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Benchmarking Productive Engagement of Females in Villages of India

Aalok Ranjan Chaurasia

Abstract

This paper measures female productive engagement in more than 554 thousand villages of India in 2010 based on an index of productive engagement that considers both extent and intensity of productive engagement. The analysis reveals that Indian villages can be grouped into nine clusters having different level of female productive engagement and there is distinct regional pattern. Female productive engagement is found to be lower in villages having higher level of female literacy than in villages having lower level of female literacy. It appears that opportunities for productive engagement of educated females were in Indian villages. Creating these opportunities is necessary not only for transforming village economy but also for empowering women. The analysis serves as the benchmark for analysing progress in female productive engagement in villages since 2010.

Introduction

The ability to earn an income by engaging in productive activities is widely regarded as an important dimension women empowerment, although productive engagement, by itself, is not a sufficient condition to ensure an increase in the bargaining power of the woman and her substantial decision-making role within the family and the society (Bardhan, 1985; Bennet, 1992; Mencher and Saradamoni,1982; Nagaraj, 1989; Sinha, 2005). However, productive engagement as a major factor in their economic flexibility has been considered as an indicator of overall well-being and status of women in the society (Mammen and Paxon, 2000). Productive engagement of women has also been widely recognised as a driver of economic growth and, therefore, indicates the potential for economic growth (Verick, 2014).

Productive engagement of women, however, is influenced by a host of economic, social and cultural factors that interact in a complex fashion within the household and in the society. Global evidence suggests that key factors that influence productive engagement of women include educational attainment, age at entry into marital union, fertility, degree of urbanisation and social norms that determine the role of women in the family and the society. In India, it is argued that the increase in the educational enrolment of young females, lack of participation opportunities and household income are some of the factors that influence engagement of females in productive activities (Chaudhary and Verick, 2014; Kapsos et al, 2014). Social norms that decide the role of the woman in the public domain continue to affect the outcomes for women. Variation in productive engagement of women across India has been found to be influenced by a wide gamut of demographic, social,

household and regional factors, although none of them are mutually exclusive and can independently explain variation in female work participation rates across India (Jose, 1989; Sinha, 2005). Previous studies also suggest that there is no universal set of factors that explains the variation in female work participation rate across Indian states (Dholakia and Dholakia, 1978; Gulati, 1975; Nath, 1970; Sundaram, 1989).

An important factor that determines the productive engagement of women is the engagement opportunities in the social and economic production system. These opportunities are contingent upon the size and the structure of the social and economic production system. Every human settlement – village or town – has its own distinct production system which emerges from the interaction between the residents of the settlement and their surroundings. Engagement opportunities for women are not uniform across human settlements, and this variation has an impact on productive engagement of women. Understanding the dynamics of productive engagement of women, therefore, requires analysis at the level of the human settlement – village or town – to account for the variation in engagement opportunities for women. However, such analyses in India have generally been carried out at national and state levels (Chandrasekhar and Ghosh, 2011; Chaudhary, 2011; Rangarajan et al, 2011; Vinoj, 2013; Das et al, 2015; Sanghi et al, 2015; Mehrotra and Parida, 2017). There are very few studies that have analysed productive engagement of women at the local, village level in India (Sinha, 2005; Rogers, 2012). These studies highlight how productive engagement of women is influenced by the size and the structure of the village social and economic production system or the village economy. However, a pan-India analysis of productive engagement of women in the villages of the country has never been carried out despite the fact that more than 70 per cent of the Indian population lived in villages according to the 2011 population census.

The above considerations constitute the rationale for the present analysis which analyses the productive engagement of women in more than 554 thousand villages of India having at least 50 females at the time of the 2011 population census. The productive engagement has been measured in terms of an index of productive engagement that has been developed for the purpose and that considers both the extensiveness and the intensiveness of productive engagement. The paper also explores how productive engagement of women varies across villages based on a set of village-specific population characteristics following the data mining approach which permits extracting information and transforming information from big data into an easy to understand and interpret patterns that are useful from the perspective of policy analysis and programme interventions (Hastie et al, 2013).

The paper is organised as follows. The next section of the paper describes the data used in the analysis. The analysis is based on the primary census abstract of the 2011 population census which is the only source of data pertaining to the productive engagement of the people in the village social and economic production system in India. Section three of the paper describes the productive engagement index that has been developed for the purpose. The productive engagement index considers both the extensiveness and the intensiveness of productive engagement. Section four presents and discusses findings of the analysis while the fifth and the last section of the paper summarises main findings of the analysis and discusses their implications in the context of improving productive engagement of women in the villages of India.

Index of Productive Engagement

The productive engagement of people in an administrative area is commonly measured in terms of the ratio of the total number of workers to the total population in that area or the worker population ratio (WPR) and in terms of labour force participation rate (LFPR) which is defined as the ratio of the total number of workers to the total working-age population which is usually taken as population aged either 15-59 years or 15-64 years. Both WPR and LFPR are head-count ratios or prevalence measures. They reflect the number of persons in any administrative area engaged in a productive activity or work at a particular point in time which is usually a year – the higher the WPR or the LFPR the higher the engagement of the people in productive activities. These measures capture only one dimension of productive engagement, the dimension of extensiveness of engagement. They do not take into consideration the second dimension of productive engagement, the intensiveness of productive engagement which may be captured through the duration of the productive engagement in a specific period – the longer the duration of productive engagement the higher the intensity of the engagement in productive activities. It is obvious that that output of productive engagement depends upon both extensiveness and intensiveness of the engagement. It has, therefore, been argued that a fuller measure of productive engagement should take into consideration both extensiveness and intensiveness of engagement (Heckman, 1993; Blundel et al, 2011).

Let the number of persons in an administrative area who are engaged in productive activities in a year is L and the average number of days of engagement in productive activities per person in a year is A. Then the total duration of productive engagement, D, in the year is

$$D = L \times A \tag{1}$$

Equation (1) suggests that if e is the index of extensiveness of productive engagement and i is the index of intensiveness of productive engagement, then and index of productive engagement, p, that incorporates both extensiveness, and intensiveness of productive engagement may be constructed as

$$p = e \times i \tag{2}$$

Both index e and index i vary between 0 and 1 so that the index of productive engagement, P, varies between 0 and 1. The index of productive engagement, p, may be calculated for different productive activities also. If e_j is the index of extensiveness and i_j is the index of intensiveness of engagement in the productive activity j, then the index of productive engagement in the productive activity j, p_j, may be defined as

$$p_j = e_j \times i_j \tag{3}$$

It is obvious that

$$p = \sum_j p_j = \sum_j e_j \times i_j \tag{4}$$

Equation (4) suggests that the change or the difference in both e and i contribute to the change or the difference in p. It can be shown that

$$\partial p = p_2 - p_1 = \sum_j e_{2j} \times i_{2j} - \sum_j e_{1j} \times i_{1j} = \sum_j \{(e_{2j} \times i_{2j}) - (e_{1j} \times i_{1j})\} \tag{5}$$

Now, following Kitagawa (1955)

$$\left(e_{2j} \times i_{2j}\right) - \left(e_{1j} \times i_{1j}\right) = \left(e_{2j} - e_{1j}\right) \times \bar{\imath}_j + \left(i_{2j} - i_{1j}\right) \times \bar{e}_j \quad (6)$$

where

$i_j = \frac{i_{2j}+i_{1j}}{2}$

and

$\bar{e}_j = \frac{e_{2j}+e_{1j}}{2}$

In other words,

$$\partial p = p_2 - p_1 = \sum_j \left(e_{2j} - e_{1j}\right) \times \bar{\imath}_j + \sum_j \left(i_{2j} - i_{1j}\right) \times \bar{e}_j \quad (7)$$

$$\partial p = \partial e + \partial i \quad (8)$$

$\partial e = \sum_j \left(e_{2j} - e_{1j}\right) \times i_j$

$\partial I = \sum_j \left(i_{2j} - i_{1j}\right) \times \bar{e}_j$

Estimation of the index of productive engagement, p, requires estimation of the index of extensiveness, e, and the index of intensiveness, i, of productive engagement. It may be noticed that the index of extensiveness, e, is nothing but the proportion of the population engaged in productive activities. On the other hand, the index of intensiveness, i, may be measured in terms of the ratio of the average number of days of productive engagement in a year per person to the maximum possible number of days of productive engagement in the year per person. Assuming that the maximum possible number of days of productive engagement in a year per person is M, and the average number of days of productive engagement in a year per person is A, then the index of the intensiveness of productive engagement, i, may be calculated as

$$i = \frac{A}{M} \quad (9)$$

The index i ranges from the minimum value of 0 to the maximum value of 1. It cannot be more than 1. It is obvious that the higher the index, i, the higher the intensity of the productive engagement. Indexes e and i determine the extent of engagement in the productive activities.

Methods

We have estimated the index p to measure the productive engagement of females at the village level in India. It is logical to assume that the index p as well as indexes, e and i of a village are influenced by a host of the defining characteristics of the village population. These characteristics include but are not limited to 1) the size of the population of the village; 2) level of education of the village population; 3) level of fertility in the village; 4) gender composition of the village population; and 5) social class structure of the village population. In order to explore how village population characteristics influence female productive engagement, we have followed the classification modelling or the segmentation

approach. This approach classifies or segments villages into mutually exclusive and exhaustive groups or cluster of villages in such a manner that within-cluster homogeneity with respect to the index *p* is the maximum. The classification modelling or segmentation approach is different from the regression-based approach (Chaurasia, 2012). Unlike the regression-based approach, there is no restriction or limitation on the structure of the explanatory variables in the classification modelling exercise. In the most general terms, classification or segmentation of villages emanating from the classification modelling exercise is based on a set of *if-then* logical conditions that permit segmenting villages into mutually exclusive, yet exhaustive groups or clusters.

We have used the Decision Tree procedure to classify villages into different mutually exclusive groups or clusters so that villages in a group or cluster are as homogenous as possible in terms of the index *p*. The procedure can be used for many purposes, and we have used it here for segmenting villages in terms of the index *p* (IBM Corporation, 2012). Among different Decision Tree methods that are available, we have used the classification and regression tree (CRT) method (Breiman et al, 1984) which is a nonparametric recursive partitioning method. CRT splits villages into groups that are as homogenous as possible with respect to the dependent variable – the index of female productive engagement, *p*. A terminal node or cluster in which all villages have the same value for the dependent variable is called a homogeneous or "pure" node. The heterogeneity in a cluster is an indication of impurity of the node or cluster in terms of the dependent variable. There are different impurity measures available. If the dependent variable is continuous, impurity is measured in terms of least-squared deviation which is computed as the within-node variance adjusted for frequency weights or influence variables as the case may be (IBM Corporation, 2012). The tree-growing process is continued until either the pure node is reached, or the prescribed stopping criterion is met (Ambalavanan et al, 2006; Lemon et al, 2003).

Classification modelling is an exploratory data analysis procedure. It has a number of advantages for segmenting the population into mutually exclusive yet exhaustive sub-groups. The main advantage is that it makes no assumption about the underlying distribution of the dependent variable or the independent variables used in the analysis. Moreover, explanatory or the independent variables can be a mix of categorical, interval, and continuous or scale variables. Another advantage of CART is that results of the analysis are not affected by the quality of data such as presence of outliers, collinearity among the explanatory variables, heteroscedasticity, or distributional error structures that normally affect the parametric procedures.

Data

The analysis is based on the primary census abstract of the 2011 population census (PCA 2011) in India which provides data on the productive engagement of all persons enumerated at the time of the census. Those persons who reported that they were engaged in a productive activity even for a day during the one year prior to the census were also asked about the duration of productive engagement grouped into three categories – at least 6 months, 3-6 months and less than 3 months. Persons who reported that they were productively engaged even for a day during the year prior to the census were also

categorised by the type of productive engagement into four categories – cultivators, agricultural labourers, household industry workers and other workers. The population census is the only source in India which provides data pertaining to both extensiveness and intensiveness of productive engagement at the village level. Data related to the status of the productive engagement of the population are also available from other sources too such as the National Sample Survey (Government of India, 2015) and Periodic Labour Fource Survey (Government of India, 2024) but these surveys do not provide village level data. Moreover, data available from these surveys are confined to the extensiveness of productive engagement only. These surveys do not provide data related to the extensiveness of productive engagement so that estimation of the index of productive engagement, p, is not possible from the data available from these surveys.

Productive engagement or work, at the 2011 population census, was defined as participation in any economically productive activity with or without compensation, wages or profit (Government of India, 2011). Participation may be both physical and mental. Work involved not only actual work but also supervision and direction. Part-time help or unpaid work on farm, family enterprise or in any other economic activity had also been classified as work at the 2011 population census. Persons who were engaged in cultivation or milk production even solely for domestic consumption were also classified as workers. Workers were also classified into four categories depending upon the nature of productive engagement – cultivators; agricultural labours; household industry workers and other workers. A worker, at the 2011 population census was classified as cultivator if she or he was engaged in cultivation on his or her own land or land owned by other individuals or institutions including government for payment in terms of money, kind or share. Cultivation included effective supervision or direction in cultivation. A person who had given out her/his land to another person or other persons or institution(s) for cultivation for money, kind or share of crop and who did not even supervise or direct cultivation of land, was not treated as cultivator. Similarly, a person working on the land of other person or persons for wages in cash or kind or a combination of both was not treated as cultivator. Cultivation involved ploughing, sowing, harvesting and production of cereals and millet crops including wheat, paddy, jowar, bajra, ragi, other crops including sugarcane, tobacco, groundnuts, tapioca, and pulses, raw jute and kindred fibre crop, cotton, cinchona and other medicinal plants, fruit growing, vegetable growing or keeping orchards or groves. Cultivation did not include tea, coffee, rubber, coconut and betel-nuts (areca). On the other hand, a person who worked on the land of another person for wages in money or kind or share was classified as agricultural labourer. She or he had no risk in the cultivation but merely works on the land of another person for wages. An agricultural labourer had no right of lease or contract on the land on which she/he worked. Similarly, a worker was classified as household industry worker if she or he was engaged in a household industry which was an industry conducted by one or more members of the household at home or within the village in the rural areas and only within the precincts of the house where the individual lived in the urban areas. The household industry was not run on the scale of a registered factory. In the urban areas, even if household members ran an industry by themselves but at a place away from the precincts of their home, it was not considered as a household industry. Household industry was related to production, processing, servicing, repairing or making and selling (but not merely selling) of goods. It did not include professions such as Pleader, Doctor, Musician, Dancer, Waterman, Astrologer, Dhobi, Barber, etc., or merely trade or business. Lastly, all

workers who were not classified as either cultivators or agricultural labourers or household industry workers were classified as other workers. They included, among others, government servants, municipal employees, teachers, factory workers, plantation workers, workers engaged in trade; commerce; business; transport; banking; mining; construction; political or social work, priests, entertainment, artists, etc.

The definition of a village adopted in the population census in India is different from the commonly used concept of the village as a human settlement (Doxiadis, 1968). In the population census, urban areas are first identified based on a clearly laid down definition of a standard urban area and population living in these urban areas is classified as the urban population. Population not classified as the urban population is classified as rural population and is organised into administrative areas following the administrative boundaries of revenue villages. A village, identified in the population census, therefore, is an administrative unit with well-defined administrative boundaries and population of the village is the number of persons enumerated within the administrative boundaries of the village. A village, in this approach, may have only one human settlement or more than one human settlement or may have no human settlement at all in which case population of the village is zero. If there are more than one human settlements in a village then PCA 2011 provides combined data of all human settlements in the village. This approach pays no attention to permanent or temporary nature of human settlements as the enumeration is carried out on the *de-facto* basis and not on the *de-jure* basis. There is always a possibility that human settlements within the boundaries of a village are permanent or temporary or both.

At the 2011 population census, there were 640949 villages in India, out of which 43330 or around 6.8 per cent villages had no population so that the number of inhabited villages was 597619. In 41283 inhabited villages, total female population enumerated at the time of the 2011 population census was less than 50 so that these villages have been excluded from the present analysis. In addition, there were 1718 villages in which there was no female worker at the time of the 2011 population census. These villages have also been excluded from the present analysis. The present analysis, therefore, is restricted to 554618 or around 86.5 per cent of the villages of the country identified at the time of the 2011 population census. Total population of the villages included in the present analysis accounted for almost 99.7 per cent of the rural population of the country enumerated at the 2011 population census.

The index of extensiveness of female productive engagement, e, in a village has been estimated from the data from the population census as the ratio of the total number of female workers to the total female population in the village. It is not possible to estimate LFPR at the village level because the distribution of the village population by age and the distribution of workers by age are not available from the population census. Therefore, only a crude measure of the index of extensiveness of female productive engagement can be calculated at the village level in India. In other words, an index e, measuring the extensiveness of female productive engagement may be calculated as

$$e = \frac{Number\ of\ female\ workers}{Total\ number\ of\ females} \qquad (10)$$

On the other hand, estimation of the index of intensiveness of female productive engagement, i, requires estimation of the average number of days of productive

engagement in a year per female in the village. Data related to the actual duration of engagement in productive activities in a year are not available from the 2011 population census. Instead, population census classifies a person enumerated at the census into three categories based on the work status of the person – non-worker, main worker and marginal worker. The main worker is classified as a worker who has worked for at least 6 months during the year prior to the census or during the year 2010. All other workers are classified as marginal workers. Marginal workers are further classified into categories depending upon the duration of productive engagement – marginal workers who had worked for 3-6 months during the year prior to the census and marginal workers who had worked for less than 3 months. The last category includes all those persons who had worked for even a day during the year prior to the census.

For estimating the index of the intensiveness of productive engagement, we have assumed that the maximum number of days of productive engagement in a year is 270 days (mid value of the interval 180-365 days). We have also assumed that the average number of days of productive engagement of workers who were productively engaged for a period of 3-6 months during the year prior to the census is 135 days (mid value of the interval 90-180 days) and the average number of days of productive engagement of workers who worked for less than 3 months during the year prior to the census is 45 days (mid value of the interval 1-90 days). Based on these assumptions, the average number of days of productive engagement in a year (*ade*) by a female during the year prior to the census is calculated as

$$ade = \frac{(270 \times F_M + 135 \times F_G + 45 \times F_L)}{F} \quad (11)$$

where F_M is the number of females who were engaged in a productive activity for at least 6 months during the year preceding the 2011 population census, F_G is the number of females who were engaged in a productive activity for 3-6 months, F_L is the number of females who were engaged in a productive activity for less than 3 months in the year preceding the population census and F is the total number of females in the village. The population census does not provide the distribution of the population and the distribution of workers by age. Once, *ade* is estimated, the index of intensiveness of productive engagement, *i*, is calculated as

$$i = \frac{ade}{270} \quad (12)$$

Finally, we have measured the level of female education in the village in terms of female literacy rate which is defined as the proportion of the females aged 7 years and above in the village who were able to read and write with understanding to the total number of females aged 7 years and above in the village at the time of the 2011 population census. On the other hand, the level of fertility in the village is surrogated by the ratio of the children aged 0-6 years to the females aged 7 years and above in the village. This ratio is very similar to the familiar child-woman ratio which is a crude indicator of fertility in the population (Shryock and Siegel, 1980). It has been assumed that the higher this ratio, the higher the level of fertility in the village. Similarly, the gender balance in the village is measured in terms of the ratio of the males aged 7 years and above to the female aged 7 years and above in the village while the social class structure of the population is measured in terms of the proportion of Scheduled Tribes females to total females in the village at the time of 2011 population census.

Female Productive Engagement in Villages

The total number of females enumerated at the 2011 population census who were engaged in any productive activity during the year prior to the 2011 population census in 554618 villages included in the present analysis was 404755217 out of which 121479177 females were reported to have engaged in some productive activity during the year prior to the census. This means that around 30 per cent of the females in these villages were engaged in a productive activity during the year 2010. The proportion of females engaged as a cultivator was around 8.6 per cent; as an agricultural labourer was around 15 per cent; as a household industry worker was 1.5 and as any other worker was 5.3 per cent. The average number of days for which a rural female was engaged in some productive activity during 2010 was around 202 days, 213 days for cultivators, 193 days for agricultural labourers, 192 days for household industry workers, and 209 days and for all other workers. This means that the index of female productive engagement, *p*, in the rural areas of the country was 0.224 in 2010. The index of the extensiveness of female productive engagement, *e*, was 0.300, but the index of the intensiveness of female productive engagement, *i*, was 0.748. Both *e*, and *i*, vary across different categories of productive engagement so that the index *p*, was the lowest in household industry workers but the highest in agricultural labourers (Table 1).

Table 1: Index of productive engagement *p*, index of extensiveness of productive engagement, *e*, index of intensiveness of productive engagement, *i*, and average duration of engagement of rural females in India, 2010.

Category of productive engagement	Index of productive engagement	Index of extensiveness of productive engagement	Index of intensiveness of productive engagement	Average number of days of productive engagement in the year
	p	*e*	*i*	*ade*
All	0.224	0.300	0.748	202
Cultivators	0.068	0.086	0.790	213
Agricultural labourers	0.104	0.146	0.717	193
Household industry workers	0.011	0.015	0.711	192
All other workers	0.041	0.053	0.775	209

Source: Author

The variation in the index, *p*, across different categories of productive engagement is due to the variation in the index *e* and the index *i*. The index *p* is the highest in agricultural labourers because of relatively the highest index *e* as the index *i* is the second lowest in this category of productive engagement. On the other hand, the index *p* is the lowest in household industry workers because both index *e* and index *i* are the lowest in this category of engagement across the four categories of engagement. In case of all other workers, the index *e* is also very low but the index *i* is the second highest in this category of productive engagement. The average number of days of productive engagement during the year preceding the 2011 population census or in 2010 was 202 days – highest in cultivators but the lowest in household industry workers.

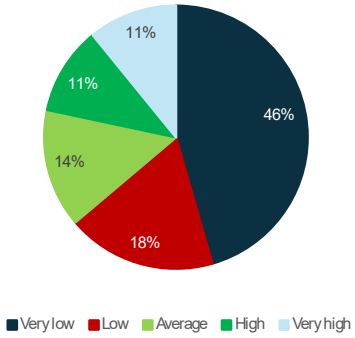
The female productive engagement index, p, is found to vary widely across the 554618 villages included in the analysis (Table 2). There is only one village – Sampanphi in sub-district Machi of Manipur – where the index p is estimated to be 1 which means that all females of the village were engaged in some productive activity for 270 days on average during the year preceding the 2011 population census. In more than 45 per cent villages, however, the female productive engagement was very low as the index p is estimated to be less than 0.200 (Table 1 and Figure 1). On the other hand, in around 11 per cent villages, the productive engagement of females in 2010 may be termed as very high as the index p was at least 0.500 in these villages. In almost two-third villages included in the present analysis, the engagement of females in productive activities was below the average ($p<0.300$) during the year preceding the 2011 population census. The kernel density plot shows that the distribution of the villages in terms of the female productive engagement index, p, is positively skewed which means that in majority of the villages included in the present analysis, the engagement of females in productive activities during the year preceding the 2011 population census was below the average. There were only around 20 per cent villages in which the engagement of females in productive activities during the year preceding the 2011 population census was above the average.

Table 2: Distribution of 554618 villages of India by in terms of indexes p, e and i according to the 2011 population census.

Distribution of villages by index of productive engagement (p) and index of extensiveness of productive engagement (e)			Distribution of villages by index of intensiveness of productive engagement (i)	
Level	p	e	Level	i
Very low (< 0.200)	45.5	32.3	Very low (< 0.500)	13.9
Low (0.200-0.300)	18.3	11.1	Low (0.500-0.600)	17.0
Average (0.300-0.400)	14.5	11.4	Average (0.600-0.700)	12.5
High (0.400-0.500)	10.8	15.8	High (0.700-0.800)	12.7
Very high (≥0.500)	10.9	29.4	Very high (≥0.800)	43.8
N	554618	554618		554618

Source: Author

The female productive engagement village is determined by both extensiveness and intensiveness of the productive engagement. Table 2 and Figures 2 and 3 show that the distribution of villages in terms of the extensiveness and in terms of the intensiveness of female productive engagement during the year 2010 was markedly different. In about one third of the villages included in the present analysis, the extensiveness of female productive engagement was very low ($e<0.200$) whereas in almost 30 per cent villages, it was very high ($e\geq0.500$). By contrast, intensiveness of female productive engagement was above the average ($i\geq0.600$) in more than 56 per cent of the villages whereas it was below the average ($i<0.600$) in around 30 per cent villages. Females in these villages were engaged in productive activities for around 162 days, on average, during the year preceding the 2011 population census. On the other hand, in close to half of the villages included in the present analysis, the intensiveness of productive engagement was very high ($i\geq0.800$) during the year preceding the 2011 population census. Females in these villages were engaged in productive engagement for at least 215 days during the year preceding the 2011 population census.



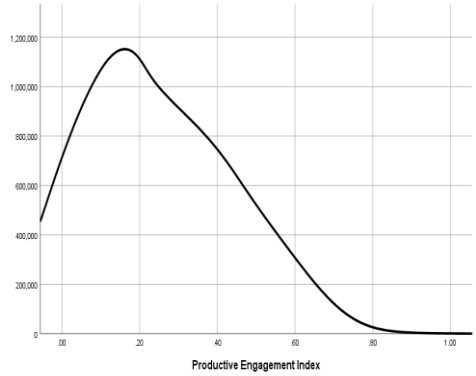
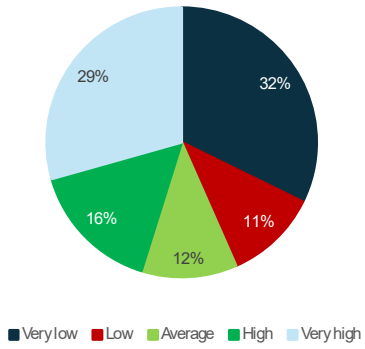


Figure 1: Distribution of villages by index *p*.
Source: Author



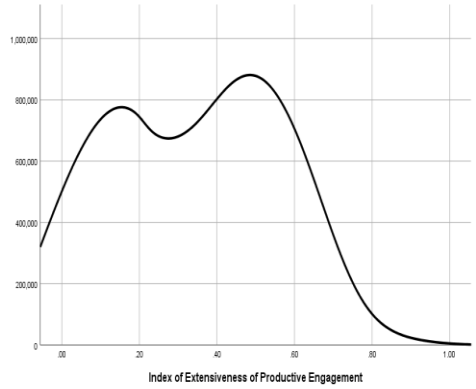
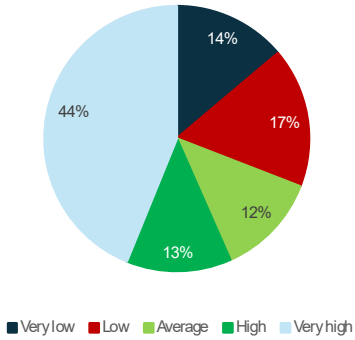


Figure 2: Distribution of villages by index *e*.
Source: Author



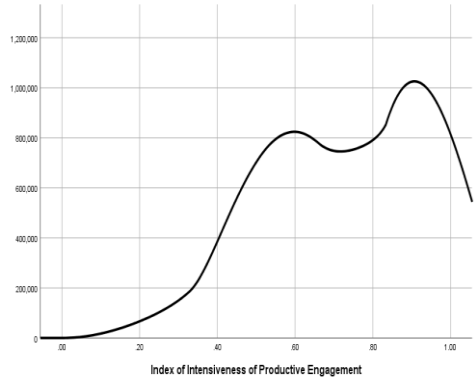


Figure 3: Distribution of villages by index *i*.
Source: Author

Table 3 gives the distribution of villages by both the level of the index of extensiveness, *e*, and the level of the index of intensiveness, *i*. In around 15 per cent villages, the intensiveness of the productive engagement of females was very high but the extensiveness of female productive engagement was very low. On the other hand, in about 13 per cent of the villages, both extensiveness and intensiveness of productive engagement of females was very high. In more than one-tenth of the villages, both intensiveness and extensiveness of the engagement of females in productive activities was below the average whereas in almost one fourth of the villages, both extensiveness and intensiveness of the engagements of females in productive activities was above the average according to the 2011 population census.

Table 3: Joint distribution of 554618 villages of India in terms of the index *e* and the index *i*, in the year 2010.

Index of extensiveness of productive engagement (*e*)	Index of intensiveness of productive engagement (*i*)					
	Very low	Low	Average	High	Very high	All
Very low	3.1	3.9	5.0	5.4	14.8	32.3
Low	1.7	2.2	1.7	1.5	4.0	11.1
Average	1.8	2.1	1.5	1.4	4.6	11.4
High	2.4	2.9	1.7	1.7	7.0	15.8
Very high	4.8	5.9	2.6	2.7	13.3	29.4
All	13.8	17.0	12.5	12.8	43.8	100.0

Source: Author

Table 4 gives the distribution of villages in according to the index *p*, index *e* and index *i* for the four categories of productive engagement – cultivators, agricultural labourers, household industry workers and all other workers – as defined at the 2011 population census. In 46806 (8.4 per cent) villages of the country, there was no female who was productively engaged as cultivator during the year prior to the 2011 population census or during the year 2010. In the remaining 507812 villages, productive engagement of females as cultivators was above the average in only around 5 per cent of the villages. Similarly, in 54120 (9.8 per cent) villages, there was no female who was productively engaged as agricultural labourer during the year prior to the census. In the remaining 500498 villages, the productive engagement of females as agricultural labourers was above the average in just around 3 per cent of the villages included in the analysis. On the other hand, in 253086 (45.6 per cent) villages, there was no female who was productively engaged as the household industry worker during the year 2010. In the remaining 301532 villages, the productive engagement of females as the household industry worker was above the average in only a negligible proportion (0.1 per cent) of the villages. Finally, in 36610 (6.6 per cent) villages, there was no female who was productively engaged in activities other than cultivator, agricultural labourer and household industry worker. In the remaining 518009 villages, the productive engagement of females as workers other than cultivators, agricultural labourers and household industry workers was above the average in only 0.4 per cent of the villages. In more than 99 per cent villages in which there was at least 1 female engaged as household industry worker in the year 2010, the female productive engagement index was estimated to be very low according to the 2011 population census.

Table 4: Distribution of female productive engagement index across villages by the category of engagement, 2010.

Index	Very low	Low	Average	High	Very high	N	No engagement
			Cultivators				
p	82.9	7.4	4.4	3.0	2.4	507812	46806
e	77.6	7.0	5.4	4.8	5.2		
i	13.8	8.2	7.3	9.2	53.1		
			Agricultural labourers				
p	79.0	12.1	5.4	2.3	1.2	500498	54120
e	67.0	12.2	9.1	6.7	5.0		
i	24.3	14.4	9.0	8.7	33.8		
			Household industry workers				
p	99.3	0.5	0.2	0.1	0.0	301532	25306
e	98.6	0.7	0.4	0.2	0.1		
i	17.2	4.9	4.4	5.5	22.3		
			All other workers				
p	97.5	1.5	0.6	0.3	0.1	518008	36610
e	95.3	2.5	1.2	0.7	0.4		
i	7.3	6.9	9.2	13.2	56.8		

Source: Author

Classification of Villages by Extensiveness and Intensiveness of Female Productive engagement

Table 5 classifies Indian villages included in the present analysis based on the index of extensiveness, *e*, and the index of intensiveness, *i* of female productive engagement The classification and regression tree method (Breiman et al, 1984) has been adopted for the purpose of classification. This method divides villages into mutually exclusive and exhaustive groups such that the within-group homogeneity in terms of the index of female productive engagement is the maximum. The results of the classification exercise are presented in table 5 which suggest that 554618 villages of the country can be grouped into 14 groups or clusters depending upon the index of extensiveness, *e*, and the index of intensiveness, *i* of female productive engagement. The average of the index of female productive engagement, *p* in villages of different groups or clusters is different. In more than 16 per cent villages, the average index of female productive engagement, *p*, was the lowest among the 14 mutually exclusive groups or clusters of villages. In villages of this cluster, less than around 8 per cent of the females were engaged in some productive activities according to the 2011 population census. This means that opportunities for productive engagement of females were extremely limited in these villages. In another 11 per cent villages, the index of female productive engagement, on average was less than 0.100, again because of the very low index of extensiveness of female productive engagement. In other words, close to 30 per cent villages included in the present analysis may be termed as the hotspot villages as far as productive engagement of females is concerned according to the 2011 population census.

Table 5: Classification of villages in terms of the index *e* and the index *i* distribution of villages in different clusters.

Cluster (Node)	*e*	*i*	*p*		
			Mean	SD	N
7	≤0.081		0.034	0.017	91085
8	>0.081 ≤0.164		0.086	0.027	63714
9	>0.164 ≤0.335	≤0.727	0.135	0.040	57973
15	>0.164 ≤0.248	>0.727	0.181	0.028	24414
16	>0.248 ≤0.335	>0.727	0.261	0.034	25090
11	>0.335	≤0.427	0.168	0.055	22069
17	>0.335 ≤0.524	>0.427 ≤0.728	0.251	0.045	62505
23	>0.524	>0.427 ≤0.589	0.313	0.040	38654
24	>0.524	>0.589 ≤0.728	0.397	0.053	17201
19	≤0.427	>0.728	0.346	0.041	31194
20	>0.427 ≤0.514	>0.728	0.432	0.046	43248
25	>0.514 ≤0.614	>0.728 ≤0.898	0.458	0.036	17974
26	>0.514 ≤0.614	>0.898	0.545	0.032	26155
14	>0.614	>0.728	0.619	0.074	23323

Source: Author

At the other extreme, there are only around 4 per cent villages in which female productive engagement was relatively the highest. In all these villages, the extensiveness of female productive engagement was more than 61 per cent. At the same time, the average number of days of female engagement in productive activities in the year preceding the 2011 population census was at least 197 days. The classification exercise also suggests that it is the extensiveness of the engagement of females in productive activities which is around three times more important than the intensiveness of the engagement in productive activities in deciding the level of female productive engagement in the village. The conventional worker population ratio depicts the extensiveness of the engagement of females in productive activities only. It does not reflect the intensiveness of the engagement which has also been found to vary widely across the villages as revealed through the data available from the 2011 population census.

Female Productive Engagement by Village Characteristics

We have also grouped villages in terms of five key characteristics of the village population to analyse how female productive engagement varies by village population characteristics. The village characteristics included in the exercise are: 1) population size; 2) gender balance measured in terms of the ratio of the number of males aged 7 years and above to the number of females aged 7 years and above; 3) social class composition measured in terms of the proportion of Scheduled Tribes females to total females; 4) female literacy rate measured in terms of the proportion of females aged 7 years and above who were able to read and write with understanding; and 5) level of fertility measured in terms of the ratio of the population aged 0-6 years to females aged 7 years and above. This exercise revealed that 554618 villages of India can be grouped into 9 clusters in terms of the five village characteristics and the average female productive engagement index across

the nine clusters varies from a minimum of just 0.162 to a maximum of 0.383 as shown in table 6 and depicted in the figure 5. The female productive engagement index was the lowest in villages having a population of at least 611 persons, villages having virtually no Scheduled Tribes population and villages with gender balance favourable to males (Node 10). They constitute almost one fourth of the villages included in the present analysis.

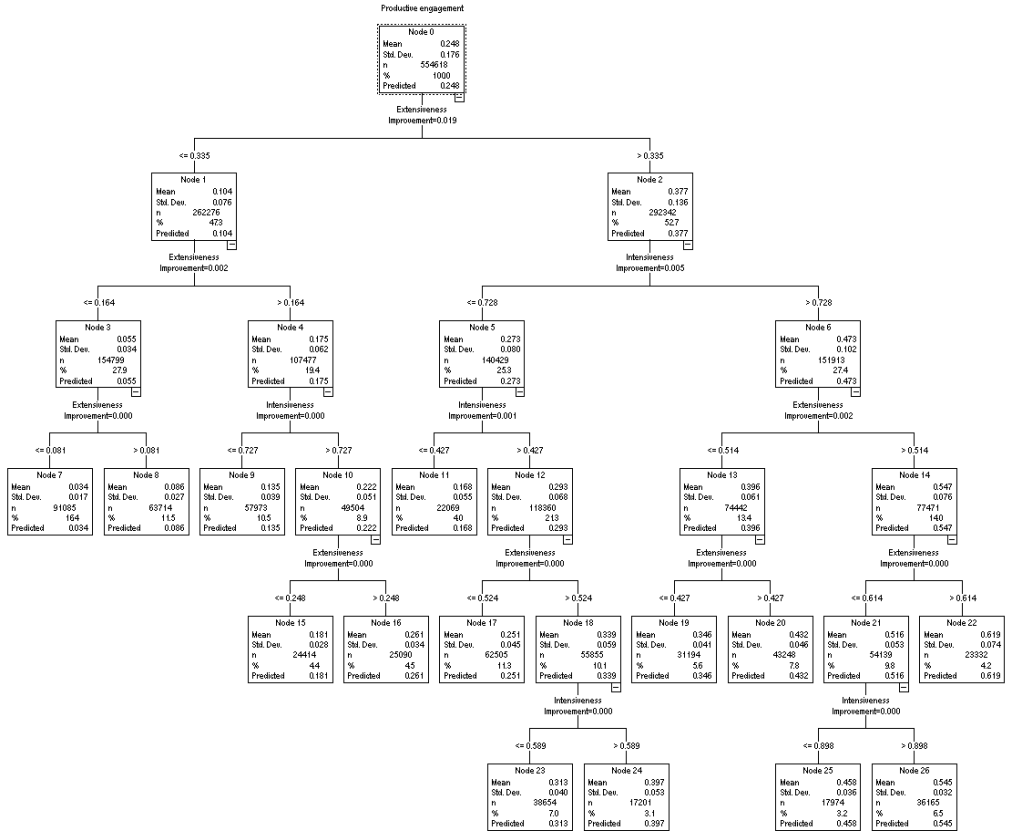


Figure 4: Classification of villages in terms of index *e* and index *i*.
Source: Author

On the other hand, female productive engagement index was the highest in villages where Scheduled Tribes females were less than 64 per cent of the total females, fertility was very low as reflected through the ratio of children aged 0-6 years to females aged 7 years and above and less than 52 per cent of the females aged 7 years and above were able to read and write with understanding (Node 15). These villages constitute less than 3 per cent of the villages included in the present analysis. Female productive engagement index was also high, on average, in villages where Scheduled Tribes female constituted more than 64 per cent of the total females (Node 6) and in villages where the gender balance in population aged 7 years and above is favourable to females and female literacy is low (Node 13).

