed—15% illiteracy in urban areas compared to 33% in rural areas—India still accounted for 318 million illiterate individuals in rural regions (Census of India, 1981 & 2011; SECC, 2011). This paper examines the urban-rural literacy disparity from 1981 to 2011 and explores socio-economic factors to provide policy recommendations for reducing educational inequality in India.

The literature highlights literacy as a key driver of social development and human capital accumulation (Gallaway & Bernasek, 2004). Even individuals who are illiterate can benefit from living in literate households, as Sen (2000) and Basu et al. (2001) suggest, with increased incomes and social empowerment. Investments in education, particularly for school-aged children, generate significant returns, and poor parents are more likely to send their children to school if the expected benefits outweigh the opportunity costs (Becker, 2009). Research on urban-rural literacy disparities identifies various factors shaping educational outcomes. Krishan and Shaym (1978) examined district-level data from the 1971 Indian Census and demonstrated how education and innovation often flow from urban to rural areas. Similarly, Zhang (2006), studying sub-Saharan Africa, found that well-resourced schools and parental encouragement help reduce urban-rural disparities in primary education outcomes. In India, Som and Mishra (2014) and Jhariya and Jain (2014) explored regional literacy disparities, highlighting the importance of financial and social factors in bridging the literacy gap. Afridi (2011) found that free meals in rural schools significantly increased school enrollment, particularly for girls. Further studies show how economic status influences educational attainment. Filmer & Pritchett (1998) used wealth proxies to demonstrate how household economic status impacts children's educational outcomes, while Mitra & Singh (2008) pointed to poverty and cultural norms as significant barriers to literacy, especially among tribal women in northeastern India. Additionally, research in Ethiopia (Mani et al., 2013) and India (Shafiqullah, 2011; Dutta & Sivaramakrishnan, 2013) emphasized the role of urbanization, household wealth, parental education, and infrastructure in literacy disparities.

This study seeks to address a gap in the literature by using Sopher's Disparity Index to analyze urban-rural literacy disparities across fifteen Indian states from 1981 to 2011, and by identifying key determinants that could help reduce these inequalities. The findings will offer insights for policymakers seeking to reduce persistent disparities in literacy and promote more equitable educational outcomes in India.

II. TRENDS OF VARIATIONS OF INEQUALITY IN URBAN-RURAL LITERACY RATES ACROSS THE INDIAN STATES:

This study focuses on the urban-rural literacy disparity in fifteen major Indian states. The disparity can be measured either in absolute terms by subtracting the rural literacy rate (R_L) from the urban literacy rate (U_L), or in relative terms by calculating the ratio between the two rates. While these methods are commonly used, they are often considered inadequate since they only account for the individual magnitudes of U_L and R_L, which are confined to a range of 0 to 100 percent (Sopher, 1974).

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To provide a more accurate measure of literacy inequality, this study employs Sopher's index. This index uses a logarithmic (base 10) odds ratio to measure the inequality between two population groups based on their literacy levels (Sopher, 1974). The formula is expressed as:

$$DLI_{U-R} = \log\left(\frac{U_L}{R_L}\right) + \log\left(\frac{100-U_L}{100-R_L}\right)$$

Where; DLI_{U-R}= Sopher's urban-rural differential literacy index
U_L= Percentage of literates in urban population
R_L= Percentage of literates in rural population
and $U_L \geq R_L$ and the value of $DLI_{U-R} = 0$ indicates perfect equality in literacy, while higher values reflect greater disparities between urban and rural literacy rates across the states.

