

An Assessment of Spatio-Temporal Patterns of Literacy Differentials and Gender Imbalance in Chitrakoot District, Uttar Pradesh, India

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Literacy and sex ratio are the ideal reference to socio-economic development and gender equity. The question under scrutiny in this research is; Which are the spatio-temporal relations of the differentials of literacy and gender imbalance in Chitrakoot District, Uttar Pradesh using block-level census data in 2001 and 2011. Among the research agenda was systematic evaluation of the general literacy trends, the disparity in male and female literacy, block-sex-ratio trends and how literacy and sex ratio are correlated. Decadal change analysis and gender-gap scrutiny of the secondary data based on the District Census Handbooks were analyzed with the help of GTS-based thematic mapping. The rank correlation coefficient of Spearman was used to examine the relationship between literacy and sex-ratio. The results reveal significant inequalities in the patterns of literacy and sex-ratio, and not evenly spread out administrative blocks. Although the female literacy levels increased, and the gender differences did too, the correlation between literacy and the sex ratio remained insignificant which explains why the specific, block-oriented measures should be taken to ensure the promotion of inclusive and gender-balanced development.

Keywords: Spatio-temporal analysis, Literacy Differentials, Gender imbalance, Decadal Growth Rate, Spearman's rank correlation coefficient.

Introduction:

Literacy and sex ratio are widely recognised as critical indicators of human development and social well-being. Literacy does not only increase individual capability and economic opportunities, but it has an imperative effect on the general mores, particularly gender equality. On its part, the sex ratio serves as an indicator of the position of women in their respective societies, revealing endemic socio-cultural, economic and demographic processes. The persistent gender disparity, which peaks in the northern states of India, has remained a source of severe developmental and ethical concerns, despite slow achievements in academic achievements.

After gaining independence, India has seen significant improvement in literacy; however, the gains have been unevenly distributed geographically, socially and

gender wise. The inequalities of literacy, especially in women, tend to be consistent with the inequalities in sex ratio, which underlines the strong association between the advancement of education and gender equality. The Chitrakoot District, located in the southern end of Uttar Pradesh, has become a perfect representation of a socio-economically disadvantaged and largely rural environment that exudes low literacy, lack of educational facilities, and gender disparities. Inter-block dissimilarity in educational attainment and demographics is even more evident in the district making it a good subject of detailed geographical analysis.

In spite of these developmental barriers in the district, there has been a dearth of scholarly attention on the concomitant growth of differentials in literacy and gender

imbalance. It is necessary to conduct a spatio-temporal inquiry in order to identify not only current tendencies of literacy and sex ratio, but also their temporal variations in spatial units. The comparative analysis of the twenty-year-old data helps to detect trends, switching regimes, and emerging inequalities, and thus the results of the research can provide a more profound understanding of the effectiveness of educational and social interventions. This is also a way of identifying badly sporting blocks that should be subjected to focused corrective measures.

Literature Review

By undertaking empirical studies in India, the issue of literacy inequities that have remained despite a widespread achievement has been shed light on. Shukla et al. (2014) discovered that although the general literacy was improving in 2001-2011, the disadvantage among females stuck. Ansari et al. (2014) also noted a high level of intra-district disparity in female literacy with regard to Uttar Pradesh, which is an indicator of unequal education progress. On the national level, Katiyar et al. (2016) found that the male-female literacy gap was still present, and the percentage of illiterate women was a significant number that increased despite the overall trends. Deepa (2017) studied Ballabgarh Tehsil, where overall literacy

(53.10 -63.16) improved between 2001 and 2011, but still there was gender inequality. In their study Kumar et al. (2019) examined the populations of scheduled-caste in Jammu Province that have shown strong spatial differences and demographic imbalance, highlighting how micro-geographical analysis is required to understand the aspects of literacy and gender disparity of the disadvantaged population. Pal et al. (2020) noticed that the Gender-Related Educational Development Index (GEDI) has improved in Uttar Pradesh between 2001 and 2011, but there were still substantial inequality levels. Even with an overall high level of literacy, Laltlansangi et al. (2021) found that in Mizoram, spatial and gender inequality continued to be present, but the differences in literacy decreased over time. According to Sakshi et al. (2023), inter-district heterogeneity in gender literacy differences was observed: some of them were narrowed down, others were significantly unequal. Kumar and Dar (2024) examined the example of Haryana and found that there are strong gender inequalities in the rural and urban areas; the literacy gap between men and women decreased by 18.61 and 13.23 in 2001 and 2011 respectively, which is evidence of a gradual progress towards equality. The study by Gupta et al. (2025) also determined socio-cultural norms, economic factors, and poor

infrastructure as major limitations to the access of girls to education in the state.

