The changing contours of fertility in India

CZ Guilmoto, IRD/CEPED, Paris

Abstract:

India provides a terrain ground for investigating the long-term dynamics of fertility change for several reasons. First, it has a unique history of early family planning activities that emerged during the 10960s. Second, it has recently witnessed a rapid economic expansion likely to accelerate the pace of demographic transformations and to reshape its geography. Finally, it is a highly heterogeneous country characterized by a complex sociocultural and religious geography compared to other large countries like China, Brazil or Russia. Using original subregional fertility levels, we will reconstruct fertility change over the last five decades in the country and examine their changing spatial and demographic patterns. In addition, we will also compare India's pace of fertility decline with trends observed elsewhere in Asia.

This paper aims at probing India's fertility trends from both internal and external perspectives in order to answer two main sets of questions: Is India's fertility transition typical of Asia or has it proceeded at a slower pace than elsewhere? Have fertility trends been parallel within India over the last decades? Can we identify distinct regional trajectories? How far have the conditions of the onset of fertility decline in each region determined its course during the following decades?

Longer summary

Our analysis starts from at the close examination of India's singular fertility trajectory. Fertility decline in India has been shown surprisingly slow and steady over the last fifty years. These two dimensions–the slow and regular pace of fertility decline–emerge from the comparative analysis of international data on fertility trends in Asia.

1 India's fertility experience and the rest of Asia

Figure 1 for instance plots fertility decline in 16 large Asian countries. Japan and Afghanistan were excluded from the list owing to their singular fertility regime. The absolute decrease is plotted against the cumulated duration of the decline measured from the time of onset. This date is taken here as the first recorded decline in fertility of more than 10%. The onset ranges from the early sixties in South Korea to the 1990s in some South Asian countries such as Pakistan. As it happens, fertility decline started in India earlier than in many Asian countries and its fertility level was already among the lowest levels in Asia during the 1950s. Yet, fertility in India is likely to the third highest in Asia by 2015 according to United Nations estimates.