Table-1: State-Level Urban-Rural Literacy Disparities According to Sopher's Index Across Fifteen Indian States in Various Census Years

Year States	1981	1991	2001	2011
AP	0.606	0.550	0.424	0.420
Bihar	0.615	0.617	0.515	0.361
Gujarat	0.553	0.460	0.454	0.417
Haryana	0.566	0.449	0.345	0.267
H Pradesh	0.590	0.516	0.427	0.341
Karnataka	0.564	0.499	0.454	0.436
Kerala	0.413	0.171	0.180	0.162
Madhya Pradesh	0.623	0.637	0.449	0.449
Maharashtra	0.573	0.484	0.394	0.417
Orissa	0.542	0.489	0.452	0.422
Punjab	0.508	0.364	0.315	0.274
Rajasthan	0.647	0.636	0.412	0.403
Tamil Nadu	0.566	0.469	0.382	0.377
Uttar Pradesh	0.545	0.432	0.319	0.205
W.B.	0.580	0.475	0.554	0.315
India	0.582	0.527	0.446	0.408

Source: Author's calculation

Table 1 shows that Rajasthan, Madhya Pradesh, and Bihar have high urban-rural differential indices from 1981 to 2011. In Rajasthan, the inequality coefficient decreased from 0.647 to 0.403, while Madhya Pradesh's index dropped from 0.623 to 0.449. Similarly, Bihar's urban-rural literacy gap decreased from 0.615 in 1981 to 0.361 in 2011. Notable reductions in the urban-rural literacy gap were also observed in Uttar Pradesh (0.545 to 0.205), Haryana (0.566 to 0.267), Karnataka (0.564 to 0.436), and Gujarat (0.553 to 0.417) during the same period.

Additionally, the study employs Sopher's index to conduct a spatio-temporal analysis of urban-rural literacy across fifteen Indian states over time, utilizing choropleth mapping to categorize states based on their literacy differential indices.

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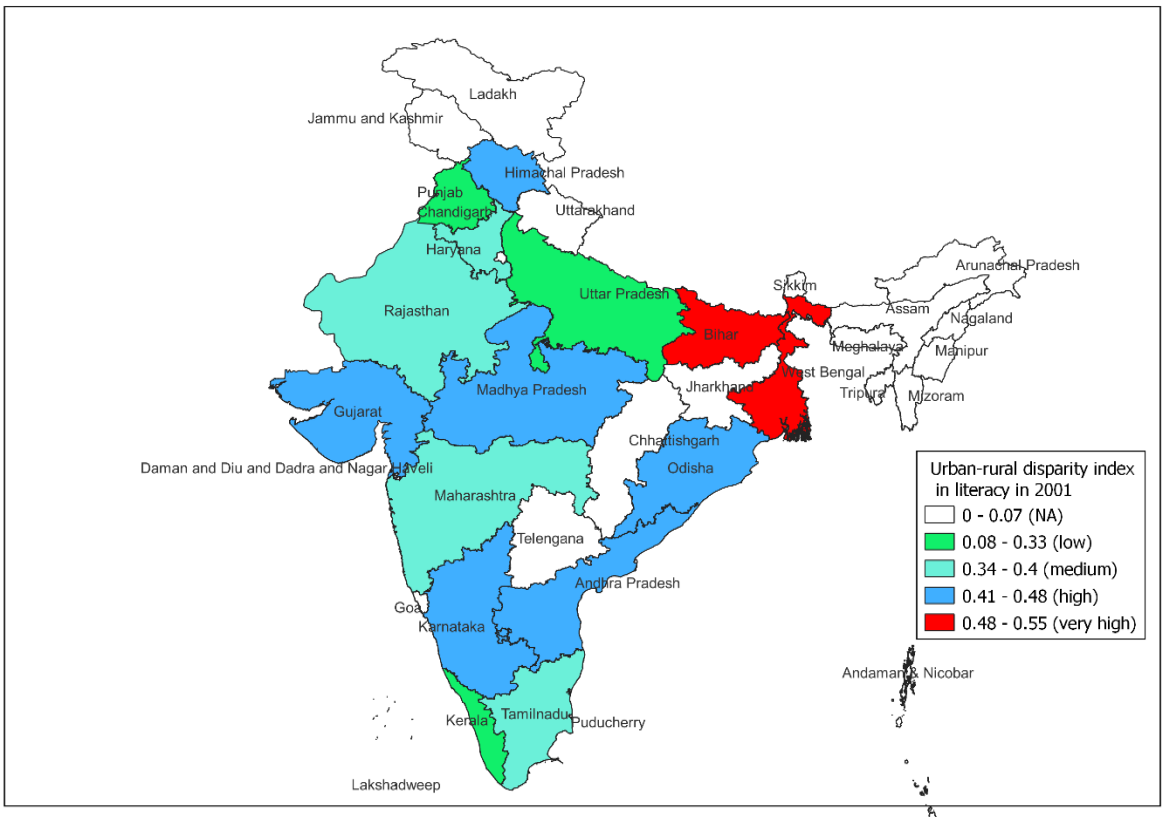

