



**PROGRAM ON THE GLOBAL  
DEMOGRAPHY OF AGING  
AT HARVARD UNIVERSITY**

**Working Paper Series**

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Sanjay K. Mohanty, Guenther Fink, Rajesh K. Chauhan, David Canning

May 2015

PGDA Working Paper No. 124

<http://www.hsph.harvard.edu/pgda/working/>

The views expressed in this paper are those of the author(s) and not necessarily those of the Harvard Initiative for Global Health. The Program on the Global Demography of Aging receives funding from the National Institute on Aging, Grant No. 1 P30 AG024409-11.

## Distal determinants of fertility decline – Evidence from 640 Indian Districts

Sanjay K. Mohanty<sup>1</sup>, Guenther Fink<sup>2</sup>, Rajesh K. Chauhan<sup>3</sup>, David Canning<sup>2</sup>

### Abstract

*Using data from national census and large-scale population surveys over the last two decades (1991-2011), this paper examines the role of female education, under-five mortality and poverty as the distal determinants of fertility across 640 districts of India. Our results suggest a remarkable degree of convergence across all distal determinants, but only limited evidence of convergence for fertility. Both the level and changes of female literacy were strongly associated with fertility change, and the same was true, even though to a lesser extent, for under-5 mortality. Our results suggest that changes in mortality and female education can explain majority of the large fertility declines observed over the sample period, while the contribution of improved socioeconomic status to fertility declines appears to be very limited.*

**Key words:** *fertility transition, district, female literacy, under-five mortality, poverty, India*

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<sup>1</sup>Harvard Center for Population and Development studies, Cambridge, MA 02138 & International Institute for Population Sciences, Mumbai, Email: [smohanty@hsph.harvard.edu](mailto:smohanty@hsph.harvard.edu); [sanjayiips@yahoo.co.in](mailto:sanjayiips@yahoo.co.in)

<sup>2</sup>Department of Global Health and Population, Harvard T. H. Chan School of Public Health, Boston

<sup>3</sup>Population Research Centre, Department of Economics, University of Lucknow, India

We are grateful to Prof David E Bloom for valuable suggestions in improving the paper. We thank Mr. Akshar Saxena for proof reading of the paper and Ms. Mamta Rajbhar for her help in preparing the data file.

## **Introduction**

The relationship between fertility and its distal as well as proximate determinants has been the subject of a long-standing and continued inquiry among demographers, economists, sociologists and researchers in other fields. Even though a relatively clearly defined set of social, economic, and demographic factors have been identified as key drivers of fertility change in theoretical literature, empirical evidence suggests that key drivers are highly context-specific with diverging patterns across both countries and time (Bongaarts & Watkins, 1996; Potter et al., 2002; Brown & Guinnane, 2002; Mason, 1997; Harttgen & Vollmer, 2014; Mikko, Hans-Peter, & Francesco 2009).

In terms of distal determinants, the most commonly identified variables are mother's educational attainment, child mortality and poverty and a broad set of economic proxies (AksAn, 2014; Amin, Casterline, & Spess, 2007; Basu, 2002; Bulatao & Lee, 1983; J. Caldwell & McDonald, 1982; J Cleland, 2001; Dreze & Murthi, 2001; Eastwood & Lipton, 1999; Jain & Nag, 1986; Merrick, 2002; Robey, 1990). Major progress has been made for all three factors at the global level: under-five mortality has declined from an average of 100 to an average of 50 deaths per 1000 live birth (UNICEF, 2014) between 1990 and 2013; average schooling for women aged 15 years and above has increased from 6.14 years in 1990 to 7.89 years by 2010 (UNDP, 2014; Barro & Lee, 2011) and the percentage of population living below poverty line at US\$1.25 per day per person at 2005 PPP has declined from 43% in 1990 to 17% by 2011 (IBRD, 2015).

Cross country analyses have shown a positive and significant association of change in fertility and socioeconomic development (Bongaarts & Watkins, 1996). The mean predicted change in TFR due to change in female education in micro regions of Brazil (rural) was -0.14 in 1960-70, -0.64 in 1970-80 and -0.67 in 1980-91 and that of under-five mortality was between -0.07 and -0.10 during the same period (Potter, Schmertmann, & Cavenaghi, 2002). Female literacy and child mortality accounted for half of the overall TFR reduction i.e., TFR reduced by 0.7 between 1981 and 1991 in 326 districts of India (Dreze and Murthi; 2001). Empirical evidence on the links between poverty and fertility appears more mixed and has fuelled the population and poverty debate (Merrick, 2002). The cross-sectional analyses found a negative association of fertility rates with economic growth and income distribution against the poor (Eastwood & Lipton, 1999). Studies found a strong and positive associations between demographic change and poverty reduction in Brazil, with demographic change accounting for nearly 15% of economic growth (Barro & Lee, 2011; Barros., Firpo, & Leite, 2001). On the other hand, the root cause of fertility reduction in Bangladesh and Addis Ababa has been attributed to poverty (Gurumu and Mace 2008; Kabeer, 2001). Recent studies from India suggest that poverty has limited power in explaining fertility reduction in the states of India (McNay, Arokiasamy, & Cassen, 2003; Mohanty & Ram, 2011). The relationship between population growth and poverty in state level analyses did not support the Malthusian view (Van de Walle, 1985)

## **Theoretical Background**

A large and growing demographic, economic and sociology literature has aimed at understanding the fundamental drivers of demographic change in general, and the determinants of fertility decline in particular. The Demographic Transition Theory (DTT), with a basic comparison of birth and death rates across developed countries, steered the literature on fertility change (Notestein, 1945; Thompson, 1929). The initial DTT framework drew sharp criticism due to its low predictive power in explaining the often highly heterogeneous trajectories of developing countries under often similar socio-economic condition (Teitebaum, 1975). In sociological literature, the importance of knowledge and preferences were highlighted by the multiphasic response theory (Davis & Blake, 1956) as well as by theories of diffusion and cultural lag (Carlson, 1996). Based on evidence from Europe, the concepts of diffusion and adoption were further extended to linguistic and cultural boundaries in the 1980s (Cleland & Wilson, 1987). The role of secularization and individualism in fertility transition was highlighted (Lesthaeghe & Surkyn, 1988). At the same time, the intermediate variable framework and proximate determinant highlighted the mechanisms of fertility change (Bongaarts, 1982; Davis & Blake, 1956). In economic literature, fertility change was mostly viewed as a result of changing benefits and costs associated with child bearing (Becker, 1960; Leibenstein, 1974).

