

The Spatial Landscape of Gender Inequality: Evaluating Female Empowerment in India Using Principal Component Analysis.

Abstract:

Female empowerment is increasingly recognized as a multidimensional determinant of economic growth, yet its regional distribution within India remains unevenly studied. This paper constructs a Female Empowerment Index for all 28 Indian states and 8 union territories using NFHS-5 (2019–2021) data across three standardized indicators: female literacy, spousal violence prevalence, and women's participation in household decision-making. Principal Component Analysis is used to derive composite weights, with the first principal component explaining approximately 68% of total variance, followed by hierarchical clustering using Ward's linkage and Euclidean distance to identify spatial patterns of empowerment across states. Silhouette score analysis identifies five distinct clusters, ranging from comprehensively high-performing states such as Kerala, Mizoram, and Goa, to structurally marginalized clusters comprising a substantial proportion of states. The analysis also reveals a subgroup—including Tamil Nadu and Manipur—where high literacy and decision-making autonomy coexist with elevated reported rates of spousal violence, highlighting the multidimensional nature of empowerment. Results indicate substantial intra-zonal as well as inter-zonal disparity, suggesting that national-level averages may mask meaningful state-level heterogeneity. The findings support a shift away from uniform, top-down policy design toward localized, state-specific interventions, particularly in education, safety, and household decision-making. As India pursues continued economic growth, the paper argues that regionally targeted investment in female literacy, safety, and household decision-making capacity is important to translating national gender policy into measurable empowerment outcomes.

***Keywords:** women's empowerment; India; NFHS-5; Principal Component Analysis; hierarchical clustering; gender inequality; regional disparities

1. Introduction:

Background

Economic opportunity is a key factor in the empowerment women feel globally; this is an established fact, but to what extent do specific factors contribute to the most empowerment? According to the European Institute for Gender Equality (EIGE), empowerment can be defined as a “process by which women gain power and control over their own lives and acquire the ability to make strategic choices” (European Institute for Gender Equality [EIGE], n.d.). While in a microeconomic perspective, measures taken to

empower women benefit them and their communities; on a macroeconomic scale, rising signs of empowerment can signal overall economic virtue in forefronts such as overall literacy, resource efficiency, and higher standards of living. According to the United Nations Sustainable Development Goal 5 (gender equality) and the World Economic Forum's Gender Gap Report (participation and opportunity), empowerment is a crucial aspect to overall global development (United Nations, 2015; World Economic Forum, 2023).

Quantifying empowerment, however, is tricky. In this paper, factors such as education, domestic violence and decision-making, will be analysed and so will their impact on female empowerment, measured through index values. Education remains a fundamental aspect toward the levels of empowerment measured. The National Family Health Survey (NFHS-5) indicates that women aged 15–49 are less literate than men by about 13%, with only 41% having completed ten or more years of schooling compared to 50.2% of men (Development Monitoring and Evaluation Office [DMEO], 2021). According to Sen (2001), literacy acts as a key resource to economic empowerment as it provides women the opportunity to contribute in economic and political forefronts. Additionally, Sen highlights labour force participation within women, allowing for projected increases in economic growth and societal development. In previous studies referenced by Rathirane (2014), decision-making in households—especially considering regressive cultural norms—is strongly linked to female empowerment. Especially at a household level, the authority to make decisions reflects societal development and empowerment. The study mainly pertains to giving clarity to structural and economic disparities across regions within India. Women's empowerment flows through several parts—economic, social, cultural, and political. Oftentimes, these various parts must cohesively work together to create a secure environment to foster their benefits.

One of the strongest aspects of empowerment is economical, opportunities to work and provide for their families and the economy; this is closely linked with educational empowerment. When women are encouraged to seek knowledge, it can prove to be beneficial when its contributions are applied to the economy. Social empowerment, which takes form in communal support and modernisation that strays away from oppressive cultural norms. Sabri and Campbell (2015) emphasise that cultural and social values and patriarchal attitudes are central to domestic violence, and community-level empowerment and social reform are necessary to shift these oppressive dynamics. Legal guidelines, which set up human rights laws and regulations around employment and rights of women, also contribute vastly to empowerment. UNFPA (1992) states that development is not achievable without the legal and human rights protection for women, including labour and decision-making rights. Given all these factors that support and encourage women, mental empowerment, through providing confidence and self-worth, bonds together the several variables that work hand in hand to explore empowerment.

Even when taking into consideration the achievements of gender equality movements recently, women continue to often be marginalised in economic contexts such as employment and political representation. Identifying these gaps and creating solutions arise from studying economic indicators of progress in female empowerment. Through observing certain prominent economic indicators—decision-making authority, labour force participation, and income equality—it provides more logical insights into how

empowerment can be quantified (Pitt, Khandker, & Cartwright, 2006). It provides insight into broad regions where opportunities must be given and depicts how the benefits are reaped from said opportunities. For example, educational empowerment lays the path to knowledge but also increases women's self-confidence and ambition, laying the groundwork for larger scale empowerment outcomes across economy, health, family, and quality of life (Hoque & Itohara, 2009). Quantifying female empowerment can also help analyse webs of benefits reaped from opportunities, for example, educationally empowering women will invariably increase their self-confidence and ambition. Overall, the study of female empowerment is intricate and provides depth over a vast array of factors.

Research Gap

Existing literature establishes that women's empowerment is multidimensional and shaped by educational, economic, social, cultural, and institutional factors (Kabeer, 2005; Duflo, 2012). Previous research has examined individual dimensions of empowerment, including education, labour force participation, household bargaining power, and exposure to domestic violence. However, these dimensions are often considered separately, making it difficult to assess how different aspects of empowerment interact across regions.

In the Indian context, substantial regional variation exists in women's educational attainment, household autonomy, and exposure to violence. However, national-level measures can obscure differences between states and union territories. There is therefore scope for an integrated state-level assessment that combines multiple dimensions of women's empowerment and subsequently identifies groups of states with similar empowerment profiles.

This study addresses this gap by constructing a composite Female Empowerment Index using three indicators derived from NFHS-5: female literacy, spousal violence prevalence, and women's participation in household decision-making. Principal Component Analysis is used to derive data-driven weights for the composite index, followed by hierarchical clustering to identify groups of states and union territories with similar patterns across the selected dimensions. This approach allows the study to examine both the overall level of empowerment and the extent to which different dimensions of empowerment coexist or diverge across Indian regions.

2. Literature survey:

Female empowerment is widely recognised as a multidimensional and dynamic process shaped by the interaction of educational, economic, social, cultural, and legal factors. Rather than emerging from isolated policy interventions, empowerment develops through cumulative progress across these domains, reinforcing the importance of integrated analytical frameworks when assessing gender outcomes (Kabeer, 2005). Economic literature increasingly

conceptualises women's empowerment as both a driver and an outcome of development, linking women's autonomy to broader indicators such as productivity, human capital accumulation, and long-term economic growth (Duflo, 2012).

Education and literacy are consistently identified as the foundational pillars of empowerment. Sen's capability approach positions literacy as a critical resource that expands women's substantive freedoms, enabling them to make informed choices and participate meaningfully in economic and social life (Sen, 2001). Empirical evidence supports this framework, demonstrating that women with higher educational attainment exhibit greater decision-making authority, improved health and nutrition outcomes within households, and increased participation in the labour market (Jejeebhoy, 1995). In the Indian context, regional disparities in female literacy reflect deeper inequalities in infrastructure, cultural norms, and access to state support, suggesting that education operates as a catalyst for empowerment rather than a standalone determinant (Jha, 2019).

Labour force participation represents a critical channel through which educational empowerment translates into economic agency. The literature identifies a non-linear relationship between female employment and economic development, often described as U-shaped, wherein participation initially declines before rising with higher education levels and structural transformation (Goldin, 1995). While employment can enhance financial independence and bargaining power, studies caution that income generation alone does not guarantee empowerment. In contexts characterised by informal employment, low wages, and job insecurity, women may remain economically vulnerable despite workforce participation (Drewry, 2020). This highlights the importance of evaluating labour force participation alongside qualitative conditions such as job stability, legal protections, and access to social security (Choudhry & Elhorst, 2018).

Beyond economic variables, social inclusion and decision-making autonomy play a pivotal role in shaping empowerment outcomes. Agarwal (1997) emphasises that household bargaining power is central to women's welfare, influencing investments in children's education, nutrition, and healthcare. Decision-making autonomy also reflects broader shifts in cultural norms, signaling the sustainability and long-term persistence of empowerment gains. Malhotra et al. (2002) argue that such autonomy exerts a multiplier effect, reinforcing progress across economic and social dimensions of empowerment. Empirical studies further demonstrate that higher levels of decision-making authority among women are associated with improved household outcomes and greater societal participation.

Domestic violence constitutes one of the most significant barriers to female empowerment, undermining physical security, psychological well-being, and economic participation. Sabri and Campbell (2015) document how intimate partner violence restricts women's mobility and labour productivity, thereby weakening their capacity to contribute fully to the economy. While legal frameworks addressing domestic violence are essential, evidence suggests that legal reforms alone are insufficient unless accompanied by cultural change and effective enforcement mechanisms (Brodeur et al., 2020). Community-level support systems and institutional responsiveness are therefore critical in translating legal rights into lived empowerment (UNFPA, 1992).