Fig 1 State-Level Urban-Rural Disparity in Educational Attainment in India in 2001

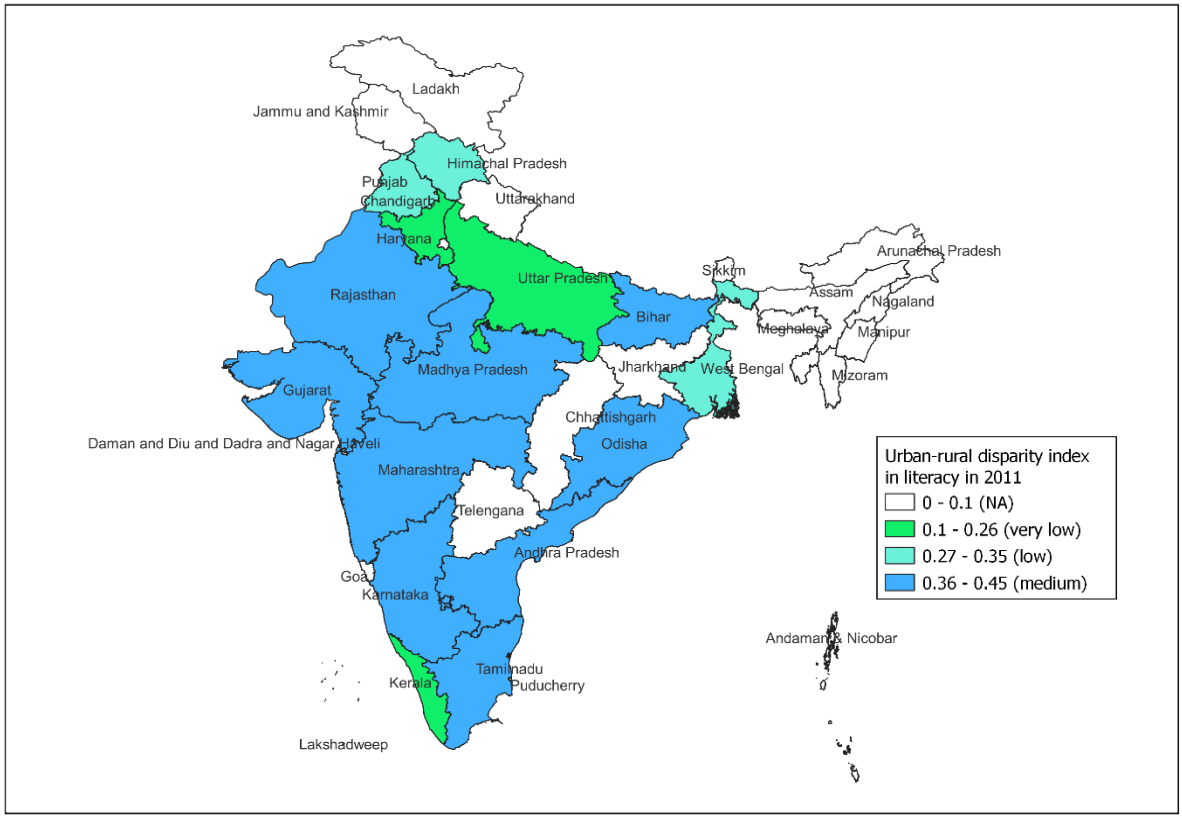

Fig 2 State-Level Urban-Rural Disparity in Educational Attainment in India in 2011

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The two choropleth maps (Figures 1 to 2) depict significant variations in the urban-rural literacy differential index across states over time. Certain states are labelled as NA (Not Applicable) in the maps, as they were excluded from the study due to the unavailability of necessary data.