Most recently, Casterline (Casterline, 2001) outlined four determinants of global fertility change namely the pace of social and economic change, the pace of change in economic aspiration and expectation, the pace of provision of birth control services and the pace of reduction of moral and social cost of birth control. Caldwell (J. C. Caldwell, 2001)

stressed the need to integrate the socioeconomic change with ideologies, attitude and the mechanism of fertility control in fertility theories. While all these theories, framework and evidence have strengthened our understanding of fertility change<sup>1</sup>, the overall understanding of the factors that truly drive fertility empirically remains limited (Brown & Guinnane, 2002; Mason, 1997).

## **Rationale and Objective**

Given that both distal and proximate determinants tend to be strongly correlated with a large number of societal norms and indicators, ruling out confounding concerns is generally difficult at the country level. Indian districts offer a perfect laboratory to study the association of fertility change and developmental indicators due to their size, diversity, socioeconomic disparity and large differences in the progression of demographic transition. The average population of an Indian district is over 2 million amid large variation in socioeconomic development. While some of the districts are still at an early stage of demographic transition with TFR larger than five, many districts have reached TFR levels below replacement. There is also considerable intra-district variation in all key indicators of human development. In 2004-05, estimated poverty was a 81% in Nawarangpur district (Odisha) and less than 10 percent in many other districts of India (Chaudhuri & Gupta, 2009).

Although some district level information is available for planners and policy makers, obtaining systematic district-level data is a daunting task for researchers, with even the most basic fertility measures becoming available only in recent years (Guilmoto & Rajan,

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<sup>1</sup> For a systematic reviews on theories of fertility and their applicability for further detail (van de Kaa 1996).

2001, 2013; Kumar & Sathyanarayana, 2012). The aim of this paper is to compile all currently available micro-data to examine the association of fertility change with female literacy, under-five mortality and poverty, at the district level.

## **Data and Methods**

### **Data**

We combine data from multiple public sources: 1) the Censuses of India from 1991, 2001 and 2011; 2) the consumption expenditure surveys conducted as part of the National Sample Surveys in 1993-94, 2004-05, and 2009-10; and 3) the Annual Health Survey from 2011 (ORGI, 2011). In addition to these data, we use estimates of under-five-mortality recently published by Ram et al (Ram et al., 2013) and background information from published reports of the National Family Health Surveys (IIPS & MacroInternational, 1995, 2007).

As of 2011, India was divided administratively into 29 states, 6 union territories, 84 agro-climatic regions and 640 districts. The number of districts has increased from 440 in 1991 to 503 in 2001 and further to 640 in 2011. In this paper we focus on districts as the unit of analysis using the 2011 district definition. In cases where districts were split between censuses, we apply the larger (merged) district estimates for all sub-district areas. The census of India was not conducted in the state of Jammu and Kashmir in 1991 – districts in this state were excluded from our analysis.

## **Outcome**

District-level Total Fertility Rates (TFR) are the main outcome of interest for our analysis. TFR estimates were generated from census data using reverse survival models (RSM) based on the number of children under seven years of age. A detailed description of the RSM methodology as well as the resulting estimates are available in Mohanty and Rajbhar (Mohanty & Rajbhar, 2014). To ensure the accuracy of these estimates, we compared them to previously published estimates generated for 2001 and 2011 by Guilmore and Rajan (2013) – the correlation between the two estimates in the 2001 and 2011 periods is 0.93.

## **Independent Variables**

The three distal determinants of fertility analyzed in this paper are female literacy, under-five mortality and poverty. Female literacy is defined as percentage of the population over age six who can read and write. District level estimates for literacy are directly available from the three rounds of the census through the Primary Census Abstracts. Data on educational attainment (primary, middle and secondary and higher secondary above) is not currently available at the district level; we have used the available state-level data in one of our robustness checks. The under-five mortality rate (U5MR) is defined as the probability of not surviving by the fifth birthday and expressed as deaths per 1000 live births. The estimates of U5MR for 1991 and 2001 have been taken from the Census of India publications (ORGI, 1997, 2009). For 2011, the under-five mortality estimates for 274 districts were available in the Annual Health Survey 2011 (ORGI, 2011). For the remaining districts, we used recent estimates published by Ram et al (2013).

For poverty, we used the consumption expenditure data from the National Sample Survey (NSS) for the years 2004-05 and 2009-10 to compute the percentage of households in each district living below the state-specific poverty lines (Planning Commission, 2012)<sup>2</sup>. In cases where the district samples were small (< 400 observations), we used regional rather than district poverty estimates. For 1993-94, we have derived the estimates of poverty for the districts of India on the assumption that the decline in poverty in districts during 2004-05 and 1993-94 was similar to that in the region the district belongs to. For this purpose, we used NSS regions: these regions comprise a group of districts with similar agro-climatic and economic conditions, and have been frequently used as spatial proxies for districts (Dreze and Murthi 2002; Bhat, 1996). NSS region estimates were used for 36 districts in 2001 and for 61 districts in the 2011. It is worth highlighting that the NSS data does not exactly map onto the census data time-wise. Thus, the computed rates may not reflect the true levels for 1991, 2001 and 2011 exactly, but reflect the data points closest to each of three time period.

## **Methods**

Our empirical approach is divided into three parts. In order to provide a first impression of the spatial and temporal variation in our variables of interest we start our analysis with basic descriptive statistics and figures showing levels and changes of all four variables. To test the strength of the associations between TFR and independent variables of interest, we plot the absolute and relative change of TFR as a function of the base values

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<sup>2</sup> With 22% of poor in India (as per Tendulkar Committee) and margin of error of 5%, the required sample size is estimated at 264 person and we have kept 400 sample persons to get robust estimates.

of our independent variables. In order to identify adjusted associations in a multi-variable setting, we start out by a standard difference-in-differences panel model, which is given by

$$\Delta TFR_i = \alpha + \beta_1 \Delta U5MR_i + \beta_2 \Delta LIT_i + \beta_3 \Delta POV_i + \varepsilon_i \quad (1)$$

where  $\Delta TFR$ ,  $\Delta U5MR$ ,  $\Delta LIT$  and  $\Delta POV$  are the changes in fertility, under-5 mortality, female literacy and poverty, respectively. We analyze three periods separately, the full sample period from 1991-2011, as well as the two sub-periods: 1991-2001, and 2001-2011. Given that we use the changes in all variables, this specification is identical to a panel specification with two periods and district level fixed effects.