Given the interconnected nature of these dimensions, composite indices have emerged as a useful methodological tool for capturing the complexity of female empowerment across regions. Such

indices allow for comparative analysis while accounting for structural heterogeneity that national averages often obscure (World Bank, 2012). Regional disparities in empowerment outcomes underscore the need for localized policy design, inter-state knowledge transfer, and culturally adaptive interventions. The literature thus supports an integrated approach to empowerment—one that recognises education, safety, economic participation, and social inclusion as mutually reinforcing pillars rather than isolated determinants.

Overall, existing scholarship provides strong theoretical and empirical justification for analysing female empowerment through a multidimensional lens. The interaction between literacy, decision-making autonomy, and freedom from violence highlights how progress in one domain may coincide with advancement in others, while also demonstrating that progress across dimensions is not necessarily uniform. This integrated framework forms the basis for examining regional variations in female empowerment within India and assessing the broader economic implications of gender-inclusive development. However, comparatively limited attention has been given to combining these dimensions into a state-level composite measure and subsequently identifying clusters of states with similar empowerment profiles. The present study therefore uses NFHS-5 data, Principal Component Analysis, and hierarchical clustering to examine the spatial distribution and multidimensional structure of women's empowerment across India.

3. Research Objectives:

This study aims to evaluate regional trends in female empowerment across Indian states. The objective is to identify measurable and consistent indicators of empowerment and assess the performance of individual states through highlighting disparities and gaps. Furthermore, using NFHS data, this study aims to explore the spatial distribution in various women-empowerment metrics, along with a clustering analysis of the same. Through this analysis, the research aims to uncover structural and policy-level challenges that hinder progress, with the ultimate goal of outlining pathways to achieving comprehensive female empowerment and unlocking its respective economic, social, and cultural benefits.

4. Research Questions:

- What is the regional trend in women empowerment across India?
- What does the intra-regional and inter-regional analysis of a composite index on women-empowerment show in terms of regional disparity and gaps?
- Is there any clustering pattern that appears countrywide?
- What is the major policy focus that the study reveals?

5. Methodology:

• 5.1 Data Source and Variable Selection

As a part of women empowerment measurement metrics, This study is based on secondary data from the National Family Health Survey (NFHS-5), conducted during 2019–2021 (International Institute for Population Sciences [IIPS] & ICF, 2021). The parameters considered in this study are namely, female literacy, the rate of spousal violence, and the rate of women's participation in household decision-making. In the NFHS-5 Key Indicators report, female literacy is listed as Indicator 14 under Characteristics of Women. Domestic violence is listed as Indicator 125 under Gender-Based Violence (Aged 18–49), while women's participation in three or more household decisions is listed as Indicator 119 under Women's Empowerment.

Three indicators were selected to represent distinct dimensions of women's empowerment: female literacy, the rate of spousal violence, and women's participation in household decision-making. Female literacy represents an educational dimension of empowerment, spousal violence represents women's safety and freedom from violence, and household decision-making represents autonomy within the household.

Indicator	Dimension	Measurement	Direction on Index
Female Literacy	Education	Percentage of women who are literate	Positive
Spousal Violence	Safety	Percentage of women experiencing spousal violence	Negative
Household decision making	Autonomy	Percentage of women participating in three or more household decisions	Positive

Table 1

The three indicators were selected to ensure that the index does not represent empowerment solely through educational attainment or household autonomy. Instead, it incorporates educational capability, freedom from violence, and decision-making autonomy as complementary dimensions.

• 5.2 Data Standardisation

As the indicators were measured using different scales and directions, the data were standardised to a range between 0 and 1 using min-max normalisation. For

indicators where higher values represent stronger empowerment, the following transformation was applied:

$$X' = (X - X_{\min}) / (X_{\max} - X_{\min})$$

For spousal violence, lower values represent more favourable outcomes. Therefore, the indicator was reverse-coded using:

$$X' = (X_{\max} - X) / (X_{\max} - X_{\min})$$

These transformations ensure that higher standardised values consistently represent more favourable outcomes across all three dimensions. Standardisation also allows the indicators to be compared despite differences in their original measurement scales.

• 5.3 Principal Component Analysis

Principal Component Analysis (PCA) was used to derive data-driven weights for the three standardised indicators and construct the Female Empowerment Index. PCA transforms correlated variables into a smaller number of uncorrelated principal components while retaining as much of the variation in the original data as possible.

The standardised female literacy, reverse-coded spousal violence, and household decision-making indicators were entered into the PCA. The first principal component was retained as the basis for the composite index because it explained 67.66% of the total variance in the three indicators. The corresponding eigenvectors for female literacy, the spousal violence index, and the decision-making index were 0.615986, 0.604718, and 0.504854, respectively.

A Principal Component Analysis (PCA) for this study was conducted to derive a composite score on female empowerment following the steps:

- i. The min-max standardized sub-indices are used in calculating the composite score.
- ii. Cumulative variance explained is examined which is approximately 70% of the total variance.

After determining the optimal weights by PCA value, the composite score is created as a weighted average.

To understand the **spatial distribution** of different empowerment factors, clustering on the basis of PCA scores has been performed using python software. Hierarchical clustering was applied to group states based on similarity across the sub-indices used. Data was first standardized to ensure comparability among variables with different scales. The Euclidean distance metric was used to measure pairwise dissimilarities, while Ward's linkage method minimized within-cluster variance during the merging process.

The Euclidean distance metric was used to measure pairwise dissimilarities between districts. For two observations $x_i = (x_{i1}, x_{i2}, \dots, x_{ip})$ and $x_j = (x_{j1}, x_{j2}, \dots, x_{jp})$, the Euclidean distance is given by:

$$d(x_i, x_j) = \sqrt{\sum_k (x_{ik} - x_{jk})^2}$$

Ward's linkage method was then employed, which merges clusters such that the increase in total within-cluster variance is minimized. Formally, at each step, the pair of clusters A and B is chosen that minimizes:

$$\Delta(A, B) = (|A||B| / (|A| + |B|)) \cdot d(\bar{x}_A, \bar{x}_B)^2$$

where $\bar{x}_A$ and $\bar{x}_B$ are the centroids of clusters A and B. This criterion yields compact, homogeneous clusters and is well-suited for dendrogram construction.

A dendrogram visually represents the nested clustering structure, where shorter linkage distances indicate higher similarity between clusters. The dendrogram cut-off point could be determined based on visual inspection and statistical criteria, identifying meaningful groups. This method allows exploration of natural clustering patterns without predefining the number of clusters. Here, to determine the optimal number of clusters, we used silhouette score following the formula:

$$D = (b_i - a_i) / \max(a_i, b_i),$$

where for each data point 'i', 'a_i' is the mean distance to other points in the same cluster (cohesion), and 'b_i' is the mean distance to points in the nearest neighboring cluster (separation). The score, ranging from -1 to +1, measures how well a data point fits into its assigned cluster, with higher scores indicating better-defined clusters.

6. Results and Analysis:

• 6.1. Female literacy trends – education as the key:

Female literacy refers to women's ability to read, write and comprehend concepts. Female literacy is directly related to the level of economic and social prosperity that is attainable for women as it opens up opportunities to gain employment, make choices and progress societies. Female literacy is thought to also be economically prosperous in terms of expanding the labor force and productive efficiency of an economy. Throughout the various states, the media rate of female literacy across India typically lies around the range of 75% with a margin of error of around 15%. The outlier values belong to the states of Kerala and Bihar, with literacy percentages of 97.4% and 55%, respectively. Various schemes and cultural influences contribute to high literacy. Typically areas with lower literacy rates primarily comprise rural regions lacking governmental support and infrastructure. Alongside the lack of development and infrastructure issues, a regressive community makes it harder to see strong literacy rates (Jha, 2019.) Intrazonal comparison suggests that there are very similar average rates of literacy between northeast India (82.8%), south India (81.5%) and west India (80.9%); whereas in the north of India (78.4%), central India (68%) and east India (64.8%) have on average lower overall rates

of literacy in that zone. Southern, Northeastern and Western India lead in female literacy rates due to states such Kerala, Goa and Nagaland. Overall, these states are culturally progressive and also receive government backup. North India has states like Delhi that perform well in terms of female literacy however it is also set off by states like Rajasthan which tend to lower overall zonal literacy. Central India all have states that perform mediocre and have literacy rates on the lower end of the median literacy rate.