Study Area

Chitrakoot District is located in the southern part of Uttar Pradesh and it is part of the Bundelkhand region- a region that is widely recognized to be socio-economically backward and limited in terms of the environment. Geographically, it lies within the latitudes of 24° 0' 48" to 25° 0' 12" N and 80° 0' 58" to 81° 0' 34" E. It has Banda to the north, Prayagraj to the east and Satna and Panna districts of Madhya Pradesh as its south and west boundaries respectively. Its physical geography is a topographic roll, rocky plateau, shallow soil, and seasonal flowing rivers, which hinder the agricultural output and infrastructural growth. Chitrakoot is an administrative unit that is further divided into a number of development blocks which are characterized by a significant socio-economic and demographic diversity. The historical record of the district shows a low level of literacy, in particular, among the women, and strong intra-district disparity in literacy attainment. Although the general literacy increased in the period of 2001-2011, there was still an uneven rate of growth of female literacy across the blocks. Chitrakoot is also in conflict with sex ratio imbalance, which is influenced by socio-cultural norms, gender

prejudice and access to health services and education.

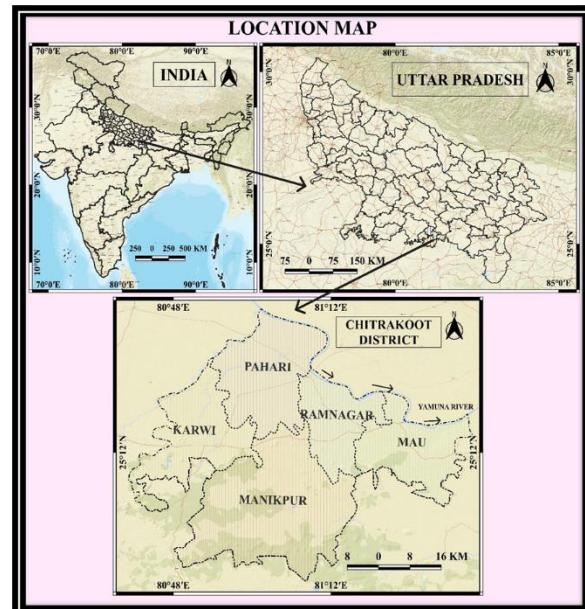


Figure 1: Location Map of the Study Area

Objectives:

The specific objectives are:

- To examine the spatio-temporal variations in literacy rate across different blocks of Chitrakoot District (2001-2011).
- To study the male-female literacy rate and gender gap in the study area (2001-2011).
- To analyse the block-wise changes in sex ratio during the study period.
- To find out the relationship between literacy and sex ratio in Chitrakoot District.

Hypothesis:

Improvements in literacy are associated with changes in sex ratio patterns in Chitrakoot District.

Materials and Methods

The current research project uses secondary data, which was obtained in the form of the District Census Handbooks of Chitrakoot District, which were released by

the Census of India in 2001 and 2011. The studies of the spatial-temporal differences in literacy and sex ratio were conducted through the synthesis of GIS and statistical analyses. The measures of decadal change were used to determine change over time whereas the differentials of gender were tested using the male-female literacy gap. Thematic cartographic representations provided thematic representations of spatial patterns. The relationship between sex ratio and literacy was tested with the help of the coefficient of Spearman rank correlation. Statistic operations were conducted in IBM SPSS Statistics (Version 27.0.1).

Result and Discussion

Table 1: Decadal Changes in Literacy Rate of Chitrakoot District (2001-2011)

Sl. No.	Block	Literacy Rate (2001)	Literacy Rate (2011)	Decadal Change
1.	Pahari	62.2	63.84	+1.64
2.	Karwi	68.0	63.83	-4.17
3.	Manikpur	58.1	60.99	+2.89
4.	Ramnagar	71.9	62.83	-9.07
5.	Mau	60.5	67.29	+6.79
Total		63.6	63.78	+0.18