In order to address contemporaneity concerns, we estimate alternative models where we test for the associations between initial levels of education, mortality and poverty and subsequent changes in fertility:

$$\Delta TFR_i = \alpha + \beta_1 U5MR_{i,t_0} + \beta_2 LIT_{i,t_0} + \beta_3 POV_{i,t_0} + \varepsilon_i \quad (2)$$

Where  $U5MR_{t_0}$ ,  $LIT_{t_0}$  and  $POV_{t_0}$  are the initial levels of under-5 mortality, literacy and poverty respectively. Last, we estimate a hybrid model, where we include both initial conditions and contemporaneous changes:

$$\Delta TFR_i = \alpha + \beta_1 U5MR_{i,t_0} + \beta_2 LIT_{i,t_0} + \beta_3 POV_{i,t_0} + \beta_4 \Delta U5MR_i + \beta_5 \Delta LIT_i + \beta_6 \Delta POV_i + \varepsilon_i \quad (3)$$

## Results

Table 1 provides an overview of the demographic and socioeconomic changes experienced in India between 1991 and 2011. TFR declined by more than one birth per woman and life expectancy has increased by five years during the last two decades.

Overall, the population grew at an annual rate of 1.8 per cent over the period, 1991-2011. Both infant mortality and the under-five mortality rates were halved suggesting significant improvement in child survival. There has been remarkable progress in female literacy and educational attainment. With the sustained annual GDP growth rate of over 5 per cent and slowing down of birth rate, the per capita income (PPPUS\$) was almost doubled. With respect to proximate determinants; about half of the married women are using modern method of contraception and the age at marriage is on the rise.

**Table 1: Demographic and socioeconomic change in India, 1991-2011**

	Data source	1991	2001	2011	Change (2011-1991)
<b>Demographic Change</b>					
Total Population in million	Census of India	846	1029	1210	364
Annual exponential growth rate of population	Census of India	NA	1.95	1.62	1.79
Average household size	Census of India	5.5	5.3	4.9	-0.6
Young dependency ratio	Census of India	672	621	510	-162
Total Fertility Rate (TFR)	SRS	3.6	3.1	2.4	-1.2
Life expectancy at birth	SRS	60.3	63.2	65.18	4.88
Infant Mortality Rate (IMR)	SRS	80	66	44	-36
Under five mortality rate (U5MR)	NFHS1/ SRS	109	99	55	-54
<b>Socio-economic Change</b>					
GDP percapita PPP (US\$)	Pen World Table	1221	1892	3755	2534
GDP growth rate	Economic Survey	5.3	4.1	8.9	3.6
Percentage of population living below poverty line	Planning Commission	45.3	37.2	21.9	-23.4
Percent urban	Census of India	17.7	27.81	31.16	13.46
Female literacy rate	Census of India	39.21	53.67	65.46	26.25
Female work participation rate	Census of India	22.3	25.6	25.5	3.2
<b>Change in Proximate Determinants<sup>1</sup></b>					
Percentage of women using modern contraception	NFHS	36.5	42.8	48.5	12
Percentage of girls married in the 15-19 age group	NFHS	60.7	33.6	30.1	-30.6
Induced abortion	NFHS	2.4	1.7	NA	
Postpartum insusceptible (amenorrhea+ abstinence)	NFHS	10.2	9.8	8.1	-2.1
<b>Administrative changes</b>					
No of States	Census of India	32	35	35	3
No of Districts	Census of India	466	593	640	174

1: Estimates refers to 1992-93, 1998-99 and 2005-06 period

During 1991-2011, three new states, namely, Chhattisgarh, Jharkhand and Uttarakhand were created from the states of Madhya Pradesh, Bihar and Uttar Pradesh respectively. While the national average is encouraging; it conceals large disparities among the districts of India.

Table 2 presents the descriptive statistics at the district level. All four variables of interest display large cross-sectional and temporal variations. For fertility, the percentage of districts with fertility rates below replacement ( $TFR < 2.1$ ) increased from 2.6 per cent in 1991 to 32.3% in 2011, while the percentage of districts with TFR of more than 3.5 declined from 61% to 18% over the same period. The inter-quartile range and the standard deviation in TFR increased between 1991 and 2001 and then declined between 2001 and 2011, as often observed as part of the demographic transition. Under-five mortality declined by over 45 deaths per 1000 live births, and a larger decline was observed during the period 2001-201. Female literacy rates increased from 38% in 1991 to 64% in 2011, with decreasing standard deviation over time. Over the same period, overall poverty rates almost halved; the percentage of districts with poverty level of 60% or more declined from 27% to 8 per cent and the percentage of districts with poverty level of less than 20% increased from 16% to 40% (121 to 256).

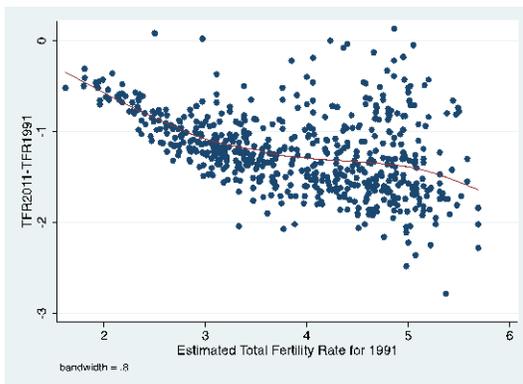
**Table 2: Summary statistics of TFR, under-five mortality, female literacy and poverty in districts of India, 1991-2011**

Variables	1991	2001	2011
<b>Total Fertility Rate (TFR)</b>			
Mean	3.87	3.30	2.67
25 percentile	3.12	2.49	1.93
Median	3.96	3.21	2.56
75 percentile	4.68	4.08	3.29
Min	1.62	1.48	1.10
Max	5.69	5.42	5.00
Standard Deviation	0.93	0.95	0.84
<b>Under-five mortality rate (per 1000 live birth)</b>			
Mean	106.2	99.4	61.0
25 percentile	78	76	39
Median	101	95	60
75 percentile	131	120	81
Min	32	39	9
Max	289	266	153
Standard deviation	36.02	31.75	27.25
<b>Female Literacy</b>			
Mean	37.89	52.64	63.76
25 percentile	23.52	41.46	54.67
Median	35.74	52.63	63.14
75 percentile	49.89	63.36	72.64
Min	7.68	16.06	30.29
Max	94.00	96.26	97.68
Standard Deviation	17.64	15.42	12.83
<b>Percentage of Population living below poverty line</b>			
Mean	51.51	38.25	30.01
25 percentile	35.77	23.41	13.97
Median	51.35	35.72	25.98
75 percentile	67.01	52.90	43.82
Min	5.88	3.66	0.00
Max	93.0	93.0	87.44
Standard Deviation	21.22	19.44	18.82

Figures 1(a) and 1 (b) show the absolute and relative change in TFR during the period, 1991-2011 as a function of initial (1991) TFR levels. Several patterns are worth highlighting. First, barring districts that already had very low fertility in 1991, large fertility reductions were visible at all levels. Second, there is a remarkable degree of heterogeneity in the changes observed, and this heterogeneity is particularly large among districts that had TFR of 4 or more in 1991. While some of these districts experienced very little change in fertility, others districts in this group experienced a TFR decline of

up to 2 births per woman. Interestingly, the lowest TFR in 1991 was in Kolkata district of West Bengal (TFR of 1.6), which further declined by 0.5 births per woman during the period 1991-2011. The low fertility in Kolkata district has been highlighted in two recent studies (Guilmoto and Rajan 2014; Kumar and Sathyanarayana, 2013). The highest TFR in 1991 (5.69) was observed in Palamu district of Jharkhand, with a subsequent reduction in TFR of more than two births. The largest decline in TFR was observed in Dhemaj district of Assam (2.8). Most of the districts of high fertility are from the states of Bihar, Jharkhand, Uttar Pradesh and Meghalaya.