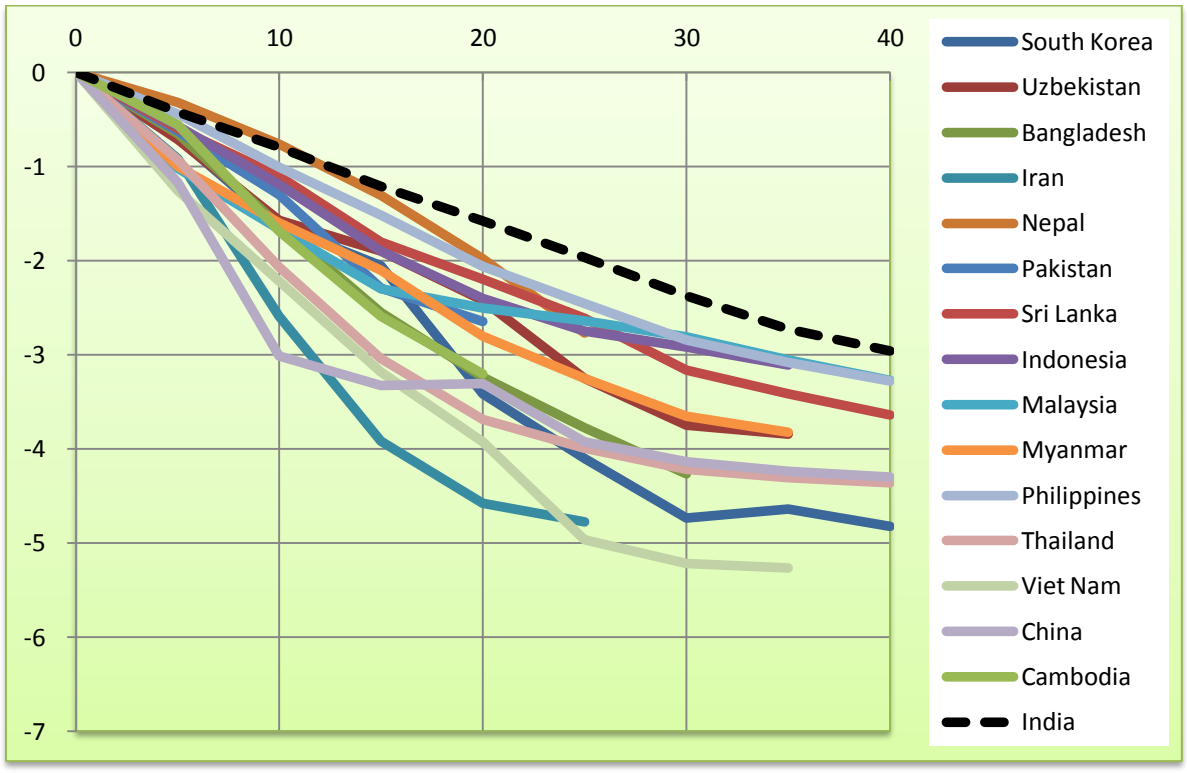


Figure 1: Net TFR decline in 16 Asian countries measured from the onset of fertility decline, 1960-2010

Since India's birth rates started diminishing earlier than the Asian average, the tempo factor itself cannot account for the moderate decline in fertility observed in India over the last fifty

years. The explanation for this modest fertility decrease therefore lies in the quantum factor as Figure 1 shows. India emerges as the country with the lowest rate of decline during the last fifty years. It took forty years for India's fertility to decrease by 3 children compared to 30 years or less almost anywhere else in Asia.

Another singular feature of India's decline is almost perfectly linear whereas most fertility declines tend to be curvilinear as Figure 1 indicates. The shape of the TFR curves in Asia is usually S-shaped due to a initial acceleration in fertility decline followed by a slowing down when fertility nears replacement level. But India's trend has remained linear during the last fifty years.

2 Fertility decline at state level

This latter observation is corroborated by annual available TFR estimates that exist in India since the 1970s thanks to the Sample Registration System. When compared with the five-year estimates of United Nations (Figure 2), the parallelism of these two series appears striking. These series are almost identical for the last fifteen years. Yet, we can identify a departure from the United Nations trend during the 1070s. The gap between both series during this decade is related to the Emergency period, during which the government introduced forceful family planning measures. Hence the brutal decline in TFR from 1975 to 1977 visible on the SRS estimates, which ended when Indira Gandhi's government fell during the 1977 elections. The short-term impact of this period is obvious on Figure 2. It was followed by an almost stabilization of TFR levels till the mid-1980s.