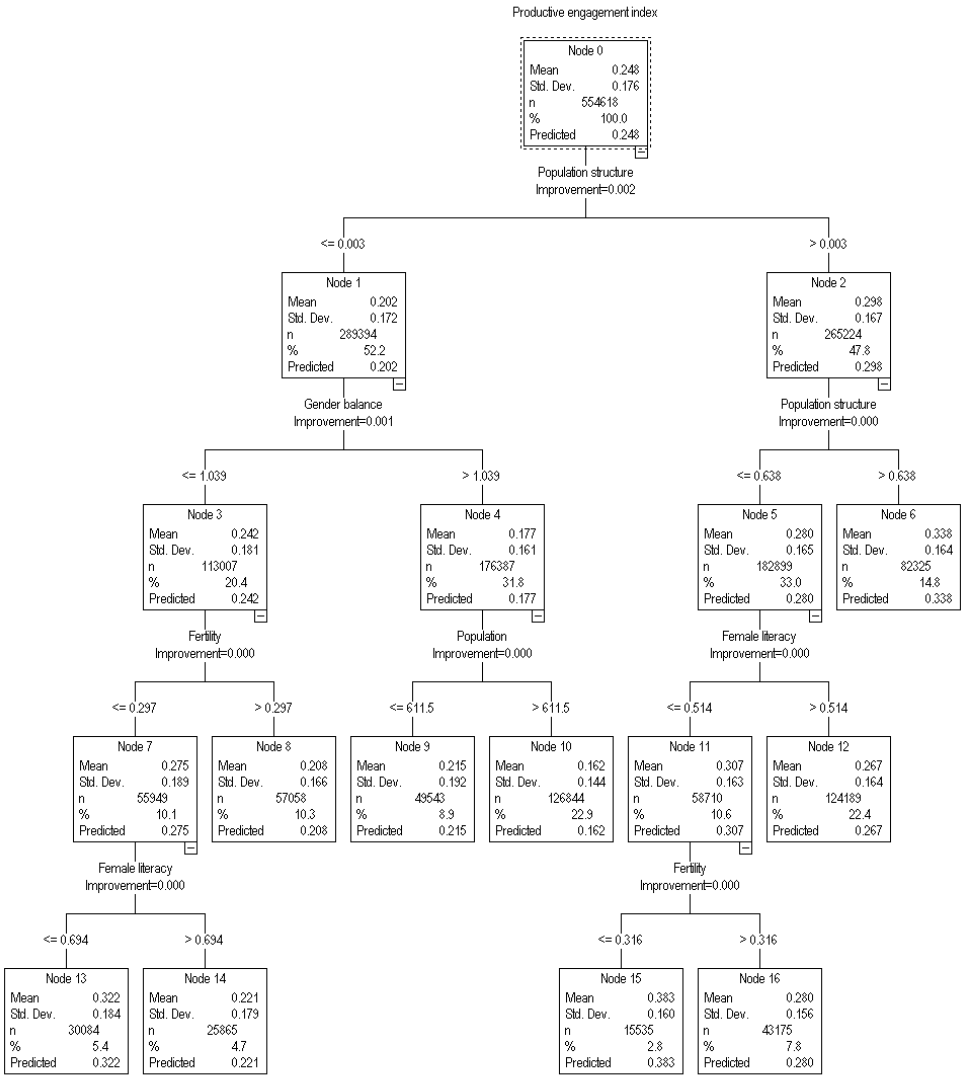


Figure 5: Classification of villages by selected characteristics of the village population. Source: Author

An interesting observation of the figure 5 is that female productive engagement is lower, on average, in villages in which female literacy is high compared to villages in which it is low. In villages where there was virtually no Scheduled Tribes population, gender balance was favourable to females, fertility was low and effective female literacy rate was low, the index p was 0.322 ± 0.184 (Node 13) compared to 0.221 ± 0.179 in villages where effective female literacy was more than 69 per cent (Node 14). Similarly, in villages where

Scheduled Tribes females constituted less than 64 per cent of the total females, the index *p* was 0.307±0.163 in villages in which the effective female literacy rate was less than 51 per (Node 11) compared to 0.267±0.164 in villages in which effective female literacy rate was more than 51 per cent (Node 12). It appears that opportunities of productive engagement for literate females was limited in the villages.

There also exists a negative association between fertility and female productive engagement. In villages having virtually little Scheduled Tribes population and gender balance favourable to females, the index *p* was 0.275±0.189 in villages in which the ratio of children aged 0-6 years to females aged 7 years and above was less than 0.300 (Node 7) compared to 0.208±0.166 in villages in which this ratio was more than 0.300 (Node 8). Similarly, in villages in which Scheduled Tribes females were less than 64 per cent of total females and effective female literacy was less than 51 per cent, the index *p* was 0.383±0.160 in villages in which the ratio of children aged 0-6 years to females aged 7 years and above was ≤ to 0.316 (Node 15) compared to villages in which this ratio was >0.316 (Node 16). The index *p* was also high in villages in which gender balance was favourable to females than in villages in which it was favourable to males (Nodes 3 and 4). The size and the social class composition of the village population has also been found to be influenced the female productive engagement in the village.

The patterns of female productive engagement in different clusters (Nodes) are presented in table 7. The variation in the index *p* across clusters is due to both variation in the index of extensiveness of productive engagement, *e*, and variation in the index of intensiveness of productive engagement, *i*. There are three clusters where more than 40 per cent of females were found to be engaged in productive activities whereas there is only one cluster where this proportion was less than 25 per cent. On the other hand, there are only two clusters in which the intensity of engagement in productive activities was more than 80 per cent which means that average number of days of female productive engagement in villages of these clusters was more than 215 days, on average. By comparison, there is only one cluster in which the intensity of engagement of females in productive activities was less than 70 per cent. This cluster is the only cluster in which average number of days of female productive engagement was less than 190 days during the year preceding the 2011 population census.

More specifically, the weighted average of the index *p* was the highest in cluster 15. Both index of extensiveness, *e*, and index of intensiveness, *i*, were the highest in this cluster. A female, in villages of this cluster was productively engaged for about 227 days out of the maximum possible 270 days of productive engagement in a year, on average. On the other hand, female productive engagement was the lowest in villages of cluster 10, on average, because of the lowest index of extensiveness of female productive engagement, *e*, although the index of intensiveness of female productive engagement, *i*, was not the lowest in this cluster. The index of the intensiveness of the female productive engagement, *i*, was the lowest in villages of cluster 8, on average. In villages of cluster 8, a female, on average, was productively engaged for only about 188 days in the year preceding the 2011 population census. Female productive engagement was also very low, on average, in villages of cluster 9 because of very low index of extensiveness of female productive engagement, *e*, although the index of intensiveness of female productive engagement, *i*, was high in the villages of this cluster.

Table 6: Classification of villages according to village characteristics and average female productive engagement index in different clusters of villages.

Node	Social class composition	Gender balance	Fertility	Literacy	Population	Productive engagement index (p)			Number of villages
						Unweighted average	SD	Weight average	
10	≤0.003	>1.039			>611	0.162	0.144	0.151	126844
8	≤0.003	≤1.039		>0.297		0.208	0.166	0.185	57058
9	≤0.003	>1.039			≤611	0.215	0.192	0.208	49543
14	≤0.003	≤1.039	>0.694	≤0.297		0.221	0.179	0.194	25865
12	>0.003 ≤0.638			>0.514		0.267	0.164	0.249	124189
16	>0.003 ≤0.638		>0.316	≤0.514		0.280	0.158	0.260	43175
13	≤0.003	≤1.039	≤0.694	≤0.297		0.322	0.184	0.335	30084
6	>0.638					0.338	0.164	0.335	82325
15	>0.003 ≤0.638		≤0.316	≤0.514		0.383	0.160	0.408	15535
All						0.248	0.178	0.224	554618

Source: Author

Table 7: Female productive engagement, effectiveness and intensiveness of engagement in different village clusters.

Index	Node/Cluster									
	6	8	9	10	12	13	14	15	16	All
Social class composition	*>0.638*	*≤0.003*	*≤0.003*	*≤0.003*	*>0.003 ≤0.638*	*≤0.003*	*≤0.003*	*>0.003 ≤0.638*	*0.003-0.638*	*All*
Gender balance	*All*	*≤1.039*	*>1.039*	*>1.039*	*All*	*≤1.039*	*≤1.039*	*All*	*All*	*All*
Fertility	*All*	*All*	*All*	*All*	*All*	*≤0.694*	*>0.694*	*≤0.316*	*>0.316*	*All*
Literacy	*All*	*>0.297*	*All*	*All*	*>0.514*	*≤0.297*	*≤0.297*	*≤0.514*	*≤0.514*	*All*
Population size	*All*	*All*	*≤611*	*>611*	*All*	*All*	*All*	*All*	*All*	*All*
					All workers					
p	0.335	0.185	0.208	0.151	0.249	0.335	0.194	0.408	0.260	0.224
e	0.470	0.266	0.295	0.213	0.316	0.405	0.252	0.486	0.368	0.300
i	0.712	0.697	0.705	0.709	0.787	0.826	0.771	0.840	0.706	0.748
ade	192	188	190	191	212	223	208	227	191	202
					Cultivators					
p	0.140	0.062	0.089	0.044	0.065	0.099	0.050	0.101	0.090	0.068
e	0.176	0.085	0.119	0.059	0.079	0.116	0.068	0.111	0.117	0.086
i	0.797	0.735	0.744	0.751	0.826	0.855	0.727	0.906	0.768	0.790
ade	215	198	201	203	223	231	196	245	207	213
					Agricultural labourers					
p	0.154	0.076	0.075	0.063	0.122	0.171	0.064	0.244	0.127	0.104
e	0.236	0.117	0.114	0.095	0.160	0.211	0.084	0.298	0.190	0.146
i	0.653	0.654	0.655	0.667	0.763	0.810	0.766	0.816	0.669	0.717
ade	176	177	177	180	206	219	207	220	181	193
					Household industry workers					
p	0.007	0.012	0.009	0.010	0.011	0.013	0.012	0.021	0.009	0.011
e	0.011	0.017	0.013	0.015	0.015	0.016	0.016	0.024	0.013	0.015
i	0.620	0.677	0.654	0.684	0.736	0.807	0.764	0.861	0.654	0.711
ade	167	183	177	185	199	218	206	232	177	192

Index	Node/Cluster									
	6	8	9	10	12	13	14	15	16	All
Social class composition	*>0.638*	*≤0.003*	*≤0.003*	*≤0.003*	*>0.003 ≤0.638*	*≤0.003*	*≤0.003*	*>0.003 ≤0.638*	*0.003-0.638*	*All*
Gender balance	*All*	*≤1.039*	*>1.039*	*>1.039*	*All*	*≤1.039*	*≤1.039*	*All*	*All*	*All*
Fertility	*All*	*All*	*All*	*All*	*All*	*≤0.694*	*>0.694*	*≤0.316*	*>0.316*	*All*
Literacy	*All*	*>0.297*	*All*	*All*	*>0.514*	*≤0.297*	*≤0.297*	*≤0.514*	*≤0.514*	*All*
Population size	*All*	*All*	*≤611*	*>611*	*All*	*All*	*All*	*All*	*All*	*All*
					Other workers					
p	0.034	0.035	0.036	0.033	0.050	0.052	0.069	0.043	0.034	0.041
e	0.048	0.047	0.049	0.044	0.062	0.062	0.085	0.052	0.048	0.053
i	0.711	0.741	0.740	0.749	0.810	0.831	0.811	0.826	0.717	0.775
ade	192	200	200	202	219	224	219	223	193	209
Number of villages	82325	57058	49543	126844	124189	30084	25865	15535	43175	554618

Source: Author

Table 8: Decomposition of the difference between all clusters average index of female productive engagement, p, and index of female productive engagement index in a cluster.

Node	∇p	Difference attributed to													
		∂e	∂i	Cultivators			Agricultural labourers			Household industry workers			Others		
				∇p	∂e	∂i	∇p	∂e	∂i	∇p	∂e	∂i	∇p	∂e	∂i
10	-0.074	-0.064	-0.010	-0.024	-0.021	-0.003	-0.041	-0.035	-0.006	0.000	0.000	0.000	-0.008	-0.007	-0.001
8	-0.039	-0.025	-0.014	-0.006	-0.001	-0.005	-0.028	-0.020	-0.008	0.001	0.002	-0.001	-0.006	-0.004	-0.002
14	-0.030	-0.036	0.006	-0.019	-0.014	-0.005	-0.040	-0.046	0.006	0.001	0.001	0.001	0.027	0.025	0.003
9	-0.017	-0.004	-0.013	0.020	0.025	-0.005	-0.030	-0.022	-0.008	-0.002	-0.001	-0.001	-0.005	-0.003	-0.002
12	0.024	0.012	0.012	-0.003	-0.006	0.003	0.018	0.010	0.007	0.000	0.000	0.000	0.009	0.007	0.002
16	0.036	0.050	-0.014	0.022	0.024	-0.002	0.023	0.031	-0.008	-0.002	-0.001	-0.001	-0.007	-0.004	-0.003
13	0.110	0.083	0.028	0.031	0.024	0.007	0.067	0.050	0.017	0.002	0.001	0.001	0.010	0.007	0.003
6	0.110	0.124	-0.014	0.072	0.071	0.001	0.050	0.062	-0.012	-0.004	-0.003	-0.001	-0.007	-0.004	-0.003
15	0.184	0.148	0.036	0.033	0.021	0.011	0.139	0.117	0.022	0.010	0.007	0.003	0.002	-0.001	0.003

Remarks: $\nabla p = \partial e + \partial i$

Source: Author

Table 7 also presents the distribution of the index *p* by different categories of productive engagement. The index *p* in cultivators was the highest in cluster 6 whereas in other workers, it was the highest in cluster 14. In case of agricultural labourers and household industry workers, the index *p* was the highest in cluster 15. Table 7 shows wide variation in indexes *e* and *i* in different categories of productive engagement across the nine clusters. The relative contribution of the two indexes to the index *p* has also been different in different categories of productive engagement in different clusters of villages identified through the classification modelling exercise.

Table 8 decomposes the difference between the index *p* in a cluster and in all clusters combined into the difference attributed to the index *e* and the index *i*. In three clusters 10, 8 and 9, both extensiveness and intensiveness of female productive engagement contributed to lower the index *p* relative to the average. Similarly, in clusters 12, 13 and 15, both extensiveness and intensiveness contributed to higher index *p* relative to the average. In the remaining three clusters, the contribution of the difference in the extensiveness of female productive engagement to female productive engagement was higher relative to the average but the contribution of the difference in the intensiveness of female productive engagement to the difference in female productive engagement was lower relative to the average. In these clusters, female productive engagement was lower than the extensiveness of female engagement in productive activities.

Table 8 also reveals that the magnitude of the contribution of the difference in the index *e* is substantially higher than that of the index *i* in all but two clusters. One reason may be the way the index *i* has been calculated because of the data constraints. At the 2011 population census, data pertaining to actual number of days of productive engagement was not collected from those who were productively engaged even for a day during the year preceding the census. Instead, every worker enumerated at the census was asked whether she or he was productively engaged either for 6 months and more or for 3-6 months or for less than 3 months during the year prior to the census. Estimate of the average number of days of productive engagement per female has, therefore, been derived by assuming that the number of days of productive engagement of a worker during the year prior to the census is either 270 days or 135 days or 45 days only. As such, the variation in the intensiveness of female productive engagement across villages is substantially limited.

Regional Pattern in Female Productive Engagement

Table 9 presents the distribution of villages by the index *p* in different states/Union Territories of the country. In 17 states/Union Territories, the index *p* was very low in more than half of the villages. In Chandigarh, female productive engagement was very low in all villages whereas in Delhi, Punjab and Andaman and Nicobar Island, it was very low in more than 80 per cent of the villages. By contrast, in eight states/Union Territories, female productive engagement was very low in less than 20 per cent of the villages. Nagaland and Andhra Pradesh are the only two states/Union Territories where female productive engagement was very low in less than 10 per cent of the villages. In Sikkim, Chhattisgarh, Maharashtra and Tamil Nadu also, female productive engagement was very low in 10-15 per cent villages. On the other hand, female productive engagement was found to be very high in more than one third villages in only Maharashtra and Andhra Pradesh. In Himachal

Pradesh, Uttarakhand, Nagaland, Manipur, Mizoram and Tamil Nadu, female productive engagement was very high in more than 20 per cent villages. In majority of the states/Union Territories, however, female productive engagement was very high in only a small number of villages. In Chandigarh, Delhi, Daman and Diu, Lakshadweep and Puducherry, there was no village where female productive engagement was very high. In 11 states/Union Territories, female productive engagement was very high in a negligible proportion of villages. There was substantial variation in female productive engagement across villages in each state/Union Territory. This variation in female productive engagement across villages shows that local, village-specific, social, economic and cultural factors play a decisive role in deciding female productive engagement.

Viewed differently, more than 40 per cent of the villages in which female productive engagement was very low in 2010 are located in Uttar Pradesh (28.7 per cent), Bihar (11.1 per cent) and Jharkhand (10.9 per cent) only whereas almost 54 per cent of the villages in which female productive engagement was very high are located in Maharashtra (22.5 per cent), Andhra Pradesh (13.9 per cent), Rajasthan (8.9 per cent) and Karnataka (8.4 per cent). Similarly, almost half of the villages in which female productive engagement was high are located in Maharashtra (15.1 per cent), Madhya Pradesh (12,3 per cent, Rajasthan (11.8 per cent) and Andhra Pradesh (10.6 per cent). On the other hand, more than one third of the villages in which female productive engagement was low were located in Madhya Pradesh (11.6 per cent), Uttar Pradesh (11.6 per cent) and Rajasthan (10.6 per cent) whereas around one third of the villages in which female productive engagement was average were in Madhya Pradesh (12.1 per cent), Uttar Pradesh (11.5 per cent) and Maharashtra (9.5 per cent). In Kerala, female productive engagement was either low or very low in all but few villages.

Conclusions

Engagement in productive activities is commonly measured in terms of the worker population ratio (WPR) and the labour force participation rate (LFPR) which are unidimensional indicators of engagement as they are based on the extent of engagement only. Both the indicators have limitations in measuring the true productive engagement as they do not consider the intensity of the productive engagement. In this paper, we have constructed an alternative index of productive engagement that considers both extensiveness and intensiveness of engagement to provide a better understanding of productive engagement. The index has been used to measure female productive engagement in more than 554 thousand villages of India during the year 2010 for which the data are available through the 2011 population census. The population census is the only source in India which provides data related to the productive engagement of the people in the villages of the country, although in a limited context. The next population census in India is going to be conducted in the year 2027. The findings presented in the present paper may, therefore, serve as a benchmark to measure the progress in the engagement of females in productive activities in the villages of the country. Since, engagement of females in productive activities is a widely used indicator of women empowerment, the present analysis also serves as benchmark to measure the progress in women empowerment at the village level in India.

Table 9: Distribution of villages in different states/Union Territories of the country by the level of female productive engagement (index *p*) as revealed through the 2011 population census.

State/Union Territory	Proportion (per cent) of villages in the state/Union Territory in which the index of female productive engagement, *p*, was					Number of villages
	Very low <0.500	Low 0.500-0.550	Average 0.550-0.600	High 0.600-0.650	Very high ≥0.650	
Jammu & Kashmir	78.2	13.8	5.1	1.8	1.2	6074
Himachal Pradesh	31.4	15.6	22.7	9.1	21.3	13402
Punjab	87.6	6.7	2.9	1.3	1.5	11612
Chandigarh	100.0	0.0	0.0	0.0	0.0	5
Uttarakhand	29.3	17.6	14.1	16.2	22.7	11534
Haryana	73.7	16.2	6.9	2.1	1.2	6487
Delhi	97.0	2.0	1.0	0.0	0.0	101
Rajasthan	20.5	26.3	22.7	17.3	13.2	40734
Uttar Pradesh	78.2	12.7	5.1	2.5	1.4	92686
Bihar	74.3	15.1	5.9	3.0	1.7	37678
Sikkim	14.6	26.1	25.3	18.9	15.1	403
Arunachal Pradesh	20.1	16.3	19.6	26.4	17.6	2826
Nagaland	5.3	10.0	19.6	33.8	31.4	1336
Manipur	20.1	16.7	18.7	21.6	22.9	2268
Mizoram	17.9	14.1	17.4	27.7	22.9	672
Tripura	57.9	24.9	11.4	4.0	1.9	859
Meghalaya	28.6	21.7	19.4	21.7	8.6	5362
Assam	58.4	17.6	12.3	6.8	4.9	23280
West Bengal	74.0	15.3	7.0	2.2	1.4	35739
Jharkhand	45.7	27.2	14.6	7.5	5.0	26813
Odisha	51.5	22.9	15.0	5.6	5.0	42089
Chhattisgarh	14.5	23.1	26.5	20.6	15.3	18864
Madhya Pradesh	29.7	23.9	19.9	15.0	11.5	49165
Gujarat	38.2	25.6	19.9	9.4	6.9	17561
Daman and Dieu	68.4	15.8	15.8	0.0	0.0	19
Dadra & Nagar Haveli	35.4	35.4	23.1	4.6	1.5	65
Maharashtra	11.3	12.8	19.2	22.6	34.1	39794
Andhra Pradesh	8.2	12.8	20.0	25.4	33.6	24987
Karnataka	19.7	19.4	23.4	17.7	19.7	25707
Goa	69.5	24.9	3.9	1.3	0.3	305
Lakshadweep	75.0	25.0	0.0	0.0	0.0	4
Kerala	71.1	23.1	4.5	0.9	0.4	1016
Tamil Nadu	14.5	20.5	22.8	21.2	20.9	14818
Puducherry	66.7	22.2	10.0	1.1	0.0	90
Andaman & Nicobar Islands	82.9	9.5	4.9	1.1	1.5	263
India	45.5	18.3	14.5	10.8	10.9	554618
Villages excluded from the analysis						

Source: Author

The present analysis reveals that female engagement in productive activities in the villages of the country was far from satisfactory around the year 2010. There are very small proportion of villages in which female engagement in productive activities may be termed as satisfactory. More specifically, there was only a nominal engagement of females in household level productive activities in all but a few villages. One reason may be very limited village level household level productive activities in India. Female engagement in productive activities in villages appears to be largely confined to engagement as agricultural labour which suggests that opportunities for productive engagement of females outside the agriculture sector are very limited in the villages of the country.

The analysis also suggests that female productive engagement in Indian villages is influenced by the size, social class structure and gender composition of the village population along with the level of female education, level of fertility. Female productive engagement is associated positively with the proportion of Scheduled Tribes population in the village but negatively with the level of fertility, level of female education and the size of the village population. The female productive engagement was also relatively lower in those villages where the gender balance was not in favour of females as compared to villages where the gender balance was in favour of females. When these five defining characteristics of the village are taken into consideration, more than 554 thousand villages of the country can be grouped into nine mutually exclusive groups or clusters, each having significantly different level of female productive engagement with strong regional pattern.

A revealing finding of the present analysis is that female productive engagement in a village is negatively associated with the level of female education in the village. This negative association contradicts the widely held argument that female education increases opportunities of engagement of women in productive activities and may be attributed to very limited opportunities of productive engagement of educated females in villages. Productive engagement opportunities in India villages is largely confined to the agriculture sector and that too in the form of agricultural labour. It is argued that females prefer women-centric work which can be discharged from the household or within the household premises in the nature of self-employment (Sanghi et al, 2015). Such opportunities of productive engagement, especially for females, appeared largely absent in the villages of the country according to the 2011 population census.

The present analysis refers to the situation that prevailed in Indian villages the year 2010. There has been no information about the participation in productive activities in the villages of the country after the 2011 population census because other sources of data on employment such as National Sample Survey and Periodic Labour Force Survey do not provide village level data on productive participation. There has, however, been very marked growth and expansion of the social and economic production system in India since the 2010 population census, and it may be expected that there would have also been significant change in the social and economic production system of the villages of the country since 2010. It is also expected that the change in the village social and economic production system would have influenced a change in the engagement of females in productive activities at the village level. The forthcoming 2027 population census will provide the village level data that will help in assessing the change in the village level social and economic production system and the productive engagement of females in the villages of the country against the benchmark presented in the present analysis. The comparison of

the situation that prevailed in 2010 with the situation that emerges from the 2027 population census data will facilitate analysing the impact of the policies and programmes directed towards women empowerment in India as female productive engagement is an integral component of all women empowerment efforts.

The main limitation of the present paper is the availability of data on productive engagement in India villages. The primary census abstract released after every decennial population census of the country is the only source that provides limited village level data about participation of the people in productive activities. The primary census abstract does not provide data related to the age composition of the population so that it is not possible to estimate refined estimates of productive engagement of the people at the village level. Another limitation of the census data is that information about the actual duration of productive engagement is not available. The present analysis, therefore, is based on crude measures of participation only.

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Perceived Threat of Climate Change and Climate Anxiety

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Abstract

With climate change and its consequences dominating the 21st century, related anxiety issues and symptoms are on the rise. Past research demonstrates surfacing of disorders such as anxiety, depression, post-traumatic stress disorder (PTSD) and others in relation to climate change (Suzuki and Hanington, 2022). The present study aims to investigate factors that contribute to climate anxiety. It is based on a survey that allowed participants to answer questions about their negative experiences with climate change, their perceived threat of climate change, and a series of questions on climate anxiety, employing a tool developed by Clayton and Karazsia (2020a). The data were analysed using various statistical procedures, notably chi-square, t-test, ANOVA, and logistic regression. Results demonstrate that females experience more climate anxiety than their male counterparts, and that the experience of climate anxiety is the least among older adults (50-64) while those ages 20-34 year experience climate anxiety the most. Level of education and place of residence has not been found to contribute to climate anxiety. The perception of the threat of climate change and experience of negative effects of climate change have a significant impact on climate anxiety. Those who have higher levels of climate anxiety are more likely to take action to prevent climate change and often feel that they should have done more to protect the environment.

Introduction

As a result of global warming, average temperatures are rising over time and disrupting the balance of nature, resulting in erratic and extreme weather conditions. Recent years have witnessed perpetual climatic catastrophes, such as hurricanes, tornadoes, landslides, melting of glaciers, tsunamis, and wildfires. Extreme weather conditions, such as cold waves and heat waves, droughts, excessive precipitation, and floods have become more common today as compared to the past. These long-term shifts in weather patterns and temperatures are termed climate change and pose severe risks not only to human beings but to all other forms of life on the Earth (United Nations, 2023). Climate change can affect health of the people through the availability of safe food and water and increases the spread of diseases (Centers for Diseases Control, n.d.). It can also hurt mental health (Suzuki and Hanington, 2020) and well-being (Clayton, 2020) of the people.

Climate change and climatic catastrophes have led to the emergence of a new phenomenon called climate anxiety. Climate anxiety is characterised by worry, stress or anxiety related to perceived climate change, its threats, and potential effects (Clayton and Karazsia, 2020b). Climate anxiety, also known as eco-anxiety, is the fear of environmental disaster that "can stem from direct experience of extreme weather events and environmental change (e.g. floods, forest fires, hurricanes, drought) or exposure to climate change information through news media and other sources" (Mental Health Commission of Canada, 2023). Individuals respond to experiences of climatic disasters differently which can affect their level of climate anxiety. Those who have higher levels of environmental care or empathy may also demonstrate a higher level of climate anxiety.

Understanding the implications climate anxiety and its determining factors is important when looking at how we plan to address this issue. This paper examines multifaceted variables that determine how and why people are more or less affected by climate anxiety. The study analyses variation in climate anxiety by demographic and social characteristics, place of residence, and past negative experiences with climate change. It also seeks to examine the relationship between perceived imminent threats to climate change and climate anxiety. Finally, the paper examines the relationship between threat perception about climate change and action to sustain the environment.

Literature Review

Climate anxiety is a new and growing domain of knowledge. Research, studies and literature on the topic are sparse, leaving ample space for growth. The focus of this literature review is on the gaps in the current understanding and information on how age, culture, region, climate behaviour, and perceived threat contribute to climate anxiety. As the effects of the climate crisis worsen, the mental health effects of the catastrophe begin to reach crisis levels. Disorders such as anxiety, depression, post-traumatic stress disorder (PTSD) and many more surface as side effects of climate change (Suzuki and Hanington, 2022). According to Clayton (2020), climate change has effects on the wellbeing, emotional state and mental health status of individuals. Climate change also contributes to the increase in physical health issues such as increased risk of stroke, cardiovascular diseases and respiratory illnesses (National Institute of Environmental Health Sciences, 2022). Climate-related anxieties and their empirical relevance are growing, as is the evidence to support their existence (Clayton, 2020).

Previous research shows that those who perceive climate change as an imminent threat are more likely to feel climate anxiety (Dodds, 2021). A recent survey on young adults aged 16-25 years showed astronomical levels of climate-related worries. It found that 59 per cent of participants were very or extremely worried, and 84 per cent were moderately or more worried. Participants reported feelings such as helplessness, guilt and anxiety among others (Hickman et al, 2021). Similarly, research looking at generation (gen) z in relation to climate change shows that gen z is the most affected by the psychological consequences of climate change (Tsevreni et al, 2023). These differences are noticeable when compared to the psychological effects felt by those of the older generation such as baby boomers, the silent generation or the greatest generation (Swim et al, 2022).

A study looking at the predicting factors of climate anxiety rules out gender and income as predictors of climate anxiety, pointing to minimal differences in anxiety levels among men and women, as well as between lower, middle and upper-class folks (Whitmarsh et al, 2022). Further, inconsistent geographical differences are noted when observing climate anxiety across nations, specifically, China, India, Japan, and the United States (Tam et al, 2023).

The psychological responses to climate change show that individual differences can affect the way a person experiences climate anxiety. Specifically, it is stated that both those who care about the environment as well as those who have been affected by some climate-related natural disaster, such as a wildfire or hurricane, are more likely to feel climate anxiety. Susceptibility to climate anxiety has also been found to have some association with individual personality (Clayton, 2020). Due to differences in emotional reactivity, those who score higher on the neuroticism continuum or those who display more signs of emotional instability, irritability, and self-doubt (Cuncic, 2026) are more likely to be affected by anxieties (Dong et al, 2022). This sort of relation could, in theory, be translated in the context of climate change and associated climate anxiety to suggest a link between personality differences and climate anxiety experiences.

Researchers have also considered the perception of threat and the possibility of direct impact in an attempt to understand connections and correlation (Tam et al, 2023). Research looking at the relevance of emotions regarding climate change details this incidence through the sentimental connections one puts on climate-related issues. Wang and others touch upon the association of the “objects of care” with individual emotional response to climate change. He exemplifies his theory through the comparison of climate scientists, students and the general public, stating that enhanced worry is experienced by climate change, essentially justifying their increased affection through their associative identity and worry for the future. Because climate scientists are intrinsically linked to the environment through their passion, career and more, they feel the burden of climate anxiety disproportionately more than everyone else (Wang et al, 2018).

In addition, climate change has both direct and indirect impact on the mental health of children (Burke et al, 2018). As described in earlier studies, significant interactions display outside influence of other variables, such as geographic locations, weaker infrastructure, poor support and inefficient services. In addition, children living in the developing world and those living in certain disadvantaged circumstances in the developed areas are also at an increased risk of climate anxiety (Burke et al, 2018). Culture may also increase the risk of climate anxiety. When looking at the Inuit community in Nunatsiavut, Canada, researchers found a disproportionate effect on climate anxiety. While taking a holistic approach to the issue, aspects such as increased family stress, greater substance use, mental health concerns and increased risk of suicide are all linked to climate change and associated climate anxiety (Cunsolo et al, 2013). Research also demonstrates a positive, linear correlation between suicide rates and climate change. With rising temperatures influencing suicide rates in India, an established link between climate change and mental health issues such as depression and suicidal ideation is clear (Carleton, 2017). With the risk of cluster suicides already prevalent in some groups (Orkin et al, 2013), solutions are direly needed.

To sum up, existing literature shows that the evidence about the effect of such factors as residence of respondents, perceived threat of climate change associated disaster, and environment-related behaviour on climate anxiety associated with climate change are rare if not non-existent. It is in the above context that the present paper adopts a sociodemographic and sociocultural perspective of the factors of climate anxiety associated with climate change. It aims to expand the research related to climate change and its psychological effects, such as climate anxiety.

Methodology

The study is based on a survey that has been designed for the purpose. The participants for the survey were recruited via different social media platforms, specifically, Instagram, Facebook, Snapchat, and WhatsApp considering their age, cultural background, and geographical location. A non-probability sampling method was used, incorporating both convenience and snowball sampling, for recruiting the respondents. Data were collected through a self-administered survey questionnaire using Google Forms that participants completed online. The survey link was shared on different social media platforms. The survey was opened on March 7^{th,} 2024, and within four days, 185 respondents from Canada completed it.

The respondents were asked how they perceived the threat of climate change on a scale of 1 to 10, with 1 being 'no threat' and 10 being the 'biggest threat.' To assess climate anxiety, a preexisting, pretested psychological instrument developed by Clayton and Karazsia (2020a) called the climate anxiety scale (CAS) was used with some modifications to fit the project requirements. Out of the 22 items on the original scale, 13 were retained in the survey. For each of these survey questions, there were five response options – never, rarely, sometimes, often, and almost always. An index of climate anxiety was constructed by assigning the following values to each response option and adding the values for all the 13 questions: Never=0, Rarely=1, Sometimes=2, Often=3, and Almost always=4. This yielded a minimum value of zero and a maximum of 52 on this scale. Various statistical techniques, specifically Chi-square, correlations, t-test, ANOVA, and logistic regressions, were used to analyse data collected from the survey. Furthermore, the index of climate anxiety was divided into two groups for logistic regression analysis – low climate anxiety (less than or equal to the median score) and high climate anxiety (more than the median score). The 'climate change associated threat' has also been categorised into two groups – low threat and high threat. If the score of a respondent was less than the median of the distribution of score across respondents, it was classified as low threat. On the other hand, if the score of a respondent was equal to or more than the median score, it was classified as high threat.

Before the actual collection of the data, researchers prioritised ethical concerns related to the study. The participation in the survey was voluntary, only those were included in the study who consented to participate, confidentiality of the response was ensured throughout the study, anonymity of the respondents was maintained so that there was no harm to the respondents for participating in the survey. The study was approved by the Research Ethics Board of the University (file number 6021802).

Results

A large majority of the study participants were female (79.5 per cent) and Caucasian (85.4 per cent), and more than half (51.1 per cent) lived in the urban areas. Majority of the respondents belonged to the age group 20-34 years (40 per cent), followed by the age group 50-64 years (21.6 per cent). Respondents below 20 years of age constituted 13.5 per cent while respondents aged 65 years and older constituted 5.4 per cent of the study sample. Nearly half of the respondents (50.3 per cent) had at least post-secondary education while 29.7 per cent of the respondents had completed a graduate or post-graduate/professional degree. More than a 28.4 per cent of the respondents reported that either they themselves or someone they knew had been affected considerably by climate change; another 35.5 per cent reported that they or their acquaintances were affected to some extent. There were only around one third of the respondents who reported that either they or their acquaintances were never affected adversely by climate change (Table 1).

Table 1: Characteristics of the study participants.

Participants' characteristics	Frequency	Per cent
Gender		
Male	33	17.8
Female	147	79.5
Other	5	2.7
Age		
Less than 20	25	13.5
20-34	74	40.0
35-49	36	19.5
50-64	40	21.6
65 and above	10	5.4
Education		
High school diploma or less	37	20.0
Some post-secondary (college or university)	93	50.3
Bachelor's degree	42	22.7
Post graduate or professional degree	13	7.0
Ethnicity		
Caucasian/White	158	85.4
Other	27	14.6
Residence		
Rural	90	48.9
Urban	94	51.1
Experience with climate related disaster		
Considerable	52	28.4
Somewhat	65	35.5
Never	66	36.1
N	185	100.0

Note: Information is missing on *residence* for one person and *adversely affected by climate change* for two persons.
Source: Authors

Perceived Threat of Climate Change

Table 2 depicts the perception of the respondents about perceived threat of climate change. A significantly higher proportion of females (46.3 per cent) perceived climate change as a high threat compared to males (27.3 per cent). By age, the proportion of those who considered the threat of climate change as high varied from 37.5 per cent in respondents aged 50-64 years to 52.8 per cent in respondents aged 35-49 years. More educated respondents perceived climate change as a high threat than less educated respondents. For example, 61.5 per cent of those who had a post-graduate or professional degree perceived climate change as a high threat, whereas 37.6 per cent of those who had some post-secondary education had a similar perception. There was hardly any difference in the perception of Caucasians and non-Caucasian respondents. However, a higher proportion of respondents living in the rural areas and respondents who themselves or their acquaintances had experienced adverse effects of climate change perceived climate change a high threat. However, the perception about climate change threat was found to be statistically significantly different between females and males only and not by other characteristics of the respondents.

Table 2: Perceived climate change threat by the background characteristics of the respondents.

