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## Geospatial mapping of crimes against women in West Bengal: Patterns, clusters, and policy insights

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### Abstract

Crime against women (CAW) is a persistent challenge in West Bengal. This study provides actionable insights through a comprehensive spatio-temporal analysis of six major forms of CAW across West Bengal, using current data from the National Crime Records Bureau (NCRB) for 2017-2022. These crimes include 'dowry deaths', 'cruelty by husband or his relatives', 'kidnapping and abduction of women', 'human trafficking', 'rape', and 'assault on women with intent to outrage her modesty.' Focusing on these crimes, this study adopted a multifaceted methodological approach to uncover their spatial and temporal patterns in the state. This study employs advanced spatial analysis techniques, such as the Crime Concentration Index to measure crime clustering, the Getis-Ord Gi\* statistic to identify local clusters of high or low crime, and Anselin's Local Moran's I to pinpoint local clusters and outliers. By integrating these methods, this study overcomes the limitations of prior research that lacks sophisticated spatial analysis, providing a deeper and more precise understanding of spatial crime patterns across the districts of West Bengal at a higher spatial resolution. This enhanced insight supports evidence-based policy formulation, facilitates targeted interventions, and ultimately contributes to building a safer and more equitable society for women.

**Keywords:** Crime Against Women, Spatio-temporal analysis, Spatial Statistics, West Bengal

### Introduction

Crimes against women (CAW) refer to acts that physically, sexually, or psychologically harm women based on their gender. Internationally, the 1993 United Nations (UN) Declaration on the Elimination of Violence Against Women (VAW) broadly defined "VAW as gender-based acts causing or likely to cause physical, sexual, or psychological harm, including threats, coercion, or arbitrary deprivation of liberty, whether in public or private life" (United Nations General Assembly, 1993) <sup>[1]</sup>. Similarly, the Council of Europe (Istanbul Convention) defines VAW as a human rights violation and a form of discrimination against women. It refers to all acts of violence that result in or are likely to result in physical, sexual, psychological, or economic harm or suffering to women, including threats, coercion, or arbitrary deprivation of liberty, whether occurring in public or private spaces (Council of Europe, 2011) <sup>[2]</sup>. While international conventions define VAW as a human rights concern, it is crucial to understand how these global principles apply at the national level. In this study, VAW and CAW are treated as synonymous, referring to legally recognized offences under the Indian Penal Code (IPC) and Special and Local Laws (SLL). In India, constitutional provisions and societal dynamics uniquely shape the contours of CAW. The Indian Constitution is the cornerstone of women's rights in India. Although the Constitution lacks a specific definition for CAW, however, Article 14 ensures equality before the law, Article 15 prohibits discrimination while allowing special provisions for women, Article 21 guarantees the right to life with dignity, and Article 51A(e) obligates citizens to reject derogatory practices against women. These constitutional provisions highlight the state's duty to legislate against crimes and prevent them.

Several theoretical perspectives frame CAW as a complex issue. For instance, economic models suggest that women's financial independence and educational attainment can mitigate violence (Hampton and Gelles, 1994; Roy, 2003) <sup>[3, 4]</sup>. In contrast, sociological theories propose a more intricate relationship, wherein individuals or societal structures sometimes employ violence to control women's access to resources (González-Brenes, 2004; Rowe *et al.* 2006) <sup>[5, 6]</sup>, because it's deeply rooted in societal norms and power imbalances that

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are products of the social construction of crimes and deviance (Madhu, 2023) <sup>[7]</sup>. According to feminist criminologists, CAW are a systemic manifestation of patriarchal power dynamics aimed at control (Lenton, 1995; Chesney-Lind, 2006) <sup>[8, 9]</sup>. India's entrenched patriarchal social structures exacerbate CAW, creating environments in which these crimes go unchallenged (Niaz, 2003) <sup>[10]</sup>. Furthermore, liberal feminists emphasize how gender inequality and biases within the criminal justice system contribute to the underreporting and inadequate addressing of offences (Malhotra *et al.*, 1995; Madhu, 2023) <sup>[11]</sup>.

Beyond these theoretical lenses, the Indian context presents a complex interplay of these perspectives within its policy and legal frameworks on CAW. Economic models support policies that promote women's education and empowerment, such as vocational training and microfinance (Paul, 2025) <sup>[12]</sup>. However, the persistence of CAW suggests that economic uplift alone cannot dismantle gender-based violence (Lolayekar *et al.*, 2020) <sup>[13]</sup>. Sociological and feminist theories, which highlight power imbalances and societal norms, inform laws such as the Protection of Women from Domestic Violence Act (PWDVA) of 2005. This act recognizes diverse forms of domestic abuse beyond physical violence and offers civil remedies and protection orders for women. However, challenges in implementation persist, including underreporting and societal acceptance of certain forms of violence. These issues underscore the ongoing struggle against deeply rooted patriarchal social structures, as theorized by Niaz (2003) <sup>[10]</sup>. In addition to this, liberal feminist criticisms of the structural systemic biases of India's criminal justice framework remain at the centre of ongoing debates on CAW. Despite initiatives to enhance police sensitivity, judicial accountability, and legal aid accessibility, the underreporting of complaints and limited redress reflect entrenched institutional shortcomings. Legislative interventions, notably the Criminal Law (Amendment) Act of 2013, introduced progressive reforms to address women's safety issues. However, low rates of reporting, prosecution, and conviction underscore continuing structural impediments.

Moving from national frameworks to specific regional manifestations, various spatial analyses have revealed significant intra-regional variations in CAW, particularly in West Bengal. For instance, studies on districts like South 24 Parganas attribute the high incidence of crimes to factors such as illiteracy and entrenched social customs (Karmakar, 2013) <sup>[14]</sup>. The range of crimes encompasses widespread physical and psychological violence, with post-marital cruelty and dowry-related abuse being the most prevalent forms of victimization in the district (Prasad, 2018; Mukherjee, 2020) <sup>[15, 16]</sup>. However, these studies often employ singular spatial methods or descriptive approaches, which limits their ability to precisely map and understand the nuanced multifactorial patterns of intra-regional variation. This study addressed this issue by integrating multiple, complementary spatial statistical techniques. Significant variations in crime patterns also exist in the context of rural-urban dynamics. In urban contexts, high-intensity districts such as North 24 Parganas, South 24 Parganas, Kolkata, and Murshidabad record major crimes such as murder, theft, and gender-based violence. Conversely, rural areas experience offences such as theft, arson, and violence against women (Karmakar, 2013; Mukherjee, 2020) <sup>[14, 16]</sup>. The literature consistently

highlights the profound mental, physical, and social impacts of these crimes on affected women (Sarkar, 2023) <sup>[17]</sup>.

According to the National Crime Records Bureau (NCRB) <sup>[18, 19, 20, 21, 22, 23]</sup>, the rate of CAW (IPC) in India surged by over 14.7% between 2017-2022 with the crime rate increasing from 57.9 to 66.4 per 100, 000 women and in case of CAW (IPC+SLL) it increased to 15.1% from 58.7 to 67.6 per 100, 000 women. The most common offences reported were cruelty by husbands or relatives, kidnapping and abduction of women, and assault on women with intent to outrage her modesty, with growth rates of 19.2%, 18.7% and 19.2%, respectively. If we look at the growth rate of CAW (IPC), we can find that states such as Uttar Pradesh (17.40%), Maharashtra (41.8%), Rajasthan (10.60%), West Bengal (12.10%), and Madhya Pradesh (7%) are foremost during the period and these states accounted for more than half (50.20) of the total CAW (IPC) in 2022. West Bengal, in particular, consistently ranked among the top five Indian states in CAW. From 2017 to 2022, cruelty by husband or his relatives, assault on women with intent to outrage her modesty, kidnapping and abduction of women, rape, and dowry deaths were major contributors to CAW. In 2022, the state ranked fourth nationally with 31, 969 cases, leading the national chart in 2021 for cruelty by husbands or his relatives with 19, 952 cases, dropping to second in 2022 with 19, 650 cases. The state also ranked fifth in dowry deaths and kidnapping and abduction of women, seventh in human trafficking, and eleventh in both rape and assault on women. This data paint a grim picture of women's safety in West Bengal, revealing a widespread and escalating crisis. The significant increase in reported cases and the high prevalence of severe offences indicate women's routine vulnerability to violence, often within their homes or at the hands of known individuals. The consistent high rankings of West Bengal underscore that these are not isolated incidents but are systemic issues.

Previous research has employed various Geographic Information System (GIS) techniques and statistical methods to analyze the spatial distribution and patterns of CAW and to identify districts with varying levels of crime concentration. However, there is still a lack of precise understanding of the spatial concentration and underlying dynamics of different types of crime. This is largely due to the absence of integrated methodological approaches that combine complementary analytical strengths for a comprehensive and accurate assessment. Therefore, this study aims to query the spatio-temporal patterns and geographical concentrations of CAW, with emphasis on major forms of IPC crimes that occurred against women across the districts of West Bengal between 2017 and 2022, and suggest their policy implications. To this end, the study underscores the necessity of applying the Crime Concentration Index (CCI), Getis-Ord Gi\* statistic (Gi\* statistic), and Anselin's Local Moran's I (LMI) to achieve the study aims.

## 2. Materials and Methods

### 2.1 Data Sources and Acquisition

In this study, district-wise and crime head-wise crime incidence data on CAW (IPC and SLL) were obtained for the years 2017 to 2022 from the NCRB, a recognized, reliable, and authoritative institution that compiles and publishes comprehensive annual crime data. Besides, population data for the year 2011 were acquired from the

State Statistical Handbook <sup>[24]</sup> and projected population data for 2021 were obtained from Pandit and Halder (2023) <sup>[25]</sup>.

## 2.2 Variables and Indicators

The analysis used four dimensions to measure the overall and gender-specific occurrence of crime. These are Total Crime (IPC+SLL), Total Crime (IPC), CAW (IPC+SLL), and CAW (IPC). Within CAW (IPC), the study considered six major forms of variables such as dowry deaths, cruelty by husband or his relatives, kidnapping and abduction of women, human trafficking, rape, and assault on women with intent to outrage her modesty. The indicators computed across the crime dimensions included district-wise crime rate (per 100, 000 female population), annual growth rate (AGR), compound annual growth rate (CAGR), percentage share, net change (2017-2022), and descriptive statistics such as sum, mean, median, min., max., range, and standard deviation (SD).

## 2.3 Analytical techniques

For each dimension, several indicators were computed to capture temporal and spatial variations in crime. Crime rates were normalized per 100, 000 population using the following standard formula:

$$CR^{i,j} = \left( \frac{N_c^{i,j}}{P^{i,j}} \right) \cdot 10^5$$

Where  $CR^{i,j}$  denotes crime rate in the  $i^{th}$  year of  $j^{th}$  unit of study,  $N_c^{i,j}$  denotes total number of reported crimes in the  $i^{th}$

year of the  $j^{th}$  unit of study,  $P^{i,j}$  represents corresponds to the relevant population denominator (i.e. total female population for crime rate against women and total population for overall crime rate) in the same year and unit. The scaling constant  $10^5$  converts the ratio into cases per 100,000 population to facilitate comparisons across regions and periods.

The AGR was calculated using the following formula:

$$AGR^{i,j} = \frac{CI_c^{i,j} - CI_p^{i,j}}{CI_p^{i,j}} \cdot 100$$

Where  $AGR^{i,j}$  denotes the annual growth rate of crime incidence in the  $i^{th}$  year of the  $j^{th}$  unit of study,  $CI_c^{i,j}$  represents the total crime incidence in the  $i^{th}$  year of the  $j^{th}$  unit of study, and  $CI_p^{i,j}$  corresponds to the crime incidence in the previous year of the same unit of study.

The percentage share was derived to assess the relative burden of CAW (IPC+SLL) against Total Crime (IPC+SLL), CAW (IPC) against Total Crime (IPC), and the six major forms of CAW (IPC) against Total Crime (IPC+SLL).

To capture the variability and distributional characteristics, descriptive statistics such as sum, mean, median, min., max., range, and standard deviation (SD) were computed. Additionally, the Net Change was calculated, representing the difference between the first and last years of the study period, and the CAGR was calculated using the following formula:

$$CAGR^j = \left( \frac{CR^{f,j}}{CR^{i,j}} \right)^{\frac{1}{n}} - 1$$

Where  $CAGR^j$  = Compound annual growth rate of crime incidents in the  $j^{th}$  unit of study,  $CR^{f,j}$  = Crime Incidents in the final year ( $f$ ) of the  $j^{th}$  unit of study,  $CR^{i,j}$  = Crime Incidents in the initial year ( $i$ ) of the  $j^{th}$  unit of study,  $n$  = Number of years between the initial and final year.

Furthermore, districts were classified into seven trend types, such as episodic surge, fluctuating rise or decline, highly volatile, persistent rise, stable or persistent rise, suppressed decline, and suppressed or volatile, based on AGR patterns, standard deviation thresholds, range values, and directionality. To enhance interpretation, heat maps were prepared using the AGR of CAW (IPC+SLL) and major forms of CAW (IPC) for all districts and for West Bengal overall, with class intervals (CI) determined using the following formula:

$$CI^i = \frac{GR_{max}^i - GR_{min}^i}{N}$$

Where  $GR_{max}^i$  and  $GR_{min}^i$  denote the maximum and minimum growth rates, respectively, in the  $i^{th}$  year across all study units, and  $N$  represents the total number of study units under consideration (for example, 19 districts of West Bengal). This formulation partitions the observed range of growth rates into equal segments corresponding to the number of study units, thereby ensuring consistent categorization and facilitating comparative analyses across districts and time periods.

To analyze the spatial concentration of the six major types of CAW (IPC) across districts, the Crime Concentration Index (CCI) technique was applied to each type of crime. Additionally, a weighted CCI was constructed by integrating these categories into a single composite measure to capture the overall burden of CAW. The CCI was calculated as follows:

$$CCI^j = \left( \frac{CR_s^j}{CR_t^j} \right) \div \left( \frac{CR_s^S}{CR_t^S} \right)$$

Where  $CCI^j$  = Crime Concentration Index for the  $j^{th}$  district,  $CR_s^j$  = Rate of a specific crime against women in the  $j^{th}$  district,  $CR_t^j$  = Rate of total crimes against women in the  $j^{th}$  district,  $CR_s^S$  = Rate of the same specific crime against women in the entire state, and  $CR_t^S$  = Rate of total crimes against women in the entire state.

The CCI measures the geographical concentration of specific crimes within districts and compares local and overall state crime rates. By calculating the ratio of specific crime rates in districts to state-wide rates, the CCI identifies regions with disproportionately high or low crime rates, which helps identify districts that require targeted interventions or further investigation due to unusual crime concentrations. This method provides a nuanced understanding of the distribution of crime. It is grounded in well-established criminological approaches applied by

scholars like Brantingham and Brantingham (1997) [26], McCord and Ratcliffe (2007) [27], Zhang and Peterson (2007) [28], Andersen (2009) [29], Brosnan (2017) [30], Mondal and Pal (2017) [31], and Beconyte (2021) [32] provides a nuanced understanding of the distribution of crime. It goes beyond mere counts and contextualizes local crime rates within a broader state framework, thus enhancing the analysis of the spatial crime distribution. To analyze spatial concentration, the CCI values were categorized into five categories using the Natural Breaks (Jenks) method i.e., Very Low Clustering (0.0000 - 0.5817), Low Clustering (0.5818 - 1.1634), Moderate Clustering (1.1635 - 1.7451), High Clustering (1.7452 - 2.3268), and Very High Clustering (2.3269 - 2.9086).

To further identify statistically significant hot spots and cold spots and measure spatial clustering and localized intensity patterns, the CCI (and weighted CCI) was enhanced using the Gi\* statistic (1992, 1995) [33]. This combined approach allowed to identify local spatial clusters.

$$G_i^* = \frac{\sum_{j=1}^n w_{ij} x_j - \bar{X} \sum_{j=1}^n w_{ij}}{S \sqrt{\frac{n \sum_{j=1}^n w_{ij}^2 - (\sum_{j=1}^n w_{ij})^2}{n-1}}}$$

where  $x_j$  is the attribute value for feature  $j$ ,  $w_{ij}$  is the spatial weight between features  $i$  and  $j$ , and  $n$  is equal to the total number of features.

This integrated approach was employed to identify local spatial clusters of high and low crime rates, commonly referred to as hot and cold spots, respectively. While the CCI identifies regions with disproportionately high or low crime rates, the Gi\* statistic focuses on local patterns, pinpointing specific areas with significantly high or low crime rates. By capturing these local spatial patterns, the Gi\* statistic offers a finer resolution of crime distribution, facilitating targeted interventions. This method refines the analysis by identifying the precise locations of crime hotspots and cold spots, which are crucial for resource allocation and policy-making.