Table 1 shows that, during the period of 2001-2011, the Chitrakoot District as a unit showed only a slight improvement as the literacy rates went up by 63.6 -63.78 or 0.18 percentage points per one decade. Such a small aggregate

change masks sharp block level spatial inequalities. Mau was the most performing block and recorded an impressive increase of 6.79 percentage points (60.5% to 67.29%), which indicates a fast growth in accessibility and participation in education. There was also significant improvement observed in Manikpur as Literacy increased by 2.89 percentage points as compared to Pahari which only improved by a modest 1.64 percentage points, which are indicative of slower but gradual improvement. On the other hand, two blocks recorded a negative change in the level of literacy, which underscores negative change over time. Ramnagar recorded the highest drop with literacy reducing by 9.07 percentage points which shows a very serious lack of education. Another percentage fall was 4.17 points by Karwi. Such negative growth rates can be indicative of an increased number of school dropouts, out-migration or a decline in the educational infrastructure and socio-economic status over the decade. All in all, the cumulative study on percentage-point change of literacy in Chitrakoot District indicates that the growth in literacy was very geographically skewed with some blocks recording a speedy growth and some experiencing backsliding. The fact that the district-wide average was virtually the same is not very encouraging, but the increasing intra-district differences make it

clear that block-specific educational planning and interventions should be implemented instead of district-wide policies.

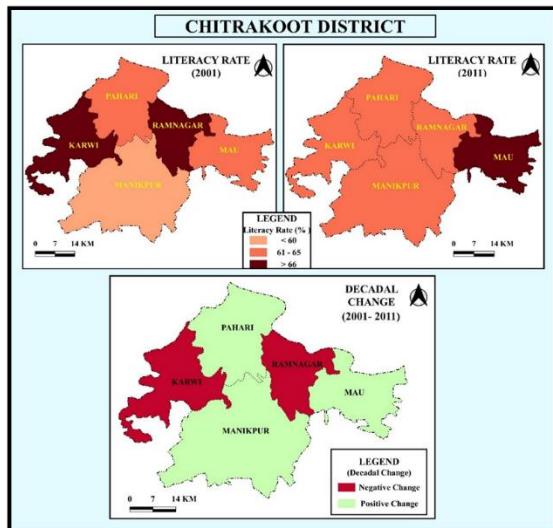


Figure 2: Literacy Rate & Decadal Change Map of Chitrakoot District (2001-2011)

Male-Female Literacy Rate and Gender Gap (2001-2011)

Table 2: Male - Female Literacy & Gender Gap in Chitrakoot District (2001-2011)

Sl. No.	Block	Literacy Rate (2001)			Literacy Rate (2011)		
		Male	Female	Gender Gap	Male	Female	Gender Gap
1.	Pahari	75.9	45.9	30.0	75.16	50.78	24.38
2.	Karwi	80.6	53.0	27.6	75.66	50.16	25.50
3.	Manikpur	71.8	42.0	29.8	71.64	48.66	22.98
4.	Ramnagar	81.5	60.7	20.8	73.80	50.18	23.62
5.	Mau	74.5	44.9	29.6	77.61	55.76	21.85
Total		76.6	48.4	28.2	74.88	51.03	23.85

As can be observed in Table 2, the Census 2001 and 2011 data show a clear trend of male-female literacy disparities and the general gap in gender in the District of Chitrakoot. In 2001, all blocks recorded high male literacy as compared to female literacy, thus creating gender gaps. The largest gender

disparity was observed in Pahari (30.0 percent), closely followed by Manikpur (29.8 percent) and Mau (29.6 percent) which show that the problem of women being disadvantaged in terms of education was acute in these rural and hilly regions. The gap was also high in Karwi (27.6.6) and Ramnagar (20.8.6) with the lowest gender disparity, and the access to education by females was relatively higher. The gender gap was 28.2 0. at the district level which shows that at the year 2001, there was a high level of male dominance in literacy. By 2011, males and females literacy in most blocks was improved and female literacy increasing more faster, thus closing the gap between males and females in all blocks. The greatest decrease in gender gap was registered in Manikpur (29.8 to 22.98), Mau (29.6 to 21.85), and Pahari (30.0 to 24.38) which means that there was a significant improvement in the education of women. In Karwi, the difference narrowed down a little to 27.6 to 25.50, whereas Ramnagar was only slightly different since the differences in female literacy was 20.8 to 23.62, indicating uneven gains in female literacy. On the district level, the general gender gap dropped to 23.85 in 2011 as compared to 28.2 in 2001, and this is positive, as the gender inequality in literacy is still present, but there is a positive direction

towards the increased educational inclusion of women in Chitrakoot district.