Characteristic	Climate change threat		χ^2
	Low	High	(df, 'p')
Gender			
Male	72.7	27.3	3.969
Female	53.7	46.3	(1, 0.046)
Age			
Less than 20	52.0	48.0	2.365
20-34	59.5	40.5	(4, 0.669)
35-49	47.2	52.8	
50-64	62.5	37.5	
65 and above	60.0	40.0	
Education			
High school diploma or less	54.1	45.9	3.403
Some post-secondary (college or university)	62.4	37.6	(3, 0.334)
Bachelor's degree	52.4	47.6	
Post graduate or professional degree	38.5	61.5	
Ethnicity			
Caucasian/White	57.0	43.0	0.019
Other	55.6	44.4	(1, 0.892)
Residence			
Rural	51.1	48.9	2.285
Urban	63.3	36.7	(1, 0.093)
Experience with climate related disaster			
Considerable	51.9	48.1	2.915
Somewhat	52.3	47.7	(2, 0.233)
Never	65.2	34.8	

Sours: Authors

Level of Climate Anxiety

Table 3 shows the degree of climate anxiety by the characteristics of the respondents. One-fifth (20 per cent) of the male respondents reported high level of climate anxiety whereas this proportion was more than 50 per cent in female respondents. There was a statistically significant difference in the mean climate anxiety score of male respondents (11.7) and female respondents (18.3), $t_{.05,173}$=-3.976 ($p < 0.001$) (not shown in table).

Table 3: Level of climate anxiety by characteristics of the respondents

Characteristic	Climate anxiety		χ^2
	Low	High	(df, 'p')
Gender			
Male	80.0	20.0	10.602
Female	48.3	51.7	(1, 0.002)
Age			
Less than 20	56.0	44.0	12.858
20-34	40.0	60.0	(4, 0.012)
35-49	48.6	51.4	
50-64	75.0	25.0	
65 and above	50.0	50.0	
Education			
High school diploma or less	51.4	48.6	1.247
Some post-secondary (college or university)	51.1	48.9	(1, 0.742)
Bachelor's degree	58.5	41.5	
Post graduate or professional degree	41.7	58.3	
Ethnicity			
Caucasian/White	55.5	44.5	4.758
Other	32.0	68.0	(1, 0.029)
Residence			
Rural	55.7	44.3	0.697
Urban	49.5	50.5	(1,0.404)
Negative experience with climate related disaster			
Considerable	40.4	59.6	12.544
Somewhat	45.2	54.8	(2, 0.002)
Never	70.3	29.7	

Source: Authors

The level of climate anxiety varies widely by age. Three-fifths (60 per cent) of the respondents aged 20-34 years experienced high level of climate anxiety while only 25 per cent respondents aged 50-64 years reported high level of climate anxiety and the difference has been found to be statistically significantly different. The ANOVA and LSD (Least Significant Difference) post-hoc test were employed to test the differences in the mean climate anxiety score between respondents of different age groups. The mean climate anxiety score was 16.8 for respondents less than 20 years of age; 20.0 for respondents aged 20-34 years, 18.2 respondents ages 35-49 years; 12.5 for respondents age 50-64 years, and 16.9 for respondents age 65 years and older. There was a statistically significant difference

in the mean climate anxiety score of at least two age groups, $F_{4,175}=5.516$ ($p<0.001$). The results of the post-hoc test showed that the mean climate anxiety score for the age group 50-64 years was significantly lower than all the other age groups. The differences in the mean climate anxiety scores of all the other age groups were statistically insignificant.

The mean anxiety score was not found to be statistically significantly different by the educational status of the respondents ($F=1.203$, $p=0.308$). The mean climate anxiety score was 16.9 for respondents having at the most, high school diploma, 17.6 for respondents having some post-secondary education (college or university), 16.1 for respondents having a bachelor's degree, and 21.3 for respondents having a postgraduate or professional degree.

The level of climate anxiety was found to be significantly lower in Caucasians (44.5 per cent) compared to other respondent groups (68.0 per cent). The mean climate anxiety score for Caucasian respondents was 16.6, and 22.2 for non-Caucasian respondents. The difference is found to be statistically significant ($t_{.05,178}=-3.096$, $p=0.002$).

There was no statistically significant difference in the level of climate anxiety between respondents living in the urban areas as compared to respondents living in rural areas. Around 44.3 per cent of the respondents living in the rural areas reported high level of climate anxiety. This proportion was 50.5 per cent in respondents living in the urban areas. The mean climate anxiety score for rural respondents (16.3) was not found to be statistically significantly different from the mean climate anxiety score for urban respondents ($t_{.05,177}=-1.562$, $p=0.06$).

The negative consequences of climate change on the life experienced either by the respondent or acquaintances of the respondent contributed to increase the level of climate anxiety. Nearly three-fifths (59.6 per cent) of those who themselves or their acquaintances experienced the negative impact of climate change showed higher level of climate anxiety compared to 29.7 per cent of the respondents who did not experience the impact and the difference has been found to be statistically significant. The mean climate anxiety score for those respondents who themselves or their acquaintance experienced high impact of climate change was 18.9 compared to 19.7 among those who experience some impact and 13.6 who experienced no impact and the difference between any two of these mean scores was statistically significantly different ($F=9.944$, $p<0.001$). The post-hoc test confirmed that the mean anxiety score for those who or whose acquaintances were never experienced negative impact of climate change was statistically significantly lower than the mean score of those who or whose acquaintances experienced some experience of negative impact of climate change.

Predictors of Climate Anxiety

The association between the perceived threat of climate change and climate anxiety was examined by using the Spearman rank order correlation coefficient. Respondents were ranked according to the perceived threat of climate change score and climate anxiety score. The rank of the respondents in terms of climate anxiety score is found to be statistically significantly associated with the rank in terms of perceived threat of climate change score ($\rho=0.58$, $p<0.001$) indicating that perception about threat of climate change is directly associated with the level of climate anxiety.

Table 4: Impact of gender, age, ethnicity, climate disaster, and perceived threat of climate change on climate anxiety

Predictor	B	p	Exp (B)
Gender (Ref – Male)			
Female	1.309	0.028	3.702
Age (Ref – Older 65+)			
Young (<35)	0.437	0.598	1.548
Middle age (35-64)	-0.515	0.541	0.598
Ethnicity (Ref – Caucasian)			
Others	-0.510	0.352	0.601
Adverse experience of climate related disaster (Ref – Never)			
Considerable	1.110	0.023	3.034
Somewhat	0.606	0.197	1.833
Perceived threat of climate change (1-10)	0.676	<0.001	1.966

Source: Authors

The binary logistic regression analysis was carried out to examine how selected characteristics of the respondents influence the level of climate anxiety. The predictor variables included in the analysis were age, gender and ethnicity of the respondent, experience about the negative experience related to the climate change, and perceived threat of climate change. The dependent variable in the model was a dichotomous variable which was assigned the value 0 if the climate anxiety score was less than the median and the value 1 if the climate anxiety score was either equal to the median or above the median. The overall model was found to be statistically significant (χ^2= 69.93, df =7, p<0.001. The predictor variables included in the model explained nearly 44.2 per cent of the variation in the level of climate anxiety (Nagelkerke R^2=0.442). Results of the binary logistic regression are shown in Table 4.

The results of the bivariate logistic regression analysis indicate that females have 3.7 times higher odds of experiencing climate anxiety compared to males. Age and ethnicity of the respondents do not have a significant impact on climate anxiety when other predictors are controlled. Those respondents who or whose acquaintances experienced considerable negative impact of climate change were more than three times more likely to have high level of climate anxiety compared to those respondents who or whose acquaintances experienced no negative impact of climate change. However, the odds of experiencing high level of climate anxiety among those who or whose acquaintances experienced some negative impact of climate change relative to those who or whose acquaintances never experienced any negative impact of climate change have not been found to be statistically significantly different from 1 meaning that the odds of having high level of climate anxiety was the same in the two groups of respondents. The perceived threat of climate change is found to be a strong and statistically significant predictor of high level of climate anxiety. For every one unit increase in the perceived threat of climate change, the odds of having high level of climate anxiety nearly doubles (OR=1.97). These findings suggest that females and individuals who or whose acquaintances are considerably affected by climate change, and those who perceive that climate change as a serious threat, are more likely to suffer from high level of climate anxiety.

Perception about Solution

Respondents were asked if they believed that there existed a solution to climate change. Their responses were cross listed with perceived threat to climate change and climate anxiety (Table 5). There was a significant association between perceived threat of climate change and belief in solutions to climate change. Three out of every five respondents who perceived climate change as a high-level threat believed that there were solutions to address it, compared to two out of every five respondents who perceived climate change as a low-level threat. Conversely, 8.8 per cent of the respondents who perceived climate change as a high-level threat and 21 per cent of those who considered it a low threat believed there were no solutions available. It indicates that the perception of threat associated with climate change also instigates the belief in solutions to deal with the potential threat.

Table 5: Belief in the climate change solutions by perceived threat of climate change and climate anxiety

Threat and anxiety	Solution to climate change			χ^2
	Yes	May be	No	(df, 'p')
Perceived threat of climate change				
High	60.0	31.3	8.8	8.620
Low	40.0	39.0	21.0	(1, 0.012)
Climate anxiety				
High	60.5	31.4	8.1	11.138
Low	38.3	39.4	22.3	(1, 0.004)

Source: Authors

The level of climate anxiety also exhibited a similar significant association with solutions to climate change. More than three-fifths (60.5 per cent) of the respondents having high level of climate anxiety believed in solutions to climate change, compared to less than two-fifths (38.3 per cent) of the respondents having low level of climate anxiety. Only 8.1 per cent of the respondents having high level of climate anxiety believed there was no solution to climate change compared to 22.3 per cent of the respondents who had low level of climate anxiety. Putting it another way, high level of climate anxiety could prompt a greater search for information on solutions to climate change.

Actions Taken to Prevent Climate Change

Respondents were also asked about the actions that they had taken as a response to the negative effects of climate change (Table 6). A large majority (82 per cent) of the respondents reported that they often or almost always adopted behaviours that contributed to mitigate the negative effects of climate change, such as using public transport instead of private vehicles and saving instead wasting resources or energy. This proportion was found to be statistically significantly higher in females (84 per cent) compared to males (70 per cent). The level of climate anxiety had also been found to be statistically significantly associated with environment friendly behaviour. Almost all respondents (92 per cent) who often or always experienced high level of climate anxiety reported that they had adopted behaviours that contributed to preventing or retarding the climate change, compared to 72 per cent of those respondents who or whose acquaintances experienced a low level of climate anxiety.

Table 6: Actions taken to prevent climate change.

Characteristic	I try to reduce behaviours that contribute to climate change			I feel guilty if I waste energy or resources			I wish I behaved more sustainably		
	Never/ rarely/ sometime	Often/ almost always	χ^2 (df, 'p')	Never/ rarely/ sometime	Often/ almost always	χ^2 (df, 'p')	Never/ rarely/ sometime	Often/ almost always	χ^2 (df, 'p')
Gender									
Male	30.3	69.7	3.687	62.5	37.5	4.679	66.7	33.3	2.020
Female	15.6	84.4	(1, 0.049)	41.5	58.5	(1, 0.031)	53.1	46.9	(1, 0.155)
Age									
<35	20.2	79.8	0.812	44.9	55.1	0.004	44.4	55.6	9.840
35+	15.1	84.9	(1, 0.367)	45.3	54.7	(1, 0.951)	67.4	32.6	(1, 0.002)
Education									
High school diploma or less	24.3	75.7	4.380	45.9	54.1	0.020	54.1	45.9	1.433
Post-secondary (college or university)	20.4	79.6	(1, 0.113)	45.2	54.8	(2, 0.990)	59.1	40.9	(2, 0.489)
Bachelor's degree and above	9.1	90.9		44.4	55.6		49.1	50.9	
Ethnicity									
Caucasian/White	17.7	82.3	0.010	46.8	53.2	1.346	55.7	44.3	0.138
Other	18.5	81.5	(1, 0.920)	34.6	65.4	(1, 0.246)	51.9	48.1	(1, 0.711)
Level of climate anxiety									
Low	27.7	72.3	13.143	59.6	40.4	19.656	80.9	19.1	50.985
High	7.0	93.0	(1,<0.001)	26.7	73.3	(2, <0.001)	27.9	72.1	(2, <0.001)
Overall	17.8	82.2		45.1	54.9		55.1	44.9	

Note: Age and education have been regrouped in this table to fulfil the requirements of the chi-square test
Source: Authors

More than half of the respondents reported that they often or almost always felt guilty when wasting energy or resources. This proportion was statistically significantly higher in females (58 per cent) than in males (38 per cent). Similarly, 73 per cent of respondents having a high level of climate anxiety felt guilty about wasting energy or resources. This proportion was only 40 per cent among those respondents who had lower level of climate anxiety.

On the other hand, less than half of the respondents (45 per cent) reported that they often or always wished that they would have behaved more sustainably. Such feelings were statistically significantly more common among respondents aged less than 35 years (56 per cent) compared to respondents aged 35 years and older (33 per cent). A substantially higher proportion of respondents having high level of climate anxiety (72 per cent) also often or almost always wished they would have behaved more sustainably compared to respondents with low level of climate anxiety (19 per cent).

Discussion

The present study has aimed to examine the factors that play a significant role in determining who is affected by climate change related anxiety or climate anxiety. The study has revealed that demographic factors like gender and age, perception about climate change related threat and past experience of climate change related disaster have strong association with climate anxiety. The study also suggests that males have significantly lower level of climate anxiety than females. These findings contradict the current literature in which gender is ruled out as a pre-determining factor for climate anxiety (Whitmarsh et al, 2022). This study has also found that persons aged 50-64 years had the lowest level of climate anxiety, whereas persons aged 20-34 years had the highest level of climate anxiety. Past research has also demonstrated similar patterns with the young generation having very high levels of climate-related anxiety in comparison to older generation (Hickman et al, 2021). The gen-z has been identified as the most affected population group generationally from climate change (Tsevreni et al, 2023).

The level of climate anxiety has also been found to be nearly similar in respondents living in rural and urban areas. Previous research shows international differences in climate anxiety, with developing countries suffering the most (Burke et al, 2018). That being said, the integration of both these findings raises the question: "Is geography really the predictor of climate anxiety?" In the present case, circumstantial and environmental factors, such as the isolation of some rural neighbourhoods, or the conditions faced by some low-income or developing countries, and the perpetual impoverishment and pollution of the global south appears to be blamed (Rentschler and Leonova, 2023).

When comparing the climate change related threat perception and its association with climate anxiety, a statistically significant positive relationship has been observed in the present study. These findings lead to the acceptance of the hypothesis that higher perceived threat about the climate change leads to an increase in climate anxiety. Further, significant differences in the level of climate anxiety have also been found between those who or whose acquaintances reported considerable experiences of climate-related disasters and

those who and whose acquaintances had no such experiences. However, no statistically significant difference in the level of climate anxiety has been observed between those who and whose acquaintances somewhat affected from the negative effects of climate change and those who and whose acquaintances were not affected from the negative effects of climate change at all. These results are comparable to those of previous research which suggests that those who perceive climate change as an imminent threat are more likely to have higher levels of climate change related anxiety as compared to those who do not perceive climate change as a threat (Dodds, 2021). Earlier studies have also observed that those who are affected by some climate-related disaster, such as floods, hurricanes, wildfires, and others, are more likely to have higher levels of climate anxiety (Clayton, 2020).

The level of education of has not been found to have any statistically significant effect on the level of climate anxiety, although people having post-graduate or professional education appear to have higher level of climate anxiety than those having lower levels of education. The level of education as a predictor of climate anxiety is a newly researched determinant and there is minimal literature on this relationship. Similarly, research on the extent of environment/climate-related knowledge has also been found to have significant effect on the level of climate anxiety. Environmental scientists have been found to be having disproportionately high level of climate anxiety because of their sheer knowledge about the consequences of climate change (Wang et al, 2018).

Interestingly, the perception about the existence of solutions to the consequences of climate change has been found to be associated with climate anxiety. It appears that those who believe that there exists solutions to the consequences of climate change have higher levels of climate anxiety as compared to those who do not believe in the existence of any such solution. High levels of climate anxiety among those who believe that a solution to consequences of climate change exists may be rooted in their concern about possible solutions not being enacted or implemented. Although the term “solution perception” is rarely used in the climate literacy today leaving no comparatively relevant data, yet it offers an interesting parallel with climate hope. There is evidence to suggest that there exists a positive associate between climate anxiety and climate hope (Sangervo et al, 2022). When people have more hope about possible solutions to the consequences of climate change, their anxiety level rises. Interpretively, this comparison can be deemed as a coping mechanism. When one has anxiety, specifically related to the consequences of climate change, creating hope (false or real) can help one feel temporary symptomatic relief. This association may also be explained through thought presence. When people believe that there is a solution or hope for a particular issue, the idea remains stagnant in their thoughts. Individuals who experience a higher level of climate anxiety are also more likely to adopt measures to prevent adverse consequences of climate change, such as reducing environmentally harmful behaviours. They often feel guilty about wasting resources or energy and express their desire to have done more to sustain the environment.

The field of research related to climate change related anxiety is new and emerging because the anxieties that the people are facing are increasing. The findings of this study could display helpful implications to the field of knowledge, such as gaining a broader understanding of the issue at hand, leading to future treatment plans and coping mechanisms in order to reduce climate change related anxiety in people. The findings of

the present study may also lead to such implications as increased awareness about the anxiety associated with the consequences of climate change leading to behavioural changes, as well as cultural sensitivity and even the recognition of climate anxiety as a real mental health issue under the public health policy. For example, cognitive behavioural therapy (CBT) care programmes may be modified to incorporate this aspect of anxiety for those affected.

There is a need of more studies under diverse social, cultural and economic settings to further elaborate on climate change related anxiety and its determining factors. Research in this area must strive to understand climate anxiety from a multidimensional perspective, looking at both who are the people who are suffering from climate change related anxiety and why are they suffering. Research in the sociological dimensions of climate change related anxiety is not only insightful but is also equally important. Parallel psychological or scientific research may also contribute to the research in climate change related anxiety, projecting its benefits onto more people and more domains. This research may also look into the neural pathways and neurochemical implications of climate change related anxiety, as well as the development of helpful coping mechanisms for symptom mediation.

Conclusions

The present study has examined the role of variables such as age, gender, place of residence, solution perception, experience with climate-related disasters, education levels and perceived threat of climate change as the implicating factors of climate change associated anxiety. All the explanatory factors included in the present analysis have shown some level of significance towards climate change associated anxiety or climate anxiety among the people surveyed. Significant differences in the level of climate change related anxiety have been found between females and males and between young and old population. The study has also found that there exists a relationship between the threat perception related to adverse consequences of climate change and climate anxiety, with those perceiving climate change as a significant threat having the highest level of climate anxiety. Similarly, those who were affected by climate-related disasters have been found to be having higher levels climate anxiety. Lastly, perception about possible solutions of the adverse consequences of climate change has also been found to be associated with the prevalence and magnitude of climate anxiety. People who have higher levels of climate anxiety have been found to be more likely to take some action to reduce climate change related environmental damage and feel guilty about wasting resources. They have also been found to be candid in accepting that they should have contributed more to promote sustainability.

That being said, understanding the implications and affecting factors of the emerging challenge of climate change associated anxiety is all the more important in the context of planning and interventions to address climate change associated anxiety and its management and treatment. Current research demonstrates surfacing of disorders such as anxiety, depression, post-traumatic stress disorder (PTSD), and others in relation to climate change (Suzuki and Hanington, 2022). Previous research has been focused on whether

someone is experiencing climate anxiety or not, as well as the exact ways people are feeling, often incorporating age as the only relational factor. Incorporation of other factors, such as place of residence, ethnicity, perceived threat, and climate-related behaviour, is rare if not non-existent in the previous studies. Examining how climate change associated anxiety is related to various background characteristics of the people in different situations is essential in order to see the progress in this field. Finally, as this area of research is new and emerging, its timeliness is non-negotiable. The relevance of these issues is perpetual as humans have done irreversible damage to earth environment so that the humanity will face lifelong consequences, necessitating climate change associated anxiety treatment, understanding and help.

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Growth of Hindu and Sikh Populations in Canada 2001–2021: Demographic Drivers, Diaspora Dynamics and Population–Development Implications

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Abstract

This study examines growth of Hindu and Sikh populations in Canada between 2001 and 2021 within a population–development framework linking Canada and India. The findings indicate that both Hindu and Sikh populations have more than doubled in Canada between 2001 and 2021. Migration – both permanent and temporary – has emerged as the dominant driver of growth. Fertility appears to have converged toward national norms and mortality differentials are largely attributed to age composition effects rather than intrinsic disparities. Demographic momentum associated with young age structure is the dominant driver of natural increase rather than elevated fertility. Population projections up to 2041 under alternative national growth scenarios indicate continued expansion with projected shares stabilising around 3-4 per cent of the Canadian population. From the population-development perspective emigration to Canada represents a modest demographic outflow relative to population of India but generates significant developmental linkages through remittances skill mobility trade networks and knowledge transfer. Contemporary religious diversification in Canada is migration-driven rather than fertility-driven.

Introduction

International migration has become the principal driver of demographic change in Canada reshaping age structure, labour force growth and religious composition. Among migrants of Indian origin Hindus and Sikhs represent two of the fastest-growing religious communities. Using census-based decomposition and indirect demographic estimation this study examines the drivers of Hindu and Sikh population growth between 2001 and 2021 and situates these trends within a Canada–India population–development framework.

Migration of Hindus and Sikhs in Canada extend over more than a century and reflect evolving immigration regimes geopolitical developments and labour market dynamics. Early Sikh migration to Canada in late nineteenth and early twentieth centuries was shaped by restrictive and exclusionary immigration policies including the Komagata Maru incident of 1914. Hindu and Sikh immigration in Canada accelerated following the introduction of points-based immigration system in Canada in the late 1960s which

emphasised education, occupational skills and human capital. Subsequent migration streams included direct arrivals from India and secondary migration from East Africa and other regions.

Hindu and Sikh communities over the years have established strong institutional cultural and economic networks particularly in major metropolitan centres such as Toronto and Vancouver. According to the 2021 population census around 828200 individuals were identified as Hindu and 771800 as Sikh in Canada. Although these groups represent modest proportions of the total population of the country their rate of growth over the past two decades have been substantial and demographically significant.

In recent years growing scholarly attention has been paid to immigration and ethnocultural diversity in Canada. However, religion-specific demographic analysis remains relatively limited. Most of the studies focus on immigrant status country of birth or visible minority categories rather than religious affiliation as a primary demographic variable. Consequently, systematic decomposition of population changes by religion – particularly for rapidly growing non-Christian populations – remains underdeveloped.

This study addresses this gap by decomposing inter-census growth of Hindu and Sikh populations in Canada between 2001 and 2021 into its principal demographic components - net immigration net non-permanent residents and natural increase. In the absence of religion-specific vital statistics fertility and mortality are estimated indirectly using age-structure adjustments and proportional allocation methods. The analysis further distinguishes between demographic and residual measures of natural increase thereby clarifying the role of demographic processes relative to statistical artifacts such as census under-coverage and religious switching.

The study is situated at the intersection of migration transition theory, demographic transition theory and diaspora–development frameworks. Canada represents an advanced stage of migration transition in which international migration increasingly drives population growth and influences religious composition. From a demographic transition perspective, fertility convergence among immigrant populations reflects adaptation to host-country demographic regimes. Diaspora–development theory conceptualises migration as a transnational process linking origin and destination societies through remittances, skill mobility, trade networks and institutional exchange. By integrating these perspectives this study demonstrates that rapid expansion of Hindus and Sikhs in Canada during 2001–2021 has structurally been migration-driven rather than fertility-driven. While youthful age structures generated demographic momentum fertility levels converged toward national norms and did not independently sustain high growth. The analysis situates religion-specific demographic change within a broader migration-transition framework and a transnational population–development nexus.

Objectives

This study pursues four interrelated objectives within a religion-specific demographic and population–development framework. First, it estimates the magnitude

and rate of growth of Hindu and Sikh populations in Canada between 2001 and 2021 using census-based measures of religious affiliation. Second it decomposes inter-census population change into its principal demographic components – net immigration net non-permanent residents and natural increase – in order to assess the relative contribution of migration and vital processes to observed growth. Third it evaluates demographic and developmental implications of emigration from India focusing Hindu and Sikh immigrants in Canada as dominant groups and leaving other groups such as Christian Muslim Jain Parsi and others within a transnational population framework linking Canada and India. The majority of these unconsidered groups in Canada are born outside India. This includes consideration of selective migration human capital mobility remittance flows and broader diaspora dynamics. Fourth the study projects Hindu and Sikh population growth in Canada up to the year 2041 under alternative national population growth scenarios thereby situating recent trends within a forward-looking demographic context. Together these objectives integrate descriptive demographic measurement methodological reconstruction of fertility and mortality and analytical interpretation within a population-development perspective. The study thereby contributes to a more systematic understanding of how migration-driven religious diversification operates within the contemporary demographic transition process in Canada.

Data Sources and Quality

Data Sources

The analysis draws primarily on data from the 2001 and 2021 population censuses in Canada to ensure consistency in religious classification and comparability across time. The 2011 National Household Survey of Canada is excluded due to its voluntary design and higher non-response rates which limit comparability with the census data.

In the population census religion is measured through a question that asks respondents to report a single religious affiliation or to indicate "No religion." The responses are coded according to standardised classification procedures established by Statistics Canada. Additional data on components of demographic growth including immigration and non-permanent residents are obtained from Statistics Canada census publications and official demographic estimates. National data on registered births and deaths and age-specific fertility and mortality rates are drawn from published vital statistics tables. Population projections are based on Statistics Canada official national projections under low- medium- and high-growth scenarios. Religion-specific projections are derived using proportional share-based methods applied to national scenarios.

Data Quality and Limitations

The religion variable in the 2021 Census exhibits relatively low non-response and imputation rates indicating generally high data quality. Nevertheless, several limitations warrant consideration. First changes in classification practices prior to 1991 limit longer-term historical comparability. The present analysis therefore focuses on the period 2001–2021 to ensure consistent religious categories. Second vital statistics system of Canada does not record births and deaths by religion. As a result, fertility and mortality must be

estimated indirectly using proportional allocation techniques based on age structure and national vital rates. Although these procedures are methodologically transparent and internally consistent, yet they require assumptions regarding the stability of religion-specific birth and death shares over time. Third religious switching between censuses cannot be directly measured using available data. Consequently, residual measures of natural increase may incorporate both demographic events and changes in religious self-identification. Fourth inter-census residual change may also reflect differential net under-coverage in 2001 and 2021 population censuses. While these factors do not invalidate the analysis, they require careful interpretation when comparing demographic and residual measures of natural increase. Despite these limitations the Canadian population census remains the most comprehensive and reliable source for religion-specific demographic analysis. When combined with indirect estimation techniques and transparent documentation of assumptions the available data permit robust assessment of the principal drivers of Hindu and Sikh population growth in Canada.

Methods

Intercensal Decomposition of Population Change

Intercensal population change between 2001 and 2021 is decomposed using the standard demographic accounting identity:

$$\Delta P_r = NI_r + IM_r + NPR_r - EMr + Sr \quad (1)$$

where:

- ΔP_r denotes the change in population of religion r between 2001 and 2021.
- NI_r represents natural increase (births minus deaths).
- IM_r denotes immigration (permanent residents); and
- NPR_r represents net non-permanent residents.
- EMr represents the net emigrants including EMCr (net emigrants captured) and EMNCr (net emigrants not captured)
- Sr represents the net switching identity such as religion

This decomposition allows direct assessment of the relative contributions of migration and vital increase to observed population growth. Natural increase can be derived either residually from intercensal population accounting or reconstructed from estimated births and deaths as described below.

Estimation of Number of Births by Religion

The Canadian vital statistics system does not classify births by religion. Therefore, religion-specific births have been estimated indirectly using a proportional allocation procedure anchored to the 2020–2021 census year. This procedure involved adjusting national ASFRs using religion specific child-woman ratios (CWRs) derived from census data and then religion-specific number of births in 2020–2021 are calculated by multiplying religion-specific ASFRs by religion-specific number of women aged 15–49 by age group:

$$B_r^{2020} = \sum(ASFR_{xr} \times W_{xr}) \quad (2)$$

where

B_r^{2020} = estimated births for religion r in 2020–2021.
$ASFR_{xr}$ = age-specific fertility rate for religion r in age group x.
W_{xr} = number of women aged 15–49 in age group x.

The religion-specific share of births has been calculated as

$$\theta_r = \frac{B_r^{2020}}{B_{2020}^{Canada}} \quad (3)$$

The share of births, θ_r, has been assumed constant over the inter-census period and applied to total registered births in Canada during 2001–2021:

$$B_r^{2001-2021} = \theta_r \times B_{2001-2021}^{Canada} \quad (4)$$

The sum of the estimated number of births across nine major religions was approximately 3.1 percent lower than the total number of registered births in Canada during 2001–2021. To ensure internal consistency with official vital statistics, estimated number of births were adjusted proportionally.

Estimation of Number of Deaths by Religion

Religion-specific number of deaths has been estimated through the same proportional allocation procedure. The national level age-specific death rates (ASDRs) for the period 2020–2021 were applied to religion-specific population by age and sex:

$$D_r^{2020} = \sum(ASDR_x \times P_{xr}) \quad (5)$$

where:

D_r^{2020} = estimated deaths for religion r in 2020–2021.
$ASDR_x$ = national age-specific death rate in age group x.
P_{xr} = religion-specific population in age group x.

The religion-specific mortality share has been calculated as

$$\phi_r = \frac{D_r^{2020}}{D_{2020}^{Canada}} \quad (6)$$

The mortality share, ϕ_r, has been assumed constant for the period 2001–2021 and applied to total registered deaths in Canada to obtain religion-specific number of deaths as

$$D_r^{2001-2021} = \phi_r \times D_{2001-2021}^{Canada} \quad (7)$$

When aggregated across the nine religions, estimated deaths were lower than total registered deaths by approximately 31 per cent over the period 2001-2021. Therefore, deaths were proportionally adjusted in the same manner as estimated births were adjusted.

Natural Increase: Vital-Based and Residual Measures

Natural increase based on reconstructed birth and death rates has been calculated as

$$NI_r^{vital} = B_r - D_r \quad (8)$$

and the residual natural increase derived from inter-census population accounting has been calculated as

$$NI_r^{residual} = \Delta P_r - (IM_r + NPR_r) \ + EMCr \quad (9)$$

The differences between these two measures reflect: 1) differential net census under-coverage between 2001 and 2021; 2) religious switching between censuses; and 3) measurement inconsistencies in migration components. The residual measure, therefore, incorporates both demographic processes and statistical artifacts. Interpretation of natural increase must accordingly distinguish between demographic reconstruction and inter-census accounting residuals.

Methodology of Population Projection

The religion-specific population projections are derived using a composition-consistent proportional growth framework, embedded within official national cohort-component projections. Let

$$S_{rt} = \frac{P_{rt}}{P_{Canadat}} \quad (10)$$

then the average annual geometric change in the share of the population is given by

$$g_r = \left(\frac{S_{r2021}}{S_{r2001}}\right)^{\frac{1}{20}} - 1 \quad (11)$$

The projected share is then obtained as

$$S_{rt+h} = S_{r2021}(1 + g_r)^h \quad (12)$$

and the normalised share is

$$\hat{S}_r = \frac{S_{rt}}{\sum_{k=1}^{9} S_{kt}} \quad (13)$$

The projected population has then been calculated as

$$P_{rt} = \tilde{S}_{rt} \cdot P_{Canadat}^{scenario} \quad (14)$$

The above methodology assumes continuation of observed share of the proportion of population of different religions, stability of migration selectivity patterns, no explicit modelling of religion-specific fertility schedules, and consistency with national demographic scenarios. The approach ensures internal consistency with official national projections, avoids unsupported religion-specific cohort modelling, preserves observed diversification dynamics, and provides composition-adjusted projections.

Hindu and Sikh populations have been developed using a share-based composition framework applied to Statistics Canada's official national projection scenarios. Religion-specific projected populations were derived as:

$$P_{rt} = S_{rt} \times P_{Canadat} \quad (15)$$

where S_{rt}represents the projected share of religion r at time t and $P_{Canadat}$denotes the projected total national population under alternative growth scenarios.

The official population projections prepared by Statistics Canada are based on census counts adjusted for net under-coverage, but religion-specific adjustment factors are not available. Published census data provide religion-specific population counts but do not

include disaggregated undercount corrections. Therefore, net census under-coverage adjustments have been applied at the aggregate population level to ensure internal consistency in observed compositional change. Adjusting only total population counts without corresponding religion-specific corrections would distort proportional distributions. In the absence of religion-specific undercount estimates retaining census-based shares preserves structural comparability between time points. Under this framework, projected shares do not vary across national growth scenarios. This outcome is mathematically expected because the share dynamics are extended independently of total population size while scenario variation affects only projected national totals. The method adopted, therefore, preserves observed diversification dynamics, maintains alignment with official national projections, avoids unsupported assumptions regarding religion-specific coverage error, and ensures proportional consistency between historical observations and forward projections. Projected differences across scenarios reflect variation in total population growth rather than variation in religious composition trajectories.

Review of Previous Studies

Research on religion in Canada has been shaped primarily by census-based descriptive analyses with comparatively limited independent demographic research treating religion as a central analytical variable. One of the earliest comprehensive national assessments Religion in Canada 2001 (Statistics Canada, 2003) documented increasing religious diversification between 1991 and 2001. Although Christianity remained predominant rapid growth among non-Christian religions—including Hinduism and Sikhism—was attributed largely to post-1960s immigration reforms that expanded migration from Asia Africa and the Middle East. Based on census data from 1981 1991 and 2001 Kalbach (2011) also identifies similar several key trends in religion in Canada. First there has been a decline in traditional Christian denominations particularly among Protestant groups. Second there is a rapid increase in religious diversity largely driven by immigration which has contributed to the growth of religions such as Islam Hinduism Sikhism and Buddhism. Third there is a significant rise in the number of people reporting **no** religious affiliation especially among younger Canadians. Overall, these trends indicate that there has been a shift from a predominantly Christian society to a more pluralistic and secular society.

Subsequent scholarship has focused more broadly on immigration, racialised populations and demographic adaptation rather than religion per se. Studies examining immigrant fertility patterns in Canada have demonstrated gradual convergence towards the fertility of native population over time (Basavarajappa, 1993; Ram and George, 1990; 1993; Ng and Nault, 1997). These analyses support the disruption and adaptation hypotheses showing that immigrant fertility often declines following settlement and aligns progressively with national fertility regimes. More recent research documents sustained fertility declines across Canada including among immigrant-origin populations within a context of historically low national fertility levels (Ng, 2011; Teng, 2025). These findings underscore the importance of distinguishing between the compositional age effects and intrinsic fertility differentials when interpreting population growth.

Similarly, research on immigrant mortality highlights the "healthy immigrant effect" whereby recent migrants tend to exhibit lower mortality risks upon arrival relative to the native-born population followed by gradual convergence over time (Ng, 2011; Trovato, 2003). Such patterns suggest that differences in aggregate mortality across groups often reflect age composition and migration selectivity rather than persistent structural health disparities. Age-standardized comparisons are therefore essential when assessing mortality differentials among immigrant-origin populations.

Recent census-based analytical reports (Statistics Canada, 2022; 2025a; Tughizadeh, 2024) provide detailed descriptive profiles of religious and ethnocultural diversity using 2021 data. These studies document the continued expansion of non-Christian religious populations including Hindus and Sikhs and highlight patterns of geographic concentration educational attainment and labour market participation. However most remain descriptive in orientation and do not systematically decompose intercensal population growth into migration and natural increase components.

Comprehensive religion-specific demographic decomposition—combined with indirect estimation of fertility and mortality and forward projections within a transnational population–development framework—remains limited in the Canadian context. By integrating intercensal decomposition reconstructed vital events and share-based projection methods the present study extends existing scholarship. It situates religion-specific demographic growth within broader processes of migration transition demographic transition and diaspora-driven development linkages between Canada and India.

Results

Demographic Characteristics

Hindu and Sikh populations in Canada exhibit demographic profiles that differ markedly from that of the total population. Both groups are comparatively young with median ages of approximately 33 years for Hindus and 32 years for Sikhs in 2021 compared with 41 years for the total Canadian population (Table 1). The median age of both groups is therefore approximately eight to nine years lower than the national median. This youthful age structure is reflected in relatively higher proportions of children and working-age adults and substantially lower proportions aged 65 years and over. These structural characteristics have important implications for labour force participation demographic momentum and future growth potential. A substantial share of both populations is foreign-born particularly within prime working ages. Concentration in younger adult cohorts enhances labour force participation and increases the potential for natural increase through demographic momentum. These structural features provide the demographic foundation for understanding intercensal growth patterns.

Gender Composition

The observed gender imbalance (more males than females) in Hindu and Sikh populations is primarily attributable to the higher proportion of men among non-permanent residents, particularly international students. According to the 2021 population census, 63 per cent of Hindus were male. This proportion was 55 per cent in Sikhs. The

gender balance does not vary substantially among permanent residents. The same pattern has been observed for South Asian permanent residents (Statistics Canada, 2025a). The gender composition of the population reflects patterns of migration selectivity and labour market integration. In prime working-age cohorts – particularly, ages 25-44 years, males slightly outnumber females in both Hindu and Sikh populations (Table 1). This imbalance reflects economically selective migration streams and subsequent family reunification processes. The male dominance is more pronounced among Sikhs in occupational sectors characterised by male-dominated employment, particularly in trades and transport.

Table 1: Age distribution of Hindu Sikh and total Canadian population 2021.