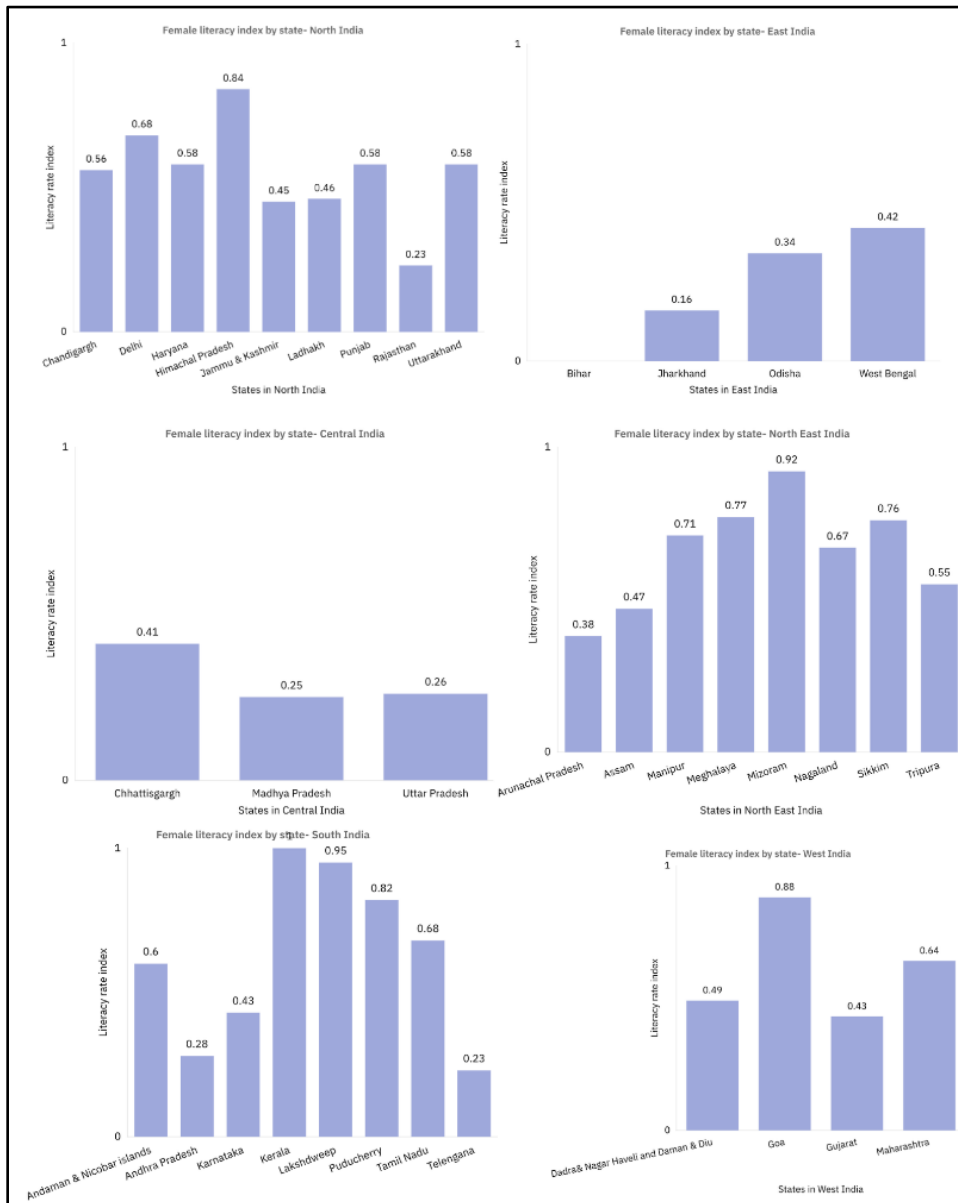


Fig 1 : Intra-zonal and Inter-zonal analysis of female literacy in India

6.2. Gender based violence – the statistics of social security:

Domestic abuse, often manifesting as physical violence by a spouse partner, has excellent social and economic implications. Support initiatives aimed at assisting victims of domestic violence, particularly when backed by strong communal and cultural frameworks, have shown a positive correlation with economic development. These efforts enhance individual confidence and empowerment, contributing to a higher quality of life for both the individual and the broader community (Kiani, et. al, 2021). Within India, Lakshadweep reports the lowest incidence of domestic violence at just 1.3%, while Karnataka records the highest at 44.4%.

These statistics suggest a strong link between domestic violence prevalence and a nation's economic potential, as violence undermines both physical health and the capacity to participate fully in the workforce. At the zonal level, the northern region of India generally exhibits lower-than-average domestic violence rates. Domestic violence thrives in circumstances with high gender discrimination, and low rates of reporting. In areas with lower rates of domestic violence (or higher reported rates of it) like the north, schemes like Protection of Women from Domestic Violence Act (PWDVA) exist. This scheme provides support to women in the form of legal custody, monetary provisions and protection orders. The national median prevalence stands at approximately 27%, with a margin of error of around 12%. The North of India ranks first in terms of the interzonal comparison, with an average domestic violence rate of 15.2% across all its states. Followed by west India (16.1%), northeast India (20.3%), south India (26%), central India (27.7%), and East India (32.3%).

These regional differences are consistent with variation across other dimensions of women's empowerment, although the descriptive analysis does not establish a causal relationship between economic development and domestic violence. In particular, reported prevalence may reflect not only the underlying incidence of violence but also differences in awareness, disclosure, reporting behaviour, and willingness to respond to survey questions. Consequently, lower reported prevalence should not necessarily be interpreted as evidence of lower underlying incidence.

The results therefore suggest an association between regional patterns of women's empowerment and reported spousal violence, while highlighting the importance of interpreting violence indicators within their social and reporting contexts. This is particularly important when comparing states with different institutional, cultural, and socioeconomic environments.

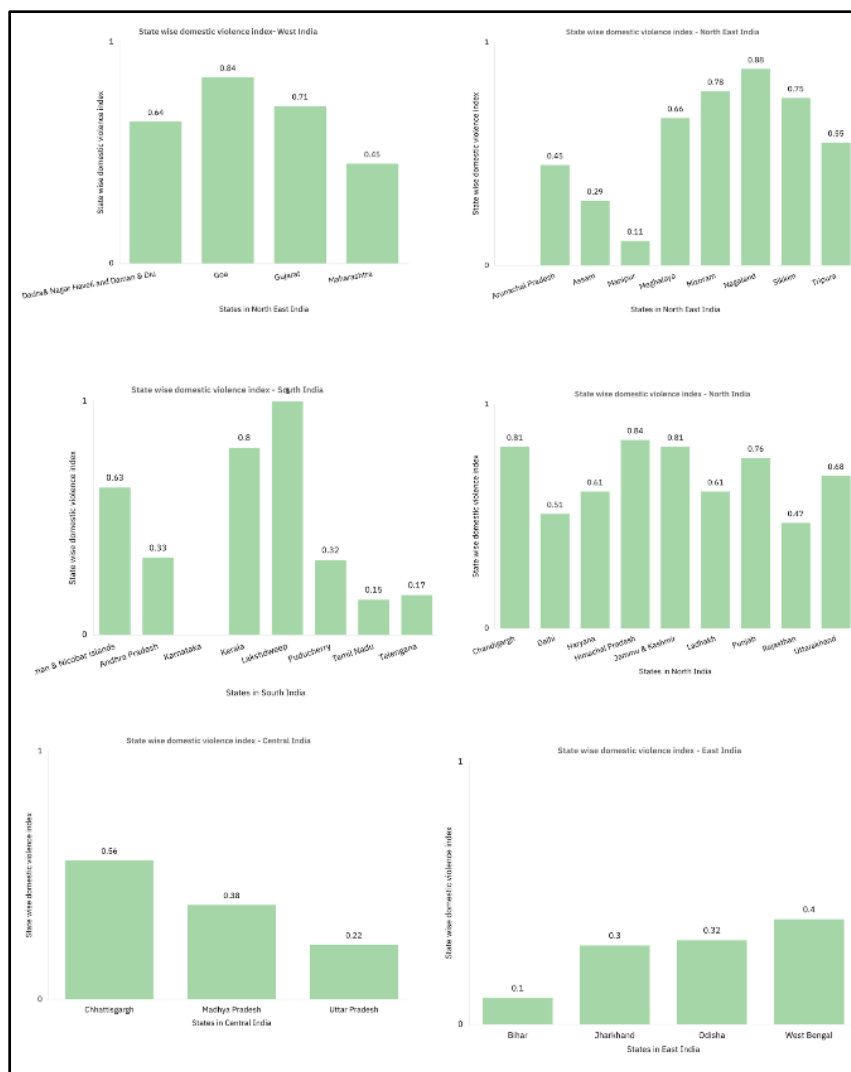
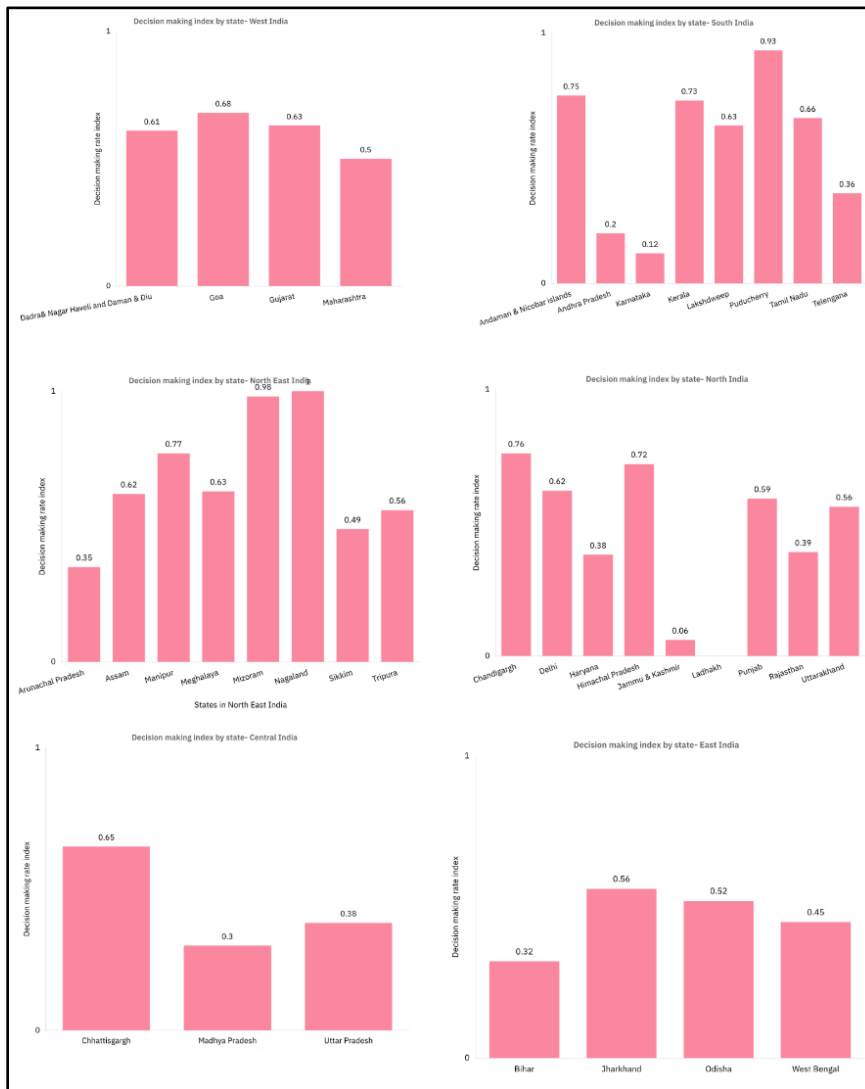