**Fig 1(a): Absolute change in fertility during 1991 and 2001(TFR2011-TFR1991) and fertility in 1991 in districts of India**



**Fig 1(b): Relative change in fertility during 1991 and 2001 (lnTFR2011-lnTFR1991) and fertility in 1991 in districts of India**

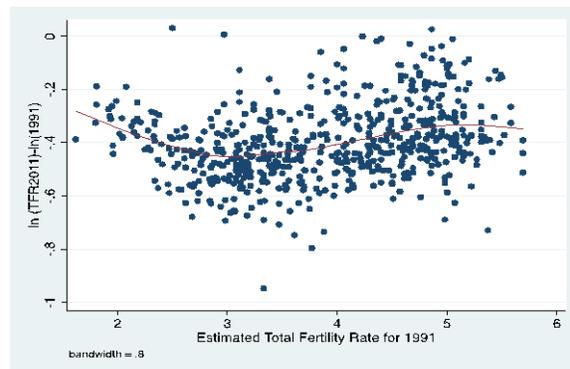


Fig 2(a) and Fig 2 (b) show the same lowess estimates for under-five mortality. Compared to fertility, absolute convergence is much stronger for mortality, with a nearly linear relationship between initial levels of mortality and subsequent changes. In 1991, the under-five mortality was lowest in the Hyderabad district of Andhra Pradesh and highest in the district of East Kameng of Arunachal Pradesh. By 2011, the under-five mortality was highest in the district of Lower Subansiri (153 per 1000 live births) of Arunachal Pradesh followed by Kandamal district of Odisha and Shraswati district of

Uttar Pradesh. Many of the poorer districts have shown a significant reduction in under-five mortality. By 2011, the under-five mortality was lowest in Kannur district of Kerala (9). The convergence in under-five mortality is higher than that of TFR. However, there are some districts where under-five mortality has not changed or even increased.

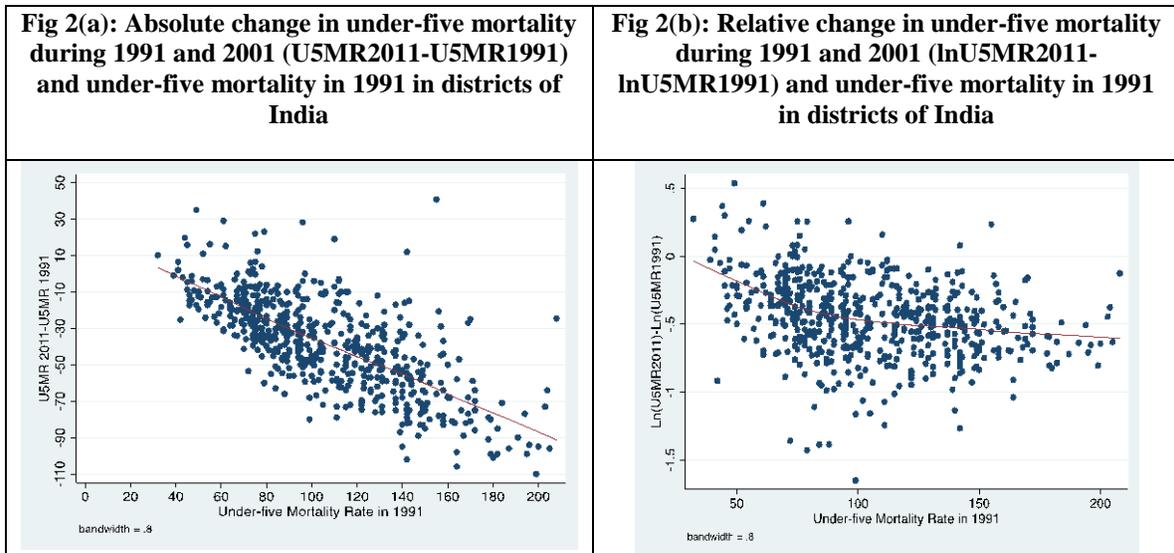


Fig 3(a) and Fig 3(b) show that the convergence patterns are even stronger for female literacy. The lowest female literacy in 1991 was in the Barmer district of Rajasthan (less than 10%) and in 2011 the lowest female literacy was in the district of Alirajpur district of Madhya Pradesh (30.3%). The largest increase in female literacy level was in Gurgaon district of Haryana (from 35% in 1991 to 78% by 2011). Most of the districts in the state of Kerala had marginal increase because of higher level of female literacy in 1991 and there are some districts, which did not do well despite their low base.