III. DATA

This study examines the urban-rural literacy disparity in fifteen major Indian states using various datasets for the census years 1981, 1991, 2001, and 2011. The data sources are as follows:

A. Literacy Rates:

State-level literacy and urban-rural literacy rates are sourced from the Office of the General and Census Commissioner, India

B. Total Fertility Rate:

Urban and rural fertility rates for 1981, 1991, 1999, and 2009 are obtained from the Ministry of Health and Family Welfare, Government of India, with interpolation used for 2001 and 2011.

C. Per Capita Net State Domestic Product (PCNSDP):

Data for PCNSDP at factor cost for the years 1980-81, 1990-91, 2000-01, and 2010-11 are drawn from the Reserve Bank of India, converted into constant prices with 1993-94 as the base year.

D. Married Female Percentages:

Percentages of married females in three age groups (below 18, 18-20, and 21+) are sourced from the Sample Registration System, with data for 1981, 1991, 2001, and 2011 estimated through interpolation.

E. Teacher-Pupil Ratio:

Data for teacher-pupil ratios from 1982-83, 1990-91, 2000-01, and 2011-12 are obtained from the Ministry of Human Development and used as proxies for the corresponding census years.

F. Labour Force Participation Rates:

Male and female labour force participation rates are collected from three rounds of the National Sample Survey (NSS) and interpolated for 1981.

G. Social Sector Expenditure:

Data on state-level social sector expenditure for 1990-91, 2000-01, and 2010-11 are sourced from the Reserve Bank of India, with estimates for 1981 derived through interpolation.

IV. KEY FACTORS INFLUENCING URBAN-RURAL LITERACY DISPARITY

To identify factors that may reduce urban-rural literacy disparities in India, the following regressors are examined:

A. Per Capita Net State Domestic Product (PCNSDP):

Represents household income and influences educational investment. Lower-income households tend to invest less in children's education (Banerji et al., 2013).

B. Percentages of Married Females by Age (MFA):

Early marriage is associated with lower educational attainment for women. Jensen and Thornton (2003) found that marrying later is linked to higher education for women. Girls who marry before 15 average less than a year of schooling, while those married between 16 and 20 gain over two years, and those married after 21 receive three to four years. Thus, early marriage is a significant barrier to female education, especially in rural areas. In the paper, three different age groups of percentages of married females by their ages in the fifteen states, such as below 18 years (MFA_{18}), 18-20 years (MFA_{18-20}), and 21+ years (MFA_{21+}) have been considered.

C. Total Fertility Rate (TFR):

Higher fertility rates in rural areas may limit access to education, as more children burden resources (Gotmark & Andersson, 2020).

D. *Literacy Rate for Rural Females (FL):*

Serves as a proxy for mothers' educational attainment, which significantly impacts child health and learning outcomes (Breierova & Duflo, 2004; Banerji et al., 2013, Das & Kundu, 2023).

E. Teacher-Pupil Ratio (TPR):

A lower ratio enhances teaching effectiveness and student achievement. A negative correlation exists between a high student-teacher ratio and student performance (Koc & Celik, 2015).

F. Rural Female Labour Force Participation Rate (FLFPR):

Female labour force participation in rural areas, measured as a percentage of the total labour force, serves as a proxy for mothers' employment. For less educated mothers, participation may improve parenting quality, but it may not benefit more educated women (Augustine, 2014). Additionally, Afridi et al. (2013) found that mothers' work can negatively affect children's education if they also handle domestic chores. Therefore, it's essential to explore how rural women's employment impacts their children's educational outcomes.

G. Rural Male Labour Force Participation Rate (MLFPR):

Male labour force participation, expressed as a ratio of total rural labour, serves (Kundu & Das, 2019) as a proxy for fathers' income, which can positively influence children's educational outcomes through the income effect (Afridi et al., 2013).