Fig 2: Intra-zonal and Inter-zonal analysis of domestic violence against women

6.3. Decision making of Females – A household empowerment narrative:

Social inclusion is characterized as a later-stage aspect of empowerment; it is a byproduct of other determinants. Through education, women gain confidence and the scope to make decisions, attain financial freedom, and reach a more empowered state (Banerjee, Alok, & George, 2020). Alongside their personal growth, the ability of women to make more household decisions reflects progress in cultural norms and stereotypes—an essential factor in the sustainability and scale of female empowerment in India. The presence of decision-making autonomy can signal the long-term persistence of empowerment due to its multiplier effect on the variables leading to empowerment. The highest rate of females making three or more household decisions is in Nagaland, at 99.2%, while the lowest is in Ladakh, at only 80.4%. Overall, the median rate of decision making is around 85% with a margin of error of 10%. Compared to other variables considered, the decision-making ability of women in India is relatively high, indicating societal transformation. When examining this variable on a zonal scale, the Northeast of India, in line with Nagaland, has the highest average rate of social inclusion at 93.1%, followed by the West

(91.75%), South India (90.7%), East India (89.2%), the North (88.9%), and finally Central India (88.8%). The data on zonal comparisons show a similar pattern between female literacy and household decision-making, with regions performing relatively strongly on literacy also generally recording higher levels of women's participation in household decisions. This descriptive association is consistent with the literature suggesting that education may contribute to women's ability to exercise greater autonomy within households (Kabeer, 2005; Jejeebhoy, 1995). However, the cross-sectional and descriptive nature of the analysis does not establish that higher literacy directly causes



greater decision-making autonomy.

Fig 3: Inter-zonal and Intra-zonal analysis of decision-making capacity of women

6.4 : PCA analysis and clustering of states:

The Eigen values and vectors along with explained variance ratio are as follows –

Eigenvalues	0.12141288
Explained Variance Ratio (proportion of variance)	67.66 %
Eigenvectors	0.61598577, 0.60471786, 0.50485429

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390 The PCA produced a first principal component with an eigenvalue of 0.12141288 and an
 391 explained variance ratio of 67.66%. This indicates that the first principal component captures
 392 approximately two-thirds of the total variation contained in the three standardised indicators.

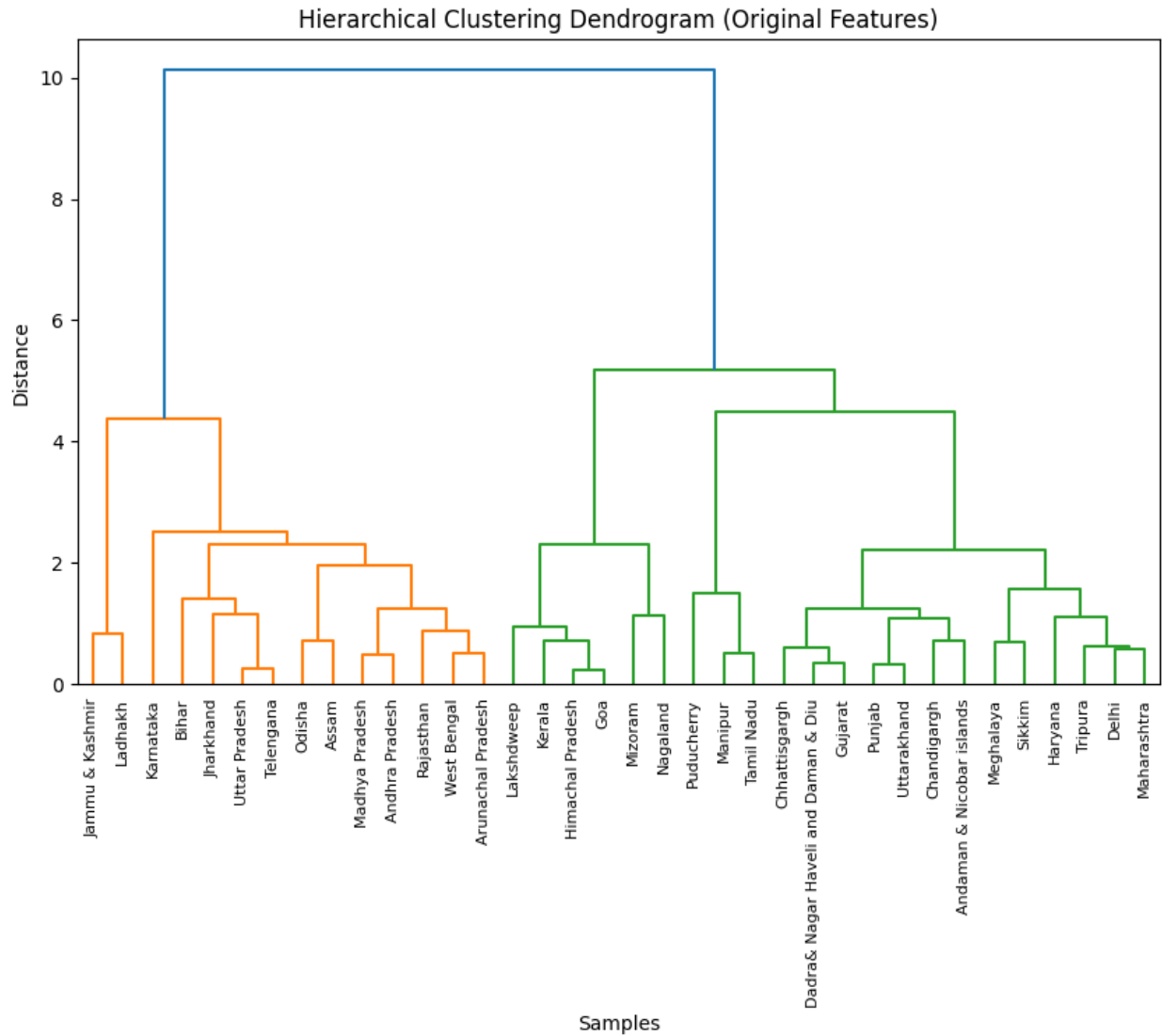
393 The corresponding eigenvector coefficients were 0.615986 for female literacy, 0.604718 for the
 394 spousal violence index, and 0.504854 for the decision-making index. These coefficients form the
 395 basis of the PCA-derived weighting structure used to construct the Female Empowerment Index.

396 PCA Weights:

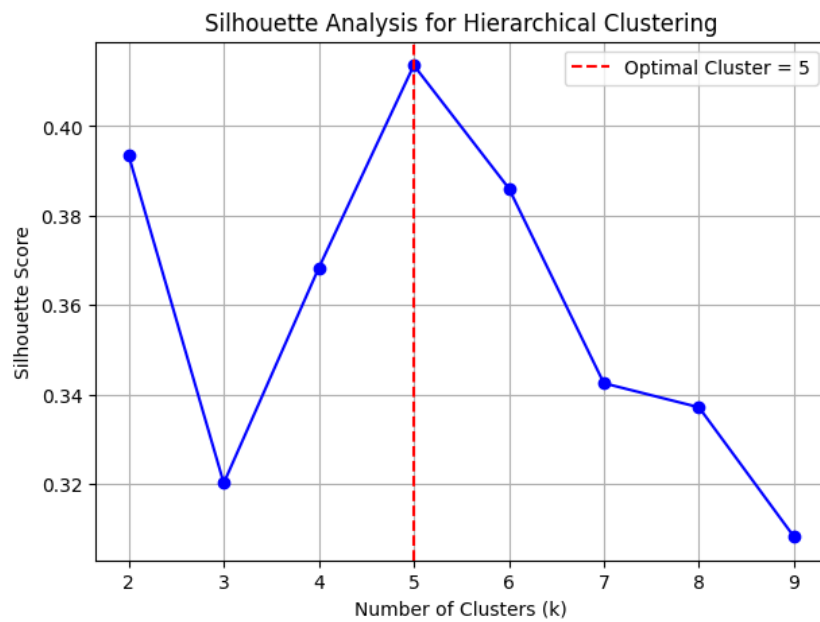
female literacy rate index	0.615986
spousal violence index	0.604718
decision making index	0.504854

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398 Based on the composite score, the dendrogram appears as follows:



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Fig 4 : Hierarchical clustering analysis on PCA score

From the silhouette score mapping, evidently 5 clusters in the data appear with distinctive features as compared to each other.