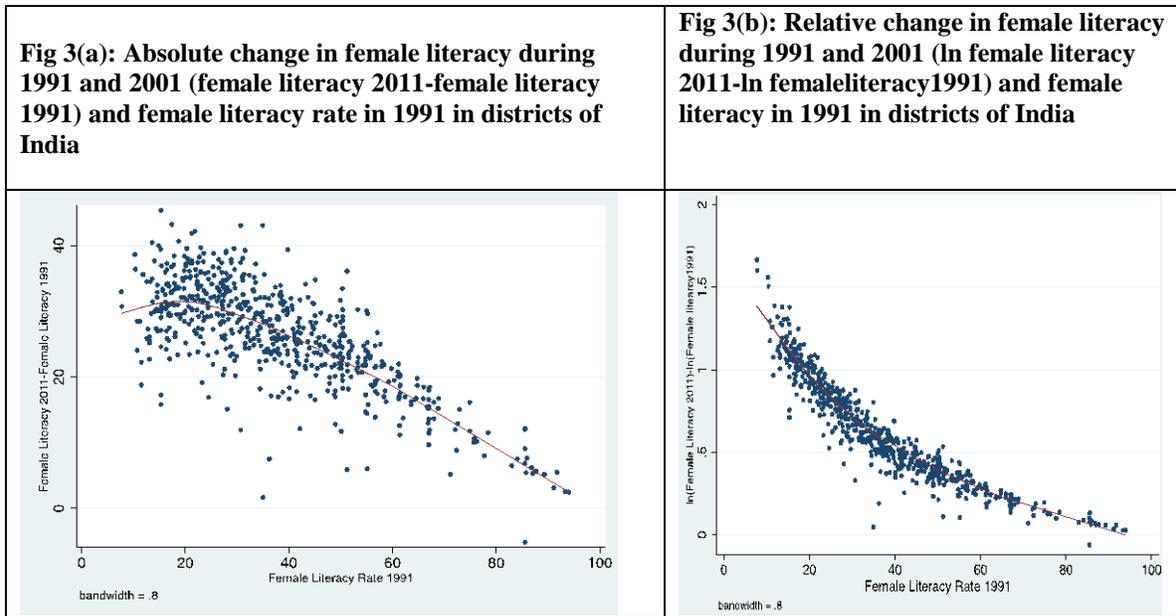
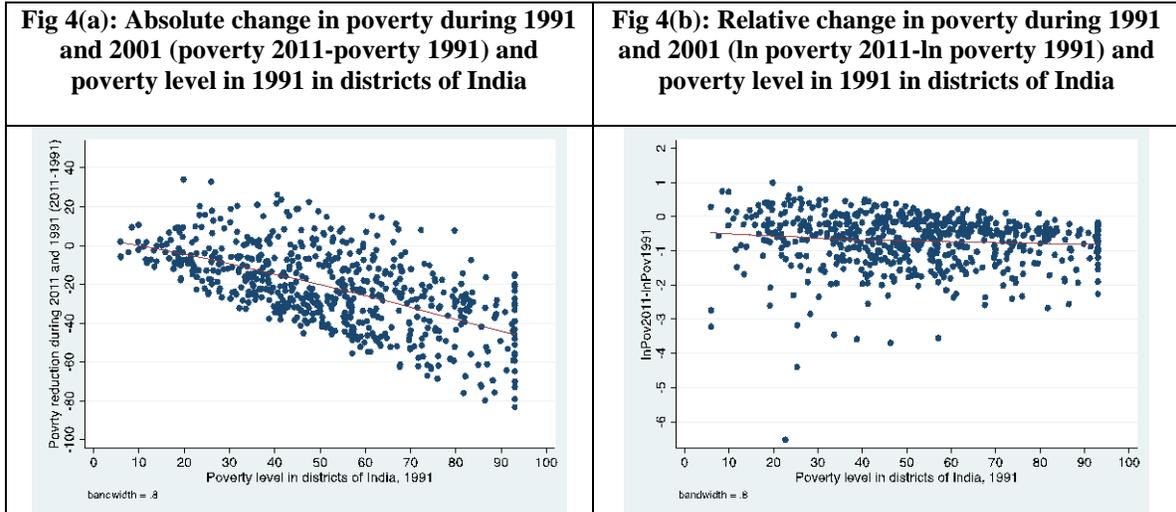


Fig 4(a) and Fig 4(b) present the absolute and relative change in poverty level. Even though some convergence patterns are observed, poverty trajectories appear more heterogeneous than the ones observed for mortality and literacy. In 1991, the district with the highest poverty level was Paschim Champarana in Bihar and the lowest was in Udupi district of Karnataka, while in 2011, the highest poverty level was in Malkanagiri district of Odisha. During 1991-2011, the largest decline in poverty was observed in the Ukuhrul district of Manipur. In general, we observed the highest convergence in female literacy rate followed by under-five mortality and poverty in the districts of India.



### Bivariate Analysis

In this section, we present TFR trajectories by varying levels of under-five mortality, female literacy and poverty level. As Table 3 shows, fertility levels were higher in the districts that had higher under-five mortality in 1991 and there has been significant reduction in fertility at all levels of under-five mortality (Table 3). The decline in TFR in districts with higher under-five mortality (110+) was sharper compared to that in other districts. The difference in TFR of districts with high and low under-five mortality had reduced from 1.8 in 1991 to 1.2 by 2011, thereby suggesting that improvement in child survival reduces fertility. With respect to female literacy, we found an interesting pattern. Though the fertility level was higher in districts with a female literacy level of less than 20%, reduction in TFR was higher in districts that had a female literacy level of 20-40%. The lowest level of fertility in 2011 was among districts that had female literacy level of 60-80% in 1991 and not 80+. This suggests that once the literacy reaches a threshold level, fertility decline continues irrespective of further increase in literacy level. With

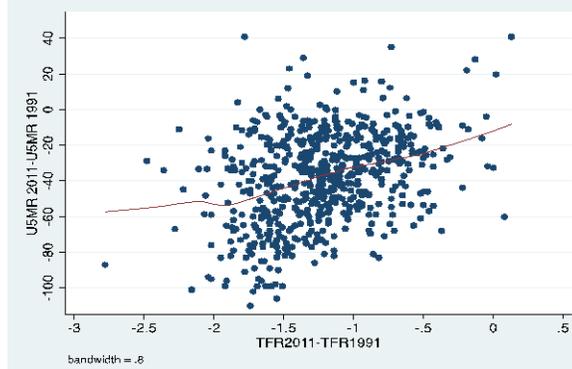
respect to poverty level, districts with a higher poverty level had higher fertility during all three periods. However, reduction in TFR was similar at all levels of poverty during the base year.

**Table 3: Distribution of Districts by estimated TFR by varying levels of Poverty, under-five mortality rate and female literacy, 1991-2011**

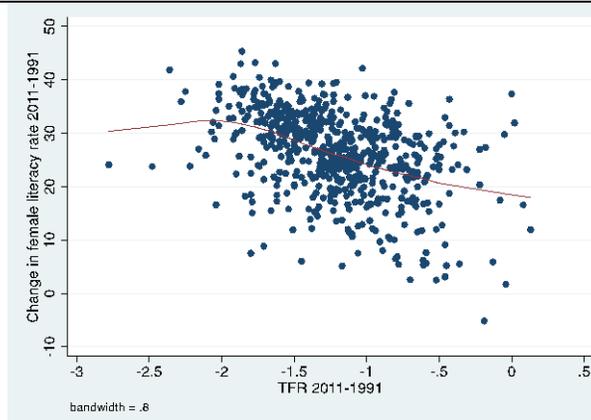
<i>Variable</i>	<i>N</i>	<i>Mean TFR 1991</i>	<i>Mean TFR 2001</i>	<i>Mean TFR 2011</i>	<i>Absolute change in TFR 1991- 2011</i>
<b>Under-five mortality rate (per 1000 live birth)</b>					
< 50	24	2.57	2.19	1.80	0.77
50-70	76	3.00	2.48	1.96	1.04
70-90	151	3.49	2.93	2.36	1.13
90-110	102	3.97	3.42	2.82	1.15
110+	265	4.41	3.79	3.01	1.40
<b>Female literacy rate (%)</b>					
< 20	101	4.76	4.40	3.58	1.18
20-40	270	4.18	3.54	2.82	1.36
40-60	177	3.27	2.67	2.13	1.14
60-80	52	2.93	2.36	1.87	1.06
80+	18	2.77	2.40	2.09	0.68
<b>Poverty level (%)</b>					
< 20	44	3.23	2.63	2.14	1.09
20-40	145	3.69	3.13	2.50	1.19
40-60	207	3.96	3.39	2.69	1.27
60+	201	4.05	3.48	2.87	1.19
Total	618	3.87	3.30	2.66	1.21

Figures 5 (a)-5(c) plot the change in fertility (TFR of 2011- TFR of 1991) by changes in the distal determinants. The correlation between changes in fertility and changes in under-five mortality over the period 1991-2011 was -0.36. The correlation between changes in TFR and change in female literacy was 0.44, while the correlation between changes in TFR and changes in poverty appears very weak (0.01).