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H. Social Sector Expenditure (SSE):

Development depends on social sector spending, especially in education, healthcare, shelter and civic amenities (Kundu & Das, 2019). Tilak (2006) noted that public investment is more effective in poorer states. Currently, government education expenditure is only 3.1% of GDP, below the 6% target (Economic Survey, 2019-20). This underfunding contributes to adult illiteracy and high dropout rates. This paper investigates the impact of inadequate investment on educational disparities across states.

V. ECONOMETRIC ANALYSIS

This study analyzes urban-rural educational inequality across fifteen Indian states from 1981 to 2011 using fixed effect panel data regression. The model is expressed as:

$DLI_{it} = \beta_1 x'_{it} + \omega_i + \varepsilon_{it}$, t = 1, 2, 3 …., 14; and i = 1, 2, 3,4; …… … (1)

Where, DLI_{it} represents the differential literacy index for the i[th] state at time t, x_{it} is a vector of regressors, ω_i captures unobserved, time-invariant heterogeneity, and ε_{it} is the idiosyncratic error term. Figures 1 and 2 highlight the heterogeneity among states, indicating different means across states and years. The fixed effect model effectively addresses omitted variable bias by allowing varying intercepts while controlling for unobserved factors that do not change over time. The Hausman test supports the use of fixed effect regression over random effect models. Consequently, the study employs the Fixed Effect with dummy variable technique (Least Squares Dummy Variable or LSDV) to assess state-specific impacts on urban-rural literacy disparities.

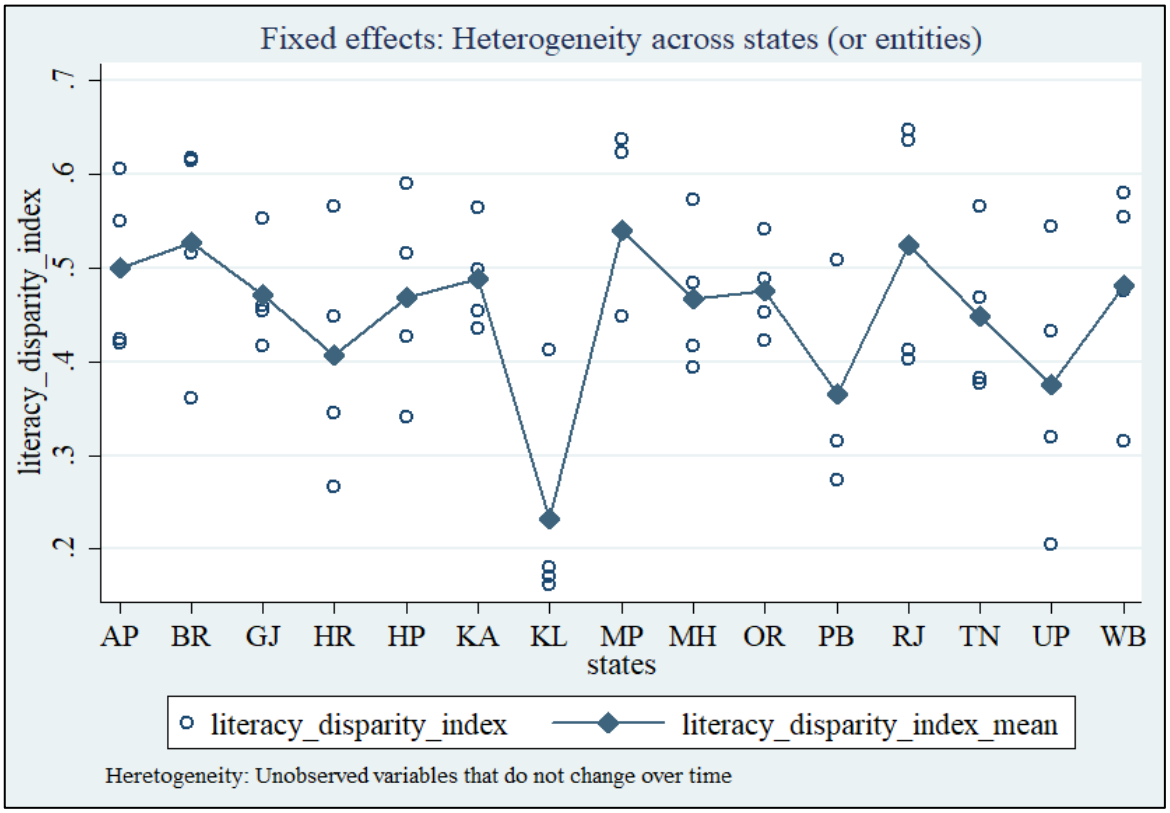

Fig 3: Heterogeneity of urban-rural disparity in literacy across the fifteen Indian states