To further augment spatial robustness, the CCI was adjusted for spatial autocorrelation by applying Anselin's Local Moran's I (LMI) (1995) [34]. This complementary technique is particularly valuable for detecting spatial clusters and outlier regions, offering insights into the underlying spatial dependencies of the crime data. Incorporating the LMI adds an additional layer of analytical precision. It identifies areas where high or low values are spatially correlated and where anomalies deviate significantly from their spatial neighbours. Mathematically, the index is defined as:

$$I_i = \frac{(x_i - \bar{x})}{S^2} \sum_j w_{ij} (x_j - \bar{x})$$

Where  $I_i$  is the Local Moran's I for location  $i$ ,  $x_i$  is the value at location  $i$ ,  $\bar{x}$  is the mean of variable  $x$ ,  $S^2$  is the variance of  $x$ ,  $w_{ij}$  is the spatial weight between locations  $i$  and  $j$ , and  $x_j$  is the value at location  $j$ .

This method offers granular insights into spatial dependencies by pinpointing districts that deviate from general patterns and highlighting local clusters. By

uncovering localized trends and outliers that broader analyses might miss, the LMI enhances the understanding of the spatial heterogeneity of crime rates. This ensures that areas with unusual patterns are not overlooked, facilitating targeted interventions and in-depth investigation.

By employing a combination of CCI, Gi\* Statistic, and LMI, this study ensured a comprehensive analysis of crime patterns, local spatial clusters, and outliers. These complementary techniques provide a multifaceted view of crime distribution, leveraging local spatial statistics to capture the full spatial dynamics and deliver accurate, reliable, and nuanced insights into the geographical and temporal patterns of crimes against women in West Bengal.

## 2.4 Statistical tools and Software

Microsoft Excel (Office 365) was used for incidence tabulation, crime rate calculations, and descriptive statistics. ArcGIS 10.8 was used for spatial statistical analysis, including the CCI, Gi\* Statistic, and LMI,

## 3. Methodological rigor and Limitations

The study framework emphasizes methodological transparency, comparability, robustness, and reproducibility. Each stage from incidence calculation, rate standardization, mean estimation, CCI development to spatial refinement was explicitly documented with formulas to ensure clarity. Crime rates were standardized per 100,000 female population to enable cross-district comparison, and sequential refinement from CCI through Gi\* statistic to LMI reduced bias and improved spatial accuracy. Although the cartographic outputs and spatial procedures generated in ArcGIS 10.8 are software dependent, the workflow remains replicable using NCRB data, census projections, and standard spatial statistics tools.

However, this study has some limitations. The study relies on 2011 female population data for crime rates for 2017-2020, while projected data for 2021 and 2022 are used due to the unavailability of recent government census data. This reliance on older or projected figures is a limitation, as demographic changes can influence the precision of crime rate calculations. Although it is common practice to use 2011 census data as a previous survey period in the absence of updated census data, this can potentially affect the accuracy.

## 4. Results:

### 4.1 Spatio-temporal trends and patterns of crime against women

#### 4.1.1 Statewide trends and patterns of crime against women (IPC and SLL)

Table 1 and figure 1 illustrate the trends in CAW (IPC+SLL) and overall crime in West Bengal. While the total crime rate (IPC+SLL) declined, CAW (IPC+SLL) remained resilient and volatile, growing in prominence within the state's crime profile. The total crime rate (IPC+SLL) consistently declined from 195,537 cases in 2017 to 180,539 in 2022, with a CAGR of - 0.01. Conversely, CAW (IPC+SLL) increased from 30,992 in 2017 to 34,738 in 2022, a net increase of 3,746 cases, with a mean AGR of 2.27%. This increased the proportion of CAW (IPC+SLL) within the total crime from 15.85% in 2017 to 19.24% in 2022 (mean: 17.86%), underscoring the growing prominence of gender-based violence. In addition, the AGR of CAW (IPC+SLL) show significant volatility.

For instance, its declines in 2018 (-1.93%) and 2019 (-1.93%) were followed by a sharp rise in 2020 (20.12%), succeeded by subsequent contractions in 2021 (-1.71%) and 2022 (-3.19%). Besides, IPC crimes also showed a similar trend, the total crime rate (IPC) decreasing from 163,999 in 2017 to 156,503 in 2022 (CAGR: -0.01), while CAW (IPC)

cases increased from 28,756 to 31,969. The share of CAW (IPC) within total crime (IPC) rose from 17.53% in 2017 to 20.43% in 2022, averaging 19.62% over the period. Notably, CAW (IPC) sharply escalated in 2020, growing by 30% and elevating its share to 23.05% of total IPC crimes.

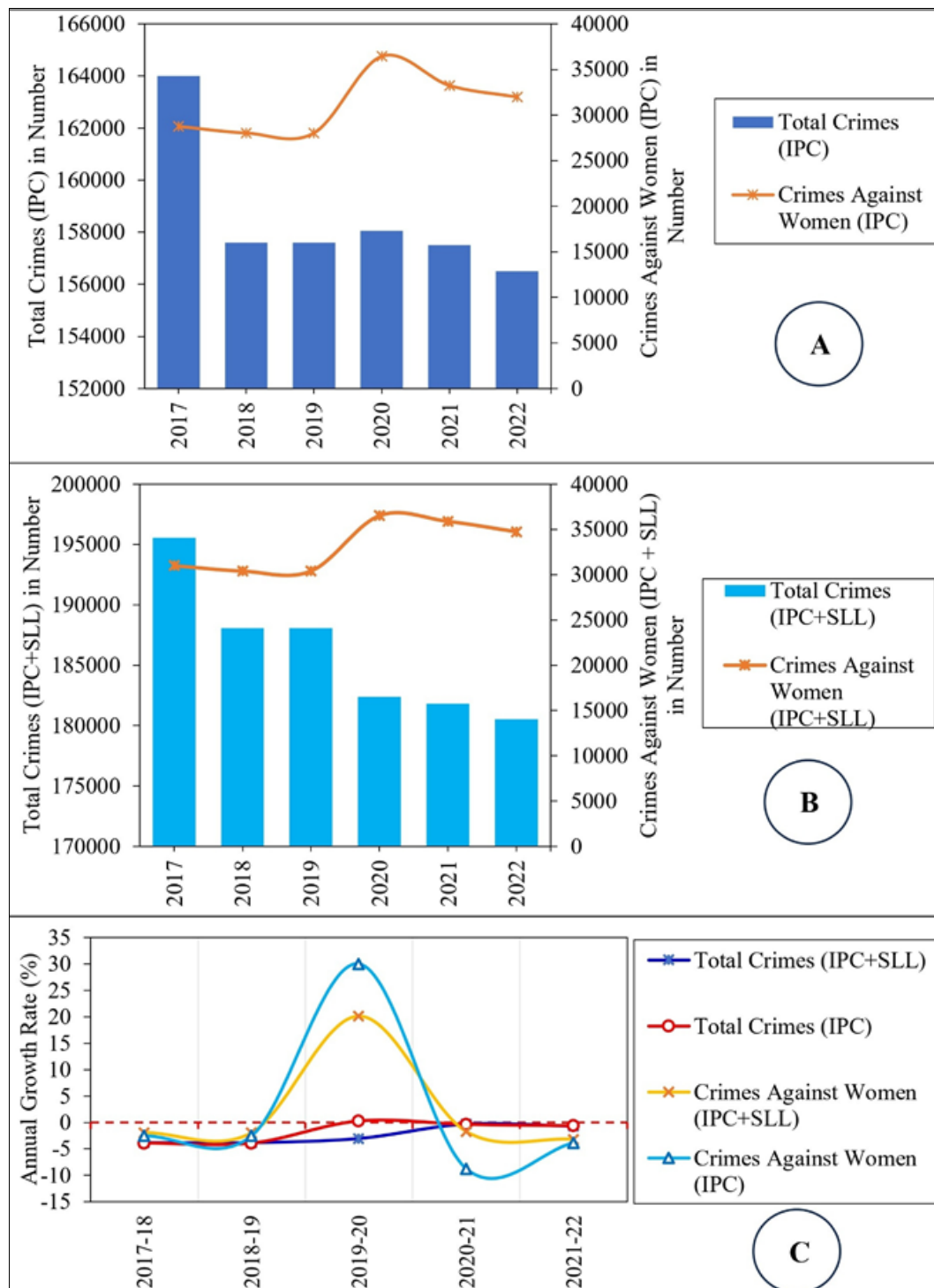


**Fig 1:** Temporal trends in (A) total crimes (IPC) and CAW (IPC), (B) total crimes (IPC+SLL) and CAW (IPC+SLL), and (C) Comparative annual growth rates (%) of total crimes (IPC+SLL), total crimes (IPC), CAW (IPC+SLL), and CAW (IPC), 2017-2022.

**Table 1:** Annual growth rate and percentage share of crimes against women in West Bengal (2017-2022).

| Year       | Total Crime (IPC & SLL) | Annual Growth Rate | Total Crime (IPC) | Annual Growth Rate | CAW (IPC+SLL) | Annual Growth Rate | CAW (IPC) | Annual Growth Rate | % of CAW (IPC+SLL) to Total Crime (IPC+SLL) | % of CAW (IPC) to Total IPC Crime |
|------------|-------------------------|--------------------|-------------------|--------------------|---------------|--------------------|-----------|--------------------|---------------------------------------------|-----------------------------------|
| 2017       | 195537                  | NA                 | 163999            | NA                 | 30992         | NA                 | 28756     | NA                 | 15.85                                       | 17.53                             |
| 2018       | 188063                  | -3.82              | 157610            | -3.90              | 30394         | -1.9295            | 28031     | -2.52              | 16.16                                       | 17.79                             |
| 2019       | 188063                  | -3.82              | 157610            | -3.90              | 30394         | -1.9295            | 28031     | -2.52              | 16.16                                       | 17.79                             |
| 2020       | 182367                  | -3.03              | 158060            | 0.29               | 36509         | 20.1191            | 36439     | 30.00              | 20.02                                       | 23.05                             |
| 2021       | 181821                  | -0.30              | 157498            | -0.36              | 35884         | -1.7119            | 33247     | -8.76              | 19.74                                       | 21.11                             |
| 2022       | 180539                  | -0.71              | 156503            | -0.63              | 34738         | -3.1936            | 31969     | -3.84              | 19.24                                       | 20.43                             |
| Total      | 1116390                 | NA                 | 951280            | NA                 | 198911        | NA                 | 186473    | NA                 | NA                                          | NA                                |
| Mean       | 186065                  | -2.34              | 158547            | -1.70              | 33152         | 2.27               | 31079     | 2.47               | 17.86                                       | 19.62                             |
| Max.       | 195537                  | -0.30              | 163999            | 0.29               | 36509         | 20.12              | 36439     | 30.00              | 20.02                                       | 23.05                             |
| Min.       | 180539                  | -3.82              | 156503            | -3.90              | 30394         | -3.19              | 28031     | -8.76              | 15.85                                       | 17.53                             |
| Range      | 14998                   | 3.52               | 7496              | 4.18               | 6115          | 23.31              | 8408      | 38.76              | 4.17                                        | 5.52                              |
| SD         | 5655.55                 | 1.71               | 2720.14           | 2.03               | 2868.01       | 9.99               | 3411.71   | 15.60              | 2.00                                        | 2.27                              |
| CAGR       | -0.01                   | NA                 | -0.01             | NA                 | 0.02          | NA                 | 0.02      | NA                 | 0.03                                        | 0.03                              |
| Net Change | -14998.00               | NA                 | -7496.00          | NA                 | 3746.00       | NA                 | 3213.00   | NA                 | 3.39                                        | 2.90                              |

#### 4.1.2 District-level trends and patterns of crime against women (IPC and SLL)

The district-level analysis of the AGR for CAW (IPC+SLL) revealed a highly heterogeneous and volatile landscape (table 2 and figure 2). The pattern is predominantly characterized by episodic surge districts, which are distinguished by high positive means and extensive ranges. Malda (mean AGR: 30.30%, range: 95.77, SD: 47.06) is particularly notable for its extreme fluctuations, exhibiting explosive growth in 2017-18 and 2018-19 (80.62%), followed by contractions in subsequent years. Similarly, Purba Medinipur (mean AGR: 9.42%, range: 93.05, SD: 36.85) and Nadia (mean AGR: 6.38%, range: 83.25, SD: 34.81) experienced sharp increases in 2019-20 (74.08% and 68.22%, respectively), followed by Jalpaiguri (mean AGR: 11.41%, range: 62.87, SD: 26.09) and Bardhaman (mean AGR: 6.89%, range: 74.32, SD: 28.15) also reflect episodic surges, with peaks in 2019-20 and subsequent contractions. South 24 Parganas (mean AGR: 15.27%, range: 84.84, SD: 35.82) recorded a dramatic escalation in 2017-18 (50.21%) but declined sharply in 2019-20 (-34.62%). These districts represent zones of instability, where socio-political shocks, enforcement changes, or heightened awareness campaigns may have amplified reporting in certain years. In contrast, several districts exhibited a suppressed decline, characterized by a consistently negative AGR and relatively low volatility. Hooghly (mean AGR: -4.12%, SD: 7.21) and Purulia (mean: -8.24%, SD: 7.29) demonstrated steady contractions, suggesting either genuine reductions or possible under-reporting. Howrah (mean: -6.02%, SD:

13.25) and Murshidabad (mean: -5.64%, SD: 37.02) reflect suppressed but volatile trajectories, with sharp declines interspersed with occasional surges. Cooch Behar (mean AGR: -3.17%, SD: 22.74) also falls into this category, with negative growth in most years but a notable spike in 2019-20 (29.46%). Alongside these, subset of districts exhibited a consistent or stable increases with minimal volatility. Birbhum (mean AGR: 1.78%, SD: 7.58) and Darjeeling (mean AGR: 0.61%, SD: 6.91) demonstrated gradual increases, indicating the structural persistence of gender-based violence without significant fluctuations. Kolkata (mean AGR: 0.85%, SD: 10.90) and Bankura (mean AGR: 3.70%, SD: 17.48) are categorized as experiencing fluctuating increases, characterized by moderate instability but overall positive trajectories. These districts suggest entrenched patterns of violence, where crimes against women remain consistently present, albeit without extreme increases in their numbers. The most extreme cases are highly volatile districts, where AGR values oscillate between sharp declines and increases. Dakshin Dinajpur (mean AGR: 0.52%, SD: 63.02, range: 150.46) recorded both the steepest decline (-50.46% in 2017-18 and 2018-19) and the highest surge (100% in 2019-20). North 24 Parganas (mean AGR: -5.20%, SD: 45.81, range: 105.97) fluctuated between -32.80% and 73.17%. Paschim Medinipur (mean AGR: -1.97%, SD: 28.36, range: 72.81) and Uttar Dinajpur (mean AGR: -2.98%, SD: 24.35, range: 58.62) also fall into the fluctuating decline category, reflecting instability without clear directional trends.