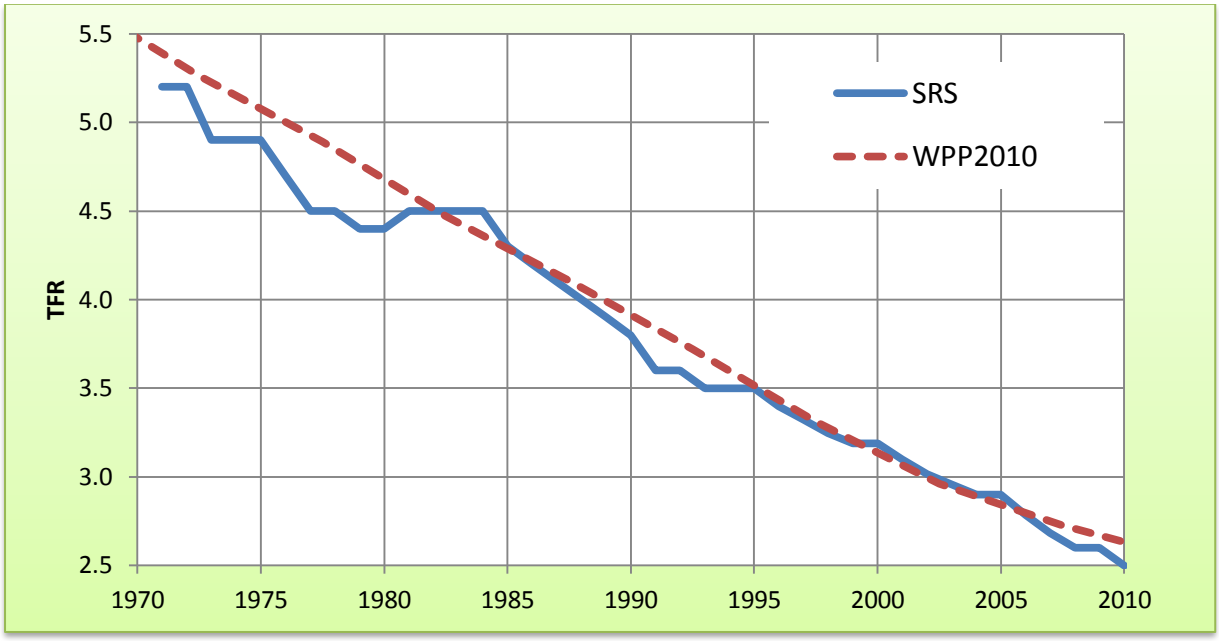


Figure 2: Fertility according to two sources, India, 1970-2010 (SRS and United Nations)

The fact that the decrease in fertility levels was almost linear over the last forty years in India could be due to compositional effects. As a matter of fact, India's trends are nothing but the composite picture of different schedules of fertility decline observed across India. Urban areas or southern states have for instance experienced earlier changes in fertility behavior than the

rest of the country. Yet, the disaggregation of fertility decline by rural and urban areas (not shown here) fails to confirm any different trends. The overall downward trends in both rural and urban remain linear and almost parallel across the 1971-2010 period. This only difference is that fertility decline started earlier in towns and cities than in the countryside.

Looking at state-level trends may better underscore the heterogeneity of demographic change across the country. The analysis is restricted to the largest 15 states for which annual TFR estimates from the SRS are available. A great deal of research on fertility decline over the last twenty years has indeed focused on India's demographic diversity.

It could be therefore assumed that India's sluggish fertility trajectory is the result of its heterogeneous nature, with on the one hand pioneer states such as Kerala (often compared to China *sans* coercive family planning) and on the other northern and central states (more akin to regions like sub-Saharan Africa). It is indeed a well-established fact that the tempo of fertility decline regions did not coincide across India (Guilmoto and Rajan 2001).

The overall process of demographic change will probably stretch over a total of more than 70 years, having started in the early 1960s or earlier in the pioneer areas in South India and being likely to end in the decade from 2030 onwards when fertility is expected to reach replacement level in the less advanced regions of North and Central India. India's slow fertility decline could thus be simply the result of the complex combination of diverging regional schedules. For instance, we could posit that the traces of the early and rapid decline in South India from the early 1960s till the late 1990s were almost cancelled out by the somewhat unchanging fertility level in North India. Similarly, it may be presumed that fertility has nearly leveled out in low-fertility regions during the last twenty years and that this has in turn affected the apparent pace of fertility decline at the all-India level, in spite of the progresses now patent in most of the least developed regions of the country.

To explore this hypothesis, we computed the overall rate of fertility decline for each of these 15 states from 1970 to 2010 and compared it with India's average rate (-.69 child per decade).[1] Results of this analysis are shown on Figure 3. They indicate that, with the exclusion of Haryana (discussed further below), the variations in the pace of fertility decline across states were of a limited extent. Observed fertility declines lie between -.87 (Punjab) and -.56 (Tamil Nadu). The slow rates in Tamil Nadu during the last forty years are also observed in Kerala and Karnataka, regions where fertility tends indeed to level off below two children per woman. In fact, TFRs have remained more or less stable in Kerala at a level close to 1.7 children per woman since the mid-1990s. In these states, the pre-1970 decline and the recent stabilization of fertility levels are therefore responsible to a large extent for the apparently slower fertility decline observed during the last four decades.