Figure 3 illustrates the variation in the mean urban-rural literacy disparity index across different states.

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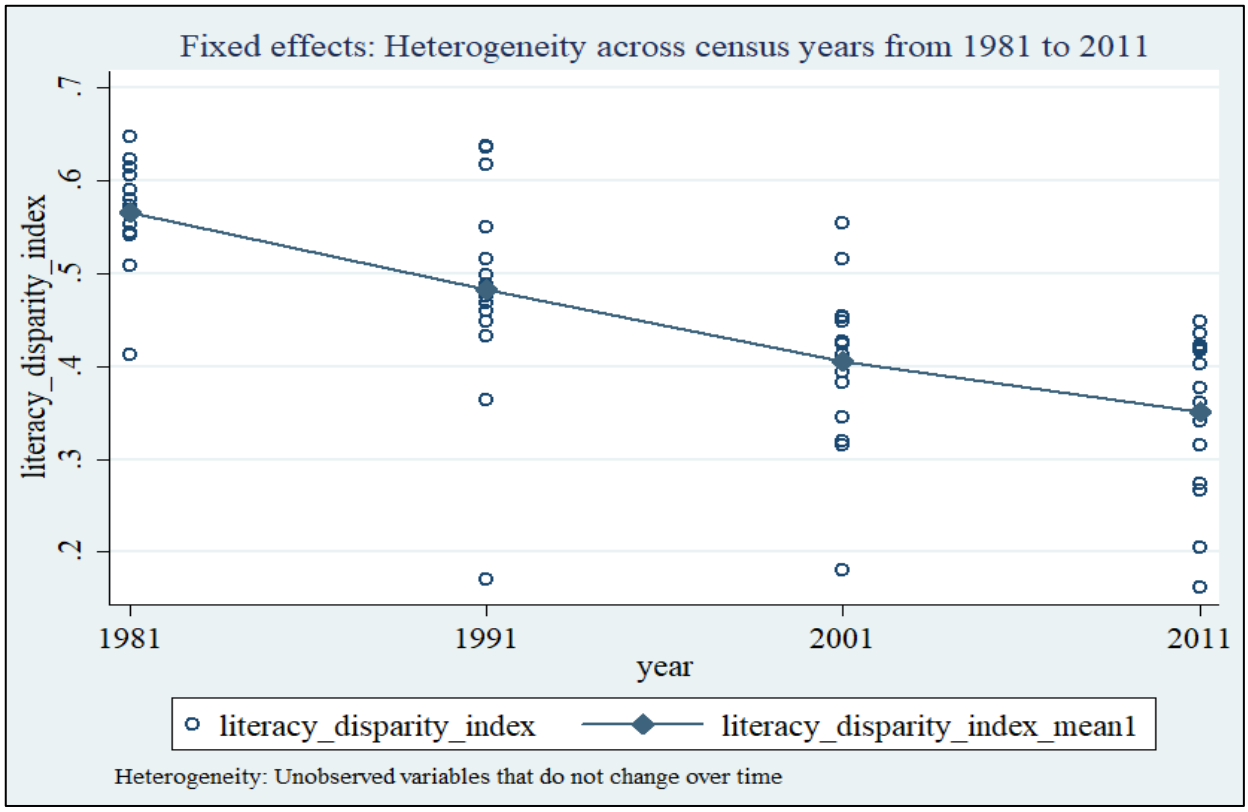

Fig 4: Fixed effects: Heterogeneity Across Census Years from 1981 to 2011

Figure 4 demonstrates the variation in the mean urban-rural literacy disparity index across census years, supporting the use of the fixed effect model with dummy variable regression as the appropriate econometric method for this study.