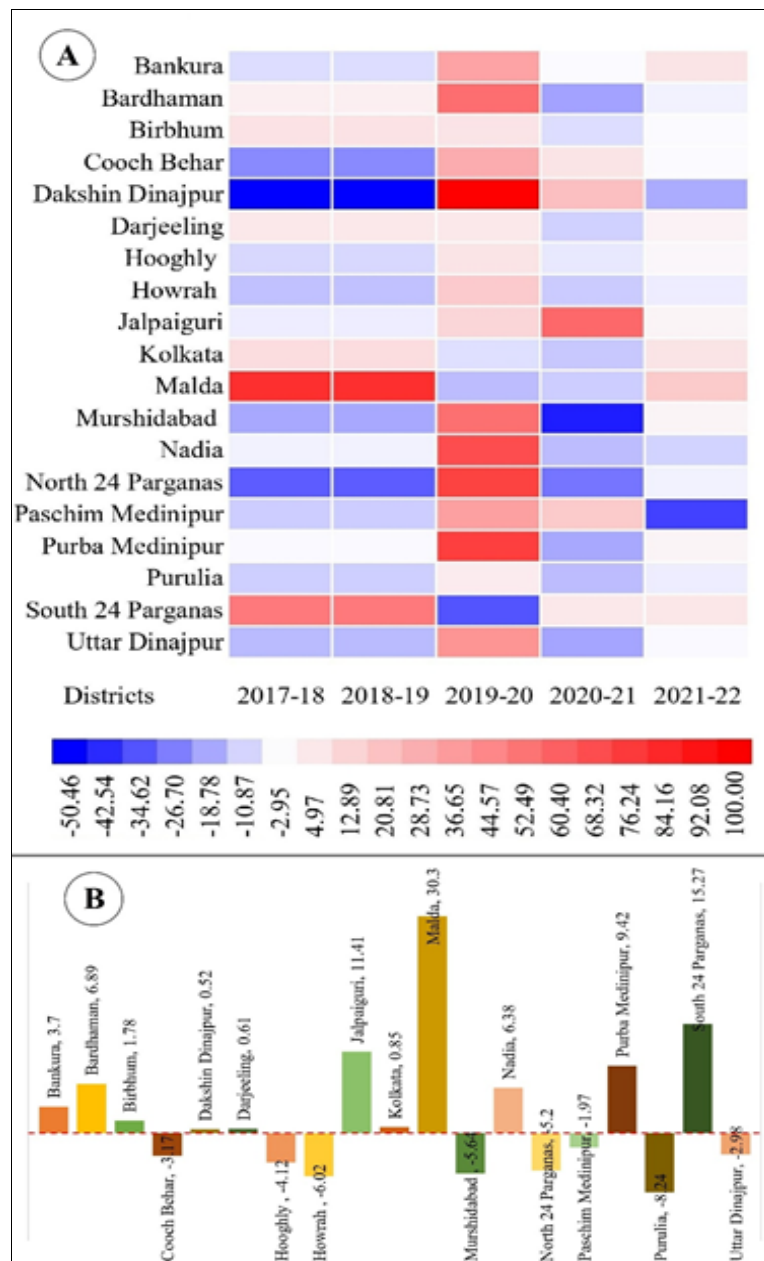


**Fig 2:** Spatio-temporal trends and variations in (A) CAW (IPC+SLL) based on annual growth rates (%) and (B) mean annual growth rates (%) of CAW (IPC+SLL) across districts in West Bengal, 2017-2022.

**Table 2:** District-wise annual growth rate of crime against women (IPC+SLL) across the district of West Bengal (2017-2022).

| Districts         | Annual Growth Rate (AGR) |         |         |         |         | Mean  | Range  | SD    |
|-------------------|--------------------------|---------|---------|---------|---------|-------|--------|-------|
|                   | 2017-18                  | 2018-19 | 2019-20 | 2020-21 | 2021-22 |       |        |       |
| Bankura           | -8.82                    | -8.82   | 32.82   | -3.47   | 6.77    | 3.70  | 41.64  | 17.48 |
| Bardhaman         | 2.27                     | 2.27    | 54.62   | -19.70  | -5.01   | 6.89  | 74.32  | 28.15 |
| Birbhum           | 7.51                     | 7.51    | 6.30    | -9.05   | -3.40   | 1.78  | 16.56  | 7.58  |
| Cooch Behar       | -24.47                   | -24.47  | 29.46   | 6.68    | -3.04   | -3.17 | 53.93  | 22.74 |
| Dakshin Dinajpur  | -50.46                   | -50.46  | 100.00  | 21.65   | -18.13  | 0.52  | 150.46 | 63.02 |
| Darjeeling        | 4.56                     | 4.56    | 4.91    | -11.32  | 0.37    | 0.61  | 16.23  | 6.93  |
| Hooghly           | -9.93                    | -9.93   | 6.86    | -6.92   | -0.65   | -4.12 | 16.79  | 7.21  |
| Howrah            | -14.38                   | -14.38  | 16.86   | -12.26  | -5.93   | -6.02 | 31.24  | 13.25 |
| Jalpaiguri        | -6.06                    | -6.06   | 12.32   | 56.81   | 0.05    | 11.41 | 62.87  | 26.46 |
| Kolkata           | 9.65                     | 9.65    | -8.76   | -13.04  | 6.76    | 0.85  | 22.69  | 10.90 |
| Malda             | 80.62                    | 80.62   | -15.15  | -11.99  | 17.42   | 30.30 | 95.77  | 47.66 |
| Murshidabad       | -18.76                   | -18.76  | 54.16   | -44.75  | -0.09   | -5.64 | 98.91  | 37.02 |
| Nadia             | -5.19                    | -5.19   | 68.22   | -15.03  | -10.88  | 6.38  | 83.25  | 34.81 |
| North 24 Parganas | -32.80                   | -32.80  | 73.17   | -28.56  | -5.01   | -5.20 | 105.97 | 45.31 |
| Paschim Medinipur | -11.84                   | -11.84  | 34.66   | 17.33   | -38.15  | -1.97 | 72.81  | 28.36 |
| Purba Medinipur   | -3.81                    | -3.81   | 74.08   | -18.97  | -0.40   | 9.42  | 93.05  | 36.85 |
| Purulia           | -11.66                   | -11.66  | 3.43    | -15.20  | -6.10   | -8.24 | 18.63  | 7.29  |
| South 24 Parganas | 50.21                    | 50.21   | -34.62  | 4.99    | 5.56    | 15.27 | 84.84  | 35.82 |
| Uttar Dinajpur    | -15.59                   | -15.59  | 39.27   | -19.35  | -3.63   | -2.98 | 58.62  | 24.35 |

### 4.1.3 Statewide trends and patterns of major forms crimes against women (IPC)

Table 3 and figure 3 illustrate the crime rates, annual growth rates, and percentage shares of major IPC crimes against women. While certain offences demonstrate long-term suppression, others remain persistent or exhibit episodic escalation. Dowry deaths have declined, with crime rates decreasing from 1.12 in 2017 to 0.81 in 2022 (CAGR: -0.05). Similarly, AGR also decreased except in 2020, where it increased from -10.71 in 2019 to 18.00% in 2020 with an average of -7.46%. The percentage share also decreased from 1.74% to 1.27%, with an average of 1.50%. In contrast, cruelty by husbands or his relatives remains the most prevalent category, with consistently high crime rates averaging 39.68 per 100,000 women annually. The rates peaked in 2020 at 44.94 but remained above 37 in all years, reflecting the persistent nature of crime. The average AGR was -7.83%, indicating stagnation rather than a significant decline and the percentage share of this crime averaged 59.27% which was peaking at 61.47% in 2022. The category of kidnapping and abduction of women demonstrates a clear upward trend, with crime rates increasing from 9.53 in 2017 to 13.16 in 2022, averaging 12.33 crimes per year. The CAGR of 0.06 confirms sustained growth. AGR were highly volatile, ranging from -5.20% to 72.57%, with a mean of 27.65%. The percentage

share increased from 14.72% to 20.63%, averaging 18.18% during the study period. Conversely, human trafficking shows a steady decline, with crime rates falling from 0.16 in 2017 to 0.06 in 2022, averaging 0.10. The CAGR of -0.15 and repeated declines of -77.79% from 2020 onwards confirm long-term suppression. The percentage share also decreased from 0.25% to 0.10%, averaging 0.15%. Rape crimes remained relatively stable, with rates ranging between 2.22 and 2.54 and an average of 2.38. The overall change was -0.22, with a CAGR of -0.02, indicating a slight decline. The AGR fluctuated, averaging -5.40%, with suppression evident until 2022. The percentage share averaged 3.56%, declining modestly from 3.77% to 3.48%. Finally, assault on women with the intent to outrage modesty show a clear declining trend, with crime rates falling from 8.63 in 2017 to 4.94 in 2022, averaging 6.57 crime per year. The CAGR of -0.09 and consistently negative AGR (mean -34.49%) confirm long-term suppression. The percentage share declined from 13.33% to 7.75%, averaging 9.94% over the study period. Collectively, these six types of crimes reveal that CAW in West Bengal have heterogeneous trajectories. Among these, dowry deaths, human trafficking, rape, and assault show declining or stable trends, while cruelty remains persistently dominant, and kidnapping and abduction of women is on the rise.

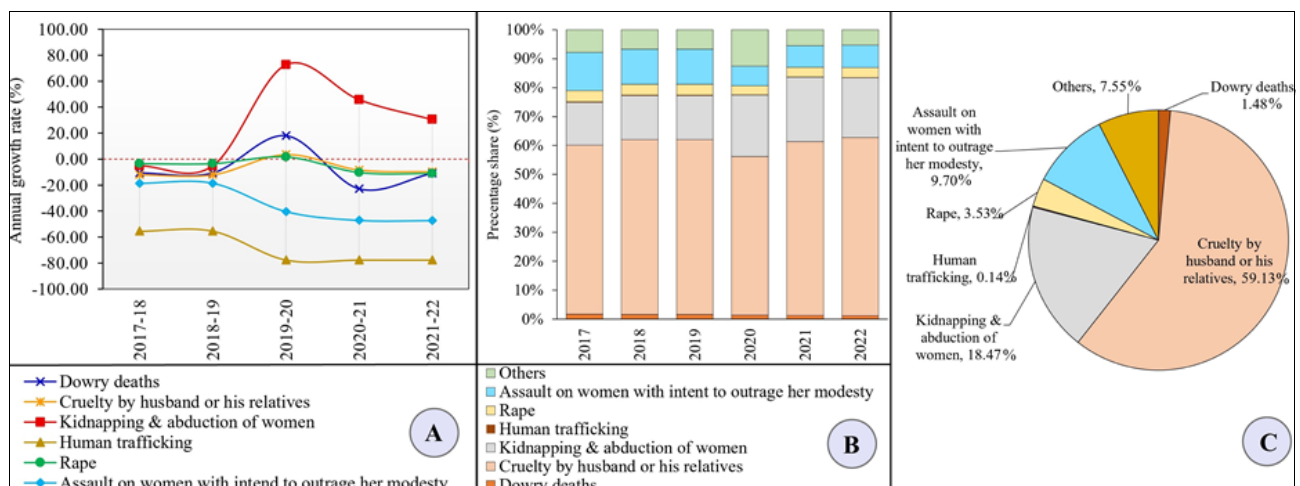


**Fig 3:** (A) Comparative annual growth rates, (B) Year-wise percentage share, and (C) Six-year cumulative percentage share of major forms of CAW (IPC) to total crimes (IPC).

**Table 3:** Crime rate, annual growth rate and percentage share of major forms of CAW (IPC) in West Bengal (2017-2022).

| Year       | Dowry deaths |        |       | Cruelty by husband or his relatives |        |       | Kidnapping & abduction of women |       |       | Human trafficking |        |       | Rape  |        |       | Assault on women with intend to outrage her modesty |        |       |
|------------|--------------|--------|-------|-------------------------------------|--------|-------|---------------------------------|-------|-------|-------------------|--------|-------|-------|--------|-------|-----------------------------------------------------|--------|-------|
|            | CR           | AGR    | %     | CR                                  | AGR    | %     | CR                              | AGR   | %     | CR                | AGR    | %     | CR    | AGR    | %     | CR                                                  | AGR    | %     |
| 2017       | 1.12         | NA     | 1.74  | 37.82                               | NA     | 58.42 | 9.53                            | NA    | 14.72 | 0.16              | NA     | 0.25  | 2.44  | NA     | 3.77  | 8.63                                                | NA     | 13.33 |
| 2018       | 1.00         | -10.71 | 1.58  | 38.16                               | -12.18 | 60.47 | 9.57                            | -5.20 | 15.16 | 0.12              | -55.58 | 0.19  | 2.41  | -3.56  | 3.81  | 7.65                                                | -18.65 | 12.13 |
| 2019       | 1.00         | -10.71 | 1.58  | 38.16                               | -12.18 | 60.47 | 9.57                            | -5.20 | 15.16 | 0.12              | -55.58 | 0.19  | 2.41  | -3.56  | 3.81  | 7.65                                                | -18.65 | 12.13 |
| 2020       | 1.18         | 18.00  | 1.43  | 44.94                               | 3.42   | 54.78 | 17.42                           | 72.57 | 21.24 | 0.06              | -77.79 | 0.07  | 2.54  | 1.65   | 3.10  | 5.60                                                | -40.45 | 6.83  |
| 2021       | 0.91         | -22.88 | 1.37  | 39.80                               | -8.41  | 60.01 | 14.71                           | 45.72 | 22.19 | 0.06              | -77.79 | 0.09  | 2.24  | -10.36 | 3.38  | 4.96                                                | -47.25 | 7.47  |
| 2022       | 0.81         | -10.99 | 1.27  | 39.20                               | -9.79  | 61.47 | 13.16                           | 30.37 | 20.63 | 0.06              | -77.79 | 0.10  | 2.22  | -11.16 | 3.48  | 4.94                                                | -47.47 | 7.75  |
| Mean       | 1.00         | -7.46  | 1.50  | 39.68                               | -7.83  | 59.27 | 12.33                           | 27.65 | 18.18 | 0.10              | -68.91 | 0.15  | 2.38  | -5.40  | 3.56  | 6.57                                                | -34.49 | 9.94  |
| Max.       | 1.18         | 18.00  | 1.74  | 44.94                               | 3.42   | 61.47 | 17.42                           | 72.57 | 22.19 | 0.16              | -55.58 | 0.25  | 2.54  | 1.65   | 3.81  | 8.63                                                | -18.65 | 13.33 |
| Min.       | 0.81         | -22.88 | 1.27  | 37.82                               | -12.18 | 54.78 | 9.53                            | -5.20 | 14.72 | 0.06              | -77.79 | 0.07  | 2.22  | -11.16 | 3.10  | 4.94                                                | -47.47 | 6.83  |
| Range      | 0.37         | 40.88  | 0.47  | 7.12                                | 15.60  | 6.69  | 7.89                            | 77.77 | 7.47  | 0.10              | 22.21  | 0.18  | 0.32  | 12.81  | 0.71  | 3.69                                                | 28.82  | 6.50  |
| SD         | 0.13         | 15.16  | 0.17  | 2.68                                | 6.49   | 2.41  | 3.33                            | 33.58 | 3.51  | 0.04              | 12.17  | 0.07  | 0.12  | 5.34   | 0.29  | 1.60                                                | 14.74  | 2.89  |
| CAGR       | -0.05        | NA     | -0.05 | 0.01                                | NA     | 0.01  | 0.06                            | NA    | 0.06  | -0.15             | NA     | -0.14 | -0.02 | NA     | -0.01 | -0.09                                               | NA     | -0.09 |
| Net Change | -0.31        | NA     | -0.47 | 1.38                                | NA     | 3.05  | 3.63                            | NA    | 5.91  | -0.10             | NA     | -0.15 | -0.22 | NA     | -0.29 | -3.69                                               | NA     | -5.58 |

Note: CR - crime rate, AGR - annual growth rate, % - percentage share to total CAW (IPC)

#### 4.1.4 District-level trends and patterns of major crimes against women (IPC)

The detailed breakdown of major IPC crimes against

women is shown in tables 4-6 and figure 4, which reveal significant variations across districts in West Bengal.