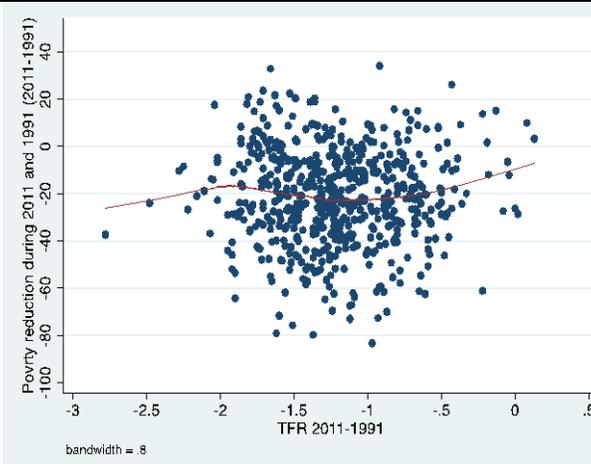
**Fig 5 (a): Change in TFR (2001-1991) and change in under-five mortality rate (2001-1991) in districts of India**



**Fig 5 (b): Change in fertility and change in female literacy during 1991 and 2011 in districts of India**



**Fig 5 (c): Change in TFR (2001-1991) and change in poverty level (2001-1991) in districts of India**



## **Multivariate Results**

In this section we present our main multivariate regression results. In all three models in Tables 4-6 the dependent variable is fertility change. Model 1 (upper panel of the table) presents the result of difference-in-difference (equation (1)); Model 2 assesses the predictive power of initial distal determinant values (equation (2)), and Model 3 (lower panel of the table) shows hybrid model results (equation (3)).

Model 1 – the difference-in-difference or district fixed effect model explains 27% of the overall changes in fertility over the period, 1991-2011 (Table 4, column 1). An estimated coefficient of 0.0046 for under-5 mortality suggests that the average decline of 46 deaths per 1000 observed over the sampler period accounted for a total TFR decline of about 0.2 births. The estimated coefficient of -0.02 for literacy implies that the observed 25 percentage point increase in literacy was associated with a 0.5 decline in TFR over the same period. No statistically significant associations were found for poverty, while the estimated constant of 0.52 suggests an unexplained (country-wide or secular) decline of 0.52 births per woman.

Similar overall patterns emerge when we focus on initial conditions in Model 2. Once again, relatively large and statistically significant effects were found for mortality and literacy, while initial poverty had very little predictive power. The estimated Model 2 coefficients are not directly comparable in magnitude to the coefficients in Model 1 given that baseline levels for mortality are higher than baseline levels in literacy, and the same also holds for the standard deviation of these variables. A one-standard deviation increase in U5MR in 1991 (36 deaths per 1000 live births) was associated with a reduction in

subsequent fertility declines of about 0.1; a one standard deviation increase in literacy (18 percentage points) increased the subsequent declines by about half as much (0.05).

**Table 4: Result of regression models under alternative model specification**  
**Dependent variable: Change in fertility (2011-1991)**  
**Associations of reduction in poverty, fertility, under-five mortality and female literacy**

<i>Period</i>	<i>1991-2011</i>		<i>1991-2001</i>		<i>2001-2011</i>	
<b>Model 1: Difference in differences (District fixed effects)</b>						
	Coeff	T Stat	Coeff	T Stat	Coeff	T Stat
Change in Under-five Mortality	0.0043	6.46	0.0048	6.59	0.0046	6.43
Change in female Literacy	-0.0208	-9.73	-0.0104	-4.93	-0.0031	-0.98
Change in Poverty	-0.0007	-0.90	0.0027	2.59	-0.0002	-0.20
Constant	-0.5202	-9.32	-0.3422	-9.08	-0.4600	-12.00
R <sup>2</sup>	0.2646		0.1487		0.0695	
<b>Model 2: Initial Values</b>						
TFR	-0.1745	-6.33	-0.0703	-3.13	-0.1941	-8.46
Under-five mortality rate	-0.0029	-4.66	-0.0019	-4.18	-0.0014	-1.89
Female Literacy	-0.0030	-1.91	-0.0064	-5.04	-0.0057	-3.22
Poverty (Percentage of population living below poverty line)	0.0010	1.18	-0.0009	-1.24	-0.0011	-1.2
Constant	-0.1726	-1.07	0.1921	1.44	0.4869	2.75
R <sup>2</sup>	0.2208		0.0661		0.2786	
<b>Model 3: Hybrid model (Changes+ initial Values)</b>						
Change in Under-five Mortality	0.0044	4.35	0.0044	4.59	0.0029	2.42
Change in female literacy	-0.0294	-8.37	-0.0181	-7.45	0.0069	1.81
Change in Poverty	0.0023	2.35	0.0023	1.66	0.0009	1.01
TFR	-0.2140	-7.85	-0.1145	-5.68	-0.2092	-8.88
Under-five mortality rate	0.0003	0.29	0.0003	0.65	-0.0002	-0.19
Female Literacy	-0.0115	-6.6	-0.0089	-6.81	-0.0039	-2.18
Poverty (Percentage of population living below poverty line)	0.0026	2.55	-0.0007	-0.78	-0.0007	-0.57
Constant	0.8751	5.170	0.5451	3.89	0.3253	1.79
R <sup>2</sup>	0.3993		0.2321		0.3020	

Note: The number of observation was 597 for 1991-2011 and 1991-2001 and 606 in 2001-11. Estimates are adjusted to robust standard error.

When we control for both initial levels and contemporaneous changes in Model 3, 40% of total fertility changes over the period 1991-2011.. For literacy, both initial levels and

subsequent changes appear to be positively associated with fertility change; for mortality, changes appear to be significantly associated only with fertility change.