The only apparent outlier among the largest Indian states is Haryana. In this state adjacent to Delhi, fertility is reputed to have declined from 6.7 in 1971 to 2.3 in 2010, at an average decadal rate of -1.13 children. The drop in Haryana's fertility rates is the fastest observed across India since 1971 and comparable to declines observed elsewhere in Asia (see Figure 1). It may even be added that this state was directly affected by the post-Emergency stalling, with

[1] Annual SRS estimates at State level are not available earlier.

flat TFR observed from 1977 till 1984. Moreover, we notice that even if the initial decline in fertility from 1971 to 1978 indeed appears vertiginous (-2 children per woman), the SRS figures used here are compatible overall with TFR estimates for Haryana derived from other sources (Rele 1987). Moreover, Haryana is not entirely isolated, since it is surrounded by other states and territories such as Punjab, Delhi and Chandigarh where decline in fertility rates has been slightly faster than average during the last four decades. Yet, Haryana represents less than 3% of India's population. As such, it has had no impact on the national trend and it remains an unexplained outlier vis-à-vis the rest of India.

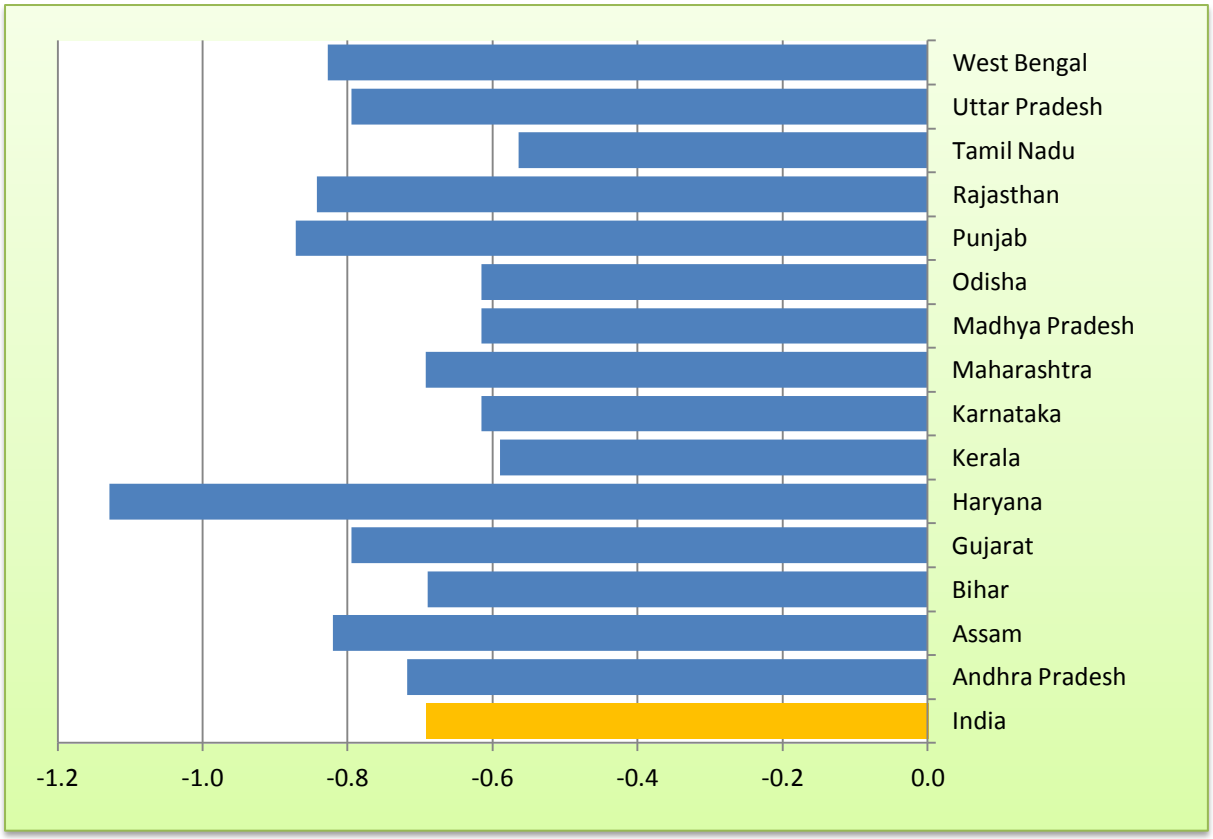


Figure 3: Average decadal fertility decline in the largest Indian states, 1971-2010