**Table 4:** District-wise annual growth rate of dowry deaths and cruelty by husband or his relatives in West Bengal (2017-2022)

| Districts         | Dowry deaths |         |         |         |         | Mean   | Range  | SD     | Cruelty by husband or his relatives |         |         |         |         | Mean  | Range  | SD     |
|-------------------|--------------|---------|---------|---------|---------|--------|--------|--------|-------------------------------------|---------|---------|---------|---------|-------|--------|--------|
|                   | 2017-18      | 2018-19 | 2019-20 | 2020-21 | 2021-22 |        |        |        | 2017-18                             | 2018-19 | 2019-20 | 2020-21 | 2021-22 |       |        |        |
| Bankura           | -5.26        | -5.26   | 38.89   | -31.74  | -5.26   | -1.73  | 70.63  | 25.44  | -7.80                               | -7.80   | 17.99   | 15.59   | 2.44    | 4.08  | 25.79  | 12.36  |
| Bardhaman         | -19.23       | -19.23  | -11.90  | -8.11   | -26.32  | -16.96 | 18.20  | 7.10   | 12.02                               | 12.02   | 74.39   | -19.77  | -13.85  | 12.96 | 94.17  | 37.30  |
| Birbhum           | -43.75       | -43.75  | 22.22   | 11.47   | -42.86  | -19.33 | 65.97  | 33.25  | -2.15                               | -2.15   | 13.60   | 20.73   | 3.92    | 6.79  | 22.87  | 10.11  |
| Cooch Behar       | 3.70         | 3.70    | -17.86  | 12.74   | -34.48  | -6.44  | 47.22  | 19.30  | -41.08                              | -41.08  | 25.82   | 22.73   | 0.00    | -6.72 | 66.90  | 32.91  |
| Dakshin Dinajpur  | -43.75       | -43.75  | 22.22   | -42.24  | 57.14   | -10.07 | 100.89 | 47.07  | -62.36                              | -62.36  | 46.27   | 51.90   | -0.61   | -5.43 | 114.26 | 55.82  |
| Darjeeling        | 11.11        | 11.11   | 30.00   | -73.05  | 0.00    | -4.17  | 103.05 | 39.99  | -3.73                               | -3.73   | 1.00    | -16.41  | -1.64   | -4.90 | 17.41  | 6.72   |
| Hooghly           | -25.64       | -25.64  | -24.14  | 16.53   | 0.00    | -11.78 | 42.17  | 19.22  | -9.21                               | -9.21   | 6.80    | -2.07   | -0.37   | -2.81 | 16.01  | 6.72   |
| Howrah            | 44.44        | 44.44   | 23.08   | 10.46   | -10.00  | 22.48  | 54.44  | 23.26  | 2.46                                | 2.46    | -2.59   | -12.33  | 2.58    | -1.49 | 14.91  | 6.45   |
| Jalpaiguri        | 36.36        | 36.36   | -6.67   | 1.43    | 21.88   | 17.87  | 43.03  | 19.83  | -21.49                              | -21.49  | 55.09   | 127.69  | 6.88    | 29.34 | 149.18 | 63.26  |
| Kolkata           | -38.46       | -38.46  | 37.50   | -55.61  | 0.00    | -19.01 | 93.11  | 37.59  | 8.59                                | 8.59    | -1.79   | -11.79  | 2.26    | 1.17  | 20.38  | 8.49   |
| Malda             | -34.78       | -34.78  | 120.00  | -61.25  | -26.67  | -7.50  | 181.25 | 72.46  | 231.95                              | 231.95  | 19.71   | -58.23  | 36.49   | 92.37 | 290.18 | 132.34 |
| Murshidabad       | -7.14        | -7.14   | -7.69   | -55.12  | -21.05  | -19.63 | 47.98  | 20.71  | -23.33                              | -23.33  | 25.21   | -21.11  | -0.50   | -8.61 | 48.54  | 21.21  |
| Nadia             | -2.00        | -2.00   | 18.37   | -25.42  | -27.08  | -7.63  | 45.45  | 18.93  | -1.67                               | -1.67   | 56.17   | -8.83   | -0.43   | 8.71  | 65.00  | 26.74  |
| North 24 Parganas | -50.00       | -50.00  | 112.12  | -37.79  | 0.00    | -5.13  | 162.12 | 68.68  | -34.51                              | -34.51  | 66.90   | -25.54  | -7.59   | -7.05 | 101.41 | 42.78  |
| Paschim Medinipur | -56.00       | -56.00  | 45.45   | -11.15  | -6.25   | -16.79 | 101.45 | 42.11  | -0.76                               | -0.76   | 95.19   | -13.69  | -32.56  | 9.48  | 127.75 | 49.65  |
| Purba Medinipur   | -14.29       | -14.29  | 325.00  | -60.00  | 8.70    | 49.02  | 385.00 | 156.28 | -1.69                               | -1.69   | 29.12   | -17.91  | 1.68    | 1.90  | 47.04  | 17.03  |
| Purulia           | -63.64       | -63.64  | 50.00   | 17.56   | 0.00    | -11.94 | 113.64 | 50.48  | 2.47                                | 2.47    | 15.66   | 1.03    | 0.00    | 4.33  | 15.66  | 6.42   |
| South 24 Parganas | 87.50        | 87.50   | -45.33  | 17.91   | -16.07  | 26.30  | 132.83 | 60.18  | 52.61                               | 52.61   | -33.30  | 0.87    | 5.26    | 15.61 | 85.91  | 36.93  |
| Uttar Dinajpur    | 66.67        | 66.67   | 40.00   | 44.65   | -4.17   | 42.76  | 70.83  | 28.97  | -9.96                               | -9.96   | 64.34   | -22.36  | -6.78   | 3.06  | 86.70  | 34.78  |

The analysis of dowry deaths across West Bengal reveals sharp spatial disparities and volatility. Districts such as Purba Medinipur (mean AGR: 49.02%, range: 385.00) and Malda (mean AGR: -7.50%, range: 181.25) demonstrated extreme fluctuations, with episodic surges followed by steep declines. North 24 Parganas (mean AGR: -5.13%, range: 162.12) and Dakshin Dinajpur (mean AGR: -10.07%, range: 100.89) also show instability, reflecting structural fragility in terms of reporting and enforcement. In contrast, Bardhaman (mean AGR: -16.96, SD: 7.10) and Hooghly (mean AGR: -11.78, SD: 19.22) exhibited a suppressed decline, suggesting consistent reductions. Howrah (mean AGR: 22.48 SD: 23.26) and Uttar Dinajpur (mean AGR: 42.76 SD: 28.97) indicate a persistent rise, while Birbhum (-19.33 SD: 33.25) and Kolkata (-19.01 SD: 37.59) reflect long-term contraction despite episodic peaks.

In case of cruelty by husband or his relatives across districts, there are sharp inter-district disparities and volatility. Malda (mean AGR: 92.37%, range: 290.18) and Jalpaiguri (mean AGR: 29.34%, range: 149.18) recorded extreme surges, reflecting episodic escalation. Bardhaman (mean AGR: 12.96%, SD: 37.30) and South 24 Parganas (mean AGR: 15.61%, SD: 36.93) also showed instability with alternating peaks and declines. In contrast, districts such as Darjeeling (mean AGR: -4.90%, SD: 6.72), Hooghly (-2.81%, SD: 6.72), and Howrah (-1.49%, SD: 6.45) exhibited a suppressed decline, suggesting consistent reductions. Dakshin Dinajpur (mean AGR: -0.61%, SD: 55.82) and North 24 Parganas (-7.05%, SD: 42.78) were highly volatile, oscillating between steep declines and sharp increases.

**Table 5:** Annual Growth Rate of Kidnapping & Abduction of Women and Human Trafficking in the Districts of West Bengal (2017-2022)

| Districts         | Kidnapping & abduction of women |         |         |         |         | Mean   | Range  | SD     | Human Trafficking |         |         |         |         | Mean   | Range  | SD     |
|-------------------|---------------------------------|---------|---------|---------|---------|--------|--------|--------|-------------------|---------|---------|---------|---------|--------|--------|--------|
|                   | 2017-18                         | 2018-19 | 2019-20 | 2020-21 | 2021-22 |        |        |        | 2017-18           | 2018-19 | 2019-20 | 2020-21 | 2021-22 |        |        |        |
| Bankura           | 45.45                           | 45.45   | 64.06   | -23.87  | 5.62    | 27.34  | 87.93  | 35.70  | -100.00           | -100.00 | 0.00    | 0.00    | -100.00 | -60.00 | 100.00 | 54.77  |
| Bardhaman         | -4.10                           | -4.10   | 66.54   | -29.34  | 18.64   | 9.52   | 95.88  | 36.11  | 0.00              | 0.00    | -100.00 | 0.00    | -100.00 | -40.00 | 100.00 | 54.77  |
| Birbhum           | 72.92                           | 72.92   | 87.95   | -48.35  | -14.13  | 34.26  | 136.30 | 61.31  | 0.00              | 0.00    | -100.00 | 0.00    | 0.00    | -20.00 | 100.00 | 44.72  |
| Cooch Behar       | 5.70                            | 5.70    | 34.89   | -6.30   | -5.85   | 6.83   | 41.19  | 16.76  | 0.00              | 0.00    | 0.00    | 0.00    | 0.00    | 0.00   | 0.00   | 0.00   |
| Dakshin Dinajpur  | -55.08                          | -55.08  | 309.43  | 19.63   | -32.52  | 37.28  | 364.52 | 155.17 | 0.00              | 0.00    | 0.00    | 0.00    | 0.00    | 0.00   | 0.00   | 0.00   |
| Darjeeling        | -20.34                          | -20.34  | 204.26  | -7.22   | -0.33   | 31.21  | 224.59 | 97.12  | 66.67             | 66.67   | -60.00  | 31.36   | 33.33   | 27.61  | 126.67 | 51.90  |
| Hooghly           | -4.26                           | -4.26   | 78.52   | -34.27  | -1.73   | 6.80   | 112.79 | 42.27  | 0.00              | 0.00    | -100.00 | 0.00    | 0.00    | -20.00 | 100.00 | 44.72  |
| Howrah            | -68.67                          | -68.67  | 421.92  | -19.29  | -34.20  | 46.22  | 490.59 | 211.13 | 66.67             | 66.67   | -100.00 | 0.00    | 300.00  | 66.67  | 400.00 | 147.20 |
| Jalpaiguri        | 6.69                            | 6.69    | 22.35   | 17.48   | -12.59  | 8.13   | 34.94  | 13.45  | -83.33            | -83.33  | -50.00  | 254.99  | -75.00  | -7.34  | 338.32 | 147.28 |
| Kolkata           | 18.11                           | 18.11   | -27.16  | 10.07   | 19.46   | 7.72   | 46.61  | 19.85  | -50.00            | -50.00  | -50.00  | -100.00 | 0.00    | -50.00 | 100.00 | 35.36  |
| Malda             | 494.12                          | 494.12  | 212.38  | -39.89  | -17.30  | 228.68 | 534.00 | 261.64 | -50.00            | -50.00  | -100.00 | 0.00    | -100.00 | -60.00 | 100.00 | 41.83  |
| Murshidabad       | -18.85                          | -18.85  | 116.54  | -40.48  | 12.73   | 10.22  | 157.01 | 62.39  | -28.57            | -28.57  | -40.00  | -71.66  | -100.00 | -53.76 | 71.43  | 31.29  |
| Nadia             | 0.74                            | 0.74    | 153.85  | -22.62  | -38.15  | 18.91  | 192.00 | 77.22  | -50.00            | -50.00  | 100.00  | -9.88   | -100.00 | -21.98 | 200.00 | 75.30  |
| North 24 Parganas | -24.69                          | -24.69  | 159.18  | -45.42  | 2.98    | 13.47  | 204.60 | 83.25  | -61.11            | -61.11  | -28.57  | 24.41   | -28.57  | -30.99 | 85.53  | 34.99  |
| Paschim Medinipur | -34.57                          | -34.57  | -3.14   | 341.36  | -49.54  | 43.91  | 390.90 | 167.14 | 0.00              | 0.00    | 0.00    | 0.00    | -50.00  | -10.00 | 50.00  | 22.36  |
| Purba Medinipur   | -4.12                           | -4.12   | 346.63  | -19.11  | -1.36   | 63.59  | 365.73 | 158.38 | -16.67            | -16.67  | -80.00  | -11.31  | 100.00  | -4.93  | 180.00 | 65.12  |
| Purulia           | 75.00                           | 75.00   | 30.61   | -36.63  | -34.78  | 21.84  | 111.63 | 55.57  | 0.00              | 0.00    | 0.00    | -100.00 | 0.00    | -20.00 | 100.00 | 44.72  |
| South 24 Parganas | 56.48                           | 56.48   | -21.52  | -3.35   | 8.67    | 19.35  | 78.00  | 35.56  | -16.67            | -16.67  | 40.00   | -50.67  | 175.00  | 26.20  | 225.67 | 89.32  |
| Uttar Dinajpur    | -28.17                          | -28.17  | 45.75   | -18.27  | -12.50  | -8.27  | 73.92  | 30.94  | 50.00             | 50.00   | -33.33  | -57.81  | 0.00    | 1.77   | 107.81 | 48.57  |

The results of kidnapping and abduction of women exhibit extreme volatility and spatial disparities in nature. Districts like Malda (mean AGR: 228.68%, range: 534.00) and Purba

Medinipur (mean AGR: 63.59%, range: 365.73) recorded explosive surges, while Paschim Medinipur (mean AGR: 43.91%, range: 390.90) and Howrah (mean AGR: 46.22%,

range: 490.59) also showed instability with sharp peaks. Besides, Dakshin Dinajpur (mean AGR: 37.28%, SD: 155.17) and Darjeeling (mean AGR: 31.21%, SD: 97.12) highlight highly volatile trajectories. In contrast, districts such as Cooch Behar (mean AGR: 6.83%, SD: 16.76) and Jalpaiguri (mean AGR: 8.13%, SD: 13.45) reflect moderate growth with limited fluctuations, while Uttar Dinajpur (mean AGR: -8.27%, SD: 30.94) shows a suppressed decline.

Human trafficking also shows sharp volatility and uneven spatial distribution pattern. Several districts, including Bankura (mean AGR: -60.00), Bardhaman (mean AGR: -

40.00), Birbhum (mean AGR: -20.00), and Malda (mean AGR: -60.00) showed a persistent decline, often reflecting the near elimination of reported cases. In contrast, Howrah (mean AGR: 66.67, range: 400.00) and Jalpaiguri (mean AGR: -7.34, range: 338.32) exhibited extreme fluctuations, with episodic surges followed by steep contractions. South 24 Parganas (mean AGR: 26.20, SD: 89.32) and Darjeeling (mean AGR: 27.61, SD: 51.90) highlight unstable upward trajectories. Districts such as Cooch Behar and Dakshin Dinajpur recorded no change, suggesting either the absence of cases or reporting stagnation.

**Table 6:** Annual growth rate of rape and assault on women with intend to outrage her modesty in the districts of West Bengal (2017-2022)

| Districts         | Rape    |         |         |         |         | Mean   | Range  | SD     | Assault on women with intend to outrage her modesty |         |         |         |         | Mean   | Range  | SD    |
|-------------------|---------|---------|---------|---------|---------|--------|--------|--------|-----------------------------------------------------|---------|---------|---------|---------|--------|--------|-------|
|                   | 2017-18 | 2018-19 | 2019-20 | 2020-21 | 2021-22 |        |        |        | 2017-18                                             | 2018-19 | 2019-20 | 2020-21 | 2021-22 |        |        |       |
| Bankura           | 8.33    | 8.33    | 38.46   | -15.17  | 0.00    | 7.99   | 53.64  | 19.55  | -33.90                                              | -33.90  | 38.46   | -15.17  | 31.37   | -2.63  | 72.36  | 35.20 |
| Bardhaman         | -8.51   | -8.51   | -9.30   | 46.82   | -21.88  | -0.28  | 68.70  | 26.93  | -3.95                                               | -3.95   | -12.94  | -34.11  | 44.04   | -2.18  | 78.14  | 28.62 |
| Birbhum           | 41.67   | 41.67   | -39.22  | -29.37  | 12.00   | 5.35   | 80.88  | 38.32  | -11.48                                              | -11.48  | -29.63  | -23.94  | 18.18   | -11.67 | 47.81  | 18.47 |
| Cooch Behar       | -16.07  | -16.07  | 27.66   | 13.26   | -26.32  | -3.51  | 53.98  | 22.85  | -42.05                                              | -42.05  | -29.41  | 11.77   | 0.00    | -20.35 | 53.81  | 24.84 |
| Dakshin Dinajpur  | -7.14   | -7.14   | -7.69   | 58.84   | 0.00    | 7.37   | 66.54  | 28.95  | -37.70                                              | -37.70  | -31.58  | -30.18  | 0.00    | -27.43 | 37.70  | 15.72 |
| Darjeeling        | 107.69  | 107.69  | -27.78  | -41.62  | -11.54  | 26.89  | 149.31 | 74.53  | 1.42                                                | 1.42    | -50.47  | 18.14   | 30.07   | 0.12   | 80.54  | 30.76 |
| Hooghly           | -8.70   | -8.70   | 14.29   | 22.08   | 0.00    | 3.80   | 30.78  | 13.88  | -46.63                                              | -46.63  | -64.21  | 5.03    | 2.56    | -29.98 | 69.24  | 31.67 |
| Howrah            | 0.00    | 0.00    | 42.31   | -14.02  | -36.11  | -1.57  | 78.42  | 28.63  | -43.10                                              | -43.10  | -46.97  | -16.68  | -16.67  | -33.31 | 30.30  | 15.26 |
| Jalpaiguri        | -20.24  | -20.24  | -11.94  | 18.83   | -11.39  | -9.00  | 39.07  | 16.14  | -29.81                                              | -29.81  | -29.20  | -1.27   | -13.48  | -20.72 | 28.55  | 12.92 |
| Kolkata           | -11.76  | -11.76  | -26.67  | -2.35   | 0.00    | -10.51 | 26.67  | 10.50  | 16.41                                               | 16.41   | -20.10  | -19.90  | 1.99    | -1.04  | 36.52  | 18.29 |
| Malda             | -24.04  | -24.04  | 155.70  | -42.19  | 36.50   | 20.39  | 197.89 | 81.29  | 44.85                                               | 44.85   | -62.34  | -28.97  | 50.67   | 9.81   | 113.01 | 52.04 |
| Murshidabad       | 15.66   | 15.66   | -29.17  | -16.22  | -19.40  | -6.69  | 44.83  | 20.96  | -20.63                                              | -20.63  | -43.33  | -9.97   | -1.11   | -19.14 | 42.22  | 15.80 |
| Nadia             | -43.24  | -43.24  | 233.33  | -42.06  | 1.11    | 21.18  | 276.58 | 120.12 | -29.01                                              | -29.01  | -38.71  | 31.23   | -7.23   | -14.54 | 69.94  | 28.07 |
| North 24 Parganas | -9.17   | -9.17   | 16.16   | -28.91  | 25.00   | -1.22  | 53.91  | 21.69  | -20.10                                              | -20.10  | 20.18   | -11.24  | -0.63   | -6.38  | 40.28  | 16.87 |
| Paschim Medinipur | -12.12  | -12.12  | -46.55  | 40.44   | -28.57  | -11.79 | 86.99  | 32.47  | -9.61                                               | -9.61   | -5.17   | -14.92  | -44.94  | -16.85 | 39.76  | 16.08 |
| Purba Medinipur   | -8.70   | -8.70   | 7.14    | 6.43    | -16.67  | -4.10  | 23.81  | 10.46  | -2.08                                               | -2.08   | -19.15  | -42.82  | 4.08    | -12.41 | 46.90  | 19.07 |
| Purulia           | -57.14  | -57.14  | 0.00    | -2.03   | 0.00    | -23.26 | 57.14  | 30.94  | -26.24                                              | -26.24  | -53.85  | -37.54  | 0.00    | -28.77 | 53.85  | 19.66 |
| South 24 Parganas | 51.46   | 51.46   | -49.36  | 36.60   | 12.00   | 20.43  | 100.82 | 42.21  | 27.62                                               | 27.62   | -79.10  | 86.02   | 1.66    | 12.76  | 165.12 | 59.94 |
| Uttar Dinajpur    | -22.22  | -22.22  | -2.38   | -7.39   | 8.89    | -9.07  | 31.11  | 13.38  | -27.27                                              | -27.27  | 37.50   | -46.30  | 50.00   | -2.67  | 96.30  | 43.31 |