As a robustness check, we estimate alternative models where we include separate trends for each of the 29 states in our model. The size, direction and the significance of the variables in each of the model were broadly similar to those in Table 4, with slightly larger and more precisely estimates associations for under-5 mortality.

**Table 5: Result of fixed effect models under alternative model specification**  
**Dependent variable: Change in fertility (2011-1991)**  
**Associations of reduction in poverty, fertility, under-five mortality and female literacy in fixed effect model**

	1991-2011		1991-2001		2001-2011	
<b>Difference in difference (with change values)</b>	Coeff	T Stat	Coeff	T Stat	Coeff	T Stat
<b>Model 1: Difference in difference (with change values)</b>						
Change in Under-five Mortality	0.0045	5.22	0.0044	6.05	0.0029	3.81
Change in female Literacy	-0.0221	-7.87	-0.0131	-4.48	-0.0015	-0.34
Change in Poverty	-0.0006	-1.00	-0.0012	-1.10	0.0002	0.33
Constant	-0.4768	-7.89	-0.3537	-7.41	-0.5294	-10.69
R <sup>2</sup>	0.6213		0.5309		0.5800	
<b>Model 2: Difference and initial values (With Base values)</b>						
TFR	-0.4837	-8.86	-0.4364	-8.58	-0.2640	-4.52
Under-five mortality rate	0.0007	0.65	0.0010	1.77	0.0005	0.46
Female Literacy	-0.0105	-3.63	-0.0106	-4.83	-0.0080	-3.33
Poverty (Percentage of population living below poverty line)	-0.0002	-0.26	0.0002	0.56	-0.0009	-1.12
Constant	0.9833	3.55	1.4021	6.30	0.6340	2.12
R <sup>2</sup>	0.6008		0.5486		0.6160	
<b>Model 3: Hybrid model (Change+ Initial Values)</b>						
Change in Under-five Mortality	0.0076	7.91	0.0039	6.11	0.0050	5.19
Change in female literacy	-0.0303	-11.22	-0.0150	-6.45	-0.0106	-1.85
Change in Poverty	-0.0010	-1.08	0.0008	0.54	-0.0008	-1.03
TFR	-0.3965	-7.98	-0.4086	-9.18	-0.2877	-4.84
Under-five mortality rate	0.0061	4.55	0.0026	5.83	0.0032	2.51
Female Literacy	-0.0149	-6.02	-0.0105	-6.56	-0.0101	-3.63
Poverty (Percentage of population living below poverty line)	-0.0011	-1.03	0.0003	0.39	-0.0014	-1.35
Constant	1.3619	4.55	1.3920	7.21	0.8477	2.48
R <sup>2</sup>	0.7640		0.6370		0.6503	

Note: The number of observation was 597 for 1991-2011 and 1991-2001 and 606 in 2001-11. Estimates are adjusted to robust standard error.

### **Effect Sizes and Interpretation**

To understand the magnitude of the observed associations, we show mean estimated effect sizes for all explanatory variables in Table 6. The single largest predictor of the fertility reductions observed was initial TFR (-0.83) followed by initial female literacy (-0.77) and the change in female literacy level (0.44). The effect of initial level of poverty on fertility reduction was 0.13 while that of reduction in poverty was -0.05; given that both the confidence intervals around both estimates are large, this suggests a rather limited role of poverty in fertility transition. The pattern is similar when we multiply the observed coefficients with standard deviations of all variables rather than means.

Overall, our estimates suggest that on average an increase in female literacy of 40% would have been necessary to reduce TFR by about 1, which is a lot. In practice, literacy increased from 38 to 64% on average, which implies a decline in TFR of 0.65, or about 60% of the total change observed. For mortality, our estimated coefficient for both levels and changes is about 0.20, which implies that a drop of more than 100 in U5MR would be needed to achieve the observed declines. Having said that, the actual decline observed (from 105 to 61) is large, which suggests that mortality can explain up to 40% of the declines observed.

**Table 6: Mean sample value and sample standard deviation of fertility reduction during 1991-2011**

Variables	Coef.	Lower confidence Interval	Upper confidence interval	Mean sample value	Effect size at		95 % lower confidence interval	95% Upper confidence interval	Sample standard deviation	Effect size of standard deviation
					Mean value					
TFR 1991	-0.2140	-0.2676	-0.1605	3.8690	<b>-0.8281</b>		-1.0352	-0.6210	0.9312	<b>-0.1993</b>
Under-five mortality (1991)	0.0003	-0.0015	0.0020	106.1537	<b>0.0278</b>		-0.1603	0.2158	36.0244	<b>0.0094</b>
Reduction in under-five mortality (1991_2011)	0.0044	0.0024	0.0064	37.9493	<b>0.1675</b>		0.0919	0.2431	25.5418	<b>0.1127</b>
Female Literacy, 1991	-0.0115	-0.0149	-0.0081	37.8386	<b>-0.4348</b>		-0.5641	-0.3054	17.6372	<b>-0.2027</b>
Increase in female literacy (2011-1991)	-0.0294	-0.0363	-0.0225	26.2807	<b>-0.7732</b>		-0.9547	-0.5917	7.8496	<b>-0.2309</b>
Poverty, 1991	0.0026	0.0006	0.0046	51.5560	<b>0.1346</b>		0.0310	0.2382	21.2986	<b>0.0556</b>
Change in poverty (2011-1991)	0.0023	0.0004	0.0042	-21.4238	<b>-0.0489</b>		-0.0080	-0.0898	20.2199	<b>0.0462</b>

## Discussion and Conclusion

India has been experiencing remarkably fast demographic and socioeconomic change over the past two decades. As this paper shows, these national trends conceal large disparities across states and districts of India. While there have been numerous studies depicting state pattern of fertility transition and its determinants, there are a few studies that examined the level and change in fertility across the districts of India. Districts in India are the unit of program implementation, a bridge between state and household; they are culturally homogeneous and show enormous variations in socio-economic development. The primary objective of this paper was to understand the role of three key developmental factors, namely, female literacy, reduction in child mortality and poverty in bringing fertility change. Though the selections of indicators is constrained by

availability of estimates at the district level, these three indicators reflect the key dimension of human development. Our analysis yielded the following main results: first, the data shows a remarkable degree of convergence in all four indicators; namely, fertility, under-five mortality, female literacy and the poverty levels in the districts of India. While one-third of the districts have reached below replacement level of fertility, under-five mortality and poverty level have reduced by half from the initial level and the female literacy level has almost doubled. The convergence patterns are strongest in female literacy, still relatively strong for under-five mortality and much less pronounced for the poverty. Second, a substantial amount of the observed fertility decline appears to be country-wide, and cannot not be attributed to either literacy, mortality or poverty, but, rather captured by either constant or initial fertility terms. Third, strong and highly consistent associations were found among mortality, literacy and fertility change. This suggests that increased educational attainment and improved child survival continue to be major drivers of fertility reduction. Fourth, rather surprisingly, we did not find any evidence of family income or poverty being associated with fertility change. This suggests that poverty is not a barrier for fertility reduction, at least in the Indian context. Fifth, in terms of magnitude, literacy effects seem to dominate mortality effects, particularly in models that take into account both the initial levels and contemporaneous changes of variables. Continued investment in both areas seems desirable both from the perspective of fertility and broader societal welfare.