Cluster_id	no. of states	Cluster mean value			States
		female literacy rate index	spousal violence index	decision making index	
Cluster I	2	0.46	0.71	0.03	Jammu & Kashmir, Ladakh
Cluster II	12	0.29	0.29	0.38	Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal, Arunachal Pradesh, Assam, Andhra Pradesh, Karnataka, Telangana
Cluster III	6	0.88	0.86	0.79	Himachal Pradesh, Mizoram, Nagaland, Goa, Kerala, Lakshadweep
Cluster IV	3	0.74	0.19	0.79	Manipur, Puducherry, Tamil Nadu
Cluster V	13	0.59	0.64	0.59	Chandigarh, Delhi, Haryana, Punjab, Uttarakhand, Chhattisgarh, Meghalaya, Sikkim, Tripura, Dadra & Nagar Haveli and Daman & Diu, Gujarat, Maharashtra, Andaman & Nicobar Islands

Cluster I consists of Jammu and Kashmir and Ladakh and shows relatively strong performance on the reverse-coded spousal violence indicator but weaker performance in female literacy and household decision-making.

Cluster II contains 12 states and displays comparatively low performance across the three dimensions, with female literacy, spousal violence, and decision-making indices all remaining below 0.50. The cluster includes several eastern states alongside states from central, northeastern, southern, and other regions, demonstrating that low performance is not confined to a single geographic zone.

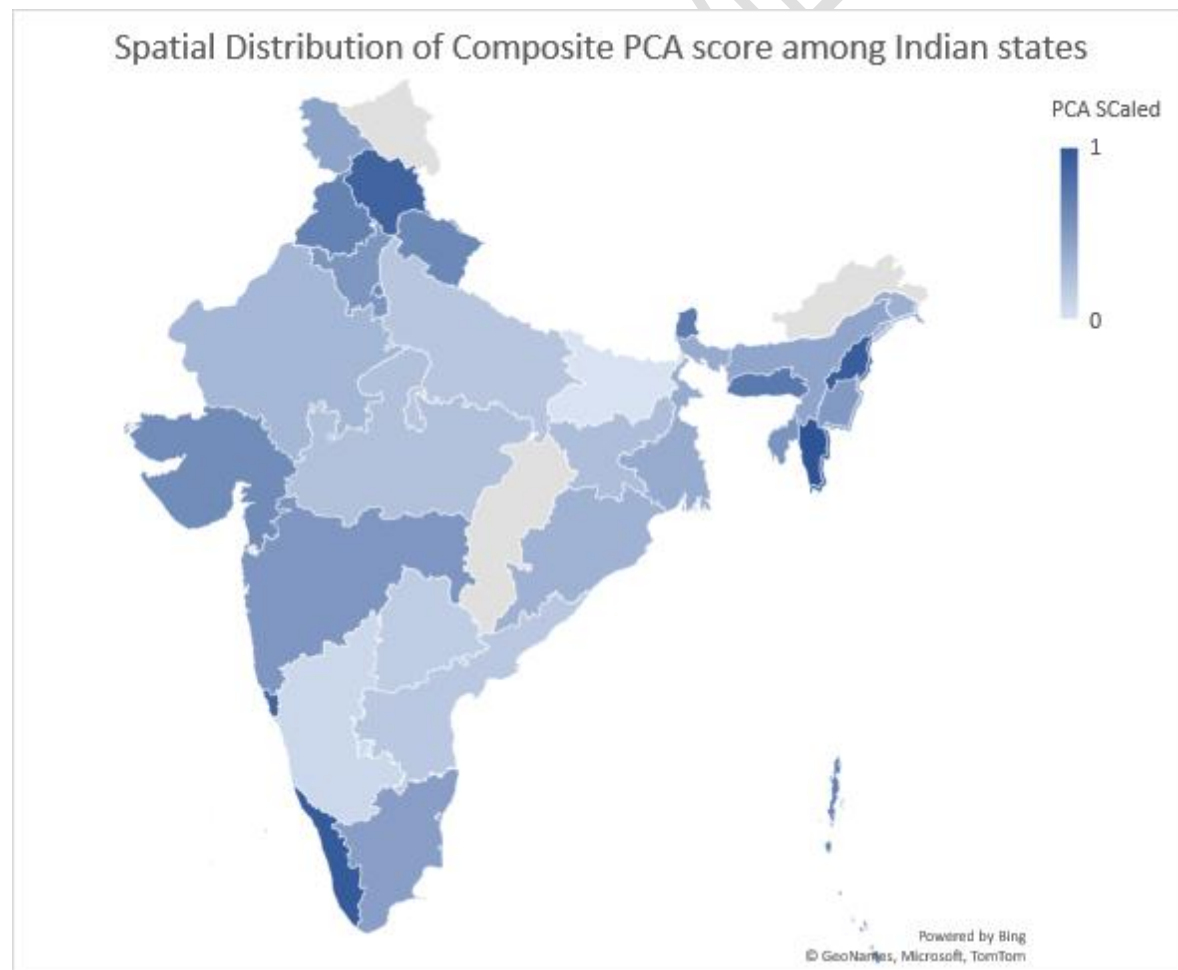
Cluster III contains six states and union territories with comparatively high values across all three dimensions. Kerala, Mizoram, Nagaland, Goa, and Lakshadweep are among the highest-performing members of this cluster.

Cluster IV consists of Manipur, Puducherry, and Tamil Nadu. These states show relatively high female literacy and decision-making scores alongside comparatively lower performance on the reverse-coded spousal violence dimension. The cluster therefore illustrates that different dimensions of women's empowerment do not necessarily improve at the same rate.

Cluster V contains 13 states and union territories with relatively balanced performance across the three indicators. The cluster mean values fall broadly within the 0.50–0.60 range across the dimensions.

One striking evidence we draw from the spatial features of women empowerment is a large variance in both across the geographic zones as well as within the same geographic zone. While all of the eastern zone marks an alarmingly low performance in various aspects of empowerment, the Northern zone marks a distribution between cluster III and V, marking a considerable improvement in the scenario. While majority states of western zone are distributed in cluster V and III, Rajasthan is lagging far behind as compared to its neighboring states and have an overall low performance in different dimensions of empowerment. In the southern and north-eastern zone, however, we see high intra-zonal variance as they are distributed among the lowest performing to highest performing clusters, drawing special attention towards regional disparities.

Overall, the clustering results demonstrate substantial variation both across geographic zones and within them. The southern and northeastern regions, in particular, contain states distributed across multiple clusters, indicating that geographic proximity does not necessarily imply similar empowerment outcomes. The findings therefore support a state-specific rather than exclusively regional interpretation of women's empowerment.



7. Policy implications:

The clear separation of clusters shows that states do not follow a uniform trajectory; some achieve high education and health outcomes without parallel economic inclusion, while others show economic activity without foundational investments. The clearly evident heterogeneous correlation between the different dimensions of empowerment also states that the trickle-down approach of empowerment, i.e, one of the dimensions will automatically get the other aspects better- will not always work. States positioned farthest in the Cluster III serve as exemplars, embodying comprehensive empowerment. Conversely, states in the Cluster II indicate structural marginalization and require urgent multidimensional intervention. Also, the presence of around 40% states in each of them raises a concern about regional disparity prevalent in women empowerment. These states in cluster I and IV show a bottleneck in achieving desired outcomes in certain aspects- hence, may be at a tipping point where targeted interventions could push them toward higher empowerment outcomes.

While analyzing the present policy framework, we find that existing schemes like Beti Bachao Beti Padhao (BBBP) could be strengthened for better outcomes. State specific initiatives inspired by Tamil Nadu's free bicycle scheme and Kanyashree in West Bengal (grant basis) can be drawn into focus. Handling barriers to education, like issues with infrastructure or families that require another working member, can help reduce barriers that hinder female literacy. In areas with high domestic violence, policies to make the reporting of abuse and support of victims more efficient must be prioritised. More One Stop Centres (OSCs) in rural areas can promote low domestic violence rates, additionally strengthening the efficacy of Protection of Women from Domestic Violence Act (PWDVA), 2005. Drawing inspiration from Kerala and Nagaland's community engagement approaches to social inclusion can help states develop under this metric. Through Deendayal Antyodaya Yojana- NRLM, gender budgeting at a Panchayat level and providing importance to SHGs in their decision-making power will help states allot more importance toward social inclusion of women and empower their decision-making capabilities. Altogether, the success of bottom-up policy approach, i.e, community engagement, forming groups at panchayat level draws attention towards policy success over top-down policies..

8. Limitations

This study has several limitations that should be considered when interpreting the findings. First, the Female Empowerment Index incorporates only three indicators: female literacy, reported spousal violence, and women's participation in household decision-making. Women's empowerment is multidimensional, and other factors—including labour force participation, income, ownership of assets, political participation, access to financial services, health, and mobility—may also contribute to empowerment but are not incorporated into the present index.

Second, the study relies on NFHS-5 data collected during 2019–2021 and therefore provides a cross-sectional assessment rather than a longitudinal analysis. The results identify patterns and associations between indicators but cannot establish causal relationships or determine how changes in one dimension produce changes in another.