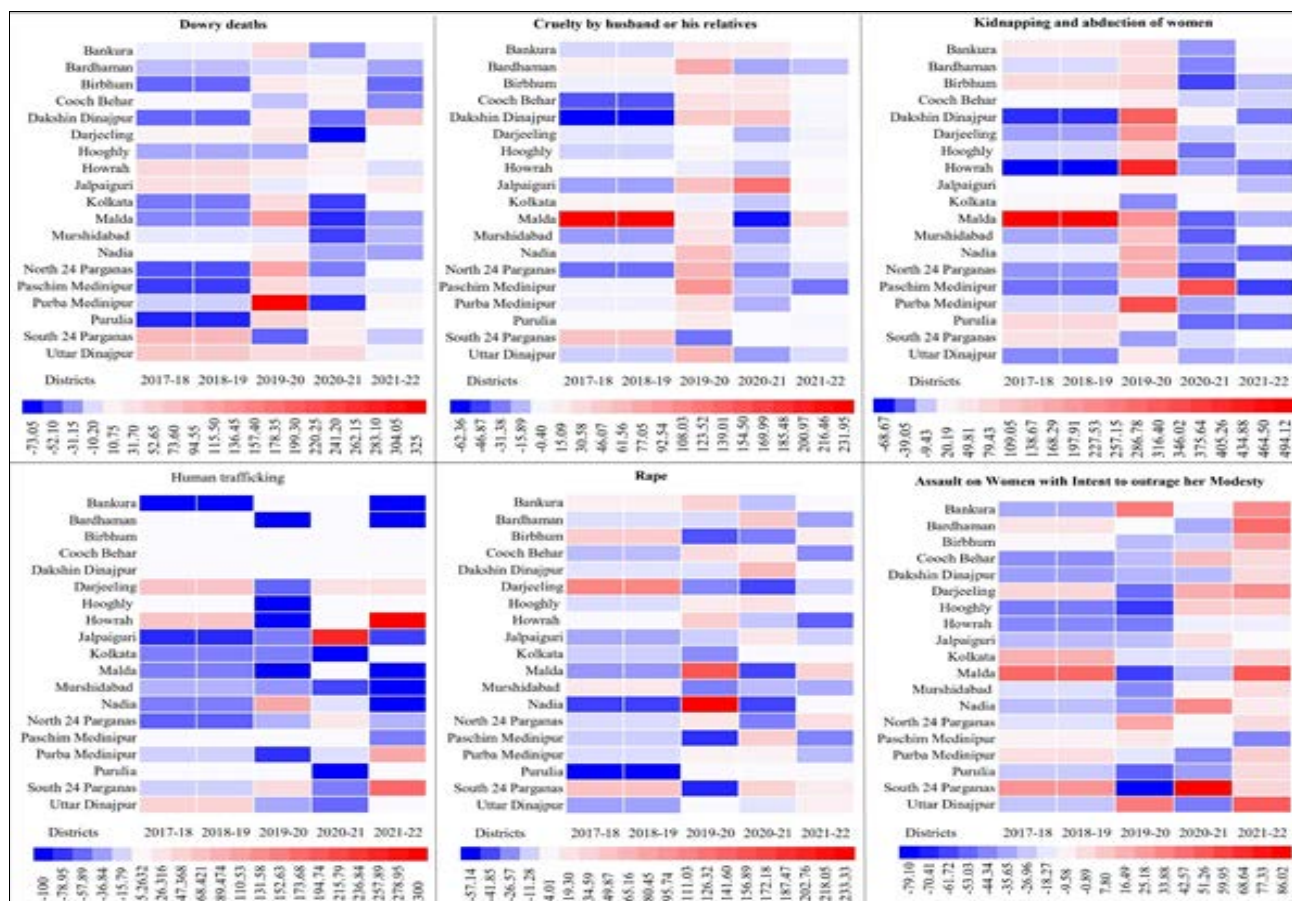


**Fig 4:** Trends and variations in major forms of CAW (IPC): dowry deaths, kidnapping and abduction of women, assault on women with the intent to outrage her modesty, rape, cruelty by husband or his relatives, and human trafficking of women across districts in West Bengal, 2017-2022.

The district-wise analysis of rape also reveals high volatility and uneven spatial patterns. Districts such as Nadia (mean AGR: 21.18%, SD: 120.12) and Malda (mean AGR: 20.39%, SD: 81.29) recorded extreme fluctuations, with episodic surges followed by sharp contractions. Darjeeling (mean AGR: 26.89%) and South 24 Parganas (mean AGR: 20.43%) also showed unstable upward trends. In contrast, districts like Kolkata (mean AGR: -10.51%) and Purulia (-23.26%) reflect persistent decline, possibly due to underreporting or improved enforcement. Bardhaman, Howrah, and Murshidabad exhibited suppressed volatility with alternating peaks and troughs.

The snap of assault on women with intent to outrage her modesty exhibits a suppressed decline with episodic volatility. Most districts, including Hooghly (mean AGR: -29.98%), Howrah (-33.31%), Purulia (-28.77%), and Dakshin Dinajpur (-27.43%), showed persistent contraction, suggesting either improved enforcement or underreporting. In contrast, Malda (mean AGR: 9.81%, SD: 52.04) and South 24 Parganas (mean AGR: 12.76%, SD: 59.94) recorded sharp fluctuations, with surges in specific years followed by steep declines. Bankura and Bardhaman show mixed trajectories, alternating between growth and suppression, whereas Kolkata (mean AGR: -1.04%) remained relatively stable.

Overall, the findings highlight that these crimes are highly uneven and heterogeneous across districts. Therefore, addressing the persistent escalation, episodic escalation and hidden declines in women's safety requires district-specific monitoring, targeted interventions, and localized policy responses, including targeted awareness-raising, survivor support, and data validation mechanisms.

## 4.2 Spatial distribution and clustering of major forms of crimes against women (IPC)

### 4.2.1 Dowry deaths:

Dowry deaths in West Bengal present significant regional disparities and notable clustering patterns (table 7 and figure 5). The CCI identified Bankura (CCI: 2.9086, very high) and Dakshin Dinajpur (CCI: 1.9423, high) as areas with highly concentrated districts. Bardhaman (CCI: 1.3958, moderate) also exhibited a notable concentration. Conversely, districts such as Kolkata (CCI: 0.2951, very low), Darjeeling (CCI: 0.4645, very low), Howrah (CCI: 0.6572, low), and South 24 Parganas (CCI: 0.7518, low) had comparatively lower intensities.

Hot spot analysis provides more detailed insights that indicate Bardhaman ( $Gi^*Z$ : 1.8437,  $p < 0.10$ ) is identified as a statistically significant hot spot, reinforcing its spatial prominence. In contrast, Howrah ( $Gi^*Z$ : -2.2063,  $p < 0.05$ ), Kolkata ( $Gi^*Z$ : -2.2318,  $p < 0.05$ ), and South 24 Parganas ( $Gi^*Z$ : -2.2318,  $p < 0.05$ ) were classified as cold spots, indicating spatial suppression or potential underreporting.

These findings are corroborated by LMI, which confirms Bardhaman (LMiZ: 1.7795,  $p < 0.05$ ) as a high-high cluster, while Howrah (LMiZ: 2.0968,  $p < 0.10$ ), Kolkata (LMiZ: 1.7556,  $p < 0.05$ ), and South 24 Parganas (LMiZ: 2.1033,

$p < 0.10$ ) emerge as low-low clusters. These spatial autocorrelation results underscore the presence of geographically contiguous zones with both elevated and suppressed dowry-related violence.

However, some districts, such as Jalpaiguri (CCI: 1.5425;  $Gi^*Z$ : 0.0708; LMiZ: -0.1929) and Cooch Behar (CCI: 1.7013;  $Gi^*Z$ : 0.9960; LMiZ: 0.5927) exhibited moderate CCI values but lacked statistically significant clustering, suggesting localized intensity without spatial dependence. Similarly, Murshidabad (CCI: 0.8706;  $Gi^*Z$ : 0.1079; LMiZ: -0.3750) and Birbhum (CCI: 1.3269;  $Gi^*Z$ : -0.0471; LMiZ: -0.1840) showed low-to-moderate concentrations and non-significant spatial patterns, indicative of dispersed or random distribution.

### 4.2.2 Cruelty by husband or his relatives:

Cruelty against women, encompassing physical, psychological, and emotional abuse by husbands or their relatives, shows significant regional variation (table 7; figure 5). According to the CCI, Hooghly (CCI: 1.2379, moderate) and South 24 Parganas (CCI: 1.2179, moderate) emerged as areas with elevated concentrations. Low clustering levels were observed in most other districts, including Howrah (CCI: 1.1628, low), North 24 Parganas (CCI: 1.0661, low), Nadia (CCI: 1.0120, low), and Kolkata (CCI: 0.8030, low). Dakshin Dinajpur (CCI: 0.5653, Very Low) exhibited the lowest concentration, indicating either minimal reported prevalence or potential underreporting.

Spatial autocorrelation analysis indicated more pronounced clustering patterns than those suggested by CCI alone. The statistically significant hot spots included North 24 Parganas ( $Gi^*Z$ : 2.7190,  $p < 0.01$ ), Nadia ( $Gi^*Z$ : 2.1584,  $p < 0.05$ ), Howrah ( $Gi^*Z$ : 2.1629,  $p < 0.05$ ), Hooghly ( $Gi^*Z$ : 2.1049,  $p < 0.05$ ), South 24 Parganas ( $Gi^*Z$ : 1.7957,  $p < 0.10$ ), and Kolkata ( $Gi^*Z$ : 1.7957,  $p < 0.10$ ), indicating spatially concentrated zones. Conversely, Dakshin Dinajpur ( $Gi^*Z$ : -2.0990,  $p < 0.05$ ), Uttar Dinajpur ( $Gi^*Z$ : -1.7780,  $p < 0.10$ ), and Malda ( $Gi^*Z$ : -1.8395,  $p < 0.10$ ) were identified as cold spots, highlighting the socio-spatial divergence of violence.

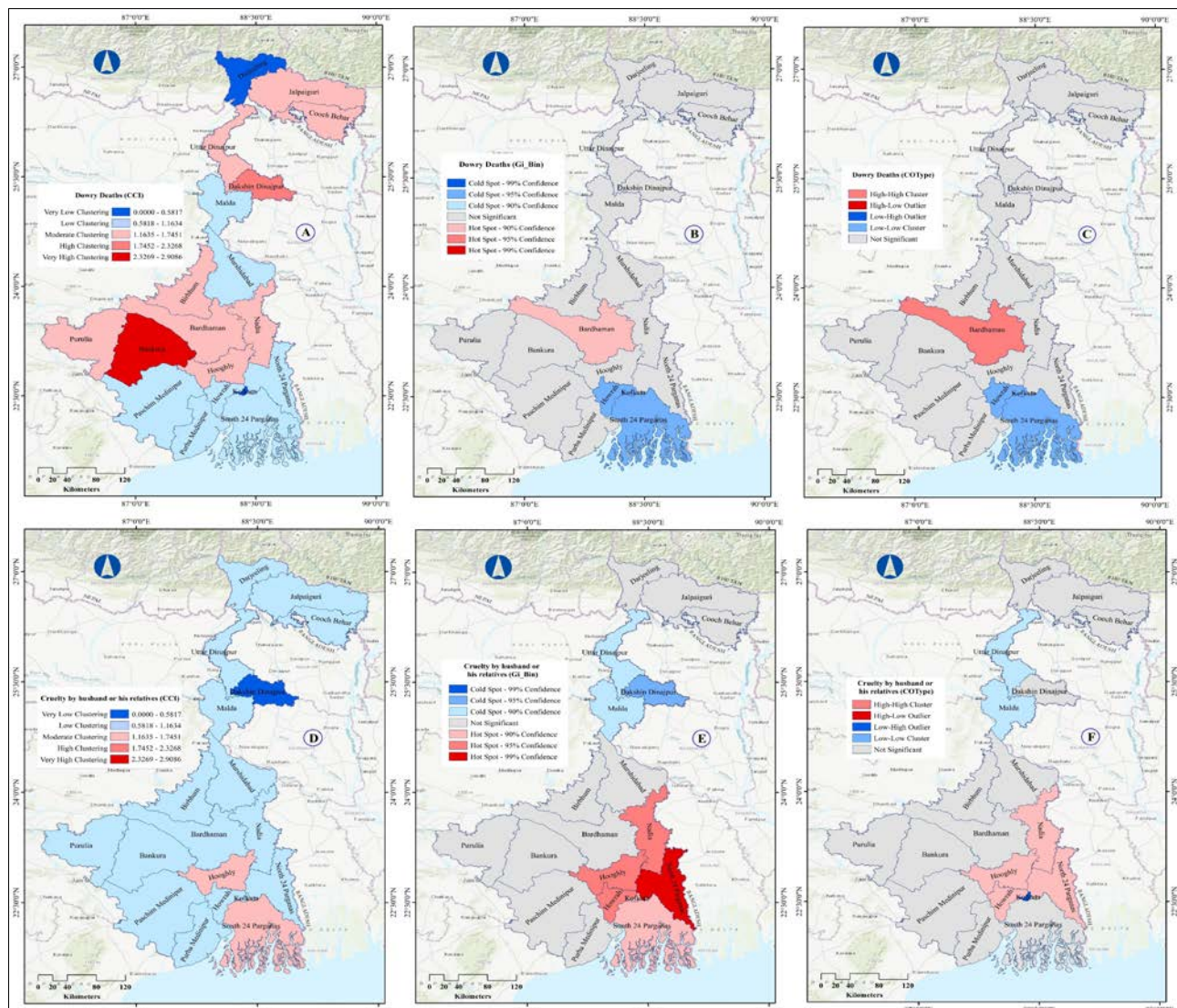
The LMI further validates this finding. High-high clusters were confirmed in North 24 Parganas (LMiZ: 2.6360,  $p < 0.01$ ), Nadia (LMiZ: 2.0832,  $p < 0.05$ ), Howrah (LMiZ: 1.8647,  $p < 0.05$ ), and Hooghly (LMiZ: 1.7122,  $p < 0.05$ ), indicating a statistically significant spatial dependence. Malda (LMiZ: 1.8485,  $p < 0.05$ ) and Uttar Dinajpur (LMiZ: 1.6491,  $p < 0.05$ ) were identified as low-low clusters, suggesting contiguous zones of low but persistent abuse. Kolkata (LMiZ: -2.4075,  $p < 0.01$ ) presents a unique case as a low-high outlier, reflecting internal intensity surrounded by low-crime neighbours.