Regional fertility levels observed in 1971 in each state appear to be better predictors of the TFR observed the subsequent 40 years than the modest differentials in the pace of fertility decline observed till 2010. In other words, little seems to have happened within India during that period that was able to significantly alter the pre-1970 demographic differentials. This analysis also suggests that the overall national trend cannot be accounted for by the variations in the schedule of fertility decline at state level. The decline was almost parallel across regions and got faithfully reflected in the national average depicted on Figure 2.[2]

[2] There were however significant variations during the troubled 1970s. But states in which fertility fell abruptly due to the family planning policies experienced stagnation in fertility afterwards. As a result, the overall rate of fertility decline from 1970 to 1990 was not significantly affected by the Emergency episode and variations across States remain moderate.

3 2011 fertility differentials

In spite of the relative sociocultural and linguistic homogeneity of Indian states, they remain large administrative entities that may be themselves characterized by some level of inner diversity. This is not surprising in view of their size, with 17 states in India having populations of more than 25 million inhabitants. As a result, mapping fertility differentials at state level tends to conceal the complex spatial patterning of fertility variations across the country.

States can be further disaggregated into districts, administrative units which had an average population of 1.9 million in 2011. For each district, we will reconstruct the fertility trends over the 1961-2011 period. These trend patterns will be modeled based on the following characteristics: date of the onset of fertility decline, pace of decline, pre-transitional fertility level, trace of an inflexion (pre-transitional fertility increase).