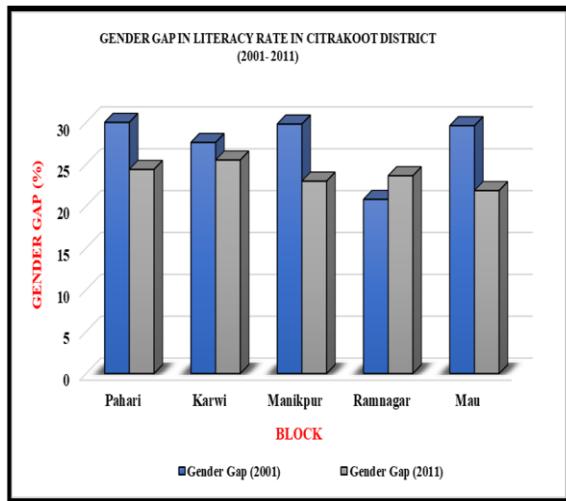


Figure 3: Gender Gap in Literacy Rate in Chitrakoot District (2001-2011)

Block-Wise Patterns and Changes in Sex Ratio (2001-2011)

Table 3: Decadal Changes of Sex Ratio in Chitrakoot District (2001-2011)

Sl. No.	Block	Sex-Ratio (2001)	Sex Ratio (2011)	Decadal Change
1.	Pahari	861	874	+13
2.	Karwi	860	873	+13
3.	Manikpur	872	871	-1
4.	Ramnagar	880	877	-3
5.	Mau	899	898	-1
Total		873	878	+5

Table 3 demonstrates that the sex-ratio increase over 2001-11 in blocks in Chitrakoot District is a very lopsided demographic transition with the block-wise analysis of sex-ratio growth. At the district level, the sex ratio changed by an margin of 873 to 878 and a net change of 5 females per 1,000 males which indicates a small general positive change. But this overall improvement covers significant

inter-block discrepancies. The most performing blocks were Pahari and Karwi, which achieved a decadal growth of 13 percentage points, which is a relatively higher growth in the female population than the male population. This implies a relatively higher socio-demographic status, increased female survival or less gender biasness in such regions over the decade. Conversely, the growth in sex ratio in Manikpur, Ramnagar and Mau was negative, which shows demographic stress. Ramnagar was the only area that registered the highest decline by 3 points in the sex ratio which implied certain relative decline in the female population. Manikpur and Mau had also recorded slight deteriorations of -1 each, which indicated no improvement or little deterioration in the gender balance. On the whole, the analysis of the growth-rate indicates that, although certain blocks progressive achieved moderate gains on the way to a more even sex-ratio, others did not progress, but remained at the level, which highlights the spatially differentiated character of demographic change in the Chitrakoot District. This indicates that area-specific interventions are necessary especially in blocks where there is negative growth to combat chronic gender imbalance.

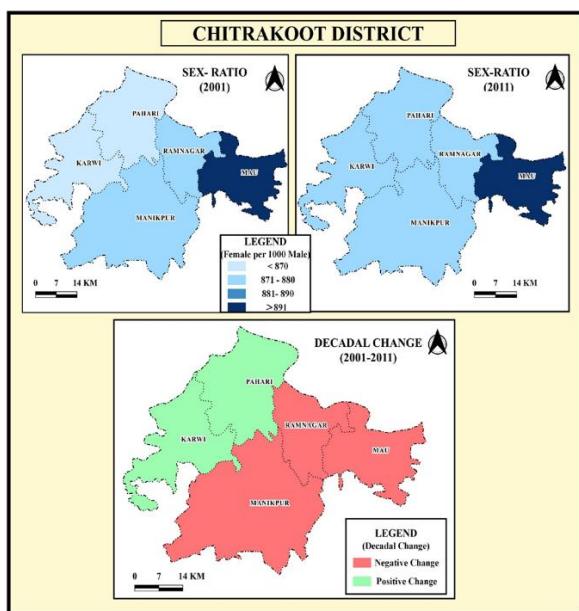


Figure 4: Sex-Ratio & Decadal Change Map of Chitrakoot District (2001-2011)

Relationship Between Literacy and Sex Ratio (2001-2011)

To fulfil the fourth objective of examining the relationship between literacy and sex ratio in Chitrakoot District, a hypothesis has been formulated to analyse the association between these two key socio-demographic variables. The analysis is based on the block-level Census data for the years 2001 and 2011, as shown in

Table 4:

Sl. No.	Block	Literacy Rate (2001)	Sex-Ratio (2001)	Literacy Rate (2011)	Sex Ratio (2011)
1.	Pahari	62.2	861	63.84	874
2.	Karwi	68.0	860	63.83	873
3.	Manikpur	58.1	872	60.99	871
4.	Ramnagar	71.9	880	62.83	877
5.	Mau	60.5	899	67.29	898
Total		63.6	873	63.78	878

To explore the correlation between literacy rate and sex ratio in the administrative blocks

of the Bhagalpur district, we used correlation analysis between the data of census of 2001 and 2011, as summarized in Table 5.