In addition, districts such as Darjeeling (LMiZ: -1.2263) and Murshidabad (LMiZ: 0.2504) exhibited low CCI and non-significant clustering, indicating spatial dispersion. Similarly, Birbhum (CCI: 0.8268;  $Gi^*Z$ : 0.2779; LMiZ: -0.7369) and Paschim Medinipur (CCI: 0.8096;  $Gi^*Z$ : 1.0188; LMiZ: -1.2993) demonstrated low concentrations and lacked significant spatial dependence.

**Table 7:** Spatial concentration of dowry death and cruelty by husband or his relatives

| Districts         | Dowry deaths |             |         |              | Cruelty by husband or his relatives |             |         |              |
|-------------------|--------------|-------------|---------|--------------|-------------------------------------|-------------|---------|--------------|
|                   | CCI          | Gi*Z        | LMiI    | LMiZ         | CCI                                 | Gi*Z        | LMiI    | LMiZ         |
| Darjeeling        | 0.4645 VL    | -0.2424     | -1.0181 | -0.4808      | 0.9550 L                            | -0.9462     | -0.2970 | -1.2263      |
| Jalpaiguri        | 1.5425 M     | 0.0708      | -0.2278 | -0.1929      | 0.7785 L                            | -0.9368     | 0.5444  | 0.6324       |
| Cooch Behar       | 1.7013 M     | 0.9960      | 0.4271  | 0.5927       | 0.7822 L                            | -1.2451     | 0.6935  | 0.9782       |
| Uttar Dinajpur    | 1.3958 M     | -0.1538     | -0.1700 | -0.3061      | 0.7796 L                            | -1.7780* C  | 1.9442  | 1.6491** LLC |
| Dakshin Dinajpur  | 1.9423 H     | 0.5955      | -0.2873 | -0.1602      | 0.5653 VL                           | -2.0990** C | 2.6165  | 1.2541       |
| Malda             | 0.8820 L     | 0.2186      | -0.5007 | -0.5400      | 0.8512 L                            | -1.8395* C  | 1.2045  | 1.8485** LLC |
| Murshidabad       | 0.8706 L     | 0.1079      | -0.4271 | -0.3750      | 0.9361 L                            | 0.2733      | 0.0308  | 0.2504       |
| Birbhum           | 1.3269 M     | -0.0471     | -0.0483 | -0.1840      | 0.8268 L                            | 0.2779      | -0.5677 | -0.7369      |
| Bardhaman         | 1.3958 M     | 1.8437*H    | 1.0656  | 1.7795** HHC | 1.0868 L                            | 0.9937      | 1.0801  | 0.6373       |
| Nadia             | 1.7172 M     | 0.0236      | -0.6377 | -0.3343      | 1.0120 L                            | 2.1584** H  | 1.8408  | 2.0832** HHC |
| North 24 Parganas | 0.7145 L     | -1.4056     | 1.6537  | 1.1174       | 1.0661 L                            | 2.7190*H    | 3.8407  | 2.6360# HHC  |
| South 24 Parganas | 0.7518 L     | -2.2318** C | 2.4162  | 2.1033# LLC  | 1.2179 M                            | 1.7957* H   | 2.5356  | 1.2935       |
| Hooghly           | 1.3951 M     | 0.7860      | 0.4022  | 0.6893       | 1.2379 M                            | 2.1049** H  | 4.7360  | 1.7122** HHC |
| Bankura           | 2.9086 VH    | 1.3650      | -0.3950 | 0.3421       | 0.8615 L                            | 0.7379      | -0.6475 | -0.9710      |
| Purulia           | 1.2563 M     | 1.3075      | 0.1587  | 1.4044       | 0.8714 L                            | -0.2226     | 0.0273  | 0.0210       |
| Howrah            | 0.6572 L     | -2.2063** C | 3.3818  | 2.0968# LLC  | 1.1628 L                            | 2.1629** H  | 4.3675  | 1.8647** HHC |
| Kolkata           | 0.2951 VL    | -2.2318** C | 3.6951  | 1.7556** LLC | 0.8030 L                            | 1.7957* H   | -2.7325 | -2.4075# LHO |
| Paschim Medinipur | 0.7174 L     | 0.6191      | -1.6658 | -0.9891      | 0.8096 L                            | 1.0188      | -1.8106 | -1.2993      |
| Purba Medinipur   | 1.1137 L     | -1.1800     | 0.2775  | 1.2844       | 0.9605 L                            | 0.5804      | 0.1489  | 0.5063       |

**Note:** Significance at #0.01 ( $p < 0.01$ ), \*\*0.05 ( $p < 0.05$ ), and \*0.10 ( $p < 0.10$ ); CCI - Crime Concentration Index; Gi\*Z - Z-score of Gi\* statistic; LMiI - Anselin Local Moran's I, and LMiZ - Z-score of Anselin Local Moran's I. VH-very high concentration; H-high concentration, M-Moderate concentration; L-low concentration, VL-very low concentration; HS-hot spots; CS-cold spots; HHC-high-high cluster; LLC-low-low clusters; HLC-high-low clusters; HLO-high-low outlier; LHO-low-high outlier

**Fig 5:** Spatial patterns of dowry deaths and cruelty by husband or his relatives: (A and D) crime concentration index, (B and E) hotspot analysis, and (C and F) local spatial autocorrelation.

### 4.2.3 Kidnapping and abduction of women

The spatial distribution of kidnapping and abduction incidents involving women varied significantly across districts (table 8 and figure 6). As per CCI, Dakshin Dinajpur (CCI: 2.2549, high) was identified as the district with the highest concentration, approaching the very high concentration category. Several other districts demonstrate moderate clustering, including Cooch Behar (CCI: 1.7428), Purba Medinipur (CCI: 1.6475), Uttar Dinajpur (CCI: 1.5440), Jalpaiguri (CCI: 1.2671), Nadia (CCI: 1.1823), and Malda (CCI: 1.1682). The remaining districts, such as Paschim Medinipur (CCI: 1.1194), Bardhaman (CCI: 0.9151), Birbhum (CCI: 0.8725), North 24 Parganas (CCI: 0.8568), and Murshidabad (CCI: 0.7914), are categorized as having a low concentration.

Hot spot analysis identified Dakshin Dinajpur ( $G_i^*Z$ : 2.4660,  $p < 0.01$ ), Uttar Dinajpur ( $G_i^*Z$ : 1.8905,  $p < 0.10$ ), and Malda ( $G_i^*Z$ : 1.7933,  $p < 0.10$ ) as statistically significant hotspots, reflecting areas of elevated spatial risk. Conversely, Bardhaman ( $G_i^*Z$ : -1.9254,  $p < 0.05$ ) and North 24 Parganas ( $G_i^*Z$ : -1.6944,  $p < 0.10$ ) were identified as cold spots, suggesting spatial suppression or lower reported incidence.

The LMI provides additional insights. Malda (LMiZ: 1.7293,  $p < 0.10$ ) was confirmed as an emerging high-high cluster, indicating spatial dependence within a concentrated zone.

Despite a low CCI, Bardhaman (LMiZ: 1.7562,  $p < 0.05$ ) demonstrated significant clustering, suggesting internal spatial dependence. Nadia (LMiZ: -1.5876,  $p < 0.05$ ) presents a high-low outlier pattern, indicating an elevated crime concentration surrounded by low-crime neighbourhoods. Meanwhile, North 24 Parganas (LMiZ: 1.4670) and Dakshin Dinajpur (LMiZ: 1.4709) showed elevated LMiZ values, but without statistical significance, suggesting potential but inconclusive spatial dependence. Districts such as Murshidabad (LMiZ: 0.4084), Birbhum (LMiZ: 0.8254), South 24 Parganas (LMiZ: 1.2743), and Kolkata (LMiZ: 1.2247) exhibited low-to-moderate CCI and non-significant clustering, reflecting spatial dispersion.

### 4.2.4 Human trafficking

Despite frequent underreporting, human trafficking reveals discernible patterns (table 8 and figure 6). The CCI categorization identified Howrah (CCI: 2.4852, Very High), Darjeeling (CCI: 2.1057, High), Uttar Dinajpur (CCI: 2.1532, High), Jalpaiguri (CCI: 2.0095, High), and Purba Medinipur (CCI: 1.7496, High) as areas of elevated concern. Additionally, North 24 Parganas (CCI: 1.2385, moderate) and Hooghly (CCI: 1.1723, moderate) showed increased vulnerabilities. The remaining districts fell within the low to very low concentration categories, including Bankura (CCI: 0.5126), Bardhaman (CCI: 0.4360), and Paschim Medinipur (CCI: 0.2220), indicating spatial dispersion.

Hot spot analysis identified Darjeeling ( $G_i^*Z$ : 2.7448,  $p < 0.01$ ) as the only statistically significant hot spot, confirming its spatial prominence. In contrast, Bankura ( $G_i^*Z$ : -1.9725,  $p < 0.05$ ) and Bardhaman ( $G_i^*Z$ : -1.8769,  $p < 0.10$ ) were classified as significant cold spots, suggesting spatial suppression. Other high-CCI districts such as Howrah ( $G_i^*Z$ : 0.5298), Jalpaiguri ( $G_i^*Z$ : 1.0361), and Purba Medinipur ( $G_i^*Z$ : 1.3072) did not exhibit statistically significant  $G_i^*Z$  scores, indicating isolated intensity without confirmed spatial clustering.

The LMI provides further insight into spatial dependence. Darjeeling (LMiZ: 2.3941,  $p < 0.05$ ) was confirmed as a high-high cluster, reinforcing its status as a spatially contiguous zone with an elevated trafficking risk. Bankura (LMiZ: 1.7969,  $p < 0.05$ ) and Bardhaman (LMiZ: 1.7979,  $p < 0.05$ ) were identified as low-low clusters, consistent with their cold spot classification. Districts such as Purba Medinipur (LMiZ: 0.8768), Jalpaiguri (LMiZ: 0.3396), Hooghly (LMiZ: 0.3163), and Howrah (LMiZ: -0.1257) show elevated or marginal values but lack statistical significance, indicating inconclusive spatial dependence.

Other districts such as Murshidabad (CCI: 1.0321;  $G_i^*Z$ : -0.9506; LMiZ: -1.0622), South 24 Parganas (CCI: 0.8882;  $G_i^*Z$ : -1.1953; LMiZ: -1.1757), and Paschim Medinipur (CCI: 0.2220;  $G_i^*Z$ : -0.0868; LMiZ: -0.5635) exhibited low concentrations and statistically non-significant clustering, reflecting spatial randomness or underreporting.

**Table 8:** Spatial concentration of kidnapping & abduction of women and human trafficking

| Districts         | Kidnapping & abduction of women |                      |         |                        | Human trafficking |                      |         |                       |
|-------------------|---------------------------------|----------------------|---------|------------------------|-------------------|----------------------|---------|-----------------------|
|                   | CCI                             | $G_i^*Z$             | LMiI    | LMiZ                   | CCI               | $G_i^*Z$             | LMiI    | LMiZ                  |
| Darjeeling        | 0.8646L                         | 0.5490               | -0.8024 | -0.8963                | 2.1057H           | 2.7448 <sup>H</sup>  | 4.2589  | 2.3941 <sup>HHC</sup> |
| Jalpaiguri        | 1.2671M                         | 0.8441               | 0.3709  | 0.7475                 | 2.0095H           | 1.0361               | 0.3972  | 0.3396                |
| Cooch Behar       | 1.7428M                         | 1.4216               | 0.5891  | 0.5893                 | 0.0000 VL         | 0.1287               | -1.5986 | -1.2259               |
| Uttar Dinajpur    | 1.5440M                         | 1.8905 <sup>H</sup>  | 2.4162  | 1.5517                 | 2.1532H           | 0.9546               | 0.2482  | 0.2758                |
| Dakshin Dinajpur  | 2.2549H                         | 2.4660 <sup>H</sup>  | 3.2624  | 1.4709                 | 0.0000VL          | 0.1394               | -1.6570 | -0.9170               |
| Malda             | 1.1682M                         | 1.7933 <sup>H</sup>  | 0.4736  | 1.7293 <sup>HHC</sup>  | 0.8320L           | 0.1926               | -0.0625 | -0.2857               |
| Murshidabad       | 0.7914L                         | -0.7134              | 0.4665  | 0.4084                 | 1.0321L           | -0.9506              | -0.2346 | -1.0622               |
| Birbhum           | 0.8725L                         | -1.0791              | 0.6355  | 0.8254                 | 0.4341 VL         | -0.7200              | 0.3236  | 0.3771                |
| Bardhaman         | 0.9151L                         | -1.9254 <sup>C</sup> | 1.5906  | 1.7562 <sup>C</sup>    | 0.4360 VL         | -1.8769 <sup>C</sup> | 2.0927  | 1.7979 <sup>LLC</sup> |
| Nadia             | 1.1823M                         | -1.3776              | -0.5371 | -1.5876 <sup>HLO</sup> | 0.5017 VL         | -0.8555              | 0.5997  | 0.7044                |
| North 24 Parganas | 0.8568L                         | -1.6944 <sup>C</sup> | 1.6514  | 1.4670                 | 1.2385M           | 0.2178               | 0.0230  | 0.1149                |
| South 24 Parganas | 0.8667L                         | -1.4300              | 1.1025  | 1.2743                 | 0.8882L           | 1.0993               | -0.1227 | -1.1757               |
| Hooghly           | 0.6436L                         | -1.4279              | 2.0775  | 1.2002                 | 0.1723 VL         | -0.5922              | 0.2711  | 0.3163                |
| Bankura           | 0.9218L                         | -1.5226              | 1.0617  | 1.3857                 | 0.5126 VL         | -1.9725 <sup>C</sup> | 1.7384  | 1.7969 <sup>LLC</sup> |
| Purulia           | 0.6713L                         | -1.0360              | 0.8382  | 0.6769                 | 0.3378 VL         | -1.5881              | 1.5609  | 1.3695                |
| Howrah            | 0.8023L                         | -1.0912              | 1.1223  | 0.8159                 | 2.4852VH          | 0.5298               | -1.6395 | -0.1257               |
| Kolkata           | 0.8051L                         | -1.4300              | 1.2893  | 1.2247                 | 0.6829L           | 1.0993               | -0.7271 | -1.3532               |
| Paschim Medinipur | 1.1194L                         | -0.9385              | -0.0799 | -0.9425                | 0.2220 VL         | -0.0868              | -0.6536 | -0.1796               |
| Purba Medinipur   | 1.6475M                         | 0.3909               | -0.8572 | -0.3841                | 1.7496H           | 1.3072               | 1.0791  | 0.8768                |

**Note:** Significance at <sup>H</sup>0.01 ( $p < 0.01$ ), <sup>C</sup>0.05 ( $p < 0.05$ ), and <sup>L</sup>0.10 ( $p < 0.10$ ); CCI - Crime Concentration Index;  $G_i^*Z$  - Z-score of  $G_i^*$  statistic; LMiI - Anselin Local Moran's I, and LMiZ - Z-score of Anselin Local Moran's I. VH-very high concentration; H-high concentration, M-Moderate concentration; L-low concentration, VL-very low concentration; HS-hot spots; CS-cold spots; HHC-high-high cluster; LLC-low-low clusters; HLC-high-low clusters; HLO-high-low outlier; LHO-low-high outlier