Initially, the multicollinearity test has examined whether there are any inter-correlations among the explanatory variables. The Variance Inflation Factor $[\text{VIF} = \frac{1}{(1-R^2)}]$ shows that the four pairs of explanatory variables such as (FL_i, TFR_i), ($PCNSDP_i$, MFA_{18-20_i}), (FL_i, MFA_{18_i}) and (FL_i, MFA_{18-20_i}) are suffering from multicollinearity problems as their VIF values are more than 4.

To reduce the biasedness, three separate panel data regression models are considered in the study. Now three equations can be written as-

$$DLI_{1it} = \alpha_{1i} + \sum_{k=2}^{15} \alpha_k D_{ki} + \beta_1 PCNSDP_{it} + \beta_2 TFR_{it} + \beta_3 FL_{it} + \beta_4 TPR_{it} + \varepsilon_{it} \ldots\ldots\ldots (2)$$

$$DLI_{2it} = \alpha'_{1i} + \sum_{2}^{15} \alpha'_k D_{ki} + \beta'_1 MFA_{18_{it}} + \beta'_2 MFA_{18-20_{it}} + \beta'_3 MFA_{21+_{it}} + \beta'_4 MLFPR_{it} + \beta'_5 SSE_{it} + \beta'_6 TPR_{it} + \varepsilon'_{it} \ldots\ldots\ldots\ldots\ldots (3)$$

$$DLI_{3it} = \alpha''_{1i} + \sum_{2}^{15} \alpha''_k D_{ki} + \beta''_1 PCNSDP_{it} + \beta''_2 FL_{it} + \beta''_3 MLFPR_{it} + \beta''_4 TPR + \varepsilon''_{it} \ldots\ldots (4)$$

Where, α_1 represents the intercepts of the state West Bengal as West Bengal is here used as reference state, and α_k ($2 \leq k \leq 14$) is the differential coefficients of 14 states in equation (2), indicating that the intercepts of 14 states differ from the intercept of West Bengal. These differences arise possibly due to different socio-economic infrastructure and the behaviour of rural and urban people. Hence, 14 dummy variables have considered in the study for 14 states and these dummy variables are binary in nature, where,

$$D_{ki} = \begin{cases} 1, if\ the\ observations\ is\ for\ state_k \\ (\text{see table} - 3 \text{ in appendix}) \\ 0, otherwise \end{cases} \quad \ldots\ldots (5)$$

Where, $2 \leq k \leq 14$

Similar explanations for α'_i ($2 \leq i \leq 14$) and α''_i ($2 \leq i \leq 14$) will be in case of equations (3) and (4).

Now, the result of Least Square Dummy Variable (LSDV) model has shown in the following table 2 as-

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Table 2: Result of Least Square Dummy Variable (LSDV) model