Third, the use of reported spousal violence as an empowerment indicator requires particular caution. Differences in reporting behaviour, awareness, willingness to disclose experiences, and access to support services may affect the observed prevalence across states. Consequently, lower reported prevalence cannot necessarily be interpreted as lower underlying incidence.

Fourth, the min-max standardisation procedure expresses each state's performance relative to the minimum and maximum values observed in the study sample. The resulting index should therefore be interpreted as a comparative measure within the NFHS-5 state and union-territory sample rather than as an absolute measure of empowerment.

Fifth, state-level analysis may mask substantial variation within states. Differences between rural and urban populations, districts, socioeconomic groups, and demographic characteristics may not be captured by state-level averages.

Finally, the PCA-derived weighting structure is specific to the indicators and observations included in this study. Alternative indicators, datasets, time periods, or weighting approaches may produce different index values and cluster structures. Future research could address these limitations by incorporating additional dimensions of empowerment, using longitudinal data where available, and conducting analysis at the district or individual level.

9. Conclusion:

Female empowerment is a dimensional construct requiring a thorough policy approach. The disparity across Indian states and regions demonstrates economic imbalances and also entrenched social norms. Specific policymaking, localized implementation, and inter-state knowledge transfer must form the basis of future strategies. By tailoring national schemes to regional contexts—especially in literacy, safety and recognition of social power—India can realize a more equitable and empowered society. Analyzing the present scenario, the study finds enough intra-zonal disparities in well-being of women, as well as persistent in the national level as well. While states like Kerala, Nagaland, Punjab, Goa, Mizoram etc, are doing exceptionally well, the poor performance of Bihar, Chattisgarh, Karnataka etc. can never be overlooked. It could also be noted that, five different types of clustering among the states prove the question of women empowerment as a collection of different metrics are not merely unidimensional in approach. Furthermore, it could be stated, the results of the study emphasize the need of localized and state-specific planning to reach the goal of gender inclusion in modern India. While India has introduced several national policies; such as the Beti Bachao Beti Padhao Scheme, PWDVA, NRLM, and Mahila E-Haat; the success of these programs depends on their localization, cultural adaptability, and state-level prioritization. States that prioritize women's rights, education, and inclusion benefit from healthier communities, stronger economies, and

521 more equitable politics. As India moves toward becoming a trillion-dollar economy, the
522 inclusion and empowerment of women will determine the scale and sustainability of that growth

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UNDER PEER REVIEW IN IJAR

10. References

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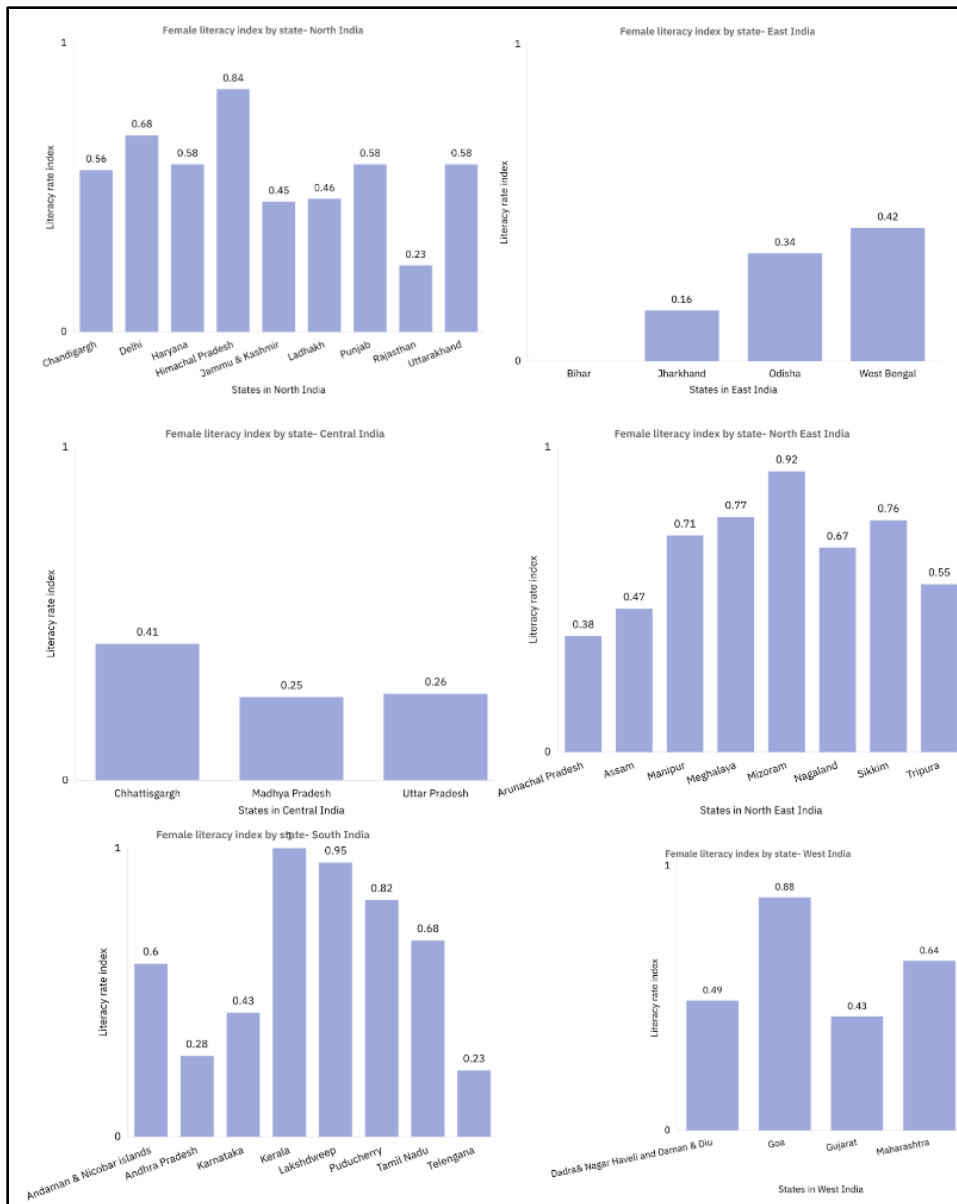
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11. Appendix:

● Appendix A — Full State/UT Dataset with Standardised Indicators

state	Female literacy rate (%)	female literacy rate index	Domestic/spousal violence (%)	spousal violence index	Females making 3 or more decisions (%)	decision making index
Chandigarh	78.7	0.5662382642	9.7	0.81	94.6	0.3813131099
Delhi	83.7	0.6788667792	22.6	0.51	92	0.8110212766
Haryana	79.7	0.7339622642	18.3	0.61	87.6	0.7780955574
Himachal Pradesh	90.7	0.8419811321	8.3	0.84	93.9	0.7180551064
Jammu & Kashmir	74.3	0.3384950566	8.6	0.82	81.6	0.03382878723
Ladakh	74.8	0.4625441509	18.1	0.61	80.4	0.9586106033
Punjab	79.4	0.7547188811	11.6	0.76	91.4	0.3861700218
Rajasthan	64.8	0.2387198811	24.3	0.47	87.1	0.3861700218
Uttarakhand	79.8	0.5844955504	15.1	0.68	91	0.5639297872
Chhattisgarh	75.5	0.4127538491	20.2	0.56	92.7	0.5642553191
Madhya Pradesh	65.5	0.2452830189	28.1	0.38	86	0.2978723404
Uttar Pradesh	66.1	0.2611724458	34.8	0.22	87.6	0.3382878234
east	55	0.1501886792	40	0.10	86.5	0.3446688351
Jharkhand	61.7	0.3419811321	31.5	0.30	91	0.3882979957
Odisha	69.5	0.4221681103	30.6	0.32	90.2	0.5212765957
West Bengal	72.9	0.3844336633	27	0.40	88.9	0.4521276596
Assam	71.3	0.7440056038	24.8	0.45	87	0.3510382298
Manipur	75.1	0.7145693943	32	0.29	62.1	0.2829848355
Mizoram	85.1	0.7668679243	39.9	0.71	94	0.7655445552
Nagaland	87.6	0.7682211561	16	0.66	92.3	0.6338978234
Tripura	83.4	0.6688132077	6.4	0.87	99.2	0.9787233874
West Bengal	87.1	0.7515682437	12.1	0.88	99.7	0.7448868611
Assam	78.3	0.5492883019	20.7	0.55	90.9	0.5566106033
Manipur	75.6	0.488490566	16.8	0.64	91.9	0.6117021274
Mizoram	82.2	0.4884926638	18.3	0.61	93.1	0.632695957
Nagaland	73.4	0.4339622642	14	0.71	92.2	0.2976595745
Tripura	82.3	0.4339622642	25.2	0.45	88.8	0.5
Assam	80.5	0.6044155843	17.2	0.63	94.5	0.75
Manipur	66.7	0.2759433992	30	0.33	84.1	0.1968020426
Mizoram	75.4	0.4339622642	44.9	0.30	82.7	0.2872340426
Nagaland	39.4	0	9.3	1.00	94.1	0.2676596745
Tripura	85.2	0.8481132075	30.3	1.00	92.2	0.9382975745
Assam	84	0.8188679225	38.1	0.35	97.8	0.6592978881
Manipur	64.8	0.2311322055	36.9	0.17	87.2	0.3617021277