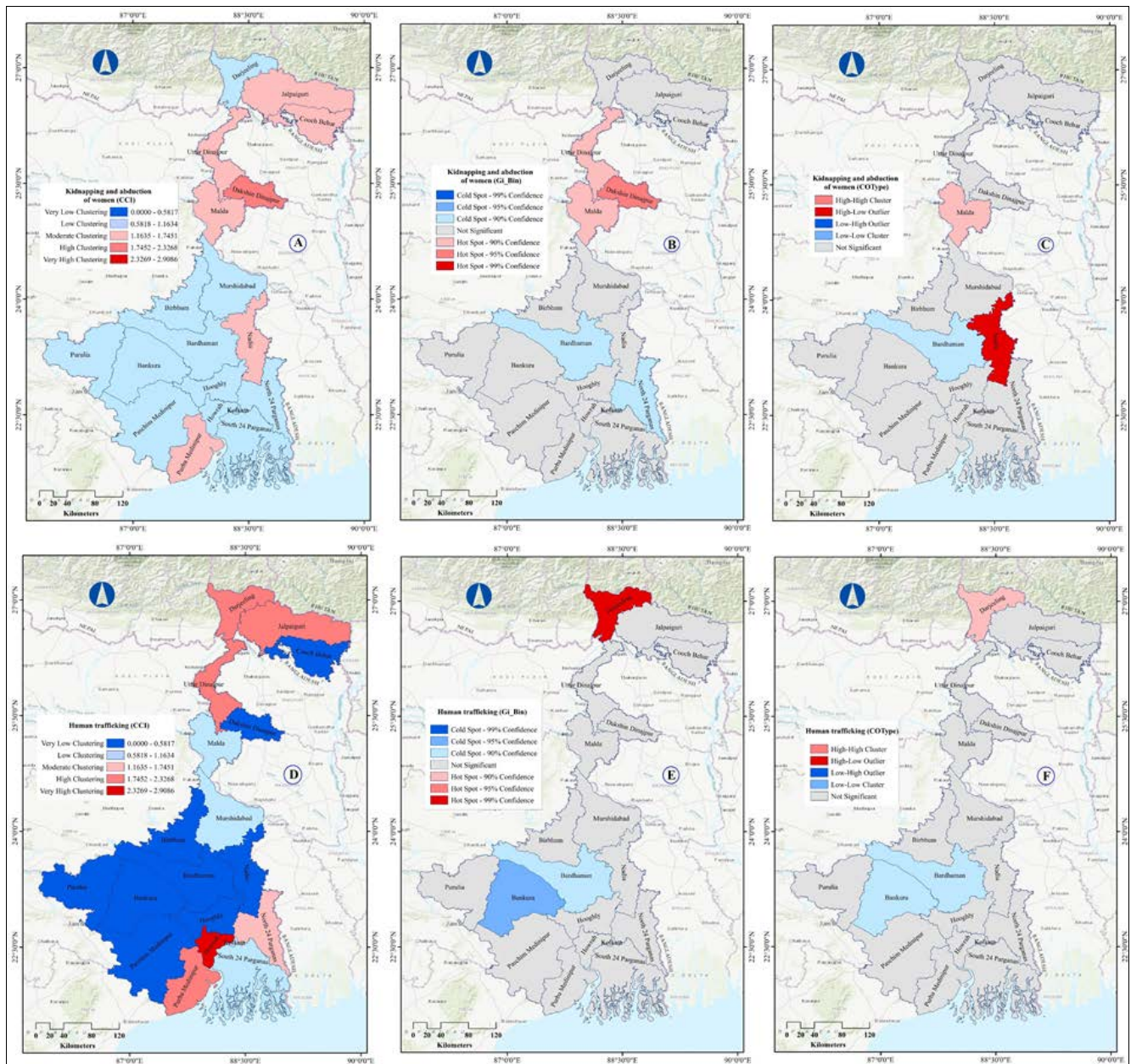


**Fig 6:** Spatial distribution of kidnapping and abduction of women and human trafficking: (A and D) crime concentration index, (B and E) hotspot analysis, and (C and F) local spatial autocorrelation.

#### 4.2.5 Rape

The spatial distribution of rape incidents indicates significant concentrations in specific districts, as shown in table 9 and figure 7. Initial evaluations utilizing the CCI identified Malda (CCI: 2.5470, very high) as the district with the highest concentration. This was followed by Uttar Dinajpur (CCI: 1.9101), Birbhum (CCI: 1.8769), and Murshidabad (CCI: 1.7718), which were classified as high cluster areas. Districts such as Cooch Behar (CCI: 1.5814), Jalpaiguri (CCI: 1.5397), Dakshin Dinajpur (CCI: 1.2043), and Nadia (CCI: 1.2009) exhibited moderate clustering. The remaining districts were categorized as having low to very low concentrations, with notably low values observed in Kolkata (CCI: 0.1989), Howrah (CCI: 0.5481), and Hooghly (CCI: 0.5103).

Hot spot analysis employing the  $G_i^*Z$  statistic identified Malda ( $G_i^*Z$ : 2.7416,  $p < 0.01$ ), Dakshin Dinajpur ( $G_i^*Z$ : 2.3902,  $p < 0.05$ ), Uttar Dinajpur ( $G_i^*Z$ : 1.8841,  $p < 0.10$ ), and Murshidabad ( $G_i^*Z$ : 2.1149,  $p < 0.05$ ) as statistically significant hot spots. Conversely, districts such as Howrah

( $G_i^*Z$ : -2.7290,  $p < 0.01$ ), North 24 Parganas ( $G_i^*Z$ : -2.4826,  $p < 0.01$ ), Hooghly ( $G_i^*Z$ : -1.9556,  $p < 0.05$ ), South 24 Parganas ( $G_i^*Z$ : -2.2977,  $p < 0.05$ ), Kolkata ( $G_i^*Z$ : -2.2977,  $p < 0.05$ ), and Paschim Medinipur ( $G_i^*Z$ : -1.6623,  $p < 0.10$ ) were identified as significant cold spots, indicating spatial suppression.

The LMI further support this result. Malda (LMiZ: 2.1763,  $p < 0.05$ ), Dakshin Dinajpur (LMiZ: 2.6408,  $p < 0.01$ ), and Murshidabad (LMiZ: 1.7478,  $p < 0.05$ ) were confirmed as high-high clusters, reinforcing their spatial vulnerability. Low-low clusters were evident in Howrah (LMiZ: 2.2855,  $p < 0.01$ ), North 24 Parganas (LMiZ: 2.3351,  $p < 0.01$ ), South 24 Parganas (LMiZ: 2.2790,  $p < 0.01$ ), Kolkata (LMiZ: 1.8364,  $p < 0.05$ ), and Hooghly (LMiZ: 1.6952,  $p < 0.05$ ), suggesting spatially contiguous zones of low incidence. Districts such as Jalpaiguri (LMiZ = 0.3267), Cooch Behar (LMiZ = 0.8859), and Birbhum (LMiZ = 0.3423) exhibited moderate CCI but lacked statistically significant clustering, indicating localized intensity without broader spatial dependence.

#### 4.2.6 Assault on women with intent to outrage her modesty:

The spatial distribution of assault cases impacting women's dignity showed significant variations (table 9 and figure 7). Utilizing the CCI, Purulia (CCI: 2.2387, high) and Paschim Medinipur (CCI: 2.2309, high) emerged as the districts with the highest concentrations. Kolkata (CCI: 1.7148), North 24 Parganas (CCI: 1.6467), and Darjeeling (CCI: 1.4933) were categorized as having moderate clustering. The remaining districts, including Murshidabad (CCI: 0.5214), Cooch Behar (CCI: 0.5339), and Nadia (CCI: 0.4833), demonstrated low to very low concentrations, suggesting spatial dispersion and potential under-reporting.

Hot spot analysis identified Purulia (Gi\*Z: 2.2860,  $p < 0.05$ ) as a statistically significant hot spot, confirming persistent spatial intensity. Bankura (Gi\*Z: 1.7343,  $p < 0.10$ ) also emerged as marginally significant. Other districts such as Paschim Medinipur (Gi\*Z: 1.2436), Howrah (Gi\*Z: 0.7769), Kolkata (Gi\*Z: 0.5937), and Hooghly (Gi\*Z: 0.4816) show positive Gi\*Z values but were not statistically significant. In contrast, districts such as Malda (Gi\*Z: -

1.1640), Murshidabad (Gi\*Z: -1.1704), Cooch Behar (Gi\*Z: -0.8616), and Nadia (Gi\*Z: -0.9225) show negative Gi\*Z values, indicating spatial suppression without confirmed clustering.

The LMI further substantiates this finding. Bankura (LMiZ: 1.7170,  $p < 0.05$ ) was confirmed as a high-high cluster, indicating spatially contiguous zones of elevated assault risk. Purulia (LMiZ: 1.5464) and Paschim Medinipur (LMiZ: 0.5716) showed elevated LMiZ values, but without statistical significance. Districts such as Darjeeling (LMiZ: -1.2702), North 24 Parganas (LMiZ: -0.7142), Uttar Dinajpur (LMiZ: -0.4562), and Howrah (LMiZ: -1.0577) exhibited moderate-to-low CCI and negative LMiZ scores, suggesting localized intensity without broader spatial dependence. Other districts such as Murshidabad (LMiZ: 0.8076), Birbhum (LMiZ: 0.8995), Jalpaiguri (LMiZ: 0.0534), and Kolkata (LMiZ: 0.0525) show very-low to moderate CCI and non-significant clustering, reinforcing spatial dispersion. South 24 Parganas (LMiZ: -1.1025) and Purba Medinipur (LMiZ: -1.1978) also reflected low concentrations and lacked spatial autocorrelation.

**Table 9:** Spatial concentration of rape and assault on women with intend to outrage her modesty

| Districts                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Rape      |              |         |              | Assault on women with intend to outrage her modesty |             |         |              |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------|---------|--------------|-----------------------------------------------------|-------------|---------|--------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | CCI       | Gi*Z         | LMiI    | LMiZ         | CCI                                                 | Gi*Z        | LMiI    | LMiZ         |
| Darjeeling                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 0.8636 L  | 0.9673       | -0.8965 | -1.4406      | 1.4933 M                                            | -0.4885     | -1.2776 | -1.1702      |
| Jalpaiguri                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 1.5397 M  | 0.6203       | 0.2068  | 0.3267       | 0.8353 L                                            | -0.2174     | 0.0086  | 0.0534       |
| Cooch Behar                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 1.5814 M  | 1.0741       | 0.5149  | 0.8859       | 0.5339 VL                                           | -0.8616     | 0.2656  | 0.4215       |
| Uttar Dinajpur                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1.9101 H  | 1.8841* HS   | 2.6663  | 1.5348       | 0.2820 VL                                           | -0.2286     | -1.0860 | -0.4562      |
| Dakshin Dinajpur                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 1.2043 M  | 2.3902** HS  | 0.4441  | 2.6408# HHC  | 0.9625 L                                            | -0.7632     | 0.1123  | 0.8621       |
| Malda                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 2.5470 VH | 2.7416# HS   | 5.9301  | 2.1763** HHC | 1.1108 L                                            | -1.1640     | -0.3391 | -1.3437      |
| Murshidabad                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 1.7718 H  | 2.1149** HS  | 3.2041  | 1.7478** HHC | 0.5214 VL                                           | -1.1704     | 1.1900  | 0.8076       |
| Birbhum                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 1.8769 H  | 0.9998       | 0.4247  | 0.3423       | 0.8503 L                                            | -0.9303     | 0.3473  | 0.8995       |
| Bardhaman                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 0.6955 L  | -0.0432      | -0.4707 | -0.2643      | 0.8283 L                                            | -0.3844     | 0.1579  | 0.3357       |
| Nadia                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 1.1900 M  | -0.7536      | -0.1493 | -0.7993      | 0.4833 VL                                           | -0.9225     | 0.7825  | 0.6553       |
| North 24 Parganas                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 0.6320 L  | -2.4826# CS  | 3.5178  | 2.3351# LLC  | 1.6467 M                                            | -0.2956     | -1.7837 | -0.7142      |
| South 24 Parganas                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 0.7167 L  | -2.2977** CS | 2.3611  | 2.2790# LLC  | 0.5440 L                                            | 0.5937      | -1.5288 | -1.1025      |
| Hooghly                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 0.5103 VL | -1.9556** CS | 3.2021  | 1.6952** LLC | 0.5927 L                                            | 0.4816      | -1.2807 | -0.7711      |
| Bankura                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 0.9380 L  | -1.4566      | 0.8053  | 1.3087       | 1.1634 L                                            | 1.7343* HS  | 0.7489  | 1.7170** HHC |
| Purulia                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 0.8898 L  | -0.9860      | 0.5474  | 0.9055       | 2.2387 H                                            | 2.2860** HS | 4.1232  | 1.5464       |
| Howrah                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 0.5481 VL | -2.7290# CS  | 4.6637  | 2.2855# LLC  | 0.7975 L                                            | 0.7769      | -0.7727 | -1.0577      |
| Kolkata                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 0.1989 VL | -2.2977** CS | 3.9419  | 1.8364** LLC | 1.7148 M                                            | 0.5937      | -0.1549 | 0.0525       |
| Paschim Medinipur                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 0.9617 L  | -1.6623* CS  | 0.8823  | 1.5308       | 2.2309 H                                            | 1.2436      | 0.9335  | 0.5716       |
| Purba Medinipur                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 0.9387 L  | -1.0012      | 0.4115  | 1.0064       | 0.5792 L                                            | 0.5843      | -1.2750 | -1.1978      |
| <b>Note:</b> Significance at *0.01 ( $p < 0.01$ ), **0.05 ( $p < 0.05$ ), and *0.10 ( $p < 0.10$ ); CCI - Crime Concentration Index; Gi*Z - Z-score of Gi* statistic; LMiI - Anselin Local Moran's I, and LMiZ - Z-score of Anselin Local Moran's I. VH-very high concentration; H-high concentration, M-Moderate concentration; L-low concentration, VL-very low concentration; HS-hot spots; CS-cold spots; HHC-high-high cluster; LLC-low-low clusters; HLC-high-low clusters; HLO-high-low outlier; LHO-low-high outlier |           |              |         |              |                                                     |             |         |              |

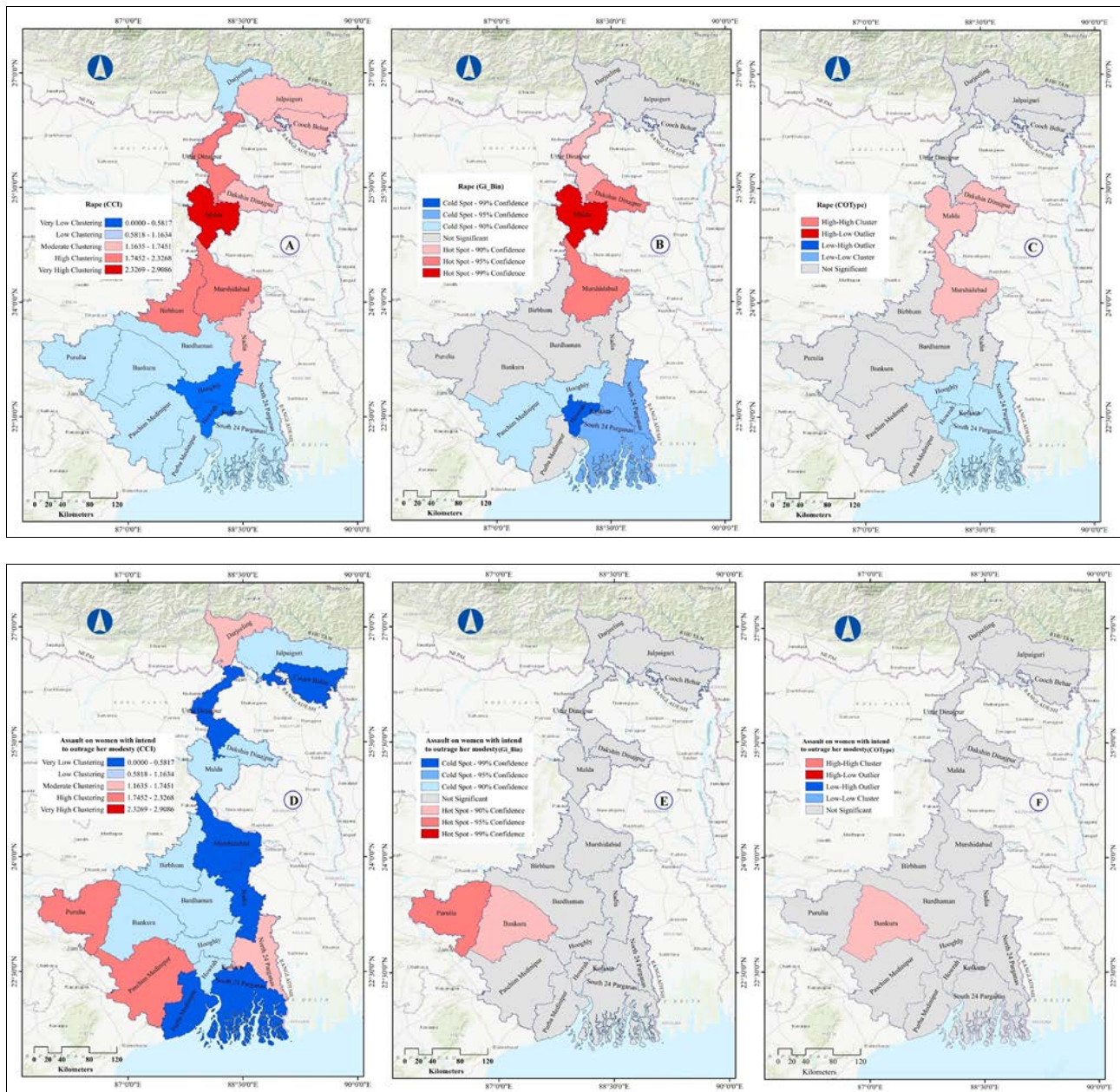


**Fig 7:** Spatial distribution of Rape and Assault on Women with Intent to Outrage Her Modesty: (A and D) crime concentration index, (B and E) hotspot analysis, and (C and F) local spatial autocorrelation.