Age Group	Total	Male	Female	Males per 100 females
		Total Canadian population		
Total (000)	36328.5	17937.2	18391.3	97.5
Percentage	100.0	100.0	100.0	
0-14	16.5	17.1	15.9	108.1
15-24	11.5	12.0	11.0	109.7
25-44	26.9	27.0	26.8	100.5
45-64	27.0	26.7	27.3	97.8
65+	18.1	17.2	19.1	90.0
Median age	41.2	40.4	42	
	Hindu population			
Total (000)	828.195	430.135	398.06	108.1
Percentage	100	100	100	
0-14	17	17	17	97.5
15-24	14	16	13	119.9
25-44	40	40	40	100.1
45-64	19	19	20	94.9
65+	9	9	10	88.2
Median Age	33.2	32.4	33.6	
	Sikh population			
Total (000)	771.8	394.3	377.5	104.5
Percentage	100.0	100.0	100.0	
0-14	16.8	17.3	16.4	105.3
15-24	18.9	20.2	17.5	114.9
25-44	34.9	34.5	35.4	97.3
45-64	17.9	17.3	18.5	93.7
65+	11.4	10.8	12.1	88.8
Median age	31.6	30.6	32.8	

Source: Statistics Canada (2024)

In the young ages (0–14 years), gender ratio approximate biological norms indicating stabilisation through family settlement and second-generation growth. In the older generation (65 years and over), female survival advantage becomes more evident, although its overall demographic impact remains limited due to relatively small elderly population in these communities. Compared with the total Canadian population – which

exhibits a pronounced female dominance at older ages due to population ageing – the young age structure of Hindu and Sikh populations maintain overall gender ratios closer to parity. These gender composition patterns reinforce the central role of economically selective migration in shaping demographic structure and have implications for family formation fertility patterns and labour market participation.

Growth and Components of Change

Between 2001 and 2021, both Hindu and Sikh populations in Canada more than doubled. This expansion substantially exceeded the overall national population growth rate during the same period. Inter-census decomposition indicates that migration, both permanent and temporary, has been the principal driver of growth. For the Hindu population, net immigration accounted for the largest share of total population increase while net non-permanent residents contributed a significant additional proportion reflecting the growing importance of international students and temporary foreign workers. Natural increase accounted for a comparatively smaller share of total growth (Table 2). A similar pattern is observed for the Sikh population. Immigration remained the dominant component of growth while non-permanent residents constituted a substantial additional contribution. Natural increase played a somewhat larger role for Sikhs than for Hindus consistent with their slightly younger age structure.

The increasing demographic significance of non-permanent residents is particularly noteworthy. Temporary migration streams now constitute a structurally important component of population change among immigrant-origin religious minorities. Overall, the decomposition confirms that migration – rather than elevated fertility differentials – has been the central engine of growth.

Table 2: Population growth and components of population growth in total Canadian population and Hindu and Sikh populations 2001-2021

Population	Total		Increase in population 2001-2021				
	2021	2001	Absolute	Proportion (Per cent)			
				Residual	Immigrants	Net emigrants	Non-permanent residents
Canada	36328475	29639035	6689440	34.9	65.6	-14.3	13.8
Hindu	828195	297200	530995	14.5	66.5	-3.1	22.1
Sikh	771790	278415	493375	27.4	51.3	-3.1	24.3

Source: Statistics Canada (2003; 2024)

Decomposition of Natural Increase

Indirect estimation indicates that out of approximately 7.4 million births registered in Canada between 2001 and 2021 roughly 3 per cent occurred among Hindus and 2-3 per cent among Sikhs (Table 3). The share of Hindus and Sikhs in the total registered deaths was, however, considerably lower because of young age composition of Hindus and Sikhs.

The relatively modest absolute contribution of natural increase to population growth in Canada must be interpreted in the context of low-fertility regime in Canada. Given persistently sub-replacement fertility at the national level, sustained rapid population growth through natural increase alone would demographically be unlikely.

The higher proportional natural increase observed among Sikhs relative to Hindus is consistent with their slightly younger median age and greater concentration of women in prime reproductive ages. These differences primarily reflect age-structure effects rather than distinct fertility regimes.

It is important to distinguish between the natural increase estimated from reconstructed number of births and deaths (Equations 2-8) and the natural increase derived residually from the inter-census population change (Equation 9). The residual measure incorporates demographic events as well as non-demographic components of population growth including differential census under-coverage and potential religious switching between population censuses. The difference between the two measures, therefore, reflect both demographic dynamics and statistical adjustments rather than substantive demographic inconsistencies.

Table 3: Decomposition of natural increase during 2001-2021 based on inter-census change before adjusting for Hindu Sikh and total Canadian population.

Components of natural increase	Estimated			Based on 2001 and 2021 Census	Factor
	Hindu	Sikh	Canada		
Adjusted number of deaths	67628	70706	3831662	5034608	1.314
Adjusted number of births	234485	188574	7084520	7354993	1.038
Natural increase based on vital statistics	166858	117868		2320385	
Natural increase after Adjustment for net census undercount	94426	166519	2871668		
Measurement gap (net emigration and religion switching	-72432	48650	551283		
Intercensal natural change (unadjusted)	76762	135368	2334471		
Population adjusted for net census undercount for 2001 census: 30966 563 and for 2021 census: 38192700.					

Source: Author based on Statistics Canada (2025b; 2025c)

After adjusting for the under-coverage in the population census, the measurement gap is found to be negative for Hindus but positive for Sikhs. If it is assumed that emigration that has not been captured during the census is small in both Hindus and Sikhs, the inter-census growth of the Hindu population is found to be negatively affected by net religious switching out whereas the Sikh population growth is found to be positively affected through net religious switching. The measurement gap, however, does not change the observation that migration has been the central engine of growth of both Hindu and Sikh populations in Canada during the period 2001-2021.

Fertility and Mortality

Fertility and mortality patterns among Hindu and Sikh populations must be interpreted within the constraints of indirect estimation given the absence of religion-specific vital statistics in Canada. Estimates derived from child–woman ratios (CWRs) and proportional adjustment to national total fertility rates (TFRs) provide internally consistent approximations of fertility of Hindu and Sikh populations (Table 4).

Fertility Levels and Differentials

Fertility among both Hindu and Sikh populations is broadly comparable to the national average and in some instances slightly below it. Religion-specific differentials are modest and insufficient to account for the magnitude of inter-census population growth. The evidence supports three important conclusions. First fertility convergence is evident. Consistent with prior Canadian research on immigrant fertility (Ram and George, 1993; Ng and Nault, 1997) religion-specific fertility levels show adaptation towards host-country norms. Given historically low fertility in Canada, sustained rapid population growth through natural increase alone would not be plausible. Second higher shares of births among these two communities reflect young age structure rather than elevated fertility. Hindu and Sikh populations are disproportionately concentrated in prime childbearing ages (20–39 years) producing larger number of births relative to their population size. This is a classic case of demographic momentum; whereby youthful age composition amplifies natural increase even when fertility levels are at approximate replacement or sub-replacement levels. Third difference between Hindu and Sikh natural increase reflect the difference in median age and proportion of women in reproductive ages rather than structurally distinct fertility regimes.

Table 4: Child-woman ratio and estimated total fertility rate for Hindu Sikh and total Canadian population 2021

Population	Children (0-4)	Women (15-19)	CWR	CWR relative to total Canadian population	Total fertility rate
Canada	1824145	8123935	225	1	1.4
Hindu	50010	235000	213	0.95	1.3
Sikh	43595	222905	196	0.87	1.2

Source: Statistics Canada (2024b; 2025e)

Mortality Patterns and Age Composition

Estimated number of deaths derived residually from estimated number of births and natural increase indicate that both Hindu and Sikh populations account for disproportionately small share of total number of deaths relative to their population size. Two structural mechanisms – age-structure effect and health migration effect – are relevant in this context. With smaller proportion of population aged 65 and older in Hindu and Sikh populations compared to the total Canadian population, aggregate crude death rates are necessarily lower. Observed mortality differences are, therefore, compositional rather than behavioural. Moreover, existing research (Ng, 2011; Trovato, 2003) documents lower initial

mortality risks among recent immigrants due to positive health selection at the time of entry. While convergence toward national mortality patterns occurs over time, selective migration contributes to temporary reduction in mortality among foreign-born populations. There is, however, no evidence to suggest religion-specific mortality regimes operating independently of age structure and migration selectivity. Aggregate mortality variation is best understood as a structural demographic effect.

The levels of fertility and mortality in Hindus and Sikhs suggest that the growth of Hindu and Sikh populations in Canada between 2001 and 2021 was migration-driven with natural increase operating primarily through demographic momentum. These structural implications are significant because, in low-fertility national context, religion-specific population growth through natural increase would eventually decrease as the age structure matures. Continued population growth, therefore, depends on sustained immigration flows and temporary migration pathways.

Population-Development Implications

From the population-development perspective, fertility and mortality convergence signals demographic integration with broader population transition regime of Canada. The absence of sustained high fertility suggests that long-term growth trajectories will remain tightly linked to immigration policy rather than autonomous demographic reproduction. At the same time young age structure supports labour force growth, intergenerational renewal and urban expansion. These characteristics enhance the economic contribution of both communities while reinforcing transnational linkages with India.

Socio-Economic Characteristics

Both Hindu and Sikh populations in Canada exhibit distinctive socio-economic profiles shaped by migration selectivity, educational attainment, and occupational concentration. Both populations are highly urbanised and geographically concentrated, particularly, in Ontario and British Columbia (Table 5). Ontario accounts for the majority of the Hindu population and a large share of the Sikh population while British Columbia has a high concentration of Sikh population. Relatively smaller but significant proportion of Hindus and Sikhs reside in Alberta and Manitoba. At the metropolitan level, Toronto and Vancouver constitute the principal settlement centres for both communities. This spatial concentration reflects historical migration pathways, labour market opportunities, institutional networks and established diaspora of the two communities. Urban concentration also reinforces economic integration through access to employment markets, educational institutions, and community organisations.

Educational Attainment

Educational attainment among Hindus aged 15 years and above exceeds that of total Canadian population with a notably high proportion holding bachelor's degrees or higher (Table 6). This pattern reflects the skill-selective nature of the immigration system of Canada, particularly points-based system that emphasises education qualifications. Sikhs also demonstrate strong educational profiles but somewhat differs from that of Hindus. Both populations display levels of human capital consistent with selective migration.

Table 5: Distribution of Hindu, Sikh and total Canada population across Provinces, Territories and selected large Census Metropolitan Areas (CMAs) and Non-metropolitan Arias (Non-CMAs), 2021

Region	Total	Hindu	Sikh
Canada	36328480	828195	771790
	100	100	100
Large CMAs	56.3	86.9	85.0
Other CMAs	15.4	8.2	10.6
Non-CMAs	28.3	4.8	4.4
Provinces and Territories			
Newfoundland and Labrador	1.4	0.1	0.1
Prince Edward Island	0.4	0.2	0.2
Nova Scotia	2.6	1.0	0.6
New Brunswick	2.1	0.4	0.2
Quebec	22.9	5.7	3.0
Ontario	38.6	69.3	38.9
Manitoba	3.6	2.2	4.6
Saskatchewan	3.0	1.7	1.2
Alberta	11.5	9.5	13.4
British Columbia	13.5	9.8	37.7
Yukon	0.1	0.0	0.0
Northwest Territories	0.1	0.0	0.0
Nunavut	0.1	0.0	0.0
Selected Large Census Metropolitan Areas			
Montréal	11.6	5.5	3.0
Québec	2.2	0.1	0.0
Hamilton	2.1	1.8	1.2
Kitchener -	1.6	2.4	1.6
Cambridge-Waterloo London	1.5	1.1	0.6
Ottawa Gatineau (Ontario part)	3.1	2.5	0.8
Toronto	16.9	55.3	31.6
Winnipeg	2.3	1.8	4.3
Calgary	4.0	4.2	7.3
Edmonton	3.8	4.3	5.8
Vancouver	7.2	8.0	28.8

1. Census metropolitan areas (CMAS) are defined by Statistics Canada.
2. Percentages may not add to 100 due to rounding.

Source: Statistics Canada (2024b)

Income Differentials and Labour Force Participation

Income and labour market indicators provide additional insight into the economic integration of Hindu and Sikh populations in the Canadian economy. The median individual income of both Hindus and Sikhs remain marginally lower than the national median income despite relatively higher educational levels, particularly of Hindus. This pattern reflects several interrelated factors – recency of arrival in Canada, transitional occupational mobility, sectoral concentration, and potential barriers in credential recognition. Newly

arrived immigrants in Canada frequently experience temporary earning penalties that diminish over time as the integration of immigrants in the labour market progresses. To quantify income differentials, the income ratio was calculated as the ratio of median income of a particular religious group divided by the national median income. Preliminary estimates suggest that the income ratio for both Hindus and Sikhs remain below 100. The deviation is, however, small compared to the differences typically observed across immigrant cohorts with shorter duration of residence in Canada. This pattern is consistent with the transitional earning effects rather than structural labour market exclusion.

The labour force participation rates (LFPR) in the prime working ages (25-54 years) are higher in both communities relative to the national average. LFPR in men are comparable to or higher than national average reflecting concentration in economically active age cohorts and high degree of attachment to the labour market. They indicate substantial integration of Hindu and Sikh workforce with the Canadian workforce. However, gender differences are evident in Sikhs as LFPR in Sikh women is lower than that in men and, in some cases, even lower than the national average. These disparities reflect differences in migration pathways, household responsibilities, cultural norms, and occupational segmentation. The coexistence of relatively higher educational attainment with modest income differentials suggest that economic integration is ongoing rather than structurally constrained. Given the young age structures of Hindu and Sikh populations, continued labour market experience, credential alignment and intergenerational mobility are likely to reduce income gap over time. From the demographic perspective, strong labour force participation rate reinforces sustainability of migration-driven population growth. High participation rates among working-age cohorts contribute to tax revenues, social insurance systems and economic productivity thereby linking demographic expansion with economic contribution. Hindu men are disproportionately represented in business, finance, management and natural and applied sciences. This pattern aligns with the educational selectivity and professional migration pathways. Sikh men, on the other hand, exhibit strong representation in trade, transport and related occupations which is consistent with the established community networks and sectoral specialisation. Among women both Hindus and Sikhs substantial representation in business, finance, health, and sales and service occupations.

Education–Income Differentials

The observed education–income gap among Hindus and Sikhs in Canada reflects several interacting factors. A substantial proportion of both communities consists of recent immigrants who may have initially experienced earning penalties relative to the native population of Canada. Returns to education often increase with the duration of residence in Canada. At the same time, foreign-acquired degrees and professional qualifications may not be immediately recognised in Canada leading to occupational downgrading or transitional employment. A part of the education-income differentials may be due to the difference in occupational structure. Hindus are mostly represented in professional and managerial occupations while Sikhs show significant representation in skilled trades and transport sectors. Earnings structures vary across occupational categories even at similar education levels. Finally, lower median age implies shorter average labour market experience which influences earnings independently of education.

Table 6: Characteristics of Hindu and Sikh population in Canada compared to the total population of Canada.

Characteristics	Canada	Hindu	Sikh
Population aged 15 years and above			
Total	30335920	685375	641920
Men	14861245	356870	326310
Women	15474675	328510	315610
Proportion of population aged 15 years and above with at least Bachelors' degree			
Total	26.7	51.9	30.8
Men	24.8	52.5	27.9
Women	28.5	51.2	33.9
Individual income			
Average income	54450	50800	41760
Median income	41200	37200	32400
Participation - Male			
LFPR	85.6	93.1	92.1
Employment rate	78.5	87	87.1
Unemployment rate	8.3	6.6	5.4
Participation - Female			
LFPR	82.2	81.8	82
Employment rate	75	72.1	74.1
Unemployment rate	8.8	11.9	9.6
Occupation Groups – Male			
All	6486630	206145	165820
Legislative and senior management	1.7	0.9	0.8
Business finance and administration	11.4	14.4	9.7
Natural and applied sciences	14.1	29.5	8.6
Health	3.3	3.7	2.5
Education, law, social community, government services	8.6	4	0
Art culture recreation and sports	3	1.1	4
Sales and service	17.9	22.1	16.7
Trade transport and equipment operators	30.4	14.9	51.2
Natural resources agriculture and related production	3.5	4.2	1.5
Manufacturing and utilities	6.1	5.3	5
Occupation Groups - Female			
All	6230395	170970	149355
Legislative and senior management	0.8	0.4	0.3
Business finance and administration	25.4	24.7	21.6
Natural and applied sciences	5.1	15.4	4.2
Health	14.8	10.8	14.1
Education, law, social community, government services	19.7	11.4	0
Art culture recreation and sports	3.7	1.6	11.1
Sales and service	23.7	25.9	31.3
Trade transport and equipment operators	3.3	3.3	6.9
Natural resources agriculture and related production	1	1.6	1.4
Manufacturing and utilities	2.6	5	9.2

Source: Author

The coexistence of relatively high educational attainment and modest income differentials does not necessarily indicate structural exclusion. Rather, it is consistent with well-documented immigrant economic assimilation patterns in which earnings converge toward national averages over time as host-country experience accumulates. From the demographic perspective, strong educational attainment combined with high labour force participation suggests long-term economic integration potential. As cohorts age and accumulate experience, the education–income differential is likely to narrow reinforcing both household economic stability and broader population–development linkages.

Both Hindu and Sikh populations demonstrate substantial economic integration and contribute meaningfully to the labour market and human capital base of Canada. Their young age structure, high labour force participation rates and educational attainment reinforce their demographic significance within an ageing national context. These socio-economic characteristics interact with demographic processes. Selective migration, urban concentration and labour market integration shape age structure, fertility timing and long-term settlement patterns. Consequently, socio-economic integration and demographic growth operate in mutually reinforcing ways within the immigration-driven population regime of Canada.

Impact of Emigration for India

According to the 2021 Census, approximately 1.2 million residents of Canada were born in India, reflecting one of the largest immigrant-origin populations in the country. While Hindu and Sikh migrants constitute the largest religious groups among Indian-origin populations in Canada, they are not the only communities of Indian-origin. A substantial proportion of Indian migrants belong to other religious groups including Christians, Muslims, Jains, Parsis and Buddhists. Although, these groups are not the focus of the present analysis, their presence contributes to the broader religious and cultural diversity of the Indian diaspora in Canada. Indian migrants in Canada represent only a small proportion of the population of India which now exceeds 1.4 billion. At the country level, emigration to Canada constitutes a limited outflow and does not materially affect the size and the composition of Indian population. However, migration is rarely regionally neutral. Migration is often positively selective with respect to education, skills and labour market experience. Consequently, the impact of emigration may be more pronounced in specific regions of India, particularly in states with high migration intensity. Selective out-migration of skilled individuals may influence local labour market, household structure and regional human capital distribution.

India remains the largest recipient of remittances from emigrants with inflows exceeding US$100 billion annually in recent years (World Bank, 2023). Canada represents an important source of these transfers. Remittances from emigrants contribute to household income stabilisation, investment in education, health, and housing and social and economic activities at the local level. Beyond the financial flows, the diaspora networks facilitate trade entrepreneurship, professional collaboration and technology exchange between Canada and India. Migration also enables circulation of skills and knowledge. Highly educated migrants may engage in transnational professional networks research

collaboration and business development linking institutions in both countries. These forms of human capital mobility extend beyond permanent settlement and contribute to broader processes of globalization and economic integration. From the population-development perspective, migration to Canada should be understood not merely as demographic redistribution but also as part of a transnational system of inter-dependence. Demographic losses due to emigration in India are modest, but developmental linkages through remittances, investment in trade and skill mobility are substantial. The demographic transition in India is characterised by regional variation in fertility decline and labour force growth. In such a scenario, regionally sensitive emigration may produce differential regional effects.

Population Projections, 2026–2041

Under the medium-growth scenario, the Hindu population in Canada is projected to reach approximately 1.8 million by year 2041, representing about 3.8 per cent of the population of Canada whereas the Sikh population is projected to reach approximately 1.7 million or roughly 3.5-3.6 per cent of the population of the country. Low- and high-growth scenarios yield proportionally lower and higher absolute numbers, but projected shares remain relatively stable. This stability reflects the extension of observed share dynamics rather than substantial shifts in relative religious composition. Growth remains strongly migration-dependent under all scenarios and is closely tied to sustained immigration. Young age structure reinforces demographic momentum. However, fertility in both Hindus and Sikhs have largely converged to national norms. Natural increase, therefore, operates as a complementary mechanism rather than the primary driver.

Table 7: Projected Hindu and Sikh population (in thousand) in Canada

Population	2021		2026		2031		2036		2041	
	N	%	N	%	N	%	N	%	N	%
					Low Growth Scenario					
Canada	36328.5	100.0	41418.5	100.0	41841.8	100.0	42451.3	100.0	42863.8	100.0
Hindu	828.2	2.3	1106.7	2.7	1284.3	3.1	1467.8	3.5	1639.1	3.8
Sikh	771.8	2.1	1030.0	2.5	1193.7	2.9	1362.4	3.2	1519.5	3.5
					Medium Growth Scenario					
Canada	36328.5	100.0	41655.4	100.0	42875.0	100.0	44432.0	100.0	45928.6	100.0
Hindu	828.2	2.3	1113.0	2.7	1316.0	3.1	1536.2	3.5	1756	3.8
Sikh	771.8	2.1	1035.9	2.5	1223.2	2.9	1426.0	3.2	1628	3.5
					High Growth Scenario					
Canada	36328.5	100.0	41932.3	100.0	44064.9	100.0	46714.5	100.0	49500.6	100.0
Hindu	828.2	2.3	1120.4	2.7	1352.5	3.1	1615.2	3.5	1892.9	3.8
Sikh	771.8	2.1	1042.7	2.5	1257.1	2.9	1499.2	3.2	1754.7	3.5

Source: Figures for Canada are from Statistics Canada (2026). Figures for Hindu and Sikh are author's calculations.

A comparative perspective with the Muslim population further contextualises these projections. By the year 2041, Muslims are projected to account for approximately 9 per cent of population of Canada, substantially higher than the projected shares of Hindus and Sikhs, because of comparatively higher fertility and a larger Canadian-born component

which indicates a more advanced stage of generational consolidation. These different trajectories illustrate that religious diversification in Canada is shaped fundamentally by international mobility, although the balance between migration, fertility and generational replacement varies across communities. Growth of Hindu and Sikh populations is migration-driven growth whereas Muslim population growth suggests a gradual transition toward endogenous generational consolidation. Population of other religious groups in Canada has also been projected, and the projected population is given in the appendix table.

Validation of projected population

Statistics Canada (2017) has produced population projections by religious groups based on 2011 National Household survey using a microsimulation approach. Table 8 presents a comparative analysis of the projected of Hindus and Sikhs for the year 2036 using the ratio method (used in this paper) and the Demosim17 microsimulation model used by Statistics Canada (2017). The ratio method consistently yields higher projections than Demosim17 suggesting more expansive assumptions regarding population growth, particularly immigration. The difference in projected population by two different methods highlights the sensitivity of projection to methodological assumptions particularly regarding migration patterns. However, both approaches indicate a clear trend toward increasing religious diversity in Canada with Hindu and Sikh populations representing a growing share of the national population.

Table 8: Comparison of projected Hindu, Sikh and Canada population for the year 2036 by the ratio method and by Demosim17 microsimulation.

Population	2021 Census	2036 scenario					
		Low		Medium		High	
		Ratio method	Demosim17	Ratio method	Demosim17	Ratio method	Demosim17
		Numbers (000)					
Canada	36328	42451	41057	44432	43816	46714	45292
Hindu	828	1470	1007	1536	1211	1654	1318
Sikh	771	1364	952	1425	1128	1535	1219
		Proportions					
Canada	100	100	100	100	100	100	100
Hindu	2.3	3.5	2.5	3.5	NA	3.5	2.9
Sikh	2.1	3.2	2.3	3.2	NA	3.2	2.7

Source: Statistics Canada (2017)

Several structural patterns emerge from the projections. First, growth remains strongly migration dependent. Second, young age structure reinforces demographic momentum. Even under conditions of fertility convergence to national norms, relatively young age distribution supports continued positive natural increase. Third, religious diversification proceeds gradually rather than abruptly. Changes in projected shares occur incrementally reflecting long-term structural processes rather than short-term fluctuations. These projections are conditional upon continuation of recent demographic trends and national population scenarios. They should be interpreted as composition-adjusted

extensions of observed share dynamics rather than independent religion-specific cohort-component projections. Nevertheless, they underscore the sustained demographic significance of Hindu and Sikh populations in Canada.

Discrimination, Hate Crimes and Social Context

The primary focus of this study is demographic change. However, social context remains relevant for understanding long-term integration trajectories and population stability. Experiences of discrimination and social exclusion may influence residential concentration, labour market mobility and institutional participation thereby indirectly shaping demographic outcomes. Recent national surveys indicate that a significant proportion of South Asian population in Canada report experiences of discrimination. While these data refer to ethnocultural identity rather than specific religious affiliation, yet they are relevant given the substantial overlap between South Asian origin and Hindu and Sikh religious identification. Reported experiences include workplace discrimination, barriers in housing markets and perceptions of unequal treatment.

Police-reported hate crimes in Canada have also increased in recent years. Although, Jewish and Muslim communities account for a larger proportion of religion-based incidents, yet Hindu and Sikh communities have reported concerns regarding vandalism, harassment and targeted acts affecting religious institutions. From the demographic perspective, persistent experiences of discrimination may affect patterns of spatial concentration, intergenerational mobility and social integration. Concentration, within established ethnic and religious enclaves, may provide social support and cultural continuity but may also influence labour market trajectories and housing choices. Ensuring inclusive institutional frameworks and equal opportunity structures is, therefore, relevant not only for minority rights and social cohesion but also for sustaining demographic and economic contributions of immigrant population. Discrimination does not appear to have constrained overall population growth during the period 2001–2021, its long-term implications warrant continued attention.

Policy Implications

Several policy implications emerge from this study. First, given that migration is the dominant driver of Hindu and Sikh population growth in Canada, immigration policy will continue to play a decisive role in shaping the size and composition of these communities. Policies governing permanent residency, temporary migration streams, international student pathways and labour market admissions directly influence demographic expansion and age structure. In the ageing society of Canada, sustained immigration contributes not only to overall population growth but also to the diversification of religious composition.

Second, although educational attainment of Hindu and Sikh populations is relatively higher, median incomes remain below the national average which calls for strengthening mechanisms for recognising foreign credentials to facilitate occupational

mobility and reducing barriers to professional integration. Improved alignment between human capital and labour market outcomes would enhance both individual economic returns and broader productivity gains.

Third, gender disparities in labour force participation – particularly, among Sikh women – highlights the need for supportive policies related to childcare access, upgrading language training skills and anti-discrimination measures.

Fourth, diaspora engagement policies can amplify developmental gains. Facilitating research collaboration, entrepreneurship networks, professional exchange and bilateral investment can strengthen transnational linkages. Migration should therefore be viewed not solely as demographic redistribution but as part of a broader system of economic and knowledge exchange.

Finally, increasing role of non-permanent residents underscores the importance of policy coherence across temporary and permanent migration streams. Given the demographic significance of international students and temporary foreign workers in recent growth patterns, pathways to permanent settlement and integration merit careful consideration within long-term population planning. Taken together these policy considerations highlight the central role of immigration systems, labour market institutions and diaspora engagement frameworks in shaping both demographic outcomes and population-development linkages in Canada.

Conclusions

Hindu and Sikh populations in Canada more than doubled between 2001 and 2021. Both permanent and temporary migration has been the principal engine of growth while natural increase contributed primarily through demographic momentum associated with young age structure. Fertility differentials are modest and show convergence toward national norms. Observed mortality variations largely reflect compositional age effects rather than intrinsic disparities.

The analysis has also highlighted the role of reconstructed births and deaths relative to intercensal accounting residuals by distinguishing between demographic and residual measures of natural increase. This methodological distinction strengthens interpretation of demographic drivers and confirms the centrality of migration in shaping religious population change in Canada.

Both Hindu and Sikh populations in Canada exhibit relatively strong human capital characteristics and high labour force participation positioning them as significant contributors to the demographic sustainability of Canada within the context of population ageing and low fertility. Income differentials and reported experiences of discrimination underscore the continuing importance of inclusive institutional and labour market frameworks.

From the Indian perspective, emigration to Canada represents a relatively small demographic outflow but generates substantial economic and institutional linkages

through remittances, skill mobility, trade networks and knowledge exchange. Migration thus functions simultaneously as demographic redistribution and as a mechanism of transnational population–development interdependence. By providing religion-specific decomposition of intercensal growth, reconstructing fertility and mortality under data constraints and situating projections within a bilateral population–development framework, this study contributes to a more systematic understanding of how diaspora-driven demographic change reshapes religious composition in destination countries while reinforcing developmental linkages with countries of origin. The evidence indicates that contemporary religious diversification in Canada is structurally migration-driven with fertility convergence and age-structure effects operating as complementary but secondary mechanisms.

In sum, population growth of Hindus and Sikhs in contemporary Canada is structurally migration-driven with fertility convergence and age-composition effects operating as secondary mechanisms within a broader transnational population-development system.

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Appendix Table: Projected population (000) by different religion groups in Canada, 2021, 2026, 2031,2036 and 2041, based on ratio method.

SN	Religious group	2021	2026	2031	2036	2041
			Low Growth Scenario			
1	Buddhist	357	385	362	334	301
2	Christian	19373	19226	16570	14065	11665
3	Jewish	335	348	314	279	242
4	Muslim	1776	2430	2887	3379	3863
5	Traditional (North American Indigenous Spirituality)	81	101	110	118	123
6	Other religions and traditional spirituality	229	326	403	490	582
7	No religion and secular perspectives	12577	16465	18719	20958	22928
			Medium Growth Scenario			
1	Buddhist	357	388	370	349	323
2	Christian	1937	19336	16979	14721	12499
3	Jewish	335	350	322	292	259
4	Muslim	1776	2444	2958	3536	4140
5	Traditional (North American Indigenous Spirituality)	81	102	113	123	132
6	Other religions and traditional spirituality	229	328	412	513	624
7	No religion and secular perspectives	12577	16559	19181	21936	24568
			High Growth Scenario			
1	Buddhist	357	390	381	367	348
2	Christian	1937	19465	17451	15477	13471
3	Jewish	335	352	331	307	279
4	Muslim	1776	2460	3041	3718	4462
5	Traditional (North American Indigenous Spirituality)	81	102	116	129	142
6	Other religions and traditional spirituality	229	330	424	539	672
7	No religion and secular perspectives	12577	16669	19713	23062	26478

Source: Author. Figures for 2021 are census count.

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Domestic Violence Against Women in India

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Abstract

This study purports to highlight the impact of women empowerment on domestic violence against women in India based on the data available from the latest round of the National Family Health Survey (NFHS-5). The analysis is based on the multinomial logit regression of the domestic violence experienced by ever married women aged 15-49 years on their selected social and economic characteristics which classifies the domestic violence experienced by women into eight mutually exclusive and exhaustive categories. The analysis reveals that domestic violence experienced by ever married women in India is statistically significantly associated with such characteristics of the woman as current marital status, age at first marriage, level of education and occupation, in addition to the use of alcohol by the husband/partner of the woman, her standard of living and religious affiliation.

Introduction

Historically, women have faced significant limitations in terms of education, work, and decision-making. Women and girls represent almost half of the world population and, therefore, half of its potential. But gender inequality persists everywhere and contributes to the stagnation of the social progress. Women empowerment and gender equality have always been emphasised as the necessary foundation for peaceful, prosperous, and sustainable development as emphasised under the United Nations 2030 Agenda for Sustainable Development (United Nations, 2015). The Goal 5 of the Agenda calls for achieving gender equality and empowering all women and girls worldwide by the year 2030. The Agenda advocates closing the gender gap in all aspects of life through ensuring equal opportunities for all women and girls. The Agenda also calls for ending all forms of discrimination against women, specifically, elimination of all forms of violence against women in public and private spheres, including elimination of harmful practices such as child, early and forced marriage and female genital mutilation, encouraging full and effective participation of women in productive activities, creating equal opportunities for women at all levels of decision-making in political, economic and public life, and ensuring universal access to sexual and reproductive health services. India is a signatory of the United Nations 2030 Agenda for Sustainable Development and has developed the national indicator-framework to monitor the progress towards the goals and targets of the United Nations Agenda. Women empowerment and gender equality occupies an important

position in the national indicator-framework adopted by the Government of India (Government of India, 2021).

Despite all the emphasis on women empowerment and gender equality, violence against women, especially, the domestic violence, remains a major development concern in India because of the typically patriarchal nature of the Indian society. The domestic violence against women in India was recognised as a criminal offence under the Indian Penal Code way back in 1983 and the Protection of Women from Domestic Violence (PWDVA) Act was enacted in 2005 which came into the effect in 2006. This Act provides comprehensive definition of domestic violence against women and girls including all forms of physical, emotional, verbal, sexual, and economic violence (Government of India, 2005). Domestic violence against women implies any form of abuse or violence faced by women and girls within the home, usually by the husband or the partner, family members, relatives, friends, and others. Different forms of domestic violence against women and girls comprise of physical, sexual, emotional, and economic violence. Physical violence implies beating, hitting, or causing bodily harm. Sexual violence comprises of coercion or forcing a woman into involuntarily and unwanted sexual acts. Emotional violence or psychological abuse implies insults, threats, and humiliation of different nature. Economic violence implies controlling money or preventing women from working. The Act has also recognised that domestic violence against women is a serious social problem that violates dignity, safety, and human rights of women. It has been argued that domestic violence against women affects health and confidence of women and constrains freedom of women and girls (Mahapatro and Kumar, 2021).

The latest (2019-2021) round of the National Family Health Survey provides an idea about the challenge of domestic violence against women in India. According to this survey, close to 30 per cent of ever married women aged 18-49 years in India appear to have ever experienced any form of physical violence, more than 6 per cent ever experienced any form of sexual violence and around 14 per cent ever experienced any form of emotional violence (Government of India, 2022b). The ever experience of any form of domestic violence by women varies widely across states and Union Territories of the country. For example, the proportion of women reporting ever experience of any form of emotional violence has been estimated to be the highest in Karnataka but the lowest in the Andaman and Nicobar Islands. On the other hand, the proportion of women who had ever experienced any form of physical violence was the highest again in Karnataka but the lowest in Lakshadweep. Lastly, the proportion ever married women aged 18-49 years who experienced any form of sexual violence has also been found to be the highest in Karnataka but the lowest in Lakshadweep (Government of India, 2022).

Factors that may be attributed to the prevalence of domestic violence against women may be grouped into three categories. The first group of factors are specific to women themselves and can be summarised in terms of their agency, capacity, and opportunity (Davis, 2015). Women empowerment has been advocated to address these factors and, therefore, is perceived as an effective strategy to address the challenge of violence against women, especially, the domestic violence. Women empowerment implies fostering self-worth, autonomy, and equal rights for women to thrive in all spheres of life. Key focus areas of women empowerment comprise of ensuring access to education,

creating economic opportunities, providing legal protection, and enhancing decision-making power, which collectively enhance women autonomy, reduce discrimination, and foster overall societal progress. Women empowerment is based on six principles: 1) self-confidence, 2) self-respect, 3) self-reliance, 4) self-support, 5) self-sufficiency, and 6) self-realisation. Women empowerment also emphasises improvement in social behaviour and enhanced community participation. Women empowerment has also been viewed as essential for sustainable development and for creating empowered families, communities, and nations. It has also been identified as a catalytic agent towards building resilient and confident individuals (Verma, 2023).

The second group of factors that contribute to domestic violence against women are related to the husband or the intimate partner of the woman (Gautam and Jeong, 2019; Pathak and Kumar, 2023). Education and occupation of the intimate partner, along with such habits as addiction to alcohol have been found to have a strong association with all forms of domestic violence – emotional, physical, and sexual violence - experienced by women. The husband-wife age difference has also been argued to be a factor that plays an important role in all forms of domestic violence experienced by women within the household. Finally, the third group of factors that influences the domestic violence against women is related to the household characteristics and religious affiliation. The standard of living of the household, the ethnicity and the place of residence are some of the factors that have been found to be associated with domestic violence experienced by ever married women.

It is in the above context that the present paper attempts to explore how the variation in women-specific factors, factors specific to the husband/intimate partner of the woman, household factors and religious affiliations explain the variation in the domestic violence experienced by ever married women in India. There are many studies that have analysed the determinants of domestic violence against women in India (Mishra et al, 2024). The domestic violence against women has been classified as either a dichotomous variable or a variable having three responses – emotional violence, physical violence, and sexual violence. The present paper differs from the existing studies in the sense that it classifies the domestic violence experienced by ever married women into eight mutually exclusive yet exhaustive categories. The paper assumes that a woman may experience either no domestic violence of any form or different combinations of the three forms of domestic violence – emotional, physical, and sexual. A woman may experience only the emotional violence or only the physical violence or only the sexual violence or she may experience, simultaneously, more than one category of domestic violence. The present paper, therefore, categorises the domestic violence experienced by ever married women or women living with a partner into seven mutually exclusive and exhaustive categories to explore how characteristics of the woman and her husband/intimate partner, household factors and religious affiliation influence the domestic violence experienced by women. To the best of our knowledge, we have not come across any study in which the domestic violence experienced by women has been categorised into seven mutually exclusive yet exhaustive categories depending upon the nature of the domestic violence. The paper, therefore, provides a deeper understanding of the domestic violence experienced by women which may have important policy and programme implications as far as reduction and ultimate elimination of domestic violence against women in concerned.