Table 5: Spearman's Rank Correlation between Literacy Rate & Sex Ratio in Chitrakoot District

Census Year	Variables Compared	N	Spearman's ρ (rho)	Sig. (2-tailed)	Nature of Relationship
2001	Literacy Rate & Sex Ratio	5	-0.200	0.747	Weak negative, not significant
2011	Literacy Rate & Sex Ratio	5	+0.300	0.624	Weak positive, not significant

The limited number of observational units and the fact that the dataset is based on aggregate census figures would not make a parametric approach appropriate. Literacy levels and sex ratio were therefore assessed using the Spearman rank correlation coefficient which is a non-parametric statistic and does not assume normality unlike the parametric statistic; it is also suitable when dealing with small samples. The Spearman findings indicate that the relationship between literacy rate and sex ratio, both in Chitrakoot District, is also weak and statistically insignificant: the estimation of the 2001 is weakly negative, and the estimation of the 2011 is weakly positive showing a slight directional change over the years. Nevertheless, the p-values are high ($p > 0.05$) which means that the increase in literacy did not have a statistically significant effect on sex-ratio patterns over the study period.

Hypothesis Decision

As a result of the Spearman analysis, the correlation of the literacy rate and sex ratio in Chitrakoot District in 2001 and 2011 were statistically insignificant ($p > 0.05$). The null hypothesis, which states that there is no relationship, is therefore accepted and the alternative hypothesis rejected, which means that literacy increases during the study did not create a statistically significant change to the sex ratio patterns in the district.

Suggestions

The results provide evidence of the importance of handling not only literacy differentials but also gender imbalance in Chitrakoot District with the help of context-specific interventions. Considerable attention needs to be directed on raising female education, particularly in blocks with low literacy and with high gender disparity through channels like scholarships, residential schools, and community-based learning centres. District level policies can not appropriately reflect the local differences, and block level educational planning is needed, taking into consideration socio-economic and cultural limitations. In order to improve sex-ratio performance, literacy interventions should be coupled with gender-sensitisation interventions, health awareness interventions, and interventions that will foster the value of the girl child. It is important to enhance the

education infrastructure by providing access to schools, the availability of qualified educators, and access to quality of education in rural and underdeveloped regions to slow down the dropout rates and maintain literacy acquisition. Laggards may be detected over time by regularly observing micro-level data and providing GIS-based analysis, as well as providing a way to assess the effectiveness of interventions over time and feedback policy improvements. Community participation, which uses local institutions, self-help organisations and non-governmental organisations, is still central in addressing the deep-rooted socio-cultural determinants of both literacy and gender imbalance.

Conclusion

The current research indicates that, the levels of literacy development in Chitrakoot District and patterns of sex ratios show both space and time differences in terms of block level. The overall literacy in the district has improved slightly between 2001 and 2011, but a lot of intra-district differences have appeared, and some blocks have gained greatly, whereas other ones have not changed or deteriorated. The level of literacy among the females improved in the majority of the blocks and this led to the narrowing of the gender gap, however, the rate of improvement was not evenly spread especially in the

backward and rural setting. The sex -ratio analysis indicates a slight increase in the district level but there are still contrasting trends in the blocks with some blocks registering an increase and others registering a decrease. As shown in the correlation analysis, although there was a change in the relationship between two variables to be weakly positive in 2011 as compared to weakly negative in 2001, the relationship was not statistically significant. Therefore, it seems that literacy gains are not enough to make significant changes in sex-ratio patterns during the period of the study. Such discoveries bring gender imbalance to the fore as a multidimensional problem that is influenced not only by education but also by the socio-cultural practices, health infrastructure, migration, and economic standards. All in all, the analysis shows the significant role of micro level spatio-temporal analysis in the comprehension of educational and demographic changes and how the averages on the district level may hide deep internal inequalities.

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