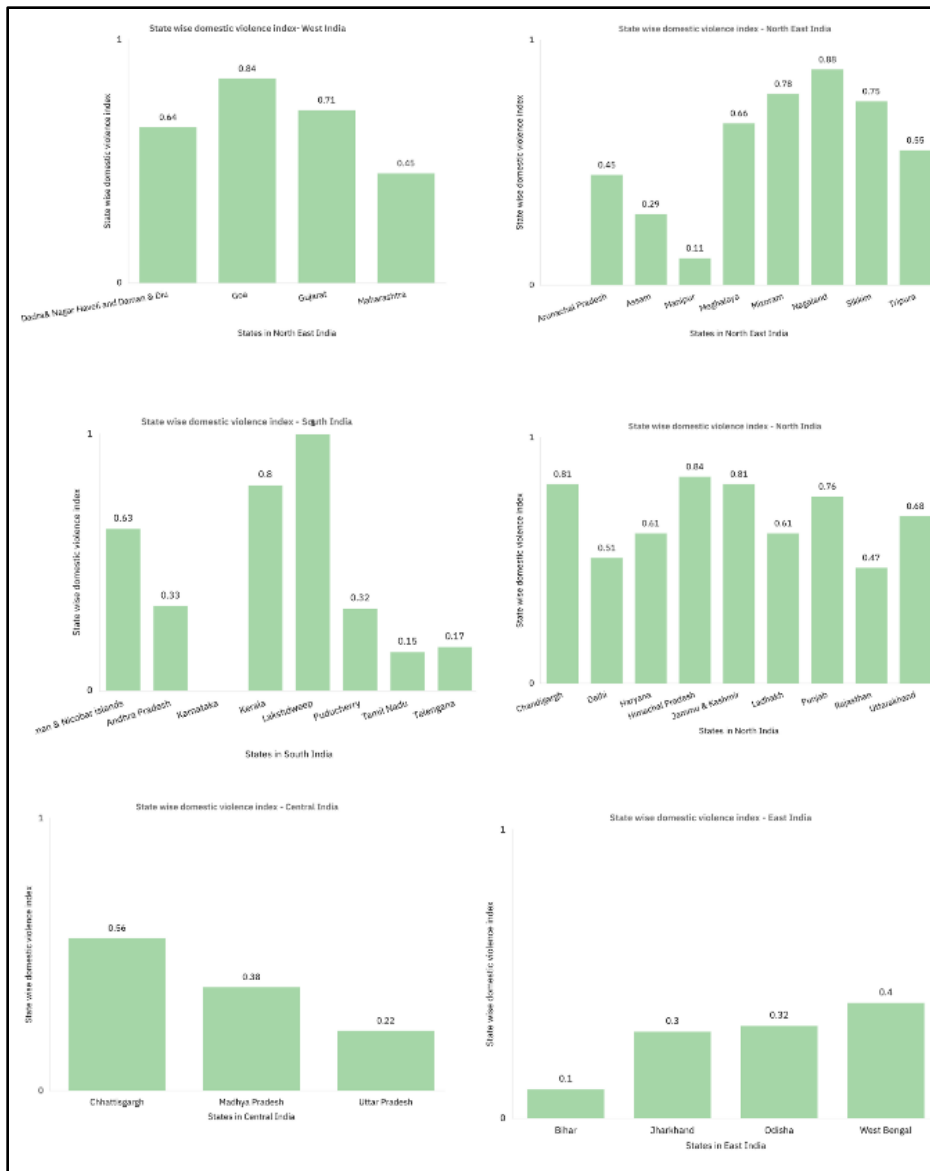
● APPENDIX B: Zonal indexes for Spousal violence, Female literacy and Decision making autonomy

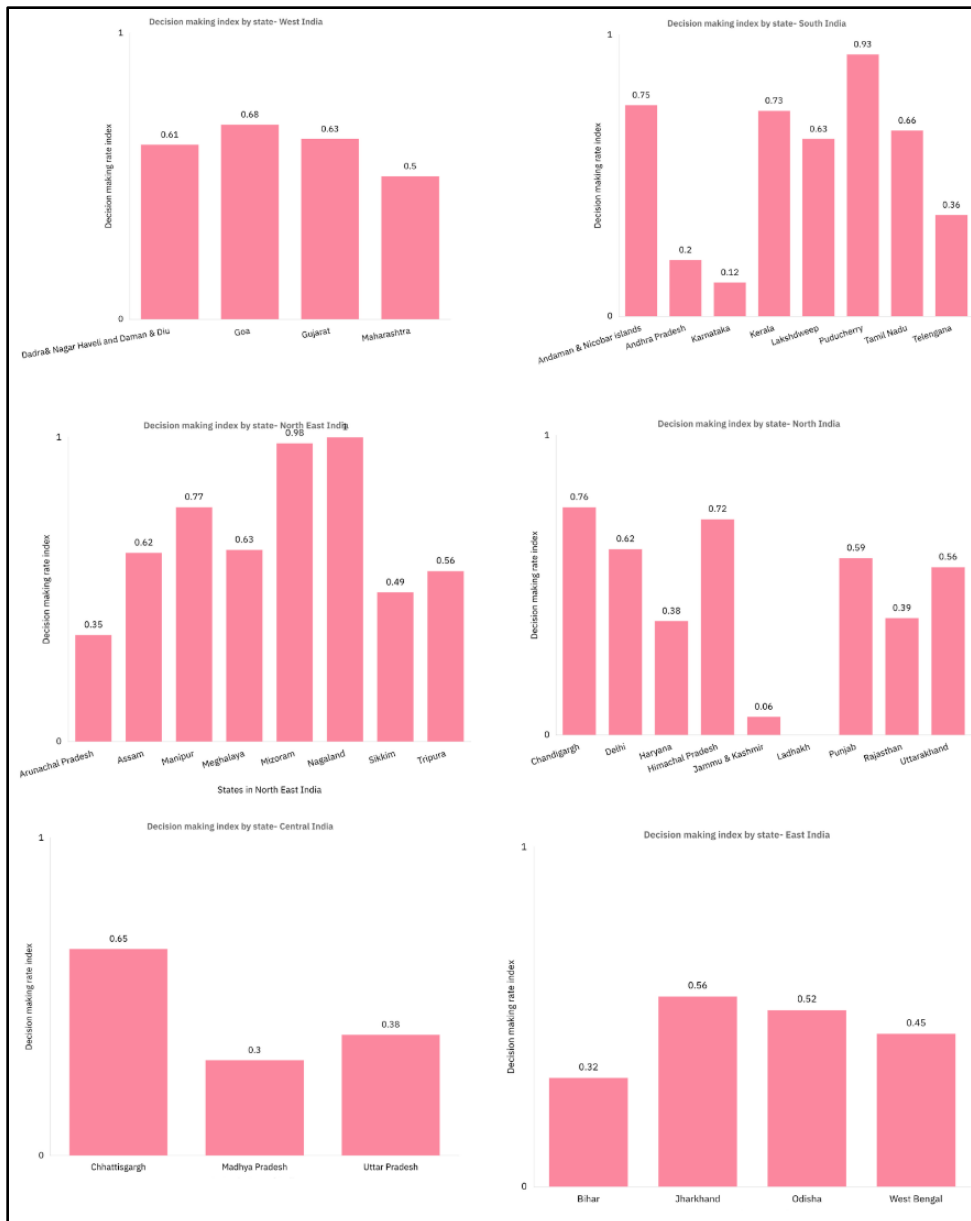


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● **APPENDIX C: PCA results**

● **C(i) Principal Component Weights**

female literacy rate index	0.615986
spousal violence index	0.604718
decision making index	0.504854