The paper is organised into six sections including this introduction. The next section of the paper describes the data source. The analysis is based on the latest (2019-2021) round of the National Family Health Survey conducted by the Government of India. Section three outlines the methodology of the analysis. We have first carried out a classification exercise to classify women in mutually exclusive and exhaustive groups based on their defining characteristics and then estimated the proportion of women who had not experienced any form of domestic violence in different groups. Women characteristics identified through classification exercise have been used to explore determinants of domestic violence against women by fitting the multinomial logit regression model. The dependent variable in the regression analysis is a categorical variable that takes eight values. Section four of the paper presents results of the bivariate analysis while results of multivariate analysis are presented in section five. The last section of the paper summarises main findings of the analysis and their policy and programme significance.

Data Source

The analysis is based on the data on domestic violence available from the latest (2019-2021) round of the National Family Health Survey (NFHS-5) in India. The National Family Health Survey Programme was instituted by the Government of India in 1990, and five rounds of the survey have so far been conducted while the sixth is in progress (Government of India, 2022). The domestic violence module of the survey was not canvassed to all ever married women but randomly to one woman per household among all eligible women in the household following the recommendations put forward by the World Health Organization (WHO, 2001). Therefore, information about the experience of domestic violence was available from 72320 women. Among these women 8469 women were never married, or they were married but their marriage was not consummated so that the present analysis is based on 63,851 ever married women.

A large part of the domestic violence module of NFHS-5 is related to the information about the violence perpetrated by the current husband/partner of the woman and the most recent husband/partner for the widowed, divorced, or separated women (Croft et al, 2018). Based on this information, women were categorised into the following eight categories on the basis of their ever experience of emotional violence, physical violence, and sexual violence:

1. Women who did not experience any emotional, physical, or sexual violence.
2. Women who experienced only emotional violence.
3. Women who experienced only physical violence.
4. Women who experienced only sexual violence.
5. Women who experienced emotional and physical violence but not sexual violence.
6. Women who experienced emotional and sexual violence but not physical violence.
7. Women who experienced physical and sexual violence but not emotional violence.
8. Women who experienced all emotional, physical, and sexual violence.

Table 1: Distribution of women by the experience of domestic violence.

Experience of domestic violence	Unweighted		Weighted	
	Number	Per cent	Number	Per cent
Experienced no domestic violence	44413	69.56	425761	68.15
Experienced only emotional violence	1673	2.62	17197	2.75
Experienced only physical violence	10049	15.74	96462	15.44
Experienced only sexual violence	403	0.63	4059	0.65
Experienced emotional and physical violence	4196	6.57	47149	7.55
Experienced emotional and sexual violence	128	0.20	1230	0.20
Experience physical and sexual violence	978	1.53	10757	1.72
Experienced emotional, physical and sexual violence	2011	3.15	22092	3.54
Total	63851	100.00	624707	100.00

Source: Authors

Table 1 gives the unweighted and weighted distribution of the ever married women interviewed by the type of the domestic violence experienced by them. Around 70 per cent of the women interviewed reported that they did not ever experience any type of domestic violence. On the other hand, the most common form of domestic violence experienced was the physical violence. At least one fourth of the women reported that they ever experienced some form of physical violence. On the other hand, the least common form of domestic violence reported was the sexual violence. Only around 6 per cent of the women interviewed reported that they ever experienced some form of sexual violence. A substantial proportion of women also reported that they experienced some form of emotional violence. Around 8 per cent of the women interviewed reported that they experienced both emotional and physical violence while around 4 per cent reported that they experienced all the three forms of domestic violence for which information was collected during NFHS-5. More than 13 per cent of the women reported that they experienced more than one form of domestic violence.

The following explanatory variables were used to examine the factors that influence the domestic violence experienced by women:

1. Age of the woman
2. Current marital status
3. Age at first cohabitation
4. Difference between age of husband/partner and woman
5. Education of the woman
6. Occupation of the woman
7. Bank account in the name of woman
8. Woman has at least one living son
9. Age of the husband/partner
10. Education of the husband/partner
11. Occupation of the husband/partner
12. Use of alcohol by husband/partner
13. Residence of the household
14. Religion of the household
15. Standard of living of the household

Table 2: Proportionate (per cent) distribution of women (Unweighted and weighted) by the background characteristics of women, their husband/partner, and the characteristics of the household.

Characteristics		Proportion (x100)		Unweighted N
		Unweighted	Weighted	
Age (years)	15-19	3.3	4.8	2082
	20-24	13.9	14.3	8888
	25-29	21.0	17.9	13386
	30-34	20.2	18.3	12884
	35-39	18.2	18.8	11589
	40-44	13.8	15.0	8812
	45-49	8.7	10.8	6210
Marital status	Married	94.7	94.0	60480
	Widow	3.8	4.3	2412
	Divorced/Separated	1.5	1.7	959
Age at marriage (years)	≤18	61.4	65.9	39192
	19-22	21.8	20.0	13903
	22-25	10.2	8.7	6488
	25-28	4.3	3.5	2746
	≥28	2.4	1.8	1522
Difference between age of husband/partner and woman (years)	< 3	42.6	35.5	25783
	3-5	23.4	24.2	14144
	5-7	13.5	15.6	8191
	≥7	20.5	24.8	12417
	No data			3371
Education	No education	29.4	28.5	18783
	Primary	14.6	13.7	9302
	Secondary	45.3	46.4	28943
	Middle	10.7	11.2	6823
Occupation	No occupation	63.7	64.5	40615
	Professional	2.6	2.8	1687
	Service/Clerical	6.1	6.7	3895
	Agriculture	19.5	17.6	12405
	Labour	6.6	6.8	4237
	Others	1.5	1.5	934
	No data			78
Living son	No	23.7	26.4	15153
	Yes	76.3	73.6	48698
Bank account	No	18.8	20.1	11978
	Yes	81.2	79.9	
Education of husband/partner	No education	18.3	19.3	11628
	Primary	14.5	15.1	9268
	Secondary	53.3	51.3	33902
	Higher	13.9	14.3	8819
	No data			234
Occupation of husband/partner	Professional	7.4	7.6	4735
	Service/Clerical	21.0	22.5	13430
	Agriculture	37.3	33.1	23834
	Labour	28.9	30.9	18428
	Others	5.4	60.0	3424

Characteristics		Proportion (x100)		Unweighted N
		Unweighted	Weighted	
Alcohol use by husband/partner	No	72.1	76.1	46019
	Yes	27.9	23.9	17832
Residence	Rural	75.7	69.3	48363
	Urban	24.3	30.7	15488
Religion	Hindu	76.0	79.1	48548
	Muslim	11.9	16.0	7585
	Others	12.1	4.8	7718
Standard of living	Very poor	20.7	19.8	13222
	Poor	21.2	21.0	13566
	Middle	20.3	20.3	12977
	Rich	19.4	20.8	12383
	Very rich	18.3	18.1	11703

Source: Authors

Table 2 shows the distribution of the explanatory variables specific to the woman, to the husband/partner of the woman and the household used in the present analysis by their mutually exclusive and exhaustive categories.

Methodology

Both bivariate and multivariate analyses were carried out to analyse the determinants of domestic violence experienced by women. The bivariate analysis analysed the distribution of women by the form of domestic violence ever experienced by them and their background characteristics, including characteristics of their husband/partner and characteristic of the household. The Pearson chi-square test was carried out to test the association of the domestic violence experienced by women with the independent variables included in the analysis.

The multivariate analysis, on the other hand, employed classification analysis and multinomial logit regression analysis to highlight important predictors of different forms of domestic violence ever experienced by women interviewed. The response variable was the categorical variable having eight mutually exclusive and exhaustive categories as described in table 1. The reference category comprised of those women who reported that they never experienced any form of domestic violence. The classification analysis was carried out through the application of classification and regression tree (CRT) procedure (Breiman et al, 1984) which is a non-parametric procedure. On the other hand, parameters of the multinomial logit regression model were estimated through the maximum likelihood estimation procedure. The estimated regression coefficients and associated odd ratios facilitate the discussion on the odds of different categories of explanatory variables on the dependent variable – form of domestic violence ever experienced by women relative to the odds in the reference category. Concerns related to the interpretation of the increase or decrease in the odd ratio in the multinomial regression analysis have been highlighted in an earlier study (Gulati, Ramesh and Retherford 1996). Details regarding the formulation, estimation procedures, and proper interpretation of the effects in the multinomial regression analysis are given elsewhere (Retherford, 1993).

Bivariate Analysis

Results of the bivariate analysis depicting the association between the explanatory variables and different forms of domestic violence experienced by ever married women are summarised in table 3. The variation in the form of domestic violence experienced by ever married women is found to be statistically significantly associated with the variation in all the 15 explanatory variables included in the present analysis. The role of different characteristics of women, their husband/partner, and their household in experiencing different forms of domestic violence has also been found to be different. For example, more than 20 per cent of divorced/separated women interviewed reported that they experienced all the three forms of domestic violence compared to less than 3 per cent of the currently married women and around 4 per cent of the women who were widow. This observation suggests that the domestic violence experienced by these women may possibly be a cause for the divorce or the separation of these women from their husband/partner.

Similarly, more than 22 per cent of the ever married women who informed that their husband/partner was alcoholic reported experience of some form of physical violence and more than 7 per cent reported experience of all the three forms of domestic violence compared to, respectively, around 13 per cent and less than 2 per cent of the women who reported that their husband/partner was not alcoholic. Alcohol use by the husband/partner appears to be a major factor in domestic violence experienced by women.

Education of the woman appears to have an impact on the experience of domestic violence as more than 82 per cent of women who had higher level of education reported that they did not experience any form of domestic violence compared to less than 62 per cent of the women who had no education. Women occupation also has a strong impact on the experience of domestic violence. Almost 80 per cent of women who were in some professional occupation reported that they did not experience any domestic violence compared to just around 60 per cent of those women who had either agriculture or labour as their occupation. Interestingly, more than 73 per cent of those women who had no occupation also reported they did not experience any domestic violence. On the other hand, having a living son or having a bank account did not appear to have any impact on the experience of domestic violence.

The education and occupation of the husband/partner have also been found to be associated with the domestic violence experienced by women interviewed. The proportion of women who experience any form of domestic violence was comparatively low in women whose husband/partner was having higher education compared to women whose husband did not have any education. Similarly, the proportion of domestic violence experienced by those women whose husband/partner was having agriculture or labour as occupation compared to women whose husband/partner was having a professional occupation. Finally, household characteristics have also been found to have a say. The proportion of urban women reporting experience of domestic violence was substantially lower than the proportion reported by rural women. The proportion reporting experience of domestic violence was the highest in Hindu women compared to women of Muslim and other religions. Similarly, the proportion of women experiencing domestic violence was the household in the poorest households but the lowest in the richest households.

Table 3: Distribution of women by different forms of domestic violence experienced and background characteristics.

Background characteristics	Proportion (per cent) of women by domestic violence experienced								Unweighted N
	No experience	Only emotional	Only physical	Only sexual	Emotional and Physical	Emotional and sexual	Physical and sexual	Emotional, physical, sexual	
Age (χ^2=161.360, df=42, p=0.000)									
15-19	75.22	2.64	11.34	1.01	5.81	0.10	1.44	2.45	2082
20-24	72.39	2.58	14.36	0.78	5.68	0.20	1.32	2.70	8888
25-29	70.02	2.87	15.19	0.64	6.32	0.18	1.55	3.23	13386
30-34	68.53	2.55	16.23	0.64	6.58	0.26	1.76	3.45	12884
35-39	69.20	2.28	16.24	0.56	6.86	0.14	1.50	3.22	11589
40-44	68.32	2.76	16.48	0.58	7.15	0.26	1.43	3.03	8812
45-49	67.17	2.74	17.38	0.47	7.26	0.18	1.56	3.25	6210
Marital status (χ^2=1563.432, df=14, p=0.000)									
Married	70.12	2.60	15.81	0.64	6.28	0.20	1.52	2.83	60480
Widow	68.45	1.99	15.96	0.41	7.30	0.12	1.49	4.27	2412
Divorced/Separated	37.12	5.53	10.43	0.42	23.15	0.52	2.40	20.44	959
Age at marriage (χ^2=735.850, df=28, p=0.000)									
≤18	66.03	2.58	17.83	0.63	7.45	0.21	1.71	3.56	39192
19-22	73.35	2.66	13.64	0.66	5.54	0.16	1.38	2.60	13903
22-25	77.45	2.67	10.85	0.55	4.59	0.22	1.14	2.53	6488
25-28	78.59	2.48	10.74	0.58	4.15	0.11	1.17	2.18	2746
≥28	75.89	3.35	10.91	0.79	6.11	0.33	0.59	2.04	1522
Difference between age of husband/partner and woman (χ^2=76.440, df=21, p=0.000)									
< 3	71.26	2.53	15.10	0.64	5.77	0.21	1.50	2.97	25751
3-5	68.24	2.71	16.80	0.78	6.69	0.18	1.75	2.85	14133
5-7	70.01	2.48	16.59	0.45	6.49	0.18	1.34	2.46	8186
≥7	69.94	2.69	15.65	0.62	6.74	0.19	1.41	2.76	12410
Education (χ^2=1369.673, df=21, p=0.000)									
No education	61.76	2.72	19.92	0.64	8.61	0.21	2.11	4.02	18783
Primary	65.94	2.76	17.85	0.75	7.11	0.23	1.82	3.55	9302
Secondary	72.65	2.65	13.99	0.59	5.81	0.20	1.29	2.82	28943

Background characteristics	Proportion (per cent) of women by domestic violence experienced								Unweighted N
	No experience	Only emotional	Only physical	Only sexual	Emotional and Physical	Emotional and sexual	Physical and sexual	Emotional, physical, sexual	
Higher	82.81	2.04	8.78	0.62	3.43	0.15	0.57	1.61	6823
Occupation (χ^2=1223.278, df=35, p=0.000)									
No occupation	73.22	2.44	14.46	0.58	5.30	0.17	1.38	2.45	40615
Professional	79.61	2.25	10.02	0.53	3.73	0.06	0.77	3.02	1687
Service/Clerical	68.24	2.88	14.56	0.69	7.98	0.23	1.46	3.95	3895
Agriculture	59.65	3.07	19.98	0.69	9.81	0.31	2.06	4.44	12405
Labour	61.41	2.74	19.31	0.80	9.02	0.14	1.82	4.77	4237
Others	66.49	3.43	14.13	0.96	6.96	0.64	1.61	5.78	934
Living son (χ^2=149.739, df=7, p=0.000)									
No	73.01	2.67	12.87	0.70	6.31	0.18	1.35	2.92	15153
Yes	68.48	2.61	16.63	0.61	6.65	0.21	1.59	3.22	48698
Bank account (χ^2=56.786 df=7, p=0.000)									
No	69.19	3.02	14.46	0.75	6.84	0.16	1.85	3.73	11978
Yes	69.64	2.53	16.03	0.60	6.51	0.21	1.46	3.02	51873
Education of husband/partner (χ^2=1296.587, df=21, p=0.000)									
No education	60.19	2.98	19.88	0.62	9.24	0.19	2.02	4.87	11628
Primary	63.78	3.00	18.43	0.64	7.87	0.27	2.06	3.96	9268
Secondary	71.47	2.52	15.03	0.67	6.00	0.18	1.40	2.73	33902
Higher	80.69	2.17	10.19	0.52	3.76	0.22	0.83	1.62	8819
Alcohol use by husband/partner (χ^2=4042.445, df=7, p=0.000)									
No	76.11	2.51	13.29	0.57	4.65	0.16	1.08	1.62	46019
Yes	52.64	2.91	22.05	0.79	11.52	0.30	2.70	7.10	17832
Occupation of husband/partner (χ^2=702.112, df=28, p=0.000)									
Professional	80.40	2.45	9.76	0.53	3.84	0.13	0.82	2.07	4735
Service/Clerical	74.24	2.61	13.10	0.73	5.30	0.21	1.33	2.49	13430
Agriculture	65.86	2.75	17.58	0.67	7.75	0.18	1.73	3.48	23834
Labour	67.49	2.43	17.47	0.55	6.82	0.22	1.65	3.37	18428
Others	73.07	3.01	12.27	0.58	5.81	0.26	1.26	3.74	3424

Background characteristics	Proportion (per cent) of women by domestic violence experienced								Unweighted N
	No experience	Only emotional	Only physical	Only sexual	Emotional and Physical	Emotional and sexual	Physical and sexual	Emotional, physical, sexual	
Residence (χ^2=146.463, df=7, p=0.000)									
Rural	68.33	2.67	16.36	0.65	6.88	0.20	1.63	3.28	48363
Urban	73.39	2.46	13.80	0.56	5.60	0.20	1.24	2.76	15488
Religion (χ^2=447.511, df=14, p=0.000)									
Hindu	68.04	2.51	16.82	0.62	7.04	0.16	1.56	3.25	48548
Muslim	70.34	3.10	14.66	0.67	5.91	0.30	1.90	3.12	7585
Others	78.36	2.84	9.96	0.67	4.30	0.34	1.01	2.51	7718
Standard of living (χ^2=1226.190, df=28, p=0.000)									
Poorest	61.42	2.65	20.19	0.67	8.31	0.23	2.05	4.47	13222
Poor	66.33	2.86	17.09	0.80	7.17	0.21	1.74	3.80	13566
Middle	68.94	2.50	16.37	0.71	6.73	0.21	1.63	2.93	12977
Rich	72.53	2.80	14.01	0.51	6.11	0.18	1.31	2.56	12383
Richest	80.04	2.25	10.28	0.44	4.23	0.16	0.84	1.77	11703
All	69.56	2.62	15.74	0.63	6.57	0.20	1.53	3.15	63851

Source: Authors

Multivariate Analysis

The multivariate analysis was carried out in two parts. The first part was related to the classification of women into mutually exclusive and exhaustive groups in terms of their characteristics and characteristics of their husband/partner and household in such a way that domestic violence experienced by women of different groups is different. The classification and regression tree (CRT) technique (Breiman et al, 1984) was used for the purpose. The exercise revealed that 63581 ever married women may be classified into 8 mutually exclusive and exhaustive groups in terms of their individual, husband/partner and household characteristics and the experience of different forms of domestic violence. Results of the classification exercise are presented in table 4. An important observation of the table 4 is that women were categorised in terms of only seven of the 15 explanatory variables. Variation in the remaining eight explanatory variables contributed little to the variation in the experience of domestic violence across different categories of women. The classification exercise, therefore, suggests that the factors influencing the experience of domestic violence should be explored in terms of the following seven explanatory variables only and the remaining eight explanatory variables can be excluded from the analysis:

1. Current marital status
2. Age at first cohabitation
3. Education of the woman
4. Occupation of the woman
5. Use of alcohol by husband/partner
6. Religion of the household
7. Standard of living of the household

Table 4 also indicates that the proportion of ever married women who reported that they had never experienced any form of domestic violence varies widely across the 17 mutually exclusive and exhaustive group of women with distinct characteristics. This proportion who had never experienced any domestic violence is found to be the lowest in those women who were either divorced or separated at the time of the interview and whose husband/partner was alcoholic irrespective of their level of education, occupation and other characteristics, characteristics and their husband/partner, and characteristics of the household. On the other hand, this proportion has been found to be more than 80 per cent in four groups of women identified through the classification exercise. The common characteristic of the women of all these four groups is the husband/partner of the woman was not alcoholic, although other characteristics of the women of the four groups were different. The classification exercise also confirms that the use of alcohol by the husband/partner of the woman is a prime factor in the domestic violence experienced by women interviewed. Another important observation of table 4 is that the current marital status of the women did not matter in terms of the experience of any form of the domestic violence when the husband/partner of the woman was not alcoholic. In women having affiliation to religions other than Hindu and Muslim religion, less than 17 per cent of the women reported experience of any form of domestic violence irrespective of any of their own characteristics or characteristics of their husband/partner or household. The use of alcohol appears to be the great divide between women who experienced and who not experienced any form of domestic violence.

Table 4: Classification of women by their individual characteristics, characteristics of husband/partner, household characteristics and their religious affiliation and the proportion of women in different groups not experiencing any form of domestic violence.

SN	Characteristics of the woman, her husband/partner, and her household							Women not experienced any domestic violence (Per cent)	Number of women
	Marital status	Age at marriage	Education	Occupation	Husband/ Partner alcoholic	Religion	Standard of living		
1	Divorced/ Separated	All	All	All	Yes	All	All	21.6	564
2	Married Widow	All	No education Primary	Agriculture Labour Others	Yes	Hindu Muslim	All	41.6	3456
3	Married Widow	All	No education Primary	No occupation Service/Clerical Professional	Yes	Hindu Muslim	All	48.3	4004
4	Married Widow	All	Secondary Higher	Service/Clerical Agriculture Labour	Yes	Hindu Muslim	All	48.5	2268
5	All	All	All	Agriculture Labour Others	Yes	Others	All	60.2	1039
6	Married Widow	All	Secondary Higher	No occupation Professional Others	Yes	Hindu Muslim	All	60.9	4735
7	All	All	No education Primary	Service/Clerical Agriculture Professional	No	All	All	65.6	5242
8	All	< 18	Secondary Higher	Agriculture Labour	No	All	All	67.4	2015
9	All	All	No education Primary	No occupation Labour	No	Hindu Muslim	Poorest Poor	69.9	9449

SN	Characteristics of the woman, her husband/partner, and her household							Women not experienced any domestic violence (Per cent)	Number of women
	Marital status	Age at marriage	Education	Occupation	Husband/ Partner alcoholic	Religion	Standard of living		
				Others			Middle		
10	Married Widow	All		No occupation Professional Service/Clerical	Yes	Others	All	72.9	1766
11	All	All	No education Primary	No occupation Labour Others	No	Hindu Muslim	Richest Rich	75.8	2886
12	All	<18	Secondary Higher	No occupation Professional Service/Clerical Other	No	All	Poorest Poor Middle Rich	76.4	6495
13	All	≥18	Secondary Higher	All	No	Hindu Muslim	Poorest Poor Middle Rich	79.7	9421
14	All	<18	Secondary Higher	No occupation Professional Service/Clerical Other	No	All	Richest	82.1	1901
15	All	All	All	All	No	Others	All	83.1	1671
16	All	≥18	All	All	No	All	Richest	86.8	6458
17	All	≥18	Secondary Higher	All	No	Others	Poorest Poor Middle Rich	87.0	1481

Source: Authors

Results of the multinomial logit regression analysis are presented in table 5 in terms of the odds of experiencing different forms of domestic violence by women having different background categories relative to the odds of experiencing different forms of domestic violence by women of the reference category. The regression coefficient (β) of the model depicts the additive effect of a unit change in the predictor variable on the log of odds of the response variable which means that exp(β) depicts the multiplicative effect on the odds-ratio or the ratio at which the odds of the response variable would respectively increase or decrease depending upon the positive or negative sign of the regression coefficient. The table shows that the current marital status and the educational status of the woman are the most important predictors of different forms of physical violence experienced by the women interviewed except a few exceptions. Currently married and currently widow women have statistically significantly lower risk of experiencing all but one form of domestic violence as compared to the risk experienced by divorced or separated women. It is only in case of only sexual violence that there appears no statistically significant difference in the risk of experience among the three categories of ever married women.

On the other hand, women having no education are estimated to have more than 43 per cent higher risk of experiencing some form of physical violence compared to women having higher education. Women without education have also been found to have more than 44 per cent higher risk of experiencing both emotional and physical violence and more than two times higher risk of experiencing both physical and sexual violence as compared to women having higher education. This observation suggests that women empowerment through universalising women education does matter in addressing the challenge of domestic violence experienced by women, particularly, any form of physical violence. However, education of the woman does not appear to have any impact on either only sexual violence or emotional and sexual violence experienced by the woman.

The effect of woman occupation on the risk of experiencing domestic experience by women has, however, not been found to be so strong, although the risk of experiencing any form of domestic violence is found to be relatively the lowest in women without any occupation relative to women engaged in some occupation. The relatively lower risk of experience of domestic violence experienced by women having no occupation may be explained in terms of the negative correlation between the level of education of the woman and her occupational status. Almost half of the women having secondary education had no occupation and this proportion was more than 15 per cent in women with higher education compared to only about 12 per cent in women having only primary education and 23 per cent in women having no education.

The other dominant factor in deciding the risk of experiencing domestic violence by women is the use of alcohol by their husband/partner. Women whose husband/partner was alcoholic were having statistically significantly higher risk of experiencing all forms of domestic violence except the sexual violence compared to women whose husband/partner was not alcoholic. Women whose husband/partner was no alcoholic were having more than 90 per cent lower risk of experiencing all the three forms of domestic violence compared to women who husband/partner was alcoholic. Similarly, the risk of experiencing physical and sexual violence in women whose husband/partner was not alcoholic was more than 60 per cent lower than the corresponding risk in women whose husband/partner was alcoholic.

Table 5: Results of the multinomial logistic regression analysis. The table shows the value of exp(β).

Characteristics		Form of domestic violence Reference category is no experience of domestic violence						
		Only emotional	Only physical	Only sexual	Emotional and physical	Emotional and sexual	Physical and sexual	Emotional, physical, sexual
Intercept	Intercept							
Current marital status	Currently married or living with partner	0.286	0.912	1.016	0.183	0.286	0.420	0.107
	Widow	0.193	0.713	0.555	0.149	0.150	0.299	0.109
	Divorced/Separated®	1	1	1	1	1	1	1
Age at marriage	<18	0.893	1.438	0.918	1.175	1.066	1.617	1.709
	18-21	0.913	1.231	0.683	0.976	1.074	1.425	1.404
	21-24	0.947	1.052	0.738	0.898	0.650	1.400	1.415
	24-27	0.907	0.979	0.683	0.711	1.315	1.143	1.096
	≥27 ®	1	1	1	1	1	1	1
Education	No education	1.477	1.726	0.819	1.790	1.089	2.601	1.675
	Primary	1.427	1.556	0.948	1.460	1.089	2.246	1.443
	Secondary	1.323	1.308	0.788	1.326	1.020	1.745	1.338
	Higher ®	1	1	1	1	1	1	1
Occupation	No occupation	0.688	0.973	0.596	0.786	0.272	0.839	0.488
	Professional	0.729	1.004	0.577	0.778	0.105	0.856	0.878
	Service/Clerical	0.849	1.074	0.758	1.175	0.377	0.949	0.692
	Agriculture	0.981	1.329	0.772	1.379	0.572	1.188	0.779
	Labour	0.835	1.294	0.887	1.202	0.244	1.024	0.736
	Others ®	1	1	1	1	1	1	1
Husband/Partner alcoholic	No	0.613	0.432	0.517	0.300	0.387	0.272	0.168
	Yes ®	1	1	1	1	1	1	1
Religion	Hindu	1.143	2.043	1.172	2.228	0.672	2.032	1.986
	Muslim	1.535	2.120	1.450	2.611	1.671	3.391	3.212

Characteristics		Form of domestic violence Reference category is no experience of domestic violence						
		Only emotional	Only physical	Only sexual	Emotional and physical	Emotional and sexual	Physical and sexual	Emotional, physical, sexual
	Others ®	1	1	1	1	1	1	1
Standard of living	Poorest	1.215	1.686	1.729	1.492	1.292	1.773	1.848
	Poor	1.295	1.499	1.978	1.413	1.194	1.663	1.771
	Middle	1.123	1.470	1.761	1.365	1.187	1.630	1.391
	Rich	1.250	1.266	1.205	1.276	1.048	1.364	1.259
	Richest ®	1	1	1	1	1	1	1

Remarks: ® Reference category. Statistically significant exp(β) ($p<0.05$) are highlighted.
Source: Authors

The household standard of living, measured in terms of the household wealth index, has also been found to be closely associated with the experience of domestic violence by women. The risk of experiencing all forms of domestic violence faced by women is found to be, in general, the lowest in the richest households, households having wealth index higher than the fifth quintile of the inter-household distribution of wealth index but relatively the highest in the poorest households, households having wealth index lower than the first quintile of the inter-household distribution of the wealth index, with only a few exceptions. Table 5 suggests that a major challenge to reducing and ultimately eliminating domestic violence against women is the challenge of reducing and ultimately eliminating household poverty.

Finally, religious affiliation has been found to have a strong effect on the domestic violence experienced by women. Among Muslim women, the risk of experiencing any form of domestic violence is found to be the highest relative to Hindu women and women of other religions. Muslim women have more than three times higher risk of experiencing all the three forms of domestic violence compared to the risk experienced by women of other religions whereas Hindu women have almost two times higher risk. It appears that the values accorded to women in different religions is a strong influencing factor as far the domestic violence against women is concerned. However, ethnicity does not appear to have any influence on the sexual violence experienced by women.

Conclusions and Recommendations

To the best of our knowledge, the present analysis is the first which classifies the domestic violence experienced by women into eight mutually exclusive and exhaustive categories. The paper reveals that the risk of experiencing different forms of domestic violence by women is determined primarily by the level of education of the woman, use of alcohol by the husband/partner of the woman, her standard of living and her religious affiliation. The only exception is the sexual violence which does not appear to be influenced by these factors. In other words, the risk of domestic violence experience by women emanates from a complex web of individual factors, social and economic factors and factors related to the behaviour of the husband/partner which suggests that addressing the problem of domestic violence against women is a challenging preposition that requires a multidimensional approach.

The most common form of the domestic violence ever experienced by Indian women is the physical violence which has been found to the clearly associated with the educational status of the woman after controlling other characteristics. Since the main plank of women empowerment is the universalisation of women education, it may be argued that women empowerment through universalising women education does matter in addressing the challenge of domestic violence against women in India It is, however, clear from the analysis that universalising women education, alone, may not be sufficient enough to effectively addressing the challenge of domestic violence against women, as another important factor that influence the domestic violence experienced by women is the use of alcohol by the husband/partner of the woman. Similarly, the standard of living of the

household has also been found to be a strong predictor of the domestic violence experienced by women.

The analysis suggests that a multi-dimensional approach is needed to address the challenge of the domestic violence experienced by women. The findings of the present analysis are in line with the comprehensive global agenda adopted in 1995 by the Beijing Platform for Action which has identified 12 critical areas of concern regarding women empowerment and alleviating domestic violence against women and which has been reiterated in the Beijing+15 and Beijing+30 conferences (United Nations, 2015; 2026).

An interesting observation of the present analysis is that risk of experiencing sexual violence has, in general, not been found to be associated with such factors as education and occupation of women, use of alcohol by their husband/partner, standard of living and religious affiliations. It is generally argued that sexual violence against women is primarily driven by unequal power dynamics, patriarchal norms, and structural gender inequality within the household that result in harmful gender stereotypes, low education, alcohol abuse, and acceptance of violence as a means of control, among others. The present analysis, however, suggests that these factors are not main determinants of sexual violence experienced by Indian women. It may be emphasised that unlike the physical violence, collecting information about sexual violence is quite tricky as "rough sex" or consensual violence or pain is often accepted as a method of increasing sexual pleasure. It is, therefore, crucial to differentiate consensual rough sex from non-consensual sexual violence.

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Demographic Transition, Migration and Sustainability in Assam, India: Population Dynamics, Inequalities and Development Outcomes

Saurav Dey

Abstract

Assam is experiencing rapid demographic transition, and complex migration flows that significantly impact its sustainability and socio-economic inequalities. This study analyses recent fertility decline, mortality improvements, migration patterns, and multidimensional poverty in Assam. Total fertility rate has dropped below the replacement level to 1.87, while infant mortality rate declined to 32 per 1,000 live births. Migration data reveal over 10 million migrants, primarily internal, driving urban growth concentrated in Guwahati and other towns, leading to land-use change and environmental pressures. Multidimensional poverty decreased from 36.97 per cent to 22.47 per cent, yet remains high in rural, tribal, and environmentally vulnerable areas. The demographic dividend window (2020-2040) offers growth potential if inclusive policies address spatial disparities, environmental risks, and labour market challenges.

Introduction

Sustainable development in India is unfolding under conditions of rapid demographic change, persistent inequalities and intense pressure on natural resources and livelihoods. Assam offers a particularly compelling lens on these dynamics because of its distinctive population history, ethnic and linguistic diversity, and exposure to recurrent environmental shocks such as floods and riverbank erosion in the Brahmaputra and Barak valleys. The demographic trajectory of the state, along with migration patterns and uneven development outcomes raises fundamental questions about how population dynamics shape and is shaped by the pursuit for sustainability.

Assam has experienced steady population growth over the recent decades, accompanied by changes in fertility, mortality and age structure that places the state at an intermediate stage of demographic transition relative to other states of India. The population density of the state increased from 340 persons per square kilometre in 2001 to about 398 persons per square kilometre in 2011, indicating continued pressure on the land and the ecosystem in a region that is already ecologically fragile. At the same time, the share of the urban population, though still below the national average, increased from 12.9 per cent in 2001 to 14 per cent in 2011, reflecting gradual but significant urbanisation and the emergence of towns and peri-urban areas along key transport and economic corridors.

These shifts suggest that Assam is undergoing a complex transition in which traditional rural, agrarian livelihoods coexist with increasing urban and non-farm livelihood opportunities, with important implications for sustainability.

Demographic transition in Assam is reflected in notable improvements in survival and reduction in fertility, even as gaps remain across districts and across social groups within. Between 2015-2016 and 2019-2021, the infant mortality rate in the state declined from about 48 deaths per 1,000 live births to around 32 while the under-five mortality rate fell from roughly 57 to 39 per 1,000 live births, indicating progress in child survival and improvement in health services (Government of India, 2022). More than one-quarter of the population of the state is below 15 years of age, suggesting that demographic momentum will continue to drive population growth in the coming years. The young age structure of the population of the state also offers a demographic window of opportunity for hastening the pace of development if education, skills, and employment opportunities can keep the pace with the demand. However, there are marked inter-district differences within the state in fertility levels and age-specific fertility patterns, with some districts progressing faster than others in terms of fertility transition, which can reinforce spatial and social inequalities in development outcomes.

Migration is another critical dimension of the population dynamics of Assam that intersects with urbanisation, labour markets, environmental vulnerability, and identity politics. Data available from 2001 and 2011 population censuses show that the number of in-migrants in Assam increased from about 6.8 million in 2001 to more than 10.6 million in 2011, reflecting a mix of internal migration within the state, in-migrants from other parts of India and neighbouring countries and circulation between rural and urban areas. Urban centres such as Guwahati have become important destinations for migrants seeking employment in services, construction, trade, and informal activities. Migration has contributed to the growth of slums and peri-urban settlements that are often inadequately serviced and exposed to environmental risks. At the same time, out-migration of youth and working-age adults from rural and ecologically stressed areas to urban areas has altered population age structure at the place of origin and at the place of destination and has influenced care arrangements and local labour availability, with implications for both agricultural sustainability and social support systems.

The development outcomes of Assam reveal persistent and multidimensional inequalities that intersect with these demographic and migratory trends. State-level human development indicators mask substantial disparities across districts, ethnic and linguistic communities, Scheduled Tribes and other marginalised groups, as well as between urban and rural areas. National and state reports on multidimensional poverty indicate that, although poverty has declined in recent years, a significant share of the population continues to experience overlapping deprivations in health, education and living standards, with particularly high concentrations in rural and riverine “char” areas, tea-garden communities and border districts (Government of India, 2022; Government of Assam, 2014). These patterns suggest that population growth, migration and demographic transition interact with structural inequalities, shaping both exposure to risks and access to opportunities.

From the sustainability perspective, the interplay between demographic change, environmental stress and economic transformation is particularly salient in Assam.

Recurrent floods, erosion, and climate-related hazards displace people, destroy land and assets and drive cycles of temporary and permanent migration, thereby reshaping settlement patterns, and livelihood strategies. Expanding urbanisation and infrastructure development can generate new economic opportunities but also lead to land-use change, congestion and pressure on water, waste, and transport systems if they are not planned and governed inclusively.

The demographic transitions and migration patterns in Assam present both substantial opportunities and critical challenges for the sustainable development of the state. The population of Assam has expanded dramatically over the last century, with its demographic composition increasingly shaped by natural population growth alongside complex internal and cross-border migration flows. These dynamics have altered landholding patterns, shifted the linguistic and cultural landscape of the state and intensified pressure on natural resources, infrastructure, and social services. The evolving religious demographics and regional population imbalances have heightened social tensions and raised concerns about identity, equity, and inclusion.

At the same time, Assam stands at a pivotal moment with a window of demographic dividend projected between 2020 and 2040. The potential to harness the economic growth and human capital benefits of a young population can be transformative, provided strategic investments in education, skill development and healthcare are made equitably across diverse social groups and geographic locations. However, the persistence of multidimensional poverty, pronounced health and education disparities, environmental vulnerabilities, such as frequent floods and erosion along urban stress call for a nuanced understanding of how demographic transition and migration interact with sustainability challenges.

It is well known that without rigorous, evidence-based analyses, linking demographic trends and migration patterns to inequalities in development outcomes, policy responses may be reactive, fragmented, or exclusionary. It is, therefore, important to provide empirically grounded insights into how population dynamics of Assam correlates with the spatial and social disparities in health, education, livelihoods, and poverty in the state. The findings of such an analysis may inform more inclusive, context-sensitive policies and programmes that strategically harness demographic opportunities while mitigating the risks posed by migration and environmental stress, thereby advancing sustainable and equitable development of Assam.

The above considerations constitute the rational for the present paper which attempts to analyse how the evolving demographic dynamics and migration patterns in Assam are linked to spatial and social inequalities in development outcomes and to key dimensions of sustainable development. More specifically, the paper has the following specific objectives:

1. To describe recent trends in fertility, mortality, and age structure in Assam, highlighting inter-district and rural–urban differentials.
2. To examine internal and cross-border migration flows and their relationship with urbanisation, environmental stress, and labour market changes.
3. To explore how population dynamics is associated with disparities in health, education, livelihoods, and multidimensional poverty in the state.