Models / Observations	Equation (2)	Equation (3)	Equation (4)
	60	60	60
Variables	Value of the Coefficient	Value of the Coefficient	Value of the Coefficient
PCNSDP	$1.29e^{-07}$ ($5.08e^{-07}$)	-	$6.39e^{-07}$ ($4.41e^{-07}$)
TFR	0.096*** (0.015)	-	-
MFA_{18}	-	0.0065*** (0.0017)	-
MFA_{18-20}	-	0.00211* (0.00105)	-
MFA_{21+}	-	-0.0032*** (0.00089)	-
FL	-	-	-0.0065*** (0.00097)
TPR	$-2.07e^{-06}$ (0.0012)	-0.00038 (0.0012)	-
MLFPR	-	-0.0056* (0.0018)	-0.0067* (0.0038)
FLFPR	0.001226 (0.00206)	-	-
SSE	-	0.000016 (0.00013)	-
D_2 (AP)	-0.0702 (0.115)	-0.105 (0.0427)	-0.0387 (0.0409)
D_3 (Bihar)	-0.0479 (0.0463)	0.034 (0.0504)	0.04438 (0.0344)
D_4 (Gujarat)	-0.134 (0.074)	-0.0912 (0.0668)	-0.04926 (0.0576)
D_5 (Haryana)	-0.0434* (0.0102)	-0.0622* (0.0215)	-0.088** (0.0359)
D_6 (H.P)	0.00846 (0.0425)	0.02453 (0.046)	0.0486 (0.0346)
D_7 (Karnataka)	-0.1362* (0.0705)	-0.147** (0.0576)	-0.0315* (0.026)
D_8 (Kerala)	-0.0933* (0.052)	-0.048* (0.019)	-0.039* (0.0116)
D_9 (M.P)	-0.0235 (0.0374)	0.0516 (0.0447)	0.0788 (0.0335)
D_{10} (Maharashtra)	-0.004 (0.0651)	0.0475 (0.0469)	0.00359 (0.0336)
D_{11} (Orissa)	-0.0787 (0.074)	0.0127 (0.0534)	-0.033 (0.038)
D_{12} (Punjab)	-0.104** (0.04637)	-0.0884*** (0.0407)	-0.0454* (0.017)
D_{13} (Rajasthan)	0.0166 (0.0391)	0.04004 (0.048)	0.0548 (0.033)
D_{14} (TN)	-0.2477** (0.0971)	-0.051* (0.022)	-0.156*** (0.0348)
D_{15} (U.P)	-0.01344* (0.005)	-0.0083* (0.0042)	-0.0589* (0.0242)
Constant	0.119*	0.99**	0.59
R^2	0.87	0.86	0.91
Adjusted R-squared	0.81	0.80	0.87
F-Statistics	15.26***	13.66***	22.64***

Note: *** indicates 1% level of significance, ** indicates 5% level of significance and * indicates 10% level of significance.

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VI. DISCUSSION OF RESULT

The fixed effect LSDV model results indicate that the total fertility rate for rural females (TFR) is positively associated with the urban-rural education gap (Martin, 1995). In contrast, the percentage of females marrying after age 21 negatively correlates with this gap, highlighting the link between later marriage and higher education for women. Early marriages (below 18 and between 18 and 20) are positively associated with urban-rural literacy disparity. Additionally, rural female literacy, reflecting mothers' education, significantly enhances literacy rates, as educated mothers are more likely to invest in their children's education. Furthermore, mothers' labour force participation positively impacts children's educational attainment. States like Haryana, Karnataka, Kerala, Punjab, Tamil Nadu, and Uttar Pradesh have significantly reduced the urban-rural literacy gap over time.

VII. CONCLUSION AND POLICY IMPLICATIONS

This study examines variations in urban-rural literacy differentials across fifteen major Indian states and identifies contributing factors. Despite literacy rising from 41% to 74% between 1981 and 2011, significant inter- and intra-regional disparities persist. Sopher's index is used to analyze these inequalities over time, revealing high differentials in states like Rajasthan, Madhya Pradesh, and Bihar, while improvements are noted in U.P, Haryana, Karnataka, and Gujarat. The fixed effect least squares dummy variable technique identifies key determinants for reducing the literacy gap, leading to four policy recommendations. Lower fertility rates among rural females decrease household burdens and enhance children's school attendance. Delaying marriage until after age 21 and increasing female literacy empower women in decision-making and education. Additionally, improving employment opportunities for rural women fosters financial independence, encouraging continued education for their children and helping to bridge the literacy gap.

APPENDIX

Table-3: List of States and their Abbreviations Considered in Order

Sl. No.	States
1	West Bengal (WB)
2	Andhra Pradesh (AP)
3	Bihar (BI)
4	Gujarat (GJ)
5	Haryana (HR)
6	Himachal Pradesh (HP)
7	Karnataka (KA)
8	Kerala (KL)
9	Madhya Pradesh (MP)
10	Maharashtra (MH)
11	Orissa (OR)
12	Punjab (PB)
13	Rajasthan (RJ)
14	Tamil Nadu (T.N.)
15	Uttar Pradesh (U.P.)

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