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**Appendix 1: Correlation coefficient of TFR, female literacy and under-five mortality in the districts of India, 1991-2011**

Variables	tfr_1991	tfr_2001	tfr_2011	U5MR_1991	U5MR_2001	U5MR_2011	flit_1991	flit_2001	flit_2011	pov_dt_1991	pov_dt_2001	pov_dt_2011
tfr_1991	1											
tfr_2001	0.933	1										
tfr_2011	0.887	0.952	1									
U5MR_1991	0.593	0.523	0.458	1								
U5MR_2001	0.631	0.629	0.578	0.827	1							
U5MR_2011	0.694	0.691	0.667	0.696	0.779	1						
flit_1991	-0.683	-0.682	-0.625	-0.564	-0.608	-0.620	1.000					
flit_2001	-0.612	-0.604	-0.606	-0.459	-0.510	-0.579	0.766	1				
flit_2011	-0.540	-0.584	-0.570	-0.435	-0.529	-0.516	0.868	0.715	1			
pov_dt_1991	0.239	0.226	0.235	0.276	0.232	0.234	-0.432	-0.445	-0.399	1		
pov_dt_2001	0.340	0.332	0.330	0.414	0.348	0.381	-0.538	-0.484	-0.438	0.846	1	
pov_dt_2011	0.447	0.448	0.454	0.376	0.407	0.443	-0.513	-0.511	-0.468	0.505	0.605	1

**NB: tfr: Total fertility rate, U5MR: Under-five mortality rate flit: female literacy rate, pov\_dt: Percentage of population living below poverty line , 1991, 2001 and 2011: Year 2001 and 2011: Year 2011**

**Appendix 2: List of districts with TFR reduction of less than 0.5 during 1991-2011 , under-five mortality, female literacy and poverty in India**

Sr	District	State	TFR 1991	TFR 2011	TFR 1991-2011	Female Literacy 1991	Female Literacy 2011	U5MR 1991	U5MR 2011	Poverty 1993	Poverty 2009
1	Shrawasti	Uttar Pradesh	5.02	4.52	-0.5	10.7	34.8	169	142	80.2	51.5
2	Purnia	Bihar	5.16	4.67	-0.5	16.8	42.3	114	92	45.3	35.6
3	Jaisalmer	Rajasthan	4.58	4.11	-0.5	11.3	39.7	124	78	46.3	16.6
4	Barmer	Rajasthan	4.56	4.10	-0.5	7.7	40.6	143	86	35.2	36.8
5	Purba	Bihar	4.96	4.53	-0.4	13.7	45.1	101	69	40.5	66.7
6	Champaran	Bihar	5.2	4.77	-0.4	10.4	46.8	136	82	81.3	55.0
7	Supaul	Bihar	4.86	4.47	-0.4	14.7	44.8	93	83	67.9	62.8
8	Pashchim Champaran	Bihar	4.79	4.46	-0.3	14.4	44.7	101	73	93.0	73.1
9	Saharsa	Bihar	4.86	4.64	-0.2	14.7	41.7	93	84	28.0	41.8
10	Dohad	Gujarat	3.85	3.63	-0.2	27.3	47.6	111	84	86.9	25.8
11	Madhepura	Bihar	4.95	4.77	-0.2	14.4	41.7	106	95	67.9	56.1
12	Khagaria	Bihar	5.05	5.00	-0.1	19.8	49.6	101	97	18.8	12.2
13	Mewat	Haryana	4.4	4.36	0.0	34.9	36.6	107	80	32.1	19.9
14	Dadra & Nagar Haveli	Dadra & Nagar Haveli	4.23	4.23	0.0	27.0	64.3	91	40	72.4	46.2
15	Kurung Kumey	Arunachal Pradesh	4.86	4.99	0.1	30.7	42.6	155	110	22.6	25.9

**Appendix 3: List of districts with TFR reduction of 2 and more during 1991-2011 , under-five mortality, female literacy and poverty in India**

Sr No	District	State	TFR1 991	TFR 2011	TFR2 1991- TFR2 011	Female Literacy 1991	Female Literacy 2011	U5 MR 199 1	U5 MR 201 1	Pover ty 1993	Pove rty 2009
1	Dhemaji	Assam	5.37	2.59	-2.78	41.1	65.2	139	52	63.6	26.2
2	West Siang	Arunachal Pradesh	4.98	2.5	-2.48	35.9	59.6	124	43	58.7	34.8
3	Ramgarh	Jharkhand	5.07	2.71	-2.36	21.2	63.1	80	46		
4	Palamu	Jharkhand	5.69	3.41	-2.28	16.2	52.1	131	64	57.2	46.8
5	Varanasi	Uttar Pradesh	5.22	2.97	-2.25	28.9	66.7	112	101	38.1	29.6
6	West Kameng	Arunachal Pradesh	5	2.78	-2.22	35.2	59.1	157	71	52.6	25.9
7	Betul	Madhya Pradesh	4.76	2.6	-2.16	33.9	60.9	180	79	93.0	72.0
8	Dibang Valley	Arunachal Pradesh	4.98	2.87	-2.11	33.3	59.2	141	76	44.7	25.9
9	North District	Sikkim	3.77	1.7	-2.07	40.7	71.0	109	50	50.6	13.7
10	East Siang	Arunachal Pradesh	4.51	2.45	-2.06	34.4	66.5	115	64	32.0	18.3
11	Lower Dibang Valley	Arunachal Pradesh	4.98	2.93	-2.05	33.3	62.2	141	39	44.7	30.6
12	New Delhi	Delhi	3.33	1.29	-2.04	67.0	83.6	70	34		
13	Rewa	Madhya Pradesh	5.02	2.98	-2.04	26.9	61.2	196	102	49.7	67.2
14	Kota	Rajasthan	4.57	2.55	-2.02	29.5	65.9	140	45	38.4	15.7
15	Jaunpur	Uttar Pradesh	5.27	3.25	-2.02	22.4	59.8	124	101	45.1	39.2
16	Garhwa	Jharkhand	5.69	3.67	-2.02	16.2	47.6	131	55	51.9	47.2
17	Dakshin Dinajpur	West Bengal	3.88	1.86	-2.02	27.9	67.0	113	51	52.0	45.4