Review of Literature

Existing research on the demographic dynamics of Assam reveals a state amid fertility and mortality transitions yet marked by persistent regional disparities and migration pressures that challenge sustainability. Studies using NFHS data document that total fertility rate of Assam has declined from 3.5 live births per woman of reproductive age in the early 1990s to 1.87 during the period 2019-2021(Government of Assam, 2014). Below replacement fertility in Assam is however associated with marked inter-district variation with district-level clustering showing high fertility pockets in Muslim-majority and rural areas alongside faster decline in urban areas and districts having high concentration of Scheduled Tribes population (Baruah et al, 2025). Mortality analyses highlight improvements in infant mortality from 48 to 32 infant death per 1,000 live births between 2015-2015 and 2019-2021 but persistent gaps linked to incomplete civil registration (57 per cent for under-5 deaths) and vulnerabilities in tea gardens and char communities (Government of Assam, 2014).

Studies on migration in Assam emphasise the role of the state both as a source and a destination. The data from the 2011 population census data indicates that there were more than 10.6 million inhabitants in the state whose place of enumeration was different from the place of birth at the time of enumeration. Reasons for migration include urbanisation (14 per cent of the migrants lived in the urban share) and environmental stressors like floods. Studies link 2010-2020 inflows to 23 per cent higher land-use change, 4.8 per cent annual urban expansion in high-migration zones, air quality degradation (PM2.5 up 45 per cent) and strained services, exacerbating ethnic tensions and informal labour saturation (Singh, 2025). Circular migration of flood survivor's underscores livelihood shifts from agriculture to urban construction, amplifying vulnerability in peri-urban slums (Kakati, et al, 2025).

On inequalities and sustainability, scholarships highlight multidimensional deprivations among Scheduled Tribes (high marginal workers, low literacy, firewood dependence) and spatial divide in health and education facilities and poverty that intersect with demographic shifts (Government of Assam, 2016; Talukdar, 2025). Human development reports of the state highlight uneven demographic dividend due to youth out-migration and gender gaps (27.8 per cent secondary dropout for girls) (Government of Assam, 2014). Broader Indian transition models caution that the state faces intermediate stage risks of stalled progress in the absence of inclusive policies (Singh et al, 2025; Jadhav 2026).

Source of Data

The study is based on the secondary data available from different sources including 2011 population census, Sample Registration System, different rounds of the National Family Health Survey (Government of India, 2022), Economic Survey of Assam (Government of Assam, 2025), Assam State Human Development Report (Government of Assam, 2014) and estimates of multidimensional poverty in the state prepared by the Government of India (2023). The last population census in India was carried out in 2011. The scheduled 2021 population census could not be carried out but the next census is due in 2027. The data

available from the population census is dated. The Sample Registration System is the only system in India which provides annual estimates of key fertility and mortality indicators of Assam. However, the system does not provide estimates of fertility and mortality for the districts of the state. The National Family Health Survey Programme has been instituted by the Government of India five rounds of the survey have so far been carried out. The first three rounds of the survey provided state level estimates of selected population and health related indicators but the fourth and fifth rounds of the survey have provided district level estimates also. Estimates of poverty for the districts of the state are prepared by the Government of India while other data used in the present analysis have been taken from the publications of the Government of Assam. All data used in the present study are anonymised, and publicly available. Therefore, no ethical clearance was required.

Methodology

The study adopts a quantitative research design based entirely on population and development related data from different secondary sources. It employs a combination of descriptive, spatial, and inferential statistical analysis techniques to examine the linkages of demographic transition in Assam with multidimensional poverty, human development, migration patterns, and associated socio-economic and environmental implications. Descriptive analysis of the demographic transition is primarily confined to the description of the change in selected demographic indicators over time in the state. On the other hand, district-level mapping and visualisation of key demography and development indicators has been done to highlight the spatial dimension of demography and development within the state. Both bivariate and multivariate statistical analysis tools have been used to analyse the relationship between demographic dynamics and development scenario in the state based on the variation in demographic patterns and development outcomes across the districts of the state. The bivariate analysis examined the relationship between such variables as female literacy and TFR, poverty headcount and infant mortality, migration rate, and urban expansion. On the other hand, multivariate regression analysis has been carried out to explore how inter-district variation in the demographic scenario is associated with the inter-district variation in the development situation as described through female education, household living conditions measured in terms of the wealth index estimated for the purpose, religious composition of the district population, degree of urbanisation in the district based on the characterisation of the population as urban and rural according to the classification adopted at the 2011 population census, access to health care facilities, the extent of exposure to floods by the population of the district, and the employment status of the working age population of the district. The reliability of the multivariate regression model was examined through testing the multicollinearity among the independent or explanatory variables used in the analysis via variance inflation function (VIF), heteroscedasticity tests, and unadjusted and adjusted proportion of the variance in the original data explained by the regression model (R^2 and adjusted R^2). The statistical significance of the parameters of the model was tested at 95 per cent and 99 per cent level of significance. The methodology adopted for the present analysis provides a comprehensive understanding of the demographic transition in Assam highlighting, at the same time, spatial inequalities in demography and development and resulting policy implications.

Findings

Demographic Transition

The population of Assam increased from 26.66 million in 2001 to 31.21 million in 2011, recording a decadal growth of more than 17 per cent which is slightly below the national average of 17.6 per cent. There has been a marked slowdown in the growth of the population of the state during the decade 2001-2011 compared to decade 1991–2001 when the population of the state increased by more than 18.8 per cent. It is projected that the population of the state would have crossed 36 million by the year 2026 *Government of India, 2020). Within the state, population growth during 2001-2011 varies widely across districts from just around 5 per cent in district Kokrajhar to more than 24 per cent in district Dhubri (Figure 1). There are three districts whereas population increased by less than 10 per cent during 2001-2011 but more than 20 per cent in 10 districts indicating substantial inter-district migration.

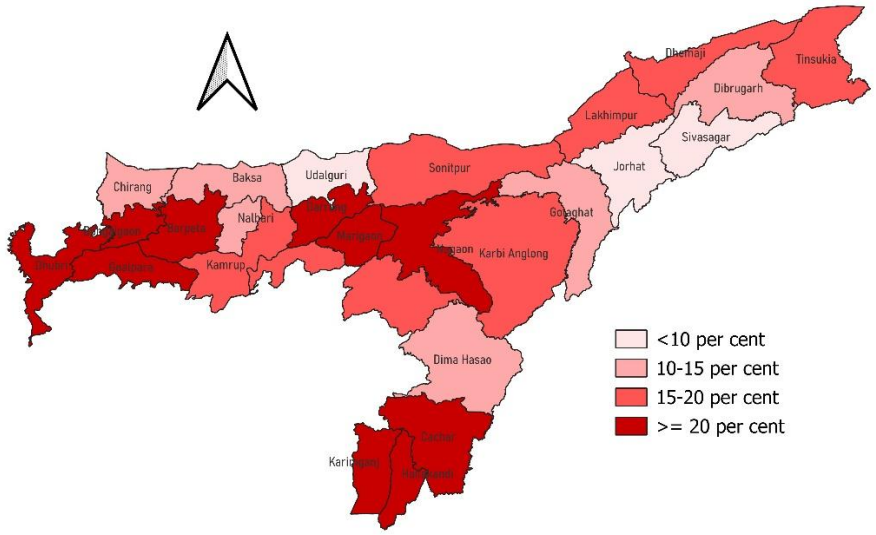

Figure 1: Decadal population growth in districts of Assam, 2001-2011.
Remarks: There were 27 districts in Assam at the time of 2011 population census.
Source: Author

There has a change in the age composition of the population which has implications for development. The proportion of the young population, population below 15 years of age decreased from 32 per cent in 2005-2006 to 26 per cent in 2019-2021 according to the National Family Health Survey while population aged 60 years and older remained virtually unchanged leading to an increase in the proportion of working age population from 58 per cent to 64 per cent. The increase in the proportion of working age population provides a demographic window of opportunity for the state.

Assam exhibits a demographic transition that is characterised by declining fertility and mortality, although inter-district disparities persist that challenge the uniform progress toward sustainability. The total fertility rate (TFR) in the state has fallen below the replacement level to around 1.9 live births per woman of childbearing age according to the latest round of NFHS (Government of India, 2022). Estimates available from the Sample Registration System also suggest that fertility in the state is now below the replacement level (Table 1).

Table 1: Trend in TFR in Assam.

Year / Period	Source	TFR (Children per Woman)	Remarks
1992-93	NFHS-1	3.5	High fertility phase
1998-99	NFHS-2	2.3	Sharp decline
2005-06	NFHS-3	2.4	Minor fluctuation
2015-16	NFHS-4	2.2	Approaching replacement level
2019-21	NFHS-5	1.9	Below replacement level (2.1)
2018	SRS	2.2	SRS annual estimate
2019	SRS	2.2	SRS annual estimate
2020	SRS	2.1	Continued decline
2023	SRS	2.0	Latest available SRS figure

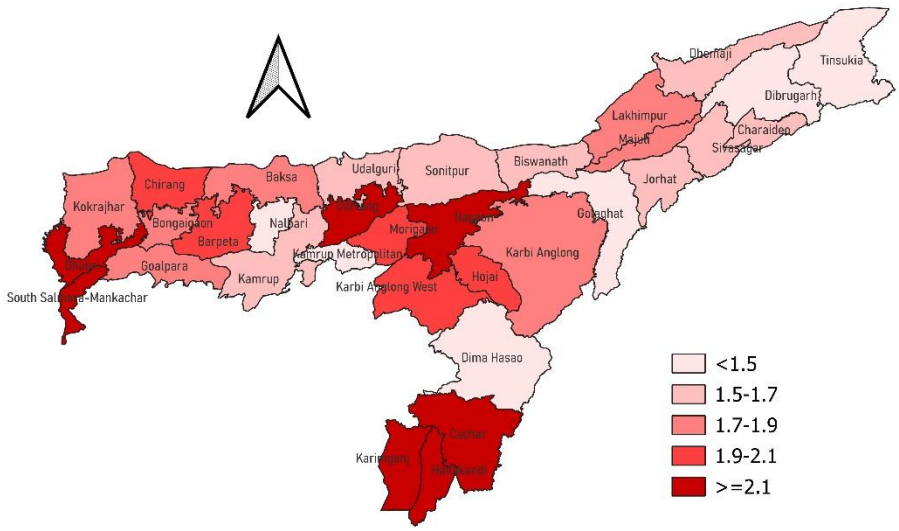

Figure 2: Inter-district variation in TFR in Assam, 2019-2021.
Remarks: There were 33 districts at the time of NFHS fifth round in Assam.
Source: Author based on the estimates prepared by Borah and Borah (2018).

Within the state, TFR varies widely across the districts (Figure 2). There are seven districts where TFR was above the replacement level according to the latest (2019-2021) round of the National Family Health Survey (Begum and Sinha, 2025). On the other hand, there are 3 districts in which TFR was well below the replacement level (TFR=2.1) according to the survey. District-level analysis reveals clustering of districts. High-fertility districts like Dhubri and South Salmara-Mankachar contrast with very low fertility districts like Kamrup Metro (1.2), because of marked variation in social and economic development and social class composition of population.

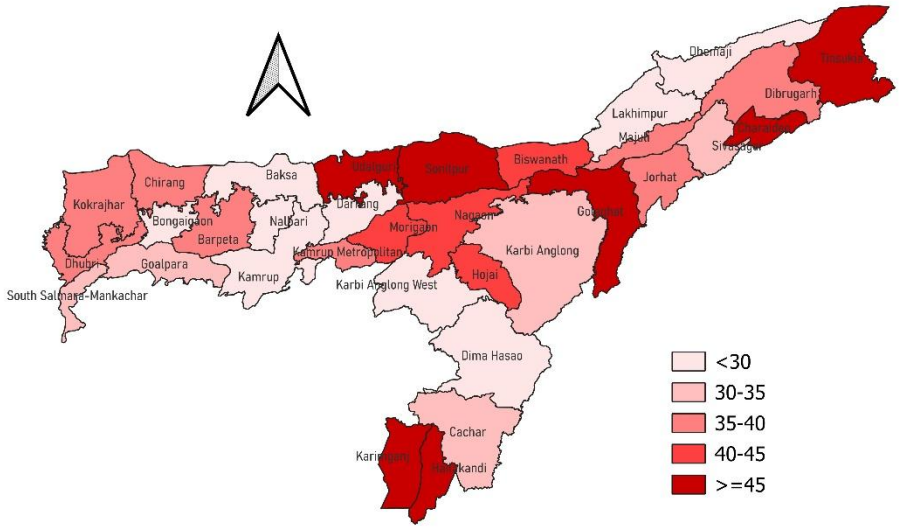

Figure 3: Inter-district variation in Under-5 mortality rate in Assam, 2019-2021.
Remarks: There were 33 districts at the time of NFHS fifth round in Assam.
Source: Author, based on the estimates prepared by Begum and Sinha (2025).

Mortality improvements are equally pronounced. The life expectancy at birth in Assam increased from 63.3 years during 2009-2013 to 68.6 years during 2019-2023 according to the estimates available from the Sample Registration System (Government of India, 2025a). The life expectancy at birth in the state, however, remains lower than life expectancy at birth in India. The infant mortality rate (IMR) dropped from 41 to 30 infant deaths per 1000 live births between 2018 and 2023 (Government of India, 2025b) while the under-five mortality rate (U5MR) dropped from 57 during 2015-2016 to 39 under-five deaths per 1000 live births during 2019-2021 according to the National Family Health Survey, although it varies widely across districts (Figure 3) ranging from less than 20 under-five deaths for every 1000 live births in district Bongaigaon and Nalbari to more than 50 under-five deaths for every 1000 live births in districts Sonitpur and Hailakandi.

Migration flows constitute a dominant force in shaping the distribution of population within Assam, across districts. According to the 2011 population census, there were 10.6 million migrants (32 per cent of total population) in the state in the sense that their place of birth was different from the place of enumeration. Within the state, movement of people from rural to urban areas has fuelled urbanisation. The proportion of the urban population to the total population in the state increased from 12.9 per cent in 2001 to 14.1 per cent in 2011. Rural to urban migration is estimated to have accounted for around 65 per cent of the urban population growth in the state between 2001-2011). The degree of urbanisation, measured in terms of the proportion of urban population to the proportion of rural population, however, is not the same in all districts of the state. According to the 2011 population census, the urban population in district Kamrup Metro was almost five times the rural population of the district whereas, in district Baska, the urban population was just around 1 per cent of the rural population of the district. Besides district Kamrup Metro, there was no other district in the state in 2011 where urban population was more than rural population of the district (Figure 4).

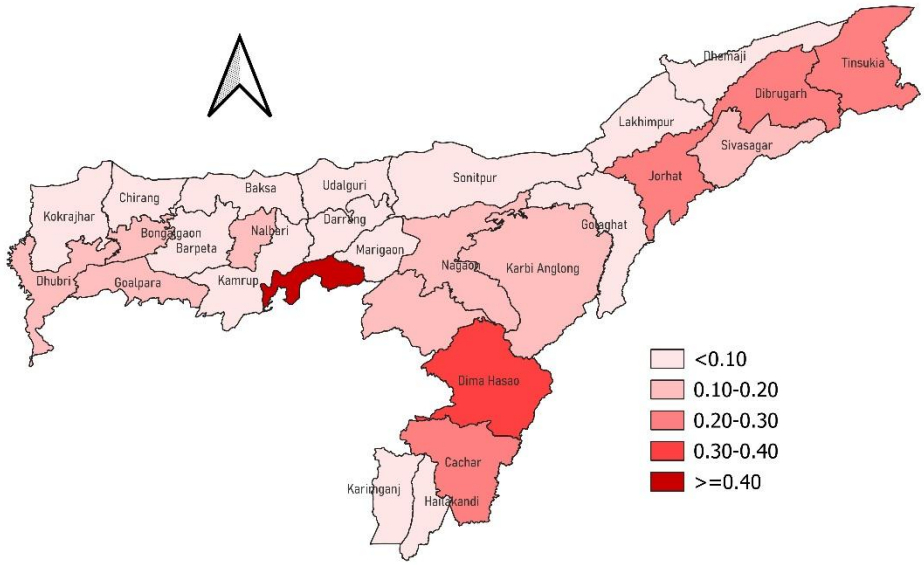

Figure 4: Degree of urbanisation in districts of Assam.
Remarks: There were 27 districts in Assam at the time of 2011 population census.
Source: Author

Cross-border and inter-state inflows, including from Bangladesh and Bihar in border districts like Dhubri and Karimganj have contributed to accelerating population growth and increasing ethnic tensions. High migration zones in the state are primarily concentrated in the Barak Valley, Central Assam, and specific border districts that act as

gateways for both inter-state and international influxes. These zones have seen significant demographic changes in the recent past (Das and Chowdhury, 2026). There has also been out-migration of rural youths from some districts of the state resulting in the depletion of agricultural labour and change in the dependency ratios.

Inequality and Sustainability

There has been a marked decrease in the poverty headcount ratio in the state from almost 37 per cent in 2013-2014 to around 22 per cent in 2023. There is, however, wide variation in the poverty headcount ratio within the state with comparatively higher poverty headcount ratio in the rural population (27 per cent), in the Scheduled Tribes population (35 per cent) and in the riverine areas of the state. According to the estimates prepared by the Government of India, the multidimensional poverty index (MPI) in the state was 0.156 in 2015-2016 which reduced to 0.086 in 2019-2021. The MPI in the state (0.086) is substantially higher than the MPI in India (0.066) during the period 2019-2021 (Government of India, 2023). Within the state MPI varies widely across districts from the lowest (0.024) in district Kamrup Metro to the highest (0.164) in district Hailakandi. There are nine districts in the state where MPI is estimated to be more than or equal to 0.100 according to the estimates prepared by the Government of India (Figure 5).

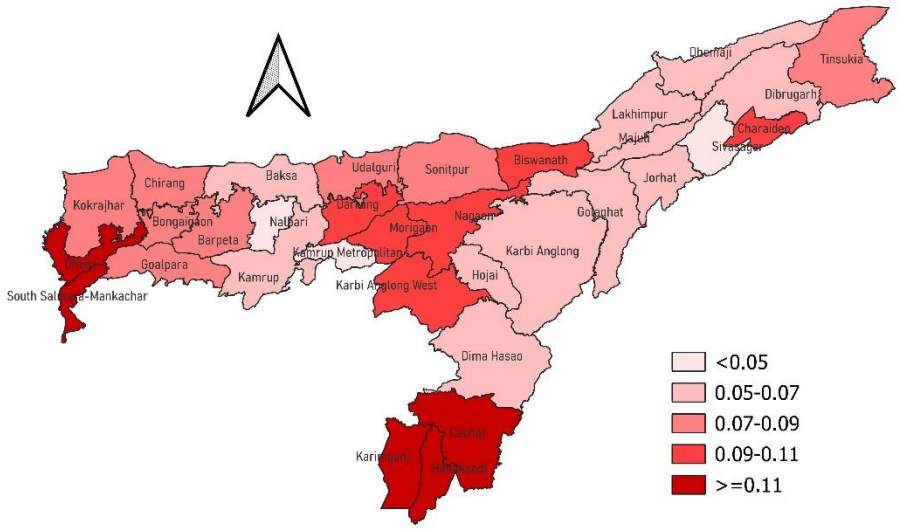

Figure 5: Inter-district variation in multidimensional poverty index (MPI) in Assam during 2019-2021.

Remarks: There were 33 districts in Assam at the time of the fifth round of National Family Health Survey (NFHS, 2019-2021).

Source: Author, based on Government of India (2023).

Finally, we carried out multivariate regression analysis to explore how inter-district variation in selected indicators of development are related to inter-district variation in selected explanatory indicators after controlling inter-district variation in a set of independent variables. For example, we analysed how variation in MPI is related to the variation in rural TFR across districts after controlling inter-district variation in female literacy, wealth index, degree of urbanisation, access to health facilities, religion, and district development index. The district of the state were divided into two categories – districts having rural TFR above the state average were coded as 1 and districts having rural TFR equal to or below states average were coded as 0. The analysis suggests that the MPI in districts in which rural TFR is higher than the state average is, on average, more than 17 per cent higher than MPI in those districts in which rural TFR is lower than the state average, after controlling the variation across districts in female literacy rate, wealth index, degree of urbanisation, access to health facilities, religion and the level of development across districts as measured by district development index (Table 2). This observation suggests concentration of poverty in those districts in which fertility is above the state average. Similarly, MPI in districts which are prone to floods is found to be around 30 per cent higher on average as compared to districts which are not prone to floods. This means that environmental exigencies have a strong impact on the incidence of multidimensional poverty in the state.

On the other hand, the U5MR has also been found to be around 25 per cent higher, on average, in districts which are prone to floods as compared to districts which are not prone floods. Similarly, U5MR is found to be almost 10 per cent higher, on average, in those districts which are classified as either tea garden districts or char (riverine) districts compared to districts which are not classified as either tea garden or Char (riverine) districts. Tea garden districts are centred in Upper Assam, while Char (riverine) districts are located along the Brahmaputra River and are prone to floods. Since U%MR is almost linearly related to the life expectancy at birth, the relationship of the environmental stress on population health of the state is obvious.

The regression analysis also reveals that an increase in the inter-district variation in migrants' inflow rate contributes to the increase in the inter-district variation in income inequality as measured through the Gini index of income inequality. Similarly, the analysis suggests that an increase in the inter-district variation in migration from rural to urban areas contributes to an increase in the inter-district variation in the urban gross domestic product (GDP) leading to increase in the income inequality across the districts of the state. Finally, the regression analysis also indicates that inter-district variation in the participation of the youth population, population aged 15-29 years, in social and economic productive activities is found to be negatively related to the inter-district variation in the proportion of youths (15-29 years) who are Scheduled Tribes and the proportion of youths who are female. The analysis, thus, reveals that even after controlling inter-district variation in such variables as female literacy urbanisation, standard of living as measured through the wealth index, ethnic composition of population and access to health facilities, a strong relationship is depicted between demographic transition and sustainable development in the state. Similarly, sustainable development in the state appears to be strongly contingent upon natural or environmental factors such as floods. Migration from rural to urban areas in search of better livelihood opportunities also appear to have resulted in an increase in income disparities within the state.

Table 2: Multivariate regression analysis results – key determinants of poverty, child mortality, inequality, and labour force participation in Assam.

Dependent Variable	Independent Variable	B	SE	β	't'	'p'	Interpretation
Multidimensional Poverty (MPI)	Rural TFR above or below state average	0.172	0.041	0.214	4.195	<0.001	17.2per cent higher poverty intensity
Multidimensional Poverty (MPI)	Flood-prone or not flood prone district	0.298	0.055	0.267	5.418	<0.001	29.8per cent higher MPI
Under-5 Mortality Rate (U5MR)	Flood-prone or not flood prone district	12.45	3.82	0.231	3.259	0.001	25per cent higher U5MR
Under-5 Mortality Rate (U5MR)	District having or not having Tea Garden/Char Area	9.87	4.12	0.178	2.395	0.017	Significantly higher mortality
Gini coefficient of income inequality	Migration inflow rate (per cent)	0.062	0.018	0.289	3.444	<0.001	Widens Gini by 0.062 points
Urban GDP growth (per cent)	Migration inflow rate (per cent)	0.347	0.091	0.251	3.813	<0.001	Positive boost to urban GDP
Labour force participation rate in population aged 15-29 years	Proportion of Scheduled Tribes aged 15-29 years above or below state average	-0.392	0.074	-0.312	-5.297	<0.001	39.2per cent lower participation
Labour force participation rate in population aged 15-29 years	Proportion of females aged 15-29 years above or below state average	-0.214	0.052	-0.189	-4.115	<0.001	Significant gender gap

Remarks: Control Variables (included in all models): Female literacy, wealth index, urban-rural residence, access to health facilities, religion, and district-level development index.
Source: Author

Discussion

The demographic transition in Assam aligns with classic population-development models but deviates through migration and environment interactions, underscoring sustainability risks faced by the state. Fertility decline signals momentum stabilization, yet pockets having above replacement fertility, such as Muslim-majority districts, sustain the pressure of population growth on the fragile ecosystem of the state, where around 23 per cent land-use shift in high migration areas threaten biodiversity and agricultural output. This echoes national patterns but are intensified in Assam due to the Brahmaputra River associated vulnerabilities. It is estimated that floods in the Brahmaputra valley displace more than 5 million people annually, driving circular migration and slum proliferation without proportional service scaling.

Urbanisation-migration nexus reveals dual edges. Around 65 per cent of the urban growth from internal migratory flows generates economic hubs, commonly known as Guwahati service boom but imposes environmental costs reflected through spikes in PM2.5 and deforestation which challenges the "Urbanisation and Migration" sub-theme of sustainable development. The inequality metrics reflects how demographic transition in the state reinforces rural-urban divide in the state – rural high-TFR zones trap families in poverty cycles, while out-migration depletes human capital, potentially squandering the advantages of demographic opportunities. The good sign, however, is that the multidimensional poverty in the state has decreased mainly through schemes like Orunodoi or 'Arunodoi Scheme 3.0,' although the decrease in multidimensional poverty at the state level masks the variation in multidimensional poverty across districts where districts dominated by char or riverine area and tea gardens face compounded deprivations. Other state sponsored programmes like Mukhya Mantri Mahila Udyamita Abhiyaan (MMUA), Chief Minister's Atmanirbhar Asom Abhiyan (CMAAA) and Assam Skill Development Mission (ASDM) Schemes are also targeted towards an accelerated reduction in multidimensional poverty.

Policy implications emerging out of the present analysis call for targeted interventions such as district-specific family planning interventions in high-fertility districts; migration-inclusive planning for urban development with s focus on green infrastructure development; skills development and improvement programmes for Scheduled Tribes youth and female youths to increase their participation in the social and economic production system to translate the demographic opportunity into economic reality and climate-resilient zoning linking SRS/NFHS data to early warning systems in the flood prone areas. The analysis emphasises the need of integrating population dynamics into sustainable development.

Conclusion

The study reveals that Assam is navigating advanced fertility decline and mortality improvement amid persistent inter-district disparities, intense migration flows and reduction in multidimensional poverty that masks the vulnerabilities in the rural areas and in the Scheduled Tribes population. These dynamics underscore the demographic transition being experienced by Assam as both an opportunity and a risk where urbanisation fuels

economic growth in urban growth centres of the state like Guwahati but strains the ecosystem and exacerbates inequalities in flood-prone char (riverine) areas and tea-garden areas. The analysis highlight the need for integrated policy action as fertility-mortality gains offer momentum stabilisation, yet high-TFR pockets sustain pressures on fragile Brahmaputra ecosystem, while migration drives 65 per cent of the urban expansion but widens income inequality. The study contributes to the nuanced, sub-state evidence for harnessing youth employment while mitigating vulnerabilities in flood prone districts of the state.

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Appendix Table: Inter-district variation in demography and development in Assam.

District	Population growth, 2001-2011 (per cent)	Degree of urbanisation 2011	Total fertility rate	Under-five mortality rate	MPI
Baksa	10.74	0.01	1.84	29.16	0.064
Barpeta	21.43	0.10	2.07	36.03	0.083
Biswanath			1.62	40.91	0.102
Bongaigaon	20.59	0.16	1.77	17.58	0.075
Cachar	20.19	0.22	2.14	30.95	0.140
Charaideo			1.52	46.28	0.095
Chirang	11.34	0.08	1.91	36.39	0.071
Darrang	22.19	0.06	2.14	28.53	0.100
Dhemaji	19.97	0.08	1.7	26.16	0.056
Dhubri	24.44	0.12	2.39	35.88	0.116
Dibrugarh	11.92	0.23	1.38	39.75	0.056
Dima-Hasao	13.84	0.40	1.48	29.48	0.061
Goalpara	22.64	0.16	1.73	33.72	0.081
Golaghat	12.75	0.10	1.37	46.42	0.065
Hailakandi	21.45	0.08	2.69	67.52	0.164
Hojai			2.02	43.67	0.059
Jorhat	9.31	0.25	1.61	38.48	0.051
Kamrup	15.69	0.10	1.54	22.61	0.053
Kamrup-Metropolitan	18.34	4.85	1.31	38.15	0.024
Karbi-Anglong	17.58	0.13	1.88	32.00	0.068
Karimganj	21.90	0.10	2.64	47.95	0.153
Kokrajhar	5.21	0.07	1.90	38.49	0.083
Lakhimpur	17.22	0.10	1.82	24.28	0.061
Majuli			1.71	37.59	0.056
Morigaon	23.34	0.08	2.03	41.88	0.100
Nagaon	22.00	0.15	2.15	44.80	0.093
Nalbari	11.99	0.12	1.47	18.71	0.049
Sivasagar	9.44	0.11	1.57	34.55	0.044
Sonitpur	15.55	0.10	1.66	50.57	0.090
South Salmara-Mankachar			2.46	31.21	0.131
Tinsukia	15.47	0.25	1.48	45.58	0.081
Udalguri	9.61	0.05	1.55	49.14	0.082
West-Karbi-Anglong			2.05	28.29	0.107

Remark: There were 27 districts in Assam at the time of 2011 population census. The number of districts increased to 33 at the time of National Family Health Survey, 2019-2021.

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Spatio-Temporal Analysis of Rural-Urban Disparity in Literacy Rate in West Bengal, India

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Abstract

Regional disparity in the literacy remains a significant concern in India and West Bengal is no exception. Despite the overall increase in literacy across decades, differences persist along various dimensions, including gender, rural-urban divide, and socio-religious factors. Rural populations consistently lag behind their urban counterparts in literacy rates across all the districts of West Bengal. This disparity in literacy rates hampers the overall development of society, as literacy is a fundamental tool for better perception of any incident and knowledge gain. Therefore, this paper tries to analyse the dynamics of the rural-urban literacy rates and disparity in literacy in West Bengal and India, based on the Census data 1991 to 2011 and PLFS data 2023-2024. Throughout this period, the urban population has maintained a higher literacy rate than the rural populations in all the districts of West Bengal. The study employs the Effective Literacy Rate, Kundu and Rao Disparity Index to measure the literacy rate and quantify the disparity in literacy rates between rural and urban populations, respectively.

Introduction

Literacy is one of the key dimensions of human development. Through literacy, people can easily access information and develop socio-economic and cultural development in society (Roy and Mondal, 2015). It plays a significant role in economic growth, promotes democracy and reduces crime and poverty (Begum, 2020). Literacy is traditionally defined as the ability to read and write. The Economic Social and Cultural Organization of the United Nations defines literacy as the ability to identify, understand, interpret, create, communicate and compute, using printed and written materials associated with varying contexts. Literacy involves a continuum of learning in enabling individuals to achieve their goals, to develop their knowledge and potential, and to participate fully in their community and wider society. Literacy also encompasses numeracy, the ability to make simple arithmetic calculations. The concept of literacy can be distinguished from measures to quantify it, such as the literacy rate and functional literacy. According to the 2011 decennial population census of India, an individual aged at least 7 years, is classified as literate if she or he can read and right with understanding in any language irrespective of whether the

individual has attended or not attended a school (Government of India, 2011). Literacy is measured and monitored in terms of the literacy rate which is defined as the proportion of the population aged at least 7 years who is literate of who can read or write with understanding. At the 2011 population census, the literacy rate in India was 74 per cent whereas the literacy rate in West Bengal was around 76 per cent. According to the Periodic Labour Force Survey (PLFS) conducted by the Government of India in 2023-2024, the literacy rate in India was 80.9 per cent while that in West Bengal was 82.6 per cent (Government of India, 2024). Among different states and Union Territories of the country, West Bengal ranks 25 according to PLFS.

Literacy is a dynamic and broad concept. It encompasses more than just the ability to read and write. Regional, gender, residence and social and economic difference in literacy in India and West Bengal are well-known. Dutta and others have argued that in terms of gender disparity in literacy, females are the deprived group in all states of north India, but some of the states like Chandigarh, Punjab, and Delhi have low gender disparity (Dutta et al, 2025). In case of educational attainment, the proportion of females having at least secondary level education is lower than that in males in all states and Union Territories. Singh (2019) has examined the trend and rural-urban disparity in the literacy rate in India. After the independence, the literacy rate has increased in both rural and urban areas of the country. However, increase in rural literacy rate has been slower than the urban literacy rate. In large part of Jammu and Kashmir, Haryana, northern Uttar Pradesh, Bihar, Jharkhand, Arunachal Pradesh, Rajasthan, northern Gujarat, western and northern district of Madhya Pradesh, southern districts of Chhattisgarh, Andhra Pradesh, north-eastern part of Karnataka and in border areas of Karnataka and Tamil Nadu contain, literacy rate remains low in both urban and rural areas. The author has concluded that low status of female, teaching in language other than the mother tongue, child labour, unequal distribution of resources, poor health conditions, low level of infrastructure facilities are some of the major causes of low level and higher disparity in literacy in India.

Ghosh (2024) has observed that literacy rate has consistently increase in the rural and urban areas of West Bengal, but the pattern of rural and urban literacy rate is heterogeneous across the districts of the state. Southern districts of the state – around the Kolkata metropolis – have comparatively higher literacy rates than the western (Purulia, Bankura, Birbhum) and northern district (Malda, Uttar Dinajpur, Dakshin Dinajpur, Jalpaiguri, Koch Bihar) of the state. The author observes that educational attainment is the most important step for enhancing quality of life, raising awareness, and developing skills within society. Higher literacy and education levels positively influence different sectors of development.

Som and Misra (2014) have also observed that the literacy rate is consistently increasing in West Bengal but there is a wide gap between male and female, rural and urban literacy in the state. There are studies that have analysed rural-urban differentials in literacy rate across the districts of West Bengal (Sarkar and Bar, 2019; Ghosh, 2024). These studies are based on an urban-rural differential index (Kishna and Shyam, 1978). This index is based on simple difference between urban and rural literacy rate which is sensitive to the level of the literacy rate. Since literacy rate in any population cannot be more than 100 per cent, the increase in the literacy rate leads to a decrease in urban-rural difference in literacy rate.

The urban-rural differential index, therefore, does not give the true perspective of the disparity in the literacy rate between urban and rural areas. This paper analyses rural-urban disparity in literacy rate in the districts of West Bengal using the Rao and Kundu version of the Sopher's index of inequality or disparity (Sopher, 1980; Kundu and Rao, 1986). The limitation of the original Sopher's Index is that it fails to satisfy principle of additive monotonicity. The additive monotonicity axiom specifies that if a constant is added to all observations in a non-negative series, ceteris paribus, the inequality or the disparity index must report a decline. Moreover, the original Sopher's index cannot be calculated if one of the variables is 100 per cent.

Data and Methods

District level estimates of literacy rate by rural and urban areas in India are available through the decennial population census only which was last conducted in the year 2011. At the state/Union Territory level, however, estimates of rural and urban literacy rate are available through the Periodic Labour Force Survey (PLFS) 2023-2024. The district level analysis presented in this paper, therefore, refers to the year 2011 whereas the state level data presented in the paper refers to the period 2023-2024. The data from the 2011 population census is dated in the present context but there is no other source that provides data about the number of literates and the number of illiterates in the districts of the country. It may be argued that there would have been marked changes in the rural-urban disparity or inequality in literacy rate in the districts of the state after 2011. The extent and the nature of these changes will be known only after the 2027 population census which is currently in progress.

The level of literacy in the population has been captured through the effective literacy rate which is defined in the 2011 population census as the proportion of the population aged 7 years and above who can read and write with understanding. The same definition has been adopted in the periodic labour force survey so that estimates of the literacy rate available from the two sources are compatible so that it is possible to analyse the trend in rural-urban disparity in the literacy rate in the state during more than 40 years between 1991 and 2022-2024. The analysis of rural-urban disparity in the district of the state, however, is confined to the period 1991-2011.

Let L_R denote the literacy rate in the rural areas and L_U denotes the literacy rate in the urban areas and assume that $L_U > L_R$. Then the Rao-Kundu version of the Sopher's inequality or disparity index (DI) is defined as

$$DI = log\left(\frac{L_U}{L_R}\right) + log\left(\frac{200 - L_R}{200 - L_U}\right)$$

When $L_U < L_R$, DI is be calculated as

$$DI = log\left(\frac{L_R}{L_U}\right) + log\left(\frac{200 - L_U}{200 - L_R}\right)$$

When $L_U = L_R$, DI=0 and there is no disparity between urban and rural literacy. On the other hand, the higher the DI the higher disparity or inequality (Chakraborty, 2013). The original Sopher's disparity index may also be conceived as the logarithm of the ratio of the odds of being literate in the urban (rural) areas to the odds of being literate in the rural(urban) areas. However, no such interpretation of the Rao Kundu version of the index is possible. The logarithm is used to reduce the levelling of the effect (Sopher, 1980).

Results and Discussion

Rural-Urban Disparity in Literacy in India and States/Union Territories, 2023-2024

Table 1 presents estimates of DI for India and states/Union Territories based on the estimates of the literacy rate derived from the data available from the Periodic Labour Force Survey (2023-2024). The rural-urban disparity in literacy rate varies widely across states and Union Territories being the highest in Telangana but the lowest in Mizoram where there is virtually no difference in the literacy rate in the rural and urban areas of the state. In most of the states and Union Territories, rural-urban disparity in the literacy rate is lower than the national average. There are only nine states and Union Territories in which the disparity is higher than the national average. The rural-urban disparity in the literacy rate in West Bengal is substantially lower than the national average. The state ranks 19 among the 35 states and Union Territories in terms of rural-urban disparity in the literacy rate. There is no rural area in the Union Territory of Chandigarh so that rural-urban disparity in the literacy rate could not be calculated.