● **C(ii) Principal Component Analysis Results**

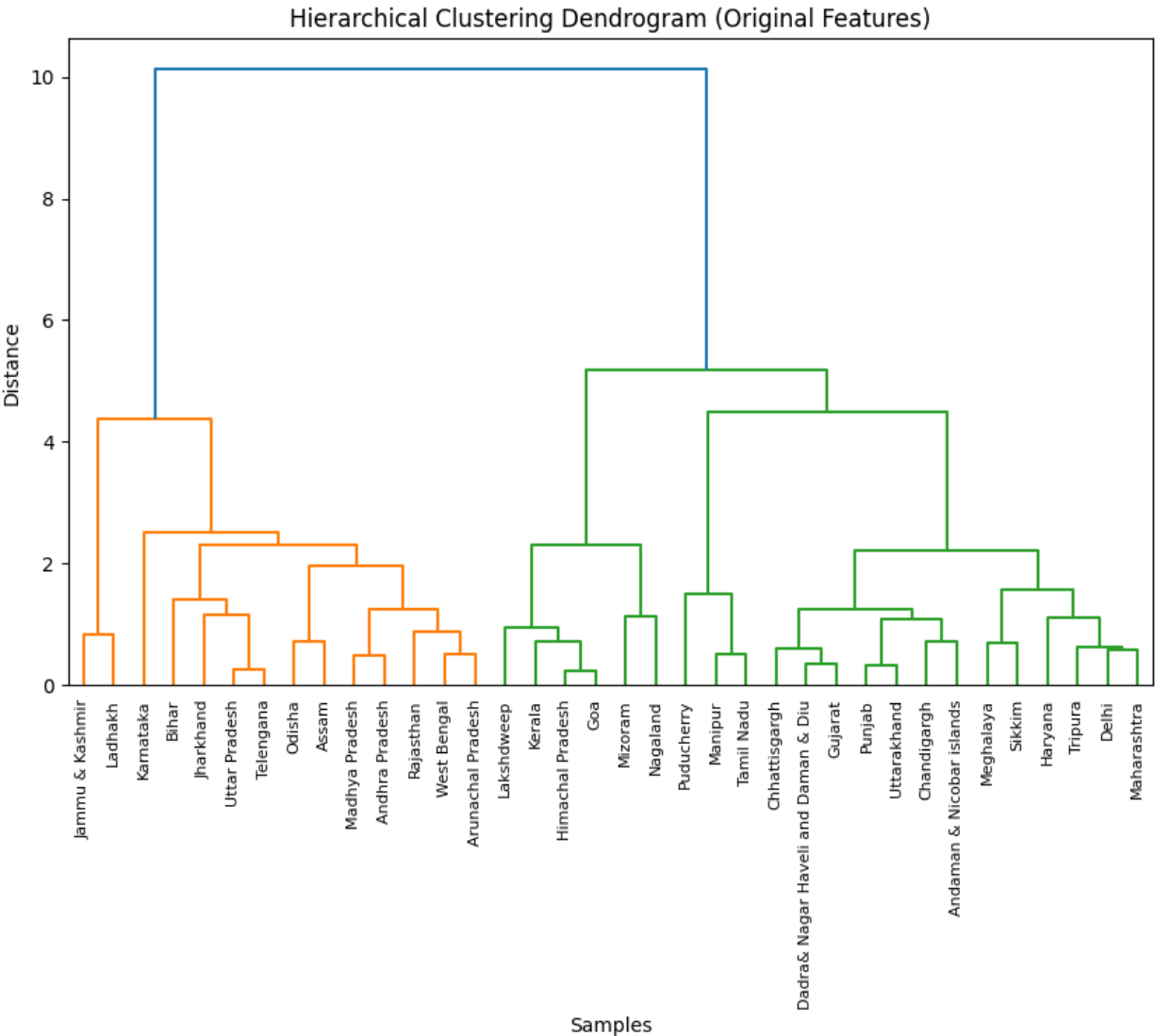
Eigenvalues	0.12141288
Explained Variance Ratio (proportion of variance)	67.66 %
Eigenvectors	0.61598577, 0.60471786, 0.50485429

● **APPENDIX D: Data Sources / NFHS-5 Indicators**

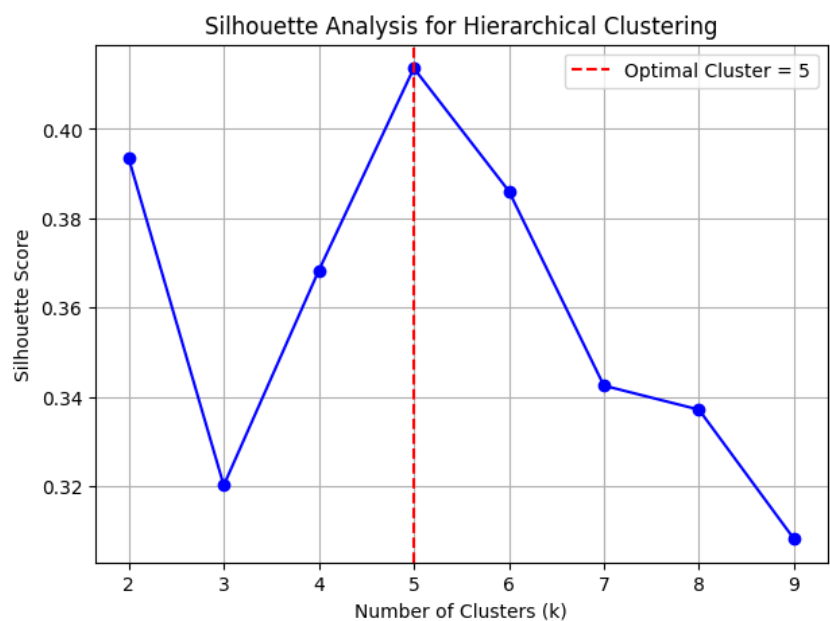
Indicator	Dimension	Measurement	Direction on Index
Female Literacy	Education	Percentage of women who are literate	Positive
Spousal Violence	Safety	Percentage of women experiencing spousal violence	Negative
Household decision making	Autonomy	Percentage of women participating in three or more household decisions	Positive

● APPENDIX E: Hierarchical Clustering and Silhouette Analysis

● E(i) Dendrogram from Hierarchical Clustering



● E(ii) Silhouette Analysis



● APPENDIX F: State and Union Territory Cluster Membership

● F(i) State/UT Cluster Classification

Cluster_id	no. of states	Cluster mean value			States
		female literacy rate index	spousal violence index	decision making index	
Cluster I	2	0.46	0.71	0.03	Jammu & Kashmir, Ladhakh
Cluster II	12	0.29	0.29	0.38	Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal, Arunachal Pradesh, Assam, Andhra Pradesh, Karnataka, Telangana
Cluster III	6	0.88	0.86	0.79	Himachal Pradesh, Mizoram, Nagaland, Goa, Kerala, Lakshadweep
Cluster IV	3	0.74	0.19	0.79	Manipur, Puducherry, Tamil Nadu

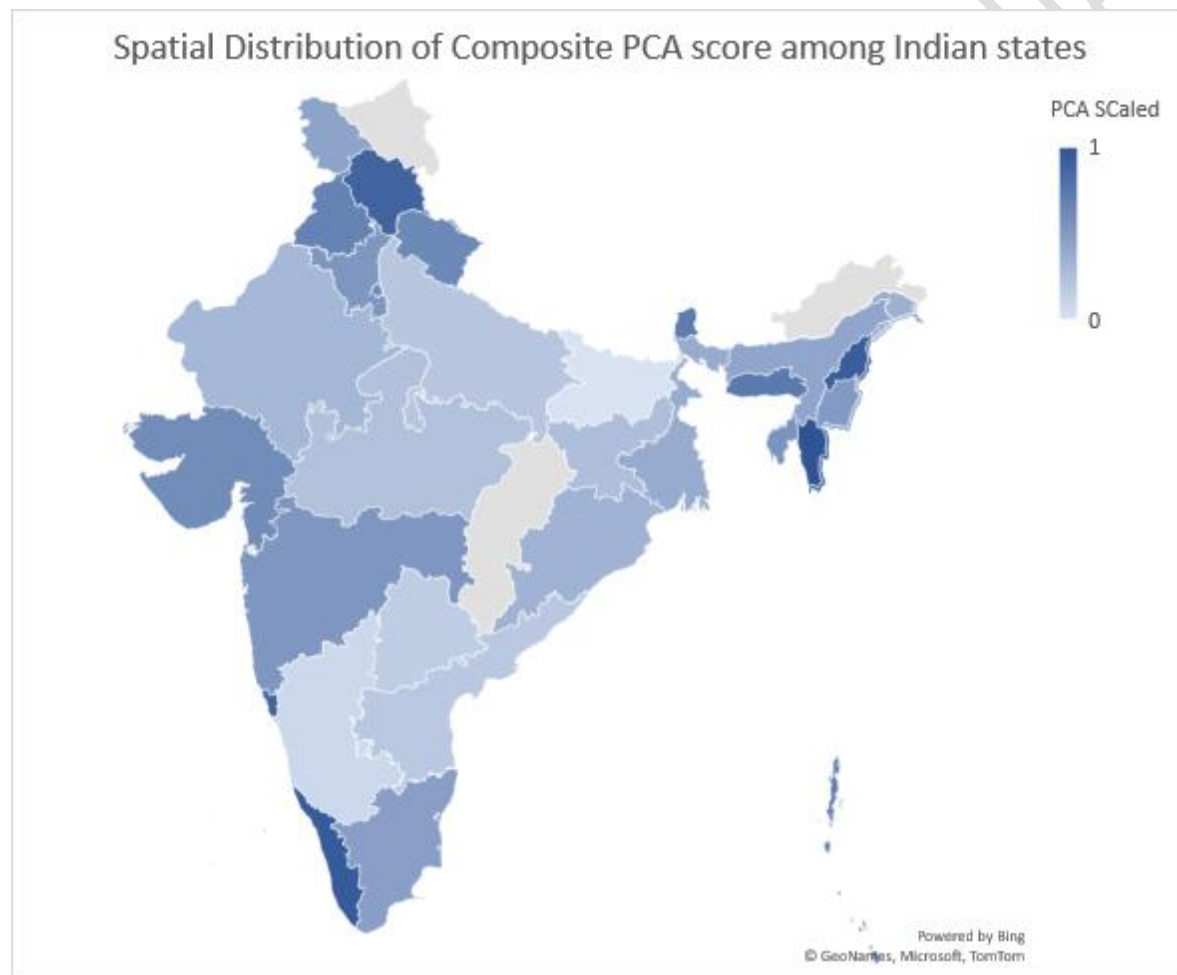
Cluster V	13	0.59	0.64	0.59	Chandigarh, Delhi, Haryana, Punjab, Uttarakhand, Chhattisgarh, Meghalaya, Sikkim, Tripura, Dadra & Nagar Haveli and Daman & Diu, Gujarat, Maharashtra, Andaman & Nicobar Islands
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- **F(ii) Spatial distribution of composite PCA score**



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