#### 4.2.7 Six year mean spatial clustering and concentration of major crimes against women (IPC)

The spatial distribution of the six-year mean of major forms of crimes against women reveals a complex and varied landscape of vulnerability, with districts showing different levels of clustering and spatial dependence (table 10 and figure 8). According to the Mean CCI, none of the 19 districts fell within the very high ( $> 2.3269$ ), high (1.7452-2.3268), or very low ( $< 0.5817$ ) categories. Instead, all districts were distributed across moderate (CCI: 1.1635-1.7451) and low (CCI: 0.5818-1.1634) clustering ranges.

Five districts, namely Uttar Dinajpur (CCI: 1.3441), Jalpaiguri (CCI: 1.3288), Malda (CCI: 1.2319), Bankura (CCI: 1.2176), and Purba Medinipur (CCI: 1.1649), fell within the moderate clustering group (CCI: 1.1635-1.7451), indicating persistent concentrations of gender-based violence. The remaining 14 districts exhibited low clustering (CCI: 0.5818-1.1634), suggesting a relatively lower intensity or spatial dispersion.

The  $G_i^*$  statistic provides further granularity, identifying Darjeeling ( $G_i^*Z$ : 2.3620,  $p < 0.05$ ), Uttar Dinajpur ( $G_i^*Z$ : 2.1227,  $p < 0.05$ ), Dakshin Dinajpur ( $G_i^*Z$ : 2.1140,  $p < 0.05$ ), and Malda ( $G_i^*Z$ : 1.6644,  $p < 0.10$ ) as statistically significant hot spots. These districts represent high-intensity zones that require targeted policy attention. Conversely, North 24 Parganas ( $G_i^*Z$ : -2.5627,  $p < 0.05$ ), Howrah ( $G_i^*Z$ : -2.1710,  $p < 0.05$ ), Nadia ( $G_i^*Z$ : -1.8433,  $p < 0.10$ ), Kolkata ( $G_i^*Z$ : -1.7963,  $p < 0.10$ ), and South 24 Parganas ( $G_i^*Z$ : -1.7963,  $p < 0.10$ ) were identified as significant cold spots, indicating spatial suppression.

The LMI further refines these spatial patterns and shows that Darjeeling (LMiZ: 2.4684,  $p < 0.01$ ) and Dakshin Dinajpur (LMiZ: 2.1098,  $p < 0.05$ ) were confirmed as high-high clusters, reinforcing their spatial vulnerabilities. North 24 Parganas (LMiZ: 2.7122,  $p < 0.01$ ) and Nadia (LMiZ: 1.8573,  $p < 0.05$ ) were identified as low-low clusters, consistent with their cold spot status. Howrah (LMiZ: -2.2452,  $p < 0.01$ ) presents a unique case as a high-low cluster, suggesting an internal intensity juxtaposed against

low crime areas. Other districts, such as Jalpaiguri (LMiZ: 0.4742), Bankura (LMiZ: -1.5558), and Purba Medinipur (LMiZ: -0.0242), showed moderate CCI but lacked significant spatial clustering, indicating dispersed or statistically inconclusive patterns. Similarly, Murshidabad (CCI: 0.9872; Gi\*Z: -0.3624; LMiZ: 0.2125), Birbhum

(CCI: 1.0313; Gi\*Z: -0.9469; LMiZ: 0.9772), Bardhaman (CCI: 0.8929; Gi\*Z: -1.2384; LMiZ: 0.9772), and Paschim Medinipur (CCI: 1.0102; Gi\*Z: -0.1724; LMiZ: 0.1598) exhibited low or average CCI and non-significant clustering, reflecting spatial randomness or statistical insignificance. 3

**Table 10:** Six-year mean spatial clustering and concentration of major crimes against women (IPC) across district

| Districts         | Mean CCI | Gi*Z         | LMiI    | LMiZ         |
|-------------------|----------|--------------|---------|--------------|
| Darjeeling        | 1.1244 L | 2.3620** HS  | 1.3774  | 2.4684# HHC  |
| Jalpaiguri        | 1.3288 M | 1.2893       | 0.6886  | 0.4742       |
| Cooch Behar       | 1.0569 L | 1.2238       | 0.0186  | 1.6203       |
| Uttar Dinajpur    | 1.3441 M | 2.1227** HS  | 3.5285  | 1.5355       |
| Dakshin Dinajpur  | 1.1549 L | 2.1140** HS  | 1.6413  | 2.1098** HHC |
| Malda             | 1.2319 M | 1.6644* HS   | 2.0033  | 1.3511       |
| Murshidabad       | 0.9872 L | -0.3624      | 0.1180  | 0.2125       |
| Birbhum           | 1.0313 L | -0.9469      | 0.1918  | 0.9703       |
| Bardhaman         | 0.8929 L | -1.2384      | 1.5796  | 0.9772       |
| Nadia             | 1.0144 L | -1.8433* CS  | 0.7942  | 1.8573** LLC |
| North 24 Parganas | 1.0258 L | -2.5627# CS  | 0.8693  | 2.7122# LLC  |
| South 24 Parganas | 0.8309 L | -1.7963* CS  | 2.4767  | 1.3134       |
| Hooghly           | 0.7586 L | -1.1006      | 0.9760  | 0.6316       |
| Bankura           | 1.2176 M | -1.0867      | -2.9460 | -1.5558      |
| Purulia           | 1.0442 L | -0.1837      | 0.0168  | 0.1200       |
| Howrah            | 1.0755 L | -2.1710** CS | -0.5711 | -2.2452# HLC |
| Kolkata           | 0.7500 L | -1.7963* CS  | 2.5014  | 1.1723       |
| Paschim Medinipur | 1.0102 L | -0.1724      | 0.0222  | 0.1598       |
| Purba Medinipur   | 1.1649 M | 0.3200       | -0.0939 | -0.0242      |

**Note:** Significance at #0.01 (p<0.01), \*\*0.05 (p<0.05), and \*0.10 (p<0.10); CCI - Crime Concentration Index; Gi\*Z - Z-score of Gi\* statistic; LMiI - Anselin Local Moran's I, and LMiZ - Z-score of Anselin Local Moran's I. M-Moderate concentration; L-low concentration; HS-hot spots; CS-cold spots; HHC-high-high cluster; LLC-low-low clusters; HLC-high-low cluster

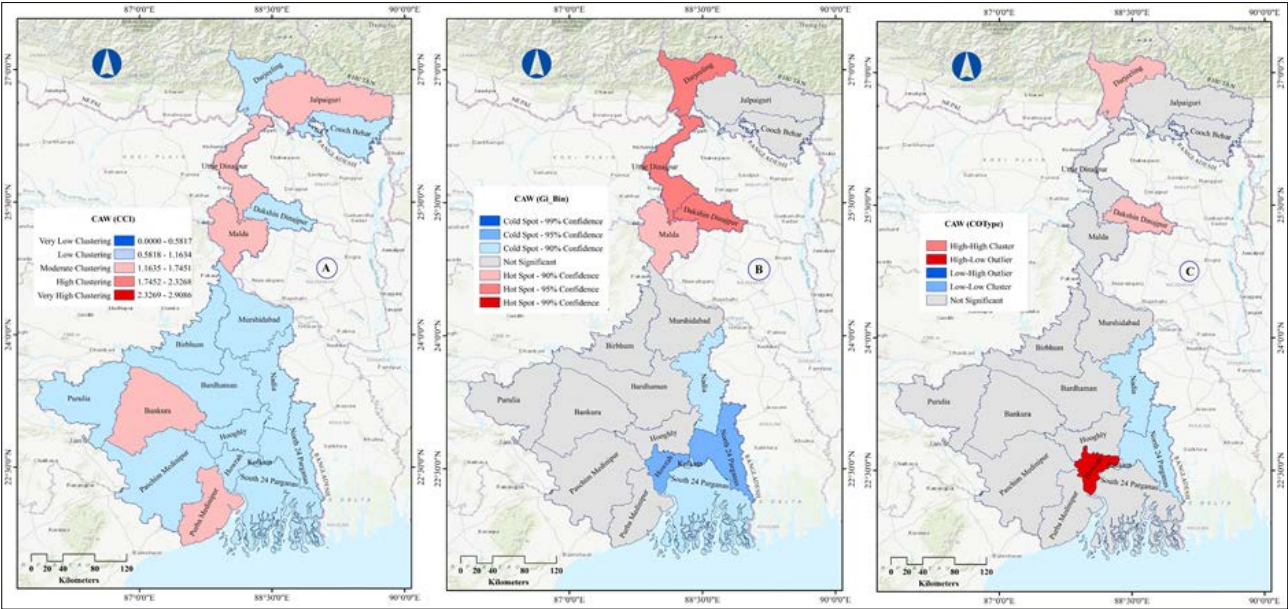


**Fig 8:** Spatial Concentration of Overall Crime against Women: (a) crime concentration index (b) hotspot analysis and (c) local spatial autocorrelation.

5. Discussion

This study presents a comprehensive analysis of the temporal trends and spatial patterns of CAW, offering critical insights into the evolving landscape of gender-based violence. The findings reveal a concerning paradox, where while the overall crime rate (IPC+SLL) has generally declined, the proportion and, in some cases, the absolute number of CAW has increased. Therefore, there is a need for deeper inquiry into the underlying socio-cultural and systemic factors which contribute to this disparity. This may

indicate more effective institutional response mechanisms or increased legal awareness. In urban settings, where anonymity is a major issue, such incidents are likely to be significantly underreported, possibly undermining traditional kinship-based violence (Nigam, 2020; Rajat, 2023) [36, 37]. Therefore, it is important to interpret these results with caution. The spatial diagnostic analysis of CAW (IPC) using Gi\* Statistic identifies concentrated hot spots and underlying spatial dependencies, which are essential for interpreting

regional disparities and for taking targeted policy measures to address these issues. Districts such as Uttar Dinajpur, Dakshin Dinajpur, and Malda have consistently emerged as statistically significant hot spots for various crime categories, especially kidnapping and abduction and rape. This observation suggests a spatial concentration, and based on prior research (Islam and Saikia, 2025) <sup>[35]</sup>, this pattern may indicate a potential socio-cultural reinforcement of violence, although direct evidence for this specific link is beyond the scope of the current study. These findings suggest a pattern that aligns with this theoretical framework, where spatial autocorrelation may indicate systemic tolerance or inadequate resistance to crime. Conversely, districts such as Kolkata and Howrah appear as significant cold spots for dowry deaths and cruelty towards women.

However, further qualitative and socio-economic research is required to empirically validate these potential influences. Nonetheless, it is crucial to recognize that low clustering should not be interpreted as an indicator of low prevalence as underreporting and gaps in institutional data in crime statistics are well-established challenges (Kumari *et al.*, 2025) <sup>[38]</sup>. This is particularly relevant as crimes are severely underreported in both public and private spheres due to fear of social stigma and reputational harm (Mukherjee, 2020; Sarkar, 2023) <sup>[16, 17]</sup>.

The identification of recurrent spatial autocorrelation through the LMI highlights that crimes are not isolated incidents but are embedded in regional contexts. The findings emphasize the necessity of multisectoral approaches that integrate legal frameworks, community engagement, and place-based interventions (Rashid & Bhat, 2025) <sup>[39]</sup>. For example, the spatial outlier observed in Bardhaman necessitates different policy attention owing to its distinct status as a high-risk neighbourhood. Upon thoroughly examining the results, this study identified distinct crime patterns across districts. In particular, dowry-related deaths are prevalent in Uttar Dinajpur, Dakshin Dinajpur, Bankura, and Bardhaman districts. Incidents of cruelty against women are concentrated in Nadia, North 24 Parganas, Howrah, South 24 Parganas, and Hooghly districts. Crimes related to kidnapping and abduction are prominent in the Malda, Nadia, Uttar Dinajpur, and Dakshin Dinajpur districts. Human trafficking is notable in Darjeeling, North 24 Parganas, Uttar Dinajpur, Jalpaiguri, and Howrah. The occurrence of high rape cases were observed in Dakshin Dinajpur, Murshidabad, Uttar Dinajpur, and Malda. The assaults on women are concentrated in Bankura, Darjeeling, North 24 Parganas, Paschim Medinipur and Purulia. Collectively, the spatial concentration of weighted CAW across these six categories was highest in Purba Medinipur, Bankura, Malda, Jalpaiguri, and Uttar Dinajpur, indicating that these districts face a greater challenge in terms of protecting women from various crimes.

The three-pronged approach utilized in this study, which incorporates general clustering, statistically significant hotspots and localized dependencies, provides a comprehensive framework for studying spatial criminology. This multi-level diagnostic method also enhances policy utility by identifying the prevalence of crime in a region and its spatial mechanism. In this context, reference can be made to UN Women (2021) <sup>[40]</sup>, which states that spatial targeting in violence prevention strategies can significantly improve

intervention outcomes, especially when integrated with local governance and community-based safety audits.

## 6. Limitations and Future Research:

This study provides valuable insights into the spatio-temporal patterns of crimes against women; however, it is subject to several limitations.

First, reliance on secondary data from the NCRB means that the analysis is constrained by the accuracy and completeness of official crime reporting, which is known to be affected by under-reporting due to social stigma and gaps in institutional data. This implies that the identified cold spots might, in some instances, reflect underreporting rather than a genuine absence of crime, potentially skewing the true spatial distribution of crime. Low clustering in certain areas may not genuinely reflect low prevalence but rather significant underreporting, particularly for sensitive crimes such as rape. This means that the findings represent reported crime patterns that may not fully capture the scope of gender-based violence.

Second, due to the lack of recent government data, female population data from the 2011 census were used to determine crime rates for 2017-2020. Projected data for 2021 were used for 2021 and 2022. Therefore, reliance on such old and projected data may subtly influence the calculations, representing a minor limitation of this study.

Third, this study employs advanced spatial statistics to execute spatio-temporal patterns of reported crimes. While the discussion section offers some theoretical interpretations, it does not incorporate socio-economic covariates (e.g., literacy rates, economic independence, and specific enforcement mechanisms) directly into spatial models. Future research would benefit from integrating such variables directly into spatial models to provide a more comprehensive understanding of the underlying socio-economic drivers of crime and strengthen the causal interpretations of the spatial patterns identified in this study.

## 7. Conclusion, Implications, and Recommendations

The present analysis reveals that the spatial concentration of gendered violence is shaped by complex interactions among geographical factors, social norms, and deficiencies in law enforcement. The findings of this study have several implications for policy and practice. First, the increasing proportion of CAW amidst a general decline in overall crime rates underscores that gender-based violence represents a distinct societal challenge, necessitating focused attention on it. However, this issue cannot be effectively addressed using general crime reduction strategies alone. Second, notable spatio-temporal variations highlight the inadequacy of uniform, state-wide interventions in addressing this problem. Instead, a district-specific approach, informed by detailed spatial analysis is essential. For instance, districts identified as hot spots for dowry deaths require interventions that differ from those experiencing high rates of human trafficking or domestic violence. The policy recommendations are as follows:

**Targeted resource allocation:** It is essential to allocate additional resources, including law enforcement personnel, specialized units focused on women's safety, and support services such as shelters, counselling, and legal aid to identified hot spots and clusters.

**Community-based interventions:** Implementing localized awareness campaigns, gender sensitization programs, and

community policing initiatives in identified hot spots, such as Malda and Uttar Dinajpur for rape and kidnapping, and North 24 Parganas for cruelty, is crucial for addressing the root causes and fostering a safer environment for women.

Strengthening reporting mechanisms: Trust in the justice system must be enhanced by ensuring victim support, confidentiality, and swift action on reported cases of sexual violence. Additionally, reporting procedures should be simplified and made more accessible, particularly in areas where underreporting may be prevalent (e.g., human trafficking).

Inter-agency collaboration: Strengthening collaboration between the police, judiciary, social welfare departments, NGOs, and local communities is vital to ensure a holistic response to CAW.

Data-driven policy making: Continuous monitoring of spatio-temporal trends using sophisticated analytical tools is required to adapt policies and interventions in real time.

In conclusion, this study offers a detailed analysis of crimes against women in West Bengal, highlighting the troubling increase in the proportion of total crimes and significant spatial concentration in specific districts. Identifying particular hot spots and clusters for various forms of CAW provides a practical framework for policymakers to formulate targeted intervention strategies to combat these crimes. By promoting data-driven, localized, and multifaceted interventions, the state can strive to create a safer and more equitable environment for women, thereby effectively addressing this persistent and critical societal issue.

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