The states and Union Territories rank differently in rural-urban disparity in male literacy rate and rural-urban disparity in female literacy rate. Mizoram and Telangana are the only two states/Union Territories which have the same rank in rural-urban disparity in male literacy rate and rural-urban disparity in female literacy rate. The rural-urban disparity in the male literacy rate is the highest in Andhra Pradesh but the lowest in Mizoram. On the other hand, rural-urban disparity in the female literacy rate is the highest in Dadra & Nagar Haveli and Daman & Diu but the lowest again in Mizoram. West Bengal ranks 14 among 35 states and Union Territories in terms of rural-urban disparity in male literacy rate but 21 in terms of rural-urban disparity in female literacy rate.

Table 1 also indicates that rural-urban disparity in female literacy rate is higher than the rural-urban disparity in the male literacy rate in the country and in all but one state/Union Territory. Delhi is the only state/Union Territory in which rural-urban disparity in the male literacy rate is found to be higher than the rural-urban disparity in the female literacy rate according to the PLFS, 2023-2024. The difference between the rural-urban disparity index in the female population and the rural-urban disparity index in the female population is the highest in Dadra & Nagar Haveli and Daman & Diu but the lowest in Mizoram and Meghalaya. This difference is also very high in Gujarat, Telangana, Rajasthan, Maharashtra and Uttar Pradesh. On the other hand, this difference is very low in all the north-eastern states of the country. In West Bengal also, the difference between the rural-urban disparity index in female and male literacy rate is very low, seventh lowest among the 35 states and Union Territories of the country.

Table 1: Variation in rural-urban disparity in the literacy rate (index DI) in India and states/Union Territories, 2023-2024.

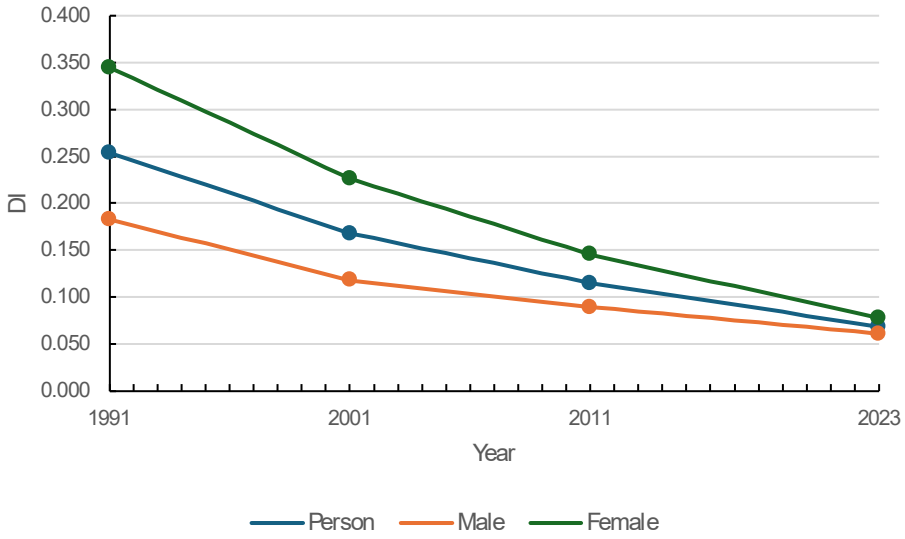
Country/State/Union Territory	Index DI			Rank in DI person
	Male	Female	Person	
India	0.072	0.133	0.102	
Andhra Pradesh	0.132	0.185	0.157	2
Arunachal Pradesh	0.069	0.080	0.072	18
Assam	0.052	0.072	0.061	20
Bihar	0.074	0.119	0.097	10
Chhattisgarh	0.050	0.120	0.086	12
Delhi	0.034	0.012	0.019	31
Goa	0.003	0.027	0.012	33
Gujarat	0.061	0.153	0.105	9
Haryana	0.050	0.118	0.082	15
Himachal Pradesh	0.020	0.080	0.053	23
Jharkhand	0.094	0.127	0.111	6
Karnataka	0.090	0.133	0.111	8
Kerala	0.011	0.026	0.019	32
Madhya Pradesh	0.106	0.159	0.129	4
Maharashtra	0.050	0.121	0.085	13
Manipur	0.030	0.042	0.036	27
Meghalaya	0.034	0.039	0.037	25
Mizoram	0.002	0.006	0.002	35
Nagaland	0.012	0.030	0.021	30
Odisha	0.093	0.146	0.121	5
Punjab	0.041	0.065	0.054	22
Rajasthan	0.071	0.147	0.111	7
Sikkim	0.065	0.122	0.093	11
Tamil Nadu	0.063	0.106	0.083	14
Telangana	0.120	0.204	0.163	1
Tripura	0.028	0.060	0.044	24
Uttarakhand	0.026	0.094	0.058	21
Uttar Pradesh	0.038	0.109	0.074	17
West Bengal	0.061	0.078	0.069	19
Andaman & N. Island	0.003	0.027	0.010	34
Dadra & Nagar Haveli & Daman & Diu	0.095	0.208	0.151	3
Jammu & Kashmir	0.003	0.052	0.026	29
Ladakh	0.051	0.104	0.076	16
Lakshadweep	0.007	0.049	0.027	28
Puducherry	0.018	0.063	0.036	26

Remarks: Rural-Urban disparity index could not be calculated for Chandigarh as there is no rural area in the state.

Source: Authors, based on the estimates of female and male literacy rates in rural and urban areas available from Government of India (2024).

Trend in Rural-Urban Disparity in Literacy Rate in West Bengal

Figure 1 shows the temporal trend of rural-urban disparity in literacy rate in West Bengal during the period 1991 through 2023-2024. The decrease in the rural-urban disparity in the literacy rate was the most rapid during the decade 1991-2001 and has slowed down considerably after 2011-2023 because the rural-urban disparity in the literacy rate was quite low in 2023-2024 compared to the rural-urban disparity in the literacy rate in 1991. The decrease in disparity is directly related to the level of disparity – the higher the level of disparity the higher the decrease in disparity. Figure 1 also shows that the decrease in rural-urban disparity has been sharper in case of female literacy as compared to male literacy in the state.



Population	1991	2001	2011	2023-2024
Person	0.254	0.168	0.115	0.069
Male	0.183	0.118	0.089	0.061
Female	0.345	0.226	0.145	0.078

Figure 1: Trend in rural-urban disparity in literacy rate in West Bengal, 1991 to 2023-2024. Source: Authors

A notable feature of the transition in the rural-urban disparity in literacy rate in West Bengal is the convergence in the rural-urban disparity between female and male literacy rate. In 1991, rural-urban disparity in female literacy rate was almost two times the rural-urban disparity in male literacy rate in the state. The data available from PLFS 2023-2024 indicates that this difference in rural-urban disparity in male and female literacy rate has now almost been wiped out. The rural-urban disparity in female literacy rate in the state is now only a shade higher than the rural-urban disparity in the male literacy rate and the level of disparity has decreased to very low levels. This is a welcome feature of the literacy scenario in the state.

Rural-Urban Disparity in Literacy Rate in Districts

Recent estimates of literacy rate for the districts of the state are not available from any source. The latest estimates of literacy rate for the district of the state are available from the 2011 population census only. Based on these estimates, the rural-urban disparity index (DI) in the literacy rate in the districts of the state is presented in table 2 and depicted in figures 2 through 3 which reflect that within the state, rural-urban disparity in literacy rate varies widely across districts. The rural-urban disparity in the literacy rate has been found to be highest in district Uttar Dinajpur of the state while it has been found to be very low in Purba Medinipur, Haora, Murshidabad, South 24 Parganas, Hugli, Paschim Medinipur and Barddhaman districts. The rural urban disparity in the literacy rate has been found to be the lowest disparity in Purba Medinipur district according to the 2011 population census. Rural-urban disparity in the literacy rate could not be calculated for district Kolkata as there was no rural population in the district at the 2011 population census.

The districts of the state can be divided into three groups based on the level of the rural-urban disparity in the literacy rate measured in terms of the disparity index DI. The first group comprises those districts in which rural-urban disparity in the literacy rate may be termed as low to very low as the disparity index, DI, is less than 0.100 in districts of this group. There are six districts in this group. The second group comprises those districts in which the rural-urban disparity in the literacy rate may be termed as high as the disparity index, DI is greater than or equal to 0.100 but less than 0.150. There are nine districts in this group. Finally, the third group comprises those districts in which rural-urban disparity in the literacy rate may be termed as very high as the disparity index, DI is at least 0.150 in districts of this group. There are three districts in this group.

Table 2 also reveals that the rural-urban disparity in the female literacy rate was markedly higher than that in the male literacy rate in all, but one districts of the state according to the 2011 population census. District Murshidabad is the only district in the state in which rural-urban disparity in the male literacy rate was higher than the rural-urban disparity in the female literacy rate in 2011. The rural-urban disparity in both female and male literacy rate was the highest in the Uttar Dinajpur district of the state. On the other hand, rural-urban disparity in both female and male literacy rate was the lowest in district Purba Medinipur. In district Puruliya, rural-urban disparity in the female literacy rate was very high but the rural-urban disparity in the male literacy rate was very low according to the 2011 population census so that the female-male difference in the rural-urban disparity in the literacy rate was the highest in the district. In district Nadia, on the other hand, female-male difference in the rural-urban disparity in the literacy rate was the lowest according to the 2011 population census. The inter-district variability in the rural-urban disparity in the male literacy rate was, however, higher than that in the rural-urban disparity in the female literacy rate. The coefficient of variation in the rural-urban disparity in the male literacy rate across the districts of the state is estimated to be 0.512 in 2011 compared to 0.451 in the rural-urban disparity in the female literacy rate. The rural-urban disparity in male literacy rate across the districts of the state, on average, is lower than that in female literacy rate but the inter-district variation in the rural-urban disparity in male literacy rate appears to be higher than the inter-district variation in the rural-urban disparity in the female literacy rate in the state.

Table 2: Rural-urban disparity in the literacy rate in districts of West Bengal, 1991-2011.

State/District	Disparity index DI								
	Person			Male			Female		
	1991	2001	2011	1991	2001	2011	1991	2001	2011
West Bengal	0.254	0.168	0.115	0.183	0.118	0.089	0.345	0.226	0.145
Darjiling	0.283	0.162	0.119	0.210	0.105	0.085	0.379	0.227	0.157
Jalpaiguri	0.351	0.204	0.117	0.271	0.144	0.085	0.477	0.279	0.153
Koch Bihar	0.365	0.195	0.137	0.270	0.144	0.108	0.508	0.259	0.172
Uttar Dinajpur	0.498	0.393	0.237	0.390	0.303	0.198	0.671	0.517	0.282
Dakshin Dinajpur		0.218	0.169		0.163	0.140		0.285	0.203
Maldah	0.474	0.321	0.167	0.389	0.268	0.140	0.612	0.392	0.198
Murshidabad	0.307	0.166	0.063	0.277	0.168	0.074	0.360	0.169	0.053
Birbhum	0.225	0.172	0.111	0.179	0.140	0.094	0.290	0.214	0.132
Barddhaman	0.142	0.109	0.082	0.107	0.087	0.073	0.179	0.134	0.090
Nadia	0.290	0.186	0.133	0.265	0.171	0.128	0.332	0.206	0.139
North Twenty Four Parganas	0.251	0.148	0.103	0.190	0.116	0.088	0.329	0.185	0.120
Hugli	0.134	0.110	0.075	0.081	0.072	0.051	0.195	0.147	0.101
Bankura	0.245	0.173	0.143	0.171	0.111	0.098	0.357	0.255	0.196
Puruliya	0.335	0.222	0.129	0.208	0.116	0.070	0.578	0.382	0.203
Haora	0.122	0.075	0.047	0.069	0.042	0.030	0.179	0.107	0.064
Kolkata	No rural population								
South Twenty Four Parganas	0.203	0.116	0.063	0.120	0.067	0.041	0.317	0.175	0.089
Paschim Medinipur	0.095	0.082	0.081	0.046	0.045	0.051	0.153	0.124	0.115
Purba Medinipur			0.016			0.006			0.026

Source: Authors, based on data from 1991, 2001 and 2011 population census.

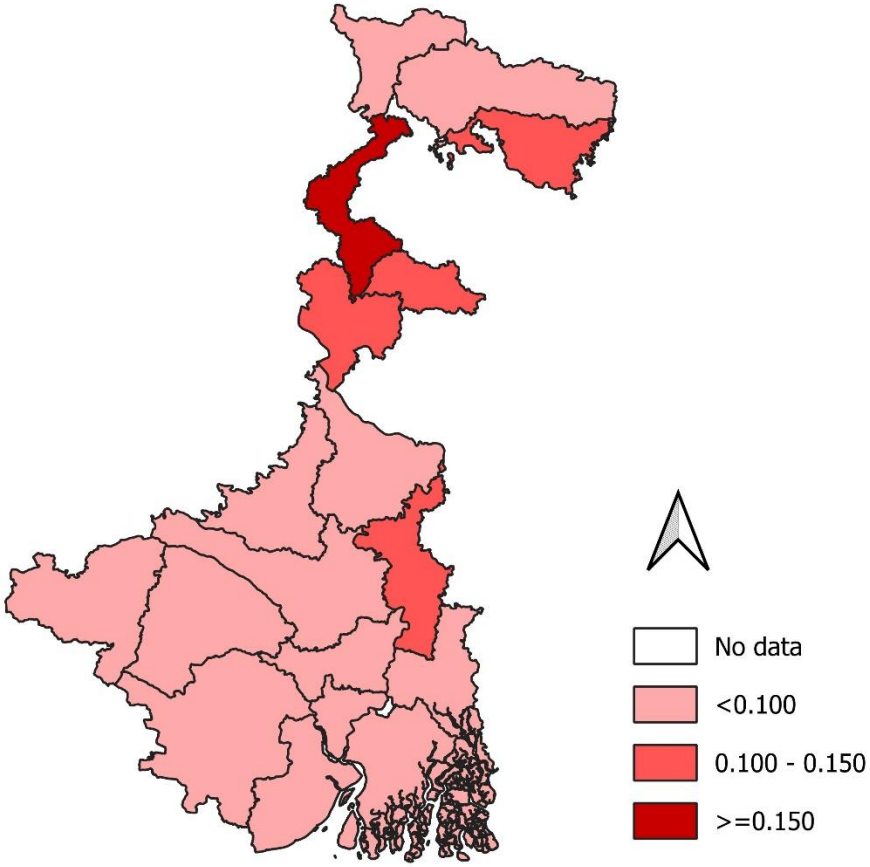


Figure 2: Inter-district variation in rural-urban disparity in the literacy rate, 2011.
Source: Authors, based on table 2.

Between 1991 and 2011, the rural-urban disparity in the literacy rate has decreased in all districts. However, the magnitude of the decrease has been different in different districts. The rural-urban disparity in female literacy decreased the most rapidly during 1991-2011 in district Maldah from 0.474 in 1991 to 0.140 in 2011. The decrease in the disparity has also been quite rapid in Jalpaiguri, Koch Bihar, Murshidabad and Puruliya districts. On the other hand, the decrease in disparity has been the slowest in district Hugli. In Barddhaman and Haora districts also, the decrease in the rural-urban disparity in the literacy rate has been very slow. The inter-district variation in rural-urban disparity in the literacy rate has however increased from 0.414 in 1991 to 0.456 in 2011 showing divergence over time in rural-urban disparity in literacy rate across districts.

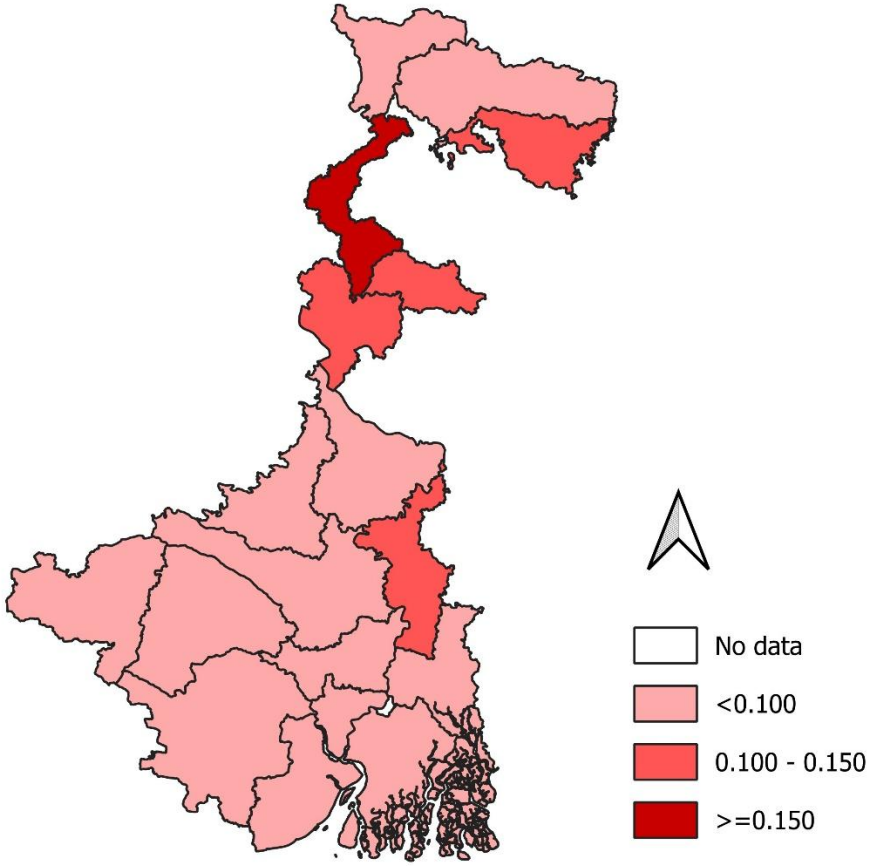


Figure 3: Inter-district variation in rural-urban disparity in male literacy rate, 2011.
Source: Authors

The rural-urban disparity in both male and female literacy rates has also decreased in all districts during 1991-2011. However, the pace of decrease has been different in different districts. The decrease in the disparity across districts has not resulted in convergence in rural-urban disparity in literacy across districts. Instead, there has been a divergence as the coefficient of variation across districts in rural-urban disparity in both male and female literacy rates increased between 1991 and 2011. This implies that the decrease in rural-urban disparity in both male and female literacy rate has been more rapid in some districts of the state but slower than average in other districts. The coefficient of variation in rural-urban disparity in male literacy rate across districts increased from 0.487 in 1991 to 0.512 in 2011 while the coefficient of variation in rural-urban disparity in female literacy rate increased from 0.410 to 0.451 during this period.

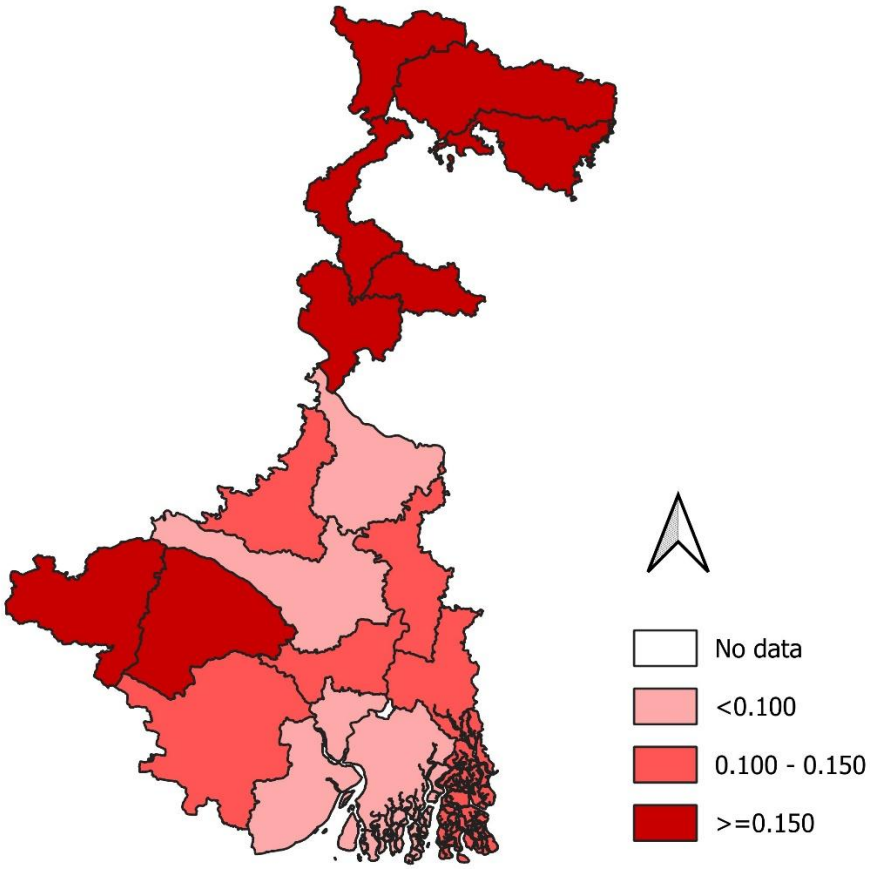


Figure 4: Inter-district variation in rural-urban disparity in female literacy rate, 2011.
Source: Authors

Conclusion

The present paper highlights the marked decrease in rural-urban disparity in the literacy rate in West Bengal since 1991. The decrease in rural-urban disparity in the literacy rate has also been associated with the narrowing of the rural-urban disparity in male literacy rate and in female literacy rate. The latest evidence suggests nearly wiping out the difference in the rural-urban disparity in the literacy rate between female and male population in the state. This is a remarkable achievement towards the realisation of universal literacy in the state.

Although, based on the data from the 2011 population census, the present analysis also suggests that rural-urban disparity in the literacy rate varies widely across the districts of the state and this variation in the rural-urban disparity in the literacy rate appears to have increased over time in terms of both female and male literacy rate. The rural-urban disparity in the literacy rate has decreased in all districts but the pace of decrease has been different in different districts so that districts have diverged, instead converged, in terms of rural-urban disparity in the literacy rate. It appears that there are district-specific factors that may be responsible for the rural-urban disparity in the literacy rate. An understanding of these factors may contribute towards reducing rural-urban disparity in the literacy rate in those districts in which progress appears to have been slow. The analysis also suggests targeted policy interventions to bridge the rural-urban divide in the literacy rate.

The rural-urban disparity in the literacy rate appears to be exceptionally high in district Uttar Dinajpur of the state. This may be due to the low level of social and economic development in the district. Majority of the people in the district are socio-economically backward, and the percentage of rural people is much higher than urban people in the district. It has also been observed that the educational infrastructure in the rural areas of the district is insufficient (Roy, 2013). Because of these reasons, the district has the lowest literacy rate compared to other districts of the state and a high rural-urban disparity in literacy rate.

The present analysis highlights the need of investment in the educational infrastructure in the rural areas of the state. This investment can bridge the significant literacy gap between urban and rural population, fostering great equality in educational opportunities and outcomes.

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Appendix Table: Estimates of rural and urban literacy rate in West Bengal and its districts, 1991, 2001, 2011 and 2023-2024.

State/District	Proportion (per cent) of population aged 7 years and above who can read and write with understanding					
	Rural			Urban		
	Person	Male	Female	Person	Male	Female
			1991			
West Bengal	50.3	61.9	37.9	75.1	81.1	68.1
Bankura	49.8	65.0	33.9	73.7	83.3	63.3
Barddhaman	56.5	66.7	45.6	70.7	78.1	61.7
Birbhum	46.3	57.3	34.7	67.2	75.6	58.1
Calcutta	No rural population			77.6	81.9	72.0
Darjeeling	49.0	59.8	37.3	76.7	81.7	70.9
Haora	61.1	72.1	49.4	73.6	79.5	66.2
Hugli	62.1	72.7	50.8	76.0	81.5	69.6
Jalpaiguri	39.3	51.0	26.6	70.9	78.0	63.0
Koch Bihar	42.6	54.8	29.4	77.1	82.5	71.4
Maldah	32.2	42.5	21.2	72.8	79.6	65.4
Medinipur	68.1	80.6	54.9	78.3	85.8	70.0
Murshidabad	35.3	43.5	26.5	60.6	68.9	51.9
Nadia	45.8	53.6	37.3	73.4	80.5	65.9
North 24 Parganas	53.1	63.6	41.8	78.3	83.8	72.0
Puruliya	40.3	59.9	19.5	70.5	81.7	58.0
South 24	52.0	66.4	36.6	71.9	79.2	63.4
West Dinajpur	32.8	44.1	20.7	76.4	81.9	70.2
			2001			
West Bengal	63.4	73.2	53.2	81.3	86.2	75.8
Bankura	62.1	75.8	47.6	80.2	88.1	71.9
Barddhaman	65.9	75.0	56.1	77.4	84.5	69.3
Birbhum	59.9	69.5	49.7	77.7	84.8	70.2
Dakshin Dinajpur	60.4	70.0	50.3	83.3	87.9	78.6
Darjiling	66.0	76.2	55.4	83.5	87.9	78.6
Haora	72.8	80.7	64.6	81.0	85.5	75.8
Hugli	71.0	79.8	62.1	83.0	87.9	77.5
Jalpaiguri	58.9	69.9	47.3	80.1	85.6	74.1
Koch Bihar	64.3	74.4	53.6	85.2	90.4	79.8
Kolkata	No rural population			80.9	83.8	77.3
Maldah	47.8	56.6	38.4	79.3	84.5	73.9
Medinipur	74.0	84.4	63.1	82.9	89.4	76.0
Murshidabad	52.3	58.5	45.7	68.4	75.7	60.8
Nadia	61.8	68.3	55.0	81.4	86.9	75.7
North Twenty Four Parganas	69.1	76.7	61.0	85.2	89.6	80.4
Puruliya	53.3	72.4	33.3	75.4	85.1	64.9
South Twenty Four Parganas	67.4	78.0	56.2	79.9	85.4	73.7
Uttar Dinajpur	42.9	54.2	30.8	80.5	85.5	74.9

State/District	Proportion (per cent) of population aged 7 years and above who can read and write with understanding					
	Rural			Urban		
	Person	Male	Female	Person	Male	Female
	2011					
West Bengal	72.1	78.4	65.5	84.8	88.4	81.0
Bankura	68.9	79.1	58.3	84.4	90.2	78.5
Barddhaman	72.7	79.1	65.9	81.5	87.3	75.3
Birbhum	69.1	75.6	62.3	81.1	86.0	76.0
Dakshin Dinajpur	70.1	76.1	63.8	88.7	91.8	85.5
Darjiling	74.3	81.8	66.6	87.5	91.4	83.5
Haora	80.0	84.8	75.0	85.2	88.2	82.0
Hugli	78.5	84.8	72.1	86.9	90.5	83.1
Jalpaiguri	69.7	77.3	61.8	82.4	86.8	77.8
Koch Bihar	73.2	79.4	66.5	88.4	91.6	85.0
Kolkata	No rural population			86.3	88.4	84.1
Maldah	59.4	64.2	54.3	76.6	78.9	74.0
Murshidabad	65.3	68.4	62.0	71.9	76.2	67.3
Nadia	70.9	74.8	66.7	85.4	88.9	81.6
North Twenty Four Parganas	77.4	81.9	72.6	88.9	91.8	85.9
Paschim Medinipur	76.9	84.5	69.0	85.9	90.3	81.3
Purba Medinipur	86.8	92.3	81.0	88.6	92.9	84.0
Puruliya	62.7	76.8	48.1	76.2	84.6	67.1
South Twenty Four Parganas	75.7	82.2	68.9	82.7	86.8	78.4
Uttar Dinajpur	56.0	62.8	48.7	80.3	83.9	76.3
	2023-2024					
West Bengal	80.3	83.8	76.8	88.0	90.7	85.4

Source: Estimated by the authors from the data from 1991, 2001 and 2011 population census. Estimates for the period 2023-2024 are from Government of India (2024). Estimates of literacy rate for the districts are not available for 2023-2024.

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Decomposition of Change in Female-Male and Urban-Rural Gap in Life Expectancy at Birth in India

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Abstract

India has experienced substantial improvement in the life expectancy at birth (*LEB*) over the last five decades. However, significant female-male and urban-rural disparities persist, and age-specific factors driving these differences remain insufficiently understood. This paper, based on the data from the Sample Registration System of India examines the contribution of broad age groups to female-male, urban-rural, and temporal differences in *LEB* in India and states. The paper highlights a pronounced shift in the age pattern of mortality improvement in India. While mortality young and reproductive ages has substantially improved population health, recent gains in *Lab*an contemporary disparities are increasingly determined by survival at older ages. The paper underscores the growing importance of healthy ageing, chronic disease prevention, and geriatric healthcare in sustaining future improvement in longevity and reducing inequalities across population groups.

Introduction

Life expectancy at birth is universally used as the measure of population health. Studies on life expectancy provide valuable insights into the health of the population. into the effects of healthcare, lifestyle, and socioeconomic factors on human longevity and play a crucial role in shaping public health strategies, planning healthcare infrastructure, and designing effective interventions for improving population health outcomes. Changes in life expectancy guide health policy and development initiatives. It also serves as a summary measure of mortality across all ages, allowing comparisons of longevity between regions and over time, even where demographic structures differ markedly (Aburto et al, 2021; Aburto et al, 2022). The steady rise in human life expectancy over the past two centuries stands as one of the most remarkable achievements of the modern civilisation (Oeppen and Vaupel, 2022; Riley, 2001). According to the United Nation Population Division (2024), the global life expectancy at birth was estimated at 73.2 years around the year 2023, while in India, it was 72.0 years. Monaco reports the highest life expectancy at birth (86.7 years) while *LEB* in Nigeria was the lowest (55 years) among the countries and areas for which estimates have been prepared by the United Nations Population Division (United Nation, 2024).

India has experienced a remarkable increase in *LEB* since independence. At the national level, *LEB* exhibits a distinct rural-urban divide, with urban residents living longer, on average, than their rural counterparts. This disparity stems from rural-urban differences in socioeconomic status of the population, access to healthcare facilities, sanitation, education, and occupational exposures. Urban population benefits from better health care facilities, higher literacy levels, improved maternal and child healthcare, and healthier living environments, leading to lower mortality rates across all age groups. Conversely, rural population often faces inadequate healthcare infrastructure, relatively higher prevalence of communicable diseases, poor nutrition, and unsafe working and living conditions, all of which contribute to shorter lifespan.

When examined by sex, a female advantage in life expectancy is evident in both rural and urban areas, but it tends to be more pronounced in the urban areas. Urban women benefit from greater access to reproductive healthcare, education, and lower maternal mortality. In contrast, persistent gender disparities in rural areas are driven by early marriage, limited healthcare access, and undernutrition which continue to influence female mortality patterns. Biological evidence across species suggests higher mortality among males than females (Borah, 2021). Globally, higher female *LEB* is almost universal and is reflected in most life tables, particularly in the developed countries (Lee, 2021; Glei and Horiuchi, 2002). Omran states that females in the adolescent and reproductive years are at a higher risk of dying than males, but at lower risk of dying at older ages. His theory also suggest that Life expectancy reaches an unprecedented high of 70+ years and is about three or more years higher for women than for men (Omran, 2001).

Several socio-behavioural and environmental factors contribute to the observed male disadvantage in survival. Historically, men have exhibited higher consumption of tobacco, alcohol, and other substances, resulting in greater risks of diseases such as lung cancer, tuberculosis, and liver cirrhosis. According to the World Health Organization, ischemic heart disease remains the leading cause of death globally, with male mortality (121.5 per 10,000) exceeding female mortality (99.4 per 10,000) (WHO, 2024). Women consistently outlive men across most countries because of both biological resilience and social determinants of health. Similarly, the United Nations highlights that population ageing is increasingly feminised, with women forming the majority of older population worldwide. In the Indian context, research using data from the National Family Health Survey and the Sample Registration System have also shown that while the sex ratio may favour males at younger ages, it shifts in favour of females at older ages due to differential survival patterns. Mayer (1999) termed it as "mortality paradox" defined as a growing masculine bias in the overall population occurring alongside real but unequal gains in female life expectancy and literacy.

Evidence available from the Sample Registration System indicates that female-male gap in *LEB* in India is widening. Life tables based on the data from the Sample Registration system suggests that up to the period 1976-1980, male *LEB* in India was higher than female *LEB*. However, after 1980, female *LEB* has become higher than the male *LEB* and the gap is widening since then. During the period 2020-2024, females are estimated to have lived more than four years longer than males in the country according to the official life tables (Government of India, 2026).

The widening male-female gap in *LEB* in India and in its states is influenced by multiple interacting factors, including behavioural risks, cause-of-death patterns, age-specific mortality changes (particularly among adults). Tobacco and alcohol use are far more prevalent among Indian men and account for a substantial share of male deaths due to cancers, cardiovascular diseases, liver disease, and injuries (Dandona et al, 2020). Young and middle-aged men also face higher risks of road traffic accidents, occupational hazards, and suicide, all of which contribute to elevated male mortality (Vasan, 2025). Moreover, social norms and health-seeking behaviours often discourage men from seeking timely medical care, allowing treatable conditions to progress into fatal ones.

From the perspective of mortality, the human life can be divided into three broad age groups – young age (0-14 years), reproductive age (15-49 years) and old age (50 years and above). The main causes of death in the three age groups are essentially different. The female-male and urban-rural difference in *LEB* should, therefore, be analysed in terms of female-male and urban-rural difference in mortality in young age, reproductive age and old age. From the policy and programme perspective, it is imperative to explore how female-male and urban-rural difference in the person-years lived in the three ages of life contribute to female-male and urban-rural difference in the difference in person-years lived in all ages or the difference in *LEB* and how, this contribution has changed over time.

It is in the above context that the present study investigates the contribution of the change in the proportionate share of person-years lived in young age, reproductive age and old age to the change in *LEB*. The study also analyses how female-male and urban-rural difference in the person-years lived in young age, reproductive age and old age to female-male and urban-rural difference in *LEB* in India and in its selected states for which abridged life tables have been made available by the Government of India through the official Sample Registration System.

The paper decomposes the change and the difference in *LEB* to the change or the difference in the proportionate share of person-years lived in young age, reproductive age and old age. Decomposition analysis has been widely used in demographic research to identify the age-specific contributions to the difference or the change in the life expectancy at birth. Early approaches were developed by Chandra Sekar (1949), Lopez and Ruzicka (1977), Pollard (1982), and Arriaga (1984). Arriaga method is widely used but it has some limitations. Namboodiri and Suchindran (1987) have also suggested an approach to decompose *LEB* into age-specific components. Subsequent studies have demonstrated the mathematical equivalence of different decomposition methods and highlighted their utility in understanding the change in the age pattern of mortality on the change in *LEB* (Ponampalli, 2005).

Chaurasia (2010) has proposed a decomposition framework based on survival probabilities in broad age groups and the logarithmic relationship between life expectancy and age-specific survival. Unlike conventional age-by-age decomposition methods, this approach partitions the difference or change in life expectancy into an average change component, and an age-specific deviation associated with different age groups. Later Chaurasia (2021) used this decomposition technique for the decomposition of the female-male and urban-rural gap in *LEB* in India for the time period 1998-2017.

Data Source

The present study is based on the abridged life tables based on the Sample Registration System (SRS) prepared by the Government of India for the periods 1976-1980, 1986-1990, 1996-2000, 2006-2010, 2016-20 and 2019-2023 (Government of India,1986; 1994; 2012; 2022; 2025). These abridged life tables are the only source of information about *LEB* in India and its selected states. They are also available for female and male population and for urban and rural areas which permit estimation of female-male and urban-rural gap in the life expectancy at birth. These life tables suggests that *LEB* in India has increased from 49.7 years during the period 1970-1975 to 70.3 years during the period 2019-2023. The male life expectancy at birth increased from 50.5 years to 68.5 years during this period whereas female life expectancy at birth increased from 49 years to 72.5 years. Similarly, rural life expectancy at birth increased from 48 years to 69.1 years during this period while urban life expectancy at birth increased from 58.9 years to 73.1 years (Government of India, 2025).

Abridged life tables for all states and Union Territories of the country are not available from the official sample registration system because of sample size constraints. During the period 2019-2023, abridged life tables for 22 states were available from the system. During the period 1976-1980, however, abridged life tables were available for only 15 states of the country. State level comparison of life expectancy at birth and female-male and urban-rural difference in *LEB* is hampered by changes in the administrative boundaries of the state. Three states – Andhra Pradesh, Madhya Pradesh and Uttar Pradesh – as they existed during 1976-80 have now been divided into Andhra Pradesh and Telangana, Madhya Pradesh and Chhattisgarh, and Uttar Pradesh and Uttarakhand so that life tables for existing Andhra Pradesh, Madhya Pradesh and Uttara Pradesh are not comparable with the erstwhile states of Andhra Pradesh, Madhya Pradesh and Uttar Pradesh. The administrative boundaries of only 12 states have remained unchanged during the period 1976-2023 to analyse the change in *LEB* between 1976-1980 and 2019-2023. Abridged life tables for Union Territories and for small states of the country are not available from the Sample Registration System. The present analysis is, therefore, confined to only those states for which abridged life tables are available from the Sample Registration System. Details about the official Sample Registration System are given elsewhere (Government of India, 2026).

Methodology

LEB is the sum of person-years lived in different ages of life. If L_x is the person-years lived in the age interval $(x, x+1)$, then.

$$LEB = \sum_{x=0}^{\omega} L_x \qquad (1)$$

where *LEB* is the life expectancy at birth. Dividing the entire duration of life into young age (0-14 years), reproductive age (15-49 years) and old age ($\geq$50 years), equation (1) can be written as

$$LEB = \sum_{x=0}^{\omega} L_x = \sum_{x=0}^{14} L_x + \sum_{x=15}^{49} L_x + \sum_{x=50}^{\omega} L_x$$

Where, $\sum_{x=0}^{14} L_x$, $\sum_{x=15}^{49} L_x$ and $\sum_{x=50}^{\omega} L_x$ are the person-years lived in young age, reproductive age and old age, respectively. In other words

$$LEB = LEB * \left(\frac{\sum_{x=0}^{14} L_x}{LEB} + \frac{\sum_{x=15}^{49} L_x}{LEB} + \frac{\sum_{x=50}^{\infty} L_x}{LEB}\right) = LEB * (p_1 + p_2 + p_3) \quad (2)$$

Equation (2) suggests that the change or the difference in *LEB* can be explained in terms of the change or the difference in p_1, p_2 and p_3 or the proportionate distribution of total person-years lived across young age, reproductive age and old age. The change in *LEB* can be decomposed following the logarithmic mean divisia index decomposition approach (Ang, 2013). Let LEB^2 denotes the *LEB* at time 2 while LEB^1 denotes the *LEB* at time 1. Then the change in *LEB* may be written as

$$\nabla^{21} = LEB^2 - LEB^1 = \sum_{i=1}^{3} LEB^2 * p_i^2 - \sum_{i=1}^{3} LEB^1 * p_i^1 \quad (3)$$

Or

$$\nabla^{21} = \sum_{i=1}^{3} LEB^2 * p_i^2 - LEB^1 * p_i^1 \quad (4)$$

We can write.

$$LEB^2 * p_i^2 - LEB^1 * p_i^1 = \frac{LEB^2 * p_i^2 - LEB^1 * p_i^1}{ln\left(\frac{LEB^2 * p_i^2}{LEB^1 * p_i^1}\right)} * ln\left(\frac{LEB^2 * p_i^2}{LEB^1 * p_i^1}\right) = L_i^{21} * ln\left(\frac{LEB^2 * p_i^2}{LEB^1 * p_i^1}\right) \quad (5)$$

where

$$L_i^{21} = \frac{LEB^2 * p_i^2 - LEB^1 * p_i^1}{ln\left(\frac{LEB^2 * p_i^2}{LEB^1 * p_i^1}\right)} \quad (6)$$

is the logarithmic mean (Carlson, 1972; Lin, 1974). In other words,

$$LEB^1 * p_i^2 - LEB^1 * p_i^1 = L_i^{21} * ln\left(\frac{LEB^2}{LEB^1}\right) + L_i^{21} * ln\left(\frac{p_i^2}{p_i^1}\right) \quad (7)$$

Equation (3) can now be written as

$$\nabla^{21} = \sum_{i=1}^{3} L_i^{21} * ln\left(\frac{LEB^2}{LEB^1}\right) + \sum_{i=1}^{3} L_i^{21} * ln\left(\frac{p_i^2}{p_i^1}\right) \quad (8)$$

It may be noted that the number of person-years lived in an age interval depends upon the number of persons entering the age interval and the risk of death in the age interval. In case of person-years lived in young age, person-years lived is determined by the risk of death in young age only as persons entering young age is always the same and are equal to the radix of the life table. On the other hand, person-years lived in reproductive age depends upon the number of persons surviving to age 15 and the risk of death in reproductive age. If mortality in young age is high, number of persons entering reproductive age will be low compared to when mortality in young age is low. Similarly, person-years lived in old age depends upon both mortality in young age and mortality in reproductive age. This means that change in person-years lived in young age is solely due to the change in mortality but change in person-years lived in reproductive age depends upon both change in mortality in young age and change in mortality in reproductive age. Similarly, change in person-years lived in old age is determined by change in mortality in young age, change in

mortality in reproductive age and change in mortality in old age. In other words, the second term on the right hand side of equation 8 can be written as

$$\sum_{i=1}^{3} L_i^{21} * ln\left(\frac{p_i^2}{p_i^1}\right) = L_1^{21} * ln\left(\frac{p_1^2}{p_1^1}\right) + L_2^{21} * ln\left(\frac{p_2^2}{p_2^1}\right) + L_1^{21} * ln\left(\frac{p_3^2}{p_3^1}\right) \quad (9)$$

We can write.

$$ln\left(\frac{p_2^2}{p_2^1}\right) = ln\left(\frac{(p_2^2/p_1^2)*p_1^2}{(p_2^1/p_1^1)*p_1^1}\right) = ln\left(\frac{(p_2^2/p_1^2)}{(p_2^1/p_1^1)}\right) + ln\left(\frac{p_1^2}{p_1^1}\right) \quad (10)$$

Similarly,

$$ln\left(\frac{p_3^2}{p_3^1}\right) = ln\left(\frac{(p_3^2/p_2^2)*(p_2^2/p_1^2)*p_1^2}{(p_3^1/p_2^1)*(p_2^1/p_1^1)*p_1^1}\right) = ln\left(\frac{(p_3^2/p_2^2)}{(p_3^1/p_2^1)}\right) + ln\left(\frac{(p_2^2/p_1^2)}{(p_2^1/p_1^1)}\right) + ln\left(\frac{p_1^2}{p_1^1}\right) \quad (11)$$

Equation (8) now reduces to

$$\nabla^{21} = \sum_{i=1}^{3} L_i^{21} * ln\left(\frac{LEB^2}{LEB^1}\right) + \sum_{i=1}^{3} L_i^{21} * ln\left(\frac{p_1^2}{p_1^1}\right) + \sum_{i=2}^{3} L_i^{21} * ln\left(\frac{(p_2^2/p_1^2)}{(p_2^1/p_1^1)}\right) + L_3^{21} * ln\left(\frac{(p_3^2/p_2^2)}{(p_3^1/p_2^1)}\right) \quad (12)$$

We are particularly interested in assessing the contribution of the change in the proportionate share of person-years lived in young age, reproductive age and old age to the change in the life expectancy at birth. Equation (12) suggests that the contribution of the change in proportionate share of person-years lived in young age (C_Y) is given by.

$$C_Y = \sum_{i=1}^{3} L_i^{21} * ln\left(\frac{p_1^2}{p_1^1}\right) \quad (13)$$

Contribution of the change in proportionate share of person-years lived in reproductive age (C_R) is given by.

$$C_R = \sum_{i=2}^{3} L_i^{21} * ln\left(\frac{(p_2^2/p_1^2)}{(p_2^1/p_1^1)}\right) \quad (14)$$

Finally, contribution of the change in proportionate share of person-years lived in old age (C_O) is given by.

$$C_O = L_3^{21} * ln\left(\frac{(p_3^2/p_2^2)}{(p_3^1/p_2^1)}\right) \quad (15)$$

It may be noticed that the sum of the proportionate share of person-years lived in young age, reproductive age and old age is always equal to 1 irrespective of the distribution of person-years lived in young age, reproductive age and old age. This implies that the sum of the change in the proportionate share of person-years lived in three periods of life is always zero.

Following the same argument, it is also possible to explore how the female-male difference in the proportionate share of person-years lived in different periods of life contributes to the female-male difference in the life expectancy at birth. Similarly, it is also possible to analyse how urban-rural difference in the proportionate share of person-years lived in young age, reproductive age and old age contributes to the urban-rural difference in life expectancy at birth.

Results

Change in *LEB* in India, 1976-2023

Table 1 summarises the change in *LEB* in India during the period 1976-1980 through 2019-2023. *LEB* in the country increased by more than 18 years from around 52 years during 1976-1980 to more than 70 years during 2019-2023. During the period 1976-1990, the *LEB* increased in the country by more than 7 years. However, the increase slowed down in subsequent 10-years intervals and, during the period 2006-2020, the *LEB* increase by less than 4 years. During the period 2016-2023, the increase in *LEB* was marginal because of the COVID-19 pandemic which resulted in the marked increase in mortality, particularly, in the old population.

Table 1 also shows that there has also been a change in the proportionate distribution of person-years lived in young age, reproductive age, and old age over time. During the period 1976-1980, person-years lived in young age accounted for more than 23 per cent of the total person-years lived or the life expectancy at birth. This proportion decreased to less than 21 per cent during the period 2016-2020 but increased marginally during the period 2019-2023. Similarly, the proportion of person-years lived in the reproductive age also decreased over time. The proportion of person-years lived in the olds age, on the other hand, increased from more than 27 per cent during the period 1976-1980 to almost 33 per cent during the period 2016-2020 but decreased marginally during the period 2019-2023.

Table 1: Life expectancy at birth, and person-years lived in young age, reproductive age and old age in India, 1976-2023.

Period	Life expectancy at birth	Person-years lived in			Proportionate distribution		
		Young age	Reproductive age	Old age	Young age	Reproductive age	Old age
1976-1980	51.94	12.17	25.72	14.05	23.43	49.52	27.05
1986-1990	57.69	12.97	28.03	16.68	22.49	48.59	28.92
1996-2000	61.92	13.53	29.64	18.76	21.85	47.86	30.29
2006-2010	66.05	13.99	31.08	20.98	21.17	47.06	31.77
2016-2020	69.96	14.40	32.58	22.98	20.58	46.57	32.85
2019-2023	70.34	14.50	32.76	23.09	20.61	46.57	32.82

Source: Authors

Table 2 decomposes the change in *LEB* in India between 1976 and 2023. The change in the proportion of person-years lived in old age contributed to the increase in *LEB* during the period 1976-2020, but the change in the proportion of person-years lived in young age and in the reproductive age contributed to the decrease in *LEB*. However, during the period 2016-2023, change in the proportion of person-years lived in old age contributed to slowdown the increase in *LEB* while the change in the proportion of person-years lived in young age contributed to the increase in the *LEB*. On the other hand, there has been little change in the proportion of the person-years lived in reproductive age so that it contributed little to change *LEB* during this period.

It may be noticed that the period 2016-2023 includes the period of COVID-19 pandemic (2020-2022) in India. During the COVID-19 pandemic, there was a significant increase in mortality. It is well-known that virtually all the increase in mortality during the COVID-19 pandemic was confined to the old population and older reproductive age population while the young population, especially, population below 5 years of age had largely been unaffected from the pandemic in terms of mortality. As such, the proportionate distribution of person-years lived across young age, reproductive age and old age changed markedly. The increase in the COVID-19 associated mortality during the period 2020-2022 appears to have resulted in the decrease in the proportionate share of person-years lived in old age resulting in the increase in the proportionate share of person-years lived in young age. The decrease in the proportionate share of person-years lived in old age due to COVID-19 associated mortality contributed to the decrease, instead increase, in *LEB* whereas the increase in the proportionate share of person-years lived in young age contributed to the increase in *LEB* during the period 2016-2023. This is in contrast to earlier periods in which change in the proportionate person-years lived in young age contributed to decrease *LEB*.

Table 2: Decomposition of the change in *LEB* in India, 1976-2023.

Period	*LEB*			Average change	Change attributed to the proportionate share of person-years lived in		
	Beginning of the period	End of the period	Change		Young age	Reproductive age	Old age
1976-1990	51.94	57.69	5.75	5.75	-2.25	0.94	1.31
1986-2000	57.69	61.92	4.24	4.23	-1.71	0.62	1.09
1996-2010	61.92	66.05	4.13	4.13	-2.03	0.75	1.28
2006-2020	66.05	69.96	3.90	3.90	-1.93	0.96	0.97
2016-2023	69.96	70.34	0.39	0.39	0.10	-0.09	-0.02
1976-2023	51.94	70.34	18.40	18.38	-7.78	3.16	4.64

Source: Authors

Table 3 presents estimates of *LEB* in India and states during 1976-1980 and 2019-2023 along with estimates of person-years lived in young age, reproductive age and old age. In India, person-years lived in old age accounted for around 27 per cent of *LEB* during 1976-1980 which increased to almost 33 per cent during 2019-2023. On the other hand, the proportionate share of person-years lived in young age has decreased over time but that of person-years lived in reproductive age has increased. This pattern may also be seen in all states except Punjab where the proportionate share of person-years lived in old age decreased during 2019-2023 compared to 1976-1980 but proportionate share of person-years lived in young age and reproductive age has increased. Punjab is the only state in which the proportionate share of person-years lived in old age decreased, instead increased. *LEB* in Punjab increased from around 63 years during 1976-1980 to almost 71 years during 2019-2023. Increase in life expectancy at birth is associated with the decrease in mortality in different ages, particularly, in young age so that an increasing proportion of population survive to old age with the increase in the life expectancy at birth. In Punjab, however, it appears that mortality in old age has increased.

Table 3: Life expectancy at birth, and person-years lived in young age, reproductive age and old age in India and states, 1976-1980 and 2019-2023.

Country/State	1976-1980							2019-2023						
	LEB	Person-years lived in			Proportionate distribution			*LEB*	Person-years lived in			Proportionate distribution		
		Young age	Reproductive age	Old age	Young age	Reproductive age	Old age		Young age	Reproductive age	Old age	Young age	Reproductive age	Old age
India	51.94	12.17	25.72	14.05	23.43	49.52	27.05	70.34	14.50	32.76	23.09	20.61	46.57	32.82
Assam	50.86	12.60	26.29	11.98	24.76	51.69	23.55	68.63	14.46	32.62	21.56	21.07	47.52	31.41
Gujarat	52.01	12.06	25.47	14.48	23.19	48.97	27.84	70.40	14.57	32.91	22.92	20.69	46.75	32.56
Haryana	54.49	12.43	26.53	15.52	22.82	48.69	28.49	68.77	14.49	32.64	21.64	21.07	47.46	31.46
Himachal Pradesh	56.17	12.85	27.70	15.61	22.88	49.32	27.80	74.36	14.67	33.45	26.24	19.73	44.98	35.29
Jammu & Kashmir	57.18	13.19	28.97	15.02	23.07	50.67	26.26	74.38	14.71	33.62	26.06	19.77	45.20	35.03
Karnataka	56.46	12.89	27.45	16.12	22.82	48.62	28.56	69.98	14.66	33.03	22.29	20.95	47.20	31.85
Kerala	65.35	13.96	31.16	20.24	21.35	47.68	30.97	75.15	14.86	33.98	26.31	19.77	45.21	35.02
Maharashtra	56.19	12.89	27.68	15.62	22.93	49.27	27.80	72.82	14.73	33.48	24.61	20.23	45.97	33.80
Odisha	48.78	12.01	24.88	11.90	24.61	51.00	24.39	70.54	14.43	32.45	23.66	20.45	46.00	33.55
Punjab	63.20	12.82	28.07	22.31	20.28	44.41	35.30	70.81	14.66	33.01	23.14	20.70	46.62	32.68
Rajasthan	51.12	12.00	25.17	13.95	23.48	49.23	27.29	70.44	14.39	32.54	23.51	20.43	46.20	33.37
Tamil Nadu	52.97	12.51	26.53	13.93	23.63	50.08	26.30	73.40	14.75	33.50	25.15	20.10	45.64	34.26

Source: Authors

Table 4: Decomposition of the change in *LEB* in India and states during the period 1976-1980 through 2019-2023.

India/ States	*LEB*			Average change	Change attributed to the proportionate share of person-years lived in		
	1976-1980	2019-2023	Increase		Young age	Reproductive age	Old age
India	51.94	70.34	18.40	18.38	-7.78	3.16	4.64
Assam	50.86	68.63	17.77	17.73	-9.57	3.55	6.07
Gujarat	52.01	70.40	18.39	18.37	-6.93	3.22	3.73
Haryana	54.49	68.77	14.28	14.27	-4.89	2.59	2.30
Himachal Pradesh	56.17	74.36	18.19	18.15	-9.58	2.85	6.77
Jammu & Kashmir	57.18	74.38	17.21	17.15	-10.05	2.05	8.06
Karnataka	56.46	69.98	13.51	13.51	-5.38	2.74	2.64
Kerala	65.35	75.15	9.80	9.79	-5.40	1.33	4.07
Maharashtra	56.19	72.82	16.63	16.60	-8.04	2.83	5.23
Odisha	48.78	70.54	21.76	21.68	-10.90	3.75	7.22
Punjab	63.20	70.81	7.60	7.60	1.36	1.49	-2.85
Rajasthan	51.12	70.44	19.32	19.29	-8.36	3.54	4.85
Tamil Nadu	52.97	73.40	20.43	20.38	-10.10	3.36	6.79

Source: Authors

Among different states of the country for which life tables are available from the Sample Registration System, the share of the person-years lived in old age was the highest in Himachal Pradesh followed by Jammu & Kashmir and Kerala during 2019-2023. In all these states, person-years lived in old age accounted for more than 35 per cent of the total person-years lived or *LEB* and, in all these states, *LEB* during 2019-2023 was more than 74 years. On the other hand, this proportion was the lowest in Assam followed by Haryana and Karnataka. In these states, person-years lived in old age accounted for less than 32 per cent of the total person-years lived or *LEB* and, in all these states, life expectancy at birth during 2019-2023 was less than 70 years. Table 3 suggests that the higher the proportion of person-years lived in old age in a state the higher *LEB* in that state.

Table 4 decomposes the change in *LEB* during the period between 1976-1980 and 2019-2023 in different states of the country. The increase in *LEB* has been the highest in Odisha followed by Tamil Nadu during this period. These are the only two states – Odisha and Tamil Nadu – in which life expectancy at birth increased by more than 20 years during 1976-2023. On the other hand, increase in life expectancy at birth was the slowest in Punjab, followed by Kerala. Odisha had the lowest life expectancy at birth while Kerala had the highest life expectancy at birth during 1976-1980. The increase in the proportionate share of person-years lived in old age increased in all states except Punjab and was the highest in Jammu & Kashmir, followed by Odisha and Tamil Nadu but the lowest in Haryana. The proportionate share of person-years lived in young age decreased in all states except Punjab. The proportionate share of person-years lived in reproductive age, however, increased in all states. Punjab is the only state in which proportionate share of person-years lived in old age decreased during 1978-2023.

Female-Male Difference in Life Expectancy at Birth, 2019-2023

Table 5 presents the proportionate distribution of person-years lived by males and females in young age, reproductive age and old age in India and states during the period 2019-2023. The most noticeable observation of table 5 is that the proportionate share of person-years lived in old age by females is substantially higher than the proportionate share of person-years lived by males in old age in the country and in all states. In India, person-years lived by females in old age accounted for almost 35 per cent of the total person-years lived in all ages compared to around 31 by males. In Himachal Pradesh and Kerala, person-years lived by females in old age accounted for more than 37 per cent of the person-years lived in all ages while this proportion was less than 31 per cent in Chhattisgarh. On the other hand, the proportion of person-years lived by males in old age was the highest in Odisha but the lowest in Chhattisgarh.

Table 6 decomposes female-male difference in *LEB* in India and states during 2019-2023 in terms of the difference in the proportionate share of person-years lived in young age, reproductive age and old age. The female life expectancy at birth was around 4 years higher than the male life expectancy at birth in India during the period 2019-2023. The proportionate share of person-years lived by females in young age was smaller than the proportionate share of person-years lived by males in young age so that female-male difference in the proportionate share of person-years lived in young age contributed to decrease female-male difference in life expectancy at birth. However, proportionate share of person-years lived by females in reproductive age and old age was larger than the proportionate share of person-years lived by males in these ages so that female-male difference in the proportionate share of person-years lived in reproductive age and old age contributed to widen the female-male difference in the life expectancy at birth.

Table 6 also shows that in all states of the country, female-male difference in the proportionate share of person-years lived in young age contributed to decrease the female-male difference in *LEB* whereas female-male difference in reproductive age and old age contributed to increase the female-male difference in *LEB*. The magnitude of the contribution, however, has been different in different states. The female-male difference in *LEB* was the highest in Himachal Pradesh where females outlived males by more than 7 years during 2019-2023. On the other hand, female-male difference in *LEB* was the narrowest in Bihar where females outlived males by less than 1 year during the period 2019-2023. In Himachal Pradesh, female-male difference in the proportionate share of person-years lived in old age accounted for almost 6 years of the female-male difference in the life expectancy at birth. In Bihar, by contrast, female-male difference in the proportionate share of person-years lived in old age accounted for less than 0.9 years of the female-male difference in *LEB*. In Gujarat, Haryana, Kerala and Tamil Nadu also, female-male difference in the proportionate share of person-years lived in old age was more than 5 years so that female-male difference in *LEB* in these states was also very large. In Jharkhand, West Bengal, Odisha and Jammu & Kashmir, on the other hand, female-male difference in the proportionate share of person-years lived in old age was less than 2 years and, therefore, female-male difference in *LEB* in these states was less than 3 years. In Jharkhand, female-male difference in *LEB* was less than 1.8 years which is the second lowest across states, next only to Bihar as may be seen from table 6.

Table 5: Life expectancy at birth, and person-years lived in young age, reproductive age and old age in male population India and states, 2019-2023.

Country/State	Male							Female						
	LEB	Person-years lived in			Proportionate distribution			LEB	Person-years lived in			Proportionate distribution		
		Young age	Reproductive age	Old age	Young age	Reproductive age	Old age		Young age	Reproductive age	Old age	Young age	Reproductive age	Old age
India	68.46	14.50	32.57	21.39	21.18	47.58	31.24	72.46	14.49	32.95	25.02	20.00	45.47	34.53
Andhra Pradesh	68.52	14.60	32.72	21.21	21.30	47.75	30.95	73.27	14.64	33.47	25.15	19.99	45.68	34.33
Assam	66.94	14.48	32.52	19.95	21.63	48.58	29.80	70.72	14.44	32.71	23.57	20.41	46.26	33.33
Bihar	68.95	14.58	32.89	21.48	21.14	47.70	31.15	69.75	14.52	32.87	22.36	20.82	47.13	32.06
Chhattisgarh	62.41	14.35	31.39	16.67	23.00	50.29	26.71	67.06	14.30	32.21	20.54	21.32	48.04	30.64
Delhi	72.28	14.78	33.67	23.84	20.44	46.58	32.98	76.79	14.78	33.93	28.07	19.25	44.19	36.56
Gujarat	67.57	14.55	32.62	20.40	21.53	48.27	30.19	73.86	14.58	33.24	26.04	19.75	45.00	35.25
Haryana	65.95	14.49	32.31	19.15	21.97	48.99	29.04	72.18	14.49	33.01	24.67	20.08	45.73	34.19
Himachal Pradesh	70.97	14.62	33.07	23.28	20.61	46.59	32.80	78.10	14.72	33.82	29.55	18.85	43.31	37.84
Jammu & Kashmir	73.39	14.71	33.55	25.13	20.04	45.71	34.25	75.48	14.71	33.69	27.08	19.49	44.64	35.87
Jharkhand	68.70	14.55	32.58	21.56	21.18	47.43	31.39	70.47	14.52	32.87	23.08	20.61	46.64	32.75
Karnataka	67.80	14.67	32.80	20.33	21.63	48.38	29.99	72.37	14.66	33.27	24.45	20.25	45.96	33.78
Kerala	71.95	14.83	33.64	23.48	20.61	46.75	32.64	78.36	14.89	34.29	29.18	19.00	43.76	37.24
Madhya Pradesh	65.39	14.21	31.59	19.59	21.73	48.31	29.96	70.28	14.23	32.19	23.85	20.25	45.81	33.94
Maharashtra	70.73	14.73	33.24	22.76	20.83	46.99	32.18	75.19	14.73	33.74	26.73	19.59	44.87	35.54
Odisha	69.35	14.40	32.22	22.73	20.77	46.46	32.77	71.85	14.45	32.69	24.71	20.11	45.50	34.39
Punjab	68.83	14.67	32.75	21.41	21.31	47.58	31.11	73.09	14.65	33.29	25.16	20.04	45.54	34.42
Rajasthan	67.84	14.44	32.47	20.94	21.28	47.86	30.86	73.28	14.34	32.61	26.33	19.57	44.50	35.94
Tamil Nadu	71.40	14.75	33.24	23.41	20.66	46.56	32.78	75.55	14.76	33.76	27.03	19.53	44.68	35.78
Telangana	68.61	14.61	32.81	21.19	21.30	47.82	30.88	73.23	14.64	33.33	25.26	19.99	45.52	34.49
Uttar Pradesh	66.47	14.27	31.98	20.22	21.47	48.11	30.42	69.79	14.24	32.16	23.38	20.41	46.08	33.50
Uttarakhand	68.12	14.64	32.78	20.70	21.49	48.13	30.39	74.84	14.63	33.31	26.89	19.55	44.51	35.93
West Bengal	71.14	14.65	33.23	23.26	20.60	46.71	32.69	74.05	14.68	33.51	25.86	19.82	45.25	34.93

Source: Author

Table 6: Decomposition of female-male difference in *LEB* in India and selected states during the period 2019-2023.

India/ States	*LEB*			Average change	Change attributed to the proportionate share of person-years lived in		
	Female	Male	Difference		Young age	Reproductive age	Old age
India	72.46	68.46	4.00	4.00	-4.04	0.68	3.37
Andhra Pradesh	73.27	68.52	4.75	4.74	-4.51	1.10	3.42
Assam	70.72	66.94	3.77	3.77	-3.98	0.48	3.50
Bihar	69.75	68.95	0.80	0.80	-1.08	0.19	0.89
Chhattisgarh	67.06	62.41	4.65	4.65	-4.89	1.50	3.40
Delhi	76.79	72.28	4.50	4.50	-4.46	0.44	4.03
Gujarat	73.86	67.57	6.28	6.28	-6.11	0.91	5.20
Haryana	72.18	65.95	6.23	6.22	-6.20	1.15	5.05
Himachal Pradesh	78.10	70.97	7.13	7.13	-6.62	0.95	5.68
Jammu & Kashmir	75.48	73.39	2.09	2.09	-2.09	0.26	1.83
Jharkhand	70.47	68.70	1.77	1.77	-1.90	0.58	1.32
Karnataka	72.37	67.80	4.57	4.57	-4.61	0.81	3.80
Kerala	78.36	71.95	6.41	6.41	-6.09	0.91	5.19
Madhya Pradesh	70.28	65.39	4.89	4.88	-4.78	0.93	3.85
Maharashtra	75.19	70.73	4.46	4.46	-4.47	0.88	3.60
Odisha	71.85	69.35	2.50	2.50	-2.27	0.63	1.64
Punjab	73.09	68.83	4.26	4.25	-4.36	0.99	3.36
Rajasthan	73.28	67.84	5.44	5.43	-5.91	0.61	5.30
Tamil Nadu	75.55	71.40	4.15	4.15	-4.11	0.87	3.24
Telangana	73.23	68.61	4.62	4.62	-4.50	0.80	3.70
Uttar Pradesh	69.79	66.47	3.33	3.33	-0.72	-1.38	2.10
Uttarakhand	74.84	68.12	6.72	6.72	-1.38	-2.58	3.97
West Bengal	74.05	71.14	2.90	2.90	-0.57	-1.06	1.62

Source: Authors

Urban-Rural Difference in Life Expectancy at Birth, 2019-2023

Table 7 gives the distribution of person-years lived in young age, reproductive age and old age in rural and urban areas of the country and the states for which data are available through the sample registration system. In India and in all states except Kerala and Uttarakhand, people living in urban areas lived longer that the people living in the rural areas. Kerala and Uttarakhand are the only states where people living in the rural areas lived longer than the people living in the urban areas during the period 2019-2023. The urban-rural difference in *LEB* was the widest in Tamil Nadu followed by Assam. In these states, people living in urban areas lived more than 5 years longer than the people living in the rural areas. On the other hand, Odisha and Himachal Pradesh are the only states in the country in which urban-rural difference in *LEB* is narrow. The urban *LEB* in these states exceeds rural *LEB* by less than 2 years.

Table 7: Life expectancy at birth, and person-years lived in young age, reproductive age and old age in male population India and states, 2019-2023.

Country/State	Rural							Urban						
	LEB	Person-years lived in			Proportionate distribution			LEB	Person-years lived in			Proportionate distribution		
		Young age	Reproductive age	Old age	Young age	Reproductive age	Old age		Young age	Reproductive age	Old age	Young age	Reproductive age	Old age
India	69.10	14.44	32.52	22.14	20.90	47.06	32.05	73.10	14.65	33.32	25.12	20.05	45.59	34.37
Andhra Pradesh	69.75	14.58	32.86	22.31	20.90	47.11	31.98	72.82	14.71	33.57	24.55	20.19	46.10	33.71
Assam	67.75	14.41	32.47	20.87	21.27	47.93	30.80	73.54	14.78	33.54	25.22	20.09	45.61	34.30
Bihar	68.98	14.55	32.86	21.58	21.09	47.63	31.28	71.48	14.57	33.08	23.83	20.39	46.28	33.33
Chhattisgarh	64.07	14.30	31.64	18.13	22.32	49.39	28.30	66.40	14.46	32.38	19.56	21.77	48.76	29.46
Delhi	72.11	14.80	33.49	23.82	20.53	46.45	33.03	74.29	14.78	33.80	25.72	19.89	45.49	34.61
Gujarat	68.65	14.48	32.54	21.62	21.10	47.40	31.50	72.72	14.68	33.39	24.65	20.19	45.91	33.90
Haryana	67.93	14.44	32.43	21.06	21.25	47.74	31.01	70.13	14.60	33.01	22.52	20.81	47.07	32.12
Himachal Pradesh	74.19	14.66	33.41	26.11	19.77	45.04	35.19	76.11	14.77	33.84	27.50	19.40	44.47	36.13
Jammu & Kashmir	73.41	14.69	33.57	25.15	20.02	45.73	34.26	76.67	14.76	33.75	28.16	19.25	44.02	36.73
Jharkhand	68.82	14.52	32.58	21.72	21.10	47.33	31.57	71.54	14.61	33.21	23.73	20.42	46.42	33.16
Karnataka	68.46	14.63	32.86	20.98	21.37	47.99	30.64	72.64	14.72	33.29	24.63	20.26	45.83	33.91
Kerala	75.71	14.88	34.05	26.78	19.66	44.97	35.37	74.59	14.83	33.90	25.85	19.89	45.45	34.66
Madhya Pradesh	66.76	14.16	31.65	20.95	21.21	47.41	31.38	70.45	14.46	32.68	23.31	20.52	46.39	33.09
Maharashtra	71.27	14.66	33.15	23.46	20.57	46.51	32.92	75.05	14.82	33.85	26.38	19.74	45.10	35.15
Odisha	70.22	14.39	32.34	23.49	20.50	46.05	33.45	72.05	14.60	33.04	24.42	20.26	45.85	33.89
Punjab	69.23	14.64	32.78	21.81	21.14	47.35	31.51	73.16	14.69	33.29	25.19	20.07	45.50	34.42
Rajasthan	69.74	14.36	32.41	22.98	20.59	46.47	32.95	72.74	14.51	32.99	25.23	19.95	45.36	34.69
Tamil Nadu	70.33	14.72	33.26	22.35	20.93	47.30	31.78	76.29	14.79	33.71	27.80	19.38	44.18	36.44
Telangana	69.80	14.56	32.68	22.56	20.86	46.82	32.32	71.95	14.71	33.57	23.66	20.44	46.67	32.89
Uttar Pradesh	67.42	14.21	31.90	21.31	21.08	47.31	31.61	70.10	14.43	32.68	22.99	20.59	46.61	32.80
Uttarakhand	71.35	14.62	32.94	23.79	20.50	46.17	33.34	70.96	14.66	33.30	23.00	20.66	46.93	32.41
West Bengal	71.45	14.65	33.34	23.45	20.51	46.67	32.83	74.82	14.71	33.44	26.67	19.66	44.70	35.64

Source: Authors

Table 8: Decomposition of urban-rural difference in life expectancy at birth in India and states, 2019-2023.

India/ States	LEB			Average change	Change attributed to the proportionate share of person-years lived in		
	Urban	Rural	Difference		Young age	Reproductive age	Old age
India	73.10	69.10	3.99	3.99	-2.95	0.55	2.40
Andhra Pradesh	72.82	69.75	3.07	3.06	-2.46	0.72	1.74
Assam	73.54	67.75	5.79	5.79	-4.02	0.41	3.61
Bihar	71.48	68.98	2.50	2.50	-2.38	0.28	2.09
Chhattisgarh	66.40	64.07	2.33	2.33	-1.60	0.60	1.00
Delhi	74.29	72.11	2.18	2.18	-2.30	0.63	1.68
Gujarat	72.72	68.65	4.08	4.07	-3.13	0.69	2.44
Haryana	70.13	67.93	2.20	2.20	-1.44	0.36	1.08
Himachal Pradesh	76.11	74.19	1.92	1.92	-1.39	0.35	1.04
J&K	76.67	73.41	3.27	3.27	-2.94	0.07	2.87
Jharkhand	71.54	68.82	2.72	2.72	-2.30	0.74	1.56
Karnataka	72.64	68.46	4.18	4.18	-3.74	0.38	3.36
Kerala	74.59	75.71	-1.12	-1.12	0.85	-0.05	-0.81
Madhya Pradesh	70.45	66.76	3.70	3.70	-2.28	0.63	1.65
Maharashtra	75.05	71.27	3.78	3.78	-3.00	0.60	2.40
Odisha	72.05	70.22	1.83	1.83	-0.83	0.42	0.41
Punjab	73.16	69.23	3.93	3.93	-3.70	0.69	3.01
Rajasthan	72.74	69.74	2.99	2.99	-2.24	0.42	1.82
Tamil Nadu	76.29	70.33	5.97	5.96	-5.60	0.49	5.12
Telangana	71.95	69.80	2.15	2.15	-1.44	0.96	0.48
Uttar Pradesh	70.10	67.42	2.68	2.68	-0.34	-0.48	0.82
Uttarakhand	70.96	71.35	-0.39	-0.39	0.12	0.54	-0.66
West Bengal	74.82	71.45	3.37	3.37	-0.62	-1.44	2.06

Source: Authors

Table 8 decomposes urban-rural difference in *LEB* in India and selected states. Urban-rural difference in the proportionate share of person-years lived in young age contributed to narrow down urban-rural difference in *LEB* in India and in all states except Kerala and Uttarakhand while urban-rural difference in the proportionate share of person-years lived in old age contributed to widen urban-rural difference in *LEB* in the country and in all states except Kerala and Uttarakhand. Urban-rural difference in the proportionate share of person-years lived in reproductive age also contributed to widen urban-rural difference in *LEB* in India and in states other than Kerala, Uttar Pradesh and West Bengal. Table 8 also shows that the urban-rural difference in *LEB* is different in different states of the country. Kerala is the only state where urban-rural difference in the proportionate share of person-years lived in reproductive age and in old age contributed to narrow down the urban-rural difference in *LEB* or urban-rural difference in person-years lived in all ages. In other states, urban-rural difference in proportionate share of person-years lived in reproductive age and old age contributed to widen urban-rural difference in *LEB*.

Discussion and Conclusions

In this paper, we have analysed how person-years lived in young age (0-14 years), reproductive age (15-49 year) and old age (50 years and older) have contributed to the change in *LEB* in India during the period 1976-2023. The analysis has also explored how female-male and urban rural difference in person-years lived in young age, reproductive age and old age has contributed to the female-male and urban-rural difference in *LEB* in India and in its states during the period 2019-2023. The analysis reveals that, the increase in *LEB* in India from around 52 years in 1976-1980 to more than 70 years in 2019-2023 has been associated with the decrease in the proportionate share of person-years lived in young age and reproductive age in the person-years lived in all ages while the proportionate share of the person-years lived in old age has increased. Although, in absolute terms person-years lived in young age, reproductive age and old age increased with the increase in the life expectancy at birth, yet, in proportionate terms, the contribution of young age has decreased but that of reproductive age and old age has increased. It is only during the period 2016-2023 that the contribution of the change in the proportionate share of person-years lived in young age contributed to increase *LEB* while change on the proportionate share of person-years lived in old age contributed to the decrease in *LEB* because of the typical age pattern of mortality associated with COVID-19 pandemic. Findings reveal that, although females experience high life expectancy in younger ages still the male proportions are more in younger ages as the sex ratio favours males over females in younger ages and as males progress to higher age, they experience high mortality as they are engaged in risky jobs and they are more likely to involve in smoking, tobacco and alcohol consumption.

The decomposition analysis has revealed significant variations in the age-specific contributions to life expectancy, highlighting the changing dynamics of mortality and survival across the life course. The analysis of the female-male differential showed that the overall female advantage in life expectancy was primarily attributable to survival advantages at older ages. While the young (0-14 years) and reproductive (15-49 years) age groups contributed less than the average female-male differential, the old-age group (50 years and above) contributed substantially more than the average, indicating that lower mortality among older women is the principal source of the observed female-male gap in longevity which may be because men are more prone to engaging in risky behaviours, whereas women generally exhibit lower participation in such activities. These behavioural differences substantially contribute to the higher life expectancy observed among females compared to males.

Similarly, the urban-rural decomposition demonstrated that differences in life expectancy are increasingly concentrated at older ages. Negative contributions from the young and reproductive age groups suggest that disparities in survival during these ages have narrowed considerably, reflecting improvement in healthcare access, maternal and child health services, and socioeconomic conditions in rural areas. However, the positive contribution of the old-age group indicates that mortality differentials among old population continue to sustain the urban advantage in life expectancy.

The temporal decomposition of life expectancy gains between 1976 and 2023 further highlights a shift in the age pattern of mortality improvement. Although substantial

reduction in mortality occurred in younger ages, their contributions have been below the average increase in life expectancy. In contrast, mortality decline among individuals aged 50 years and above exceeded the average contribution and emerged as the dominant driver of longevity gains. This finding reflects the progression of demographic and epidemiological transition in India, whereby further improvement in life expectancy will increasingly depend upon survival in old ages rather than reductions in mortality in young ages.

Overall, the study underscores the growing importance of mortality in old age in shaping both life expectancy differentials and longevity improvement in India. While remarkable progress has been achieved in reducing mortality during childhood and adulthood, future gains in life expectancy and reduction in population disparities will depend increasingly upon effective strategies to improve health and survival of the old population. Strengthening geriatric healthcare services, expanding access to chronic disease prevention and management, and promoting healthy ageing should therefore constitute key priorities for public health policy in India.

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