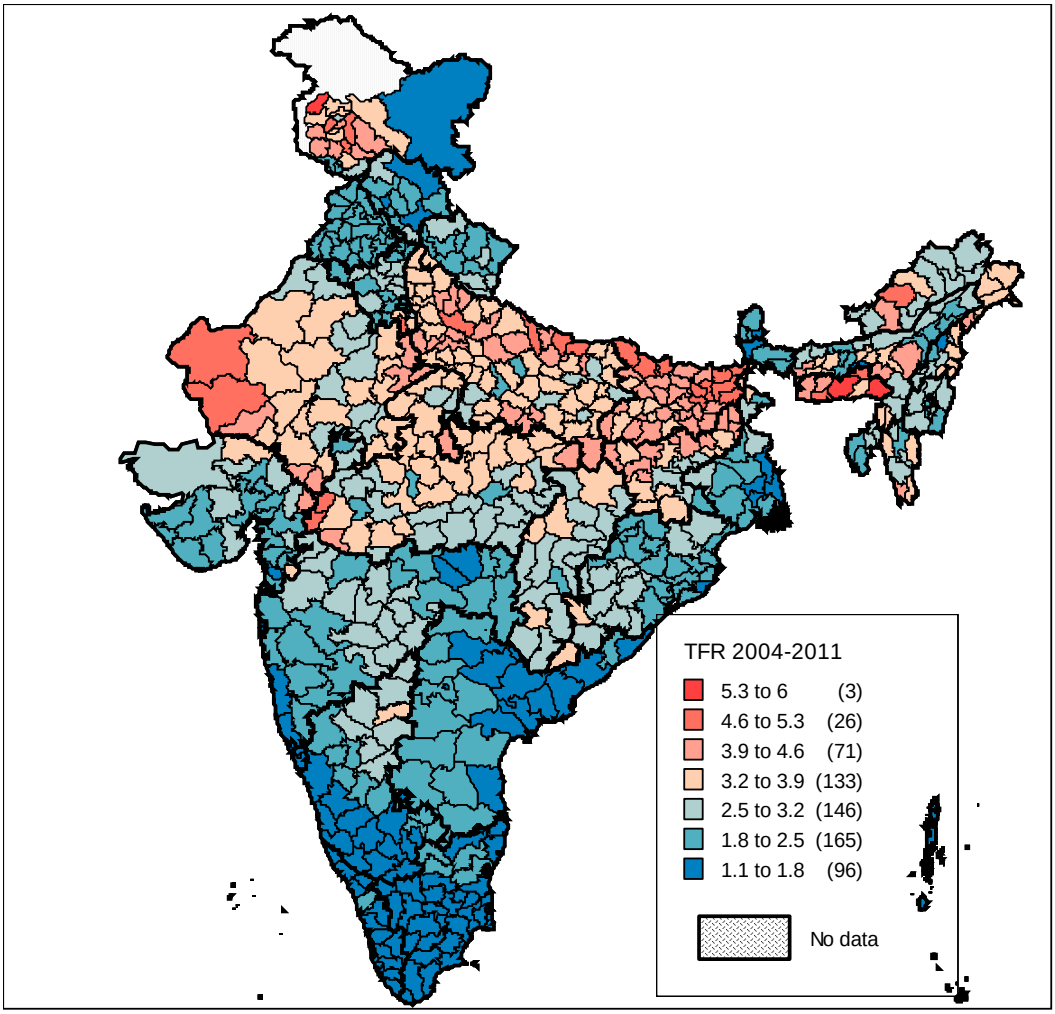


Figure 4: TFR estimates at district level, 2004-11 (Guilmoto and Rajan 2013)

If we now want to look below state level, we can start with the results of the most recent TFR estimation derived from the 2011 census. The map below (Figure 4) is based on TFR estimates derived from the age distribution at district level from the 2011 census and from

indirect estimation of district-level differentials in child mortality from various sources (see appendix below). They refer to the seven-year period prior to 2011 (2004-07).

This map displays features typical of the strong spatial patterning of fertility variations across India. While fertility has significantly decreased over the last four decades, there are still large areas with an average number of children per woman above 3 shown in orange and red in the map. These are concentrated in North-central India, in a region extending from Rajasthan to the West to Bihar to the East.

Areas with very low to ultra-low fertility (less than 1.8 children per woman) are spread from South and coastal India, with another low-fertility pocket concentrated around Punjab. The overall picture of fertility distribution is extremely regular, with gradual transition from high-fertility areas to low-fertility areas.

4 Long-term analysis

We also have older data to examine the trajectories of different subregions of India and we have therefore reconstructed fertility series for States and districts starting from the first census of independent India. From 1981 onwards, we have several reliable TFR estimates at district level. For 1951-1981, we can also use another series based on child-woman ratios. The main challenge concerns the adjustments for boundary changes during every ten-year period and the conversion of child-woman ratios into fertility equivalent. We use the 1981-1991 period for which we have both series of estimates for this. Maps are converted from ordinary district maps to surface and then contour maps by geostatistical modeling and this will allow in turn estimating fertility levels in the past for newly created administrative areas (see Appendix for methodological details).

We will in particular examine the course of fertility decline across Indian districts and see whether it remains determined by the conditions of the onset of fertility decline, with limited variations in the pace of fertility decline. Based on this longitudinal analysis, we will also see at which level fertility seems to stabilize in low-fertility districts and examine the future trends for ultra-low fertility.

The maps displayed on Figure 5 summarize the revolution in Indian fertility over the last forty years and delineate its distinct spatial contours. The first map is based on the 1961 age distribution and it shows fertility differentials on the eve of the first significant decline. There were already significant differences across India, with Kerala and Tamil Nadu exhibiting levels below 5 children per woman. Values above 6 were at the same time common in many tracts of North India. The lack of comparable subregional estimates for the 1940s or the 1950s prevents us from determining whether variations observed in 1961 reflect only long-term fertility differentials between South and North India or whether fertility had already slightly diminished during the 1950s in parts of South India.

In fact, the decline during the next decade is modest and the 1971 map points only to a small extension of the areas with less than 5 children along the western and eastern coasts of South India. However, the number of districts reporting more than 7 children also tends to slowly shrink in Central India. A few adjacent districts along the Kerala-Tamil Nadu border even report fertility levels below four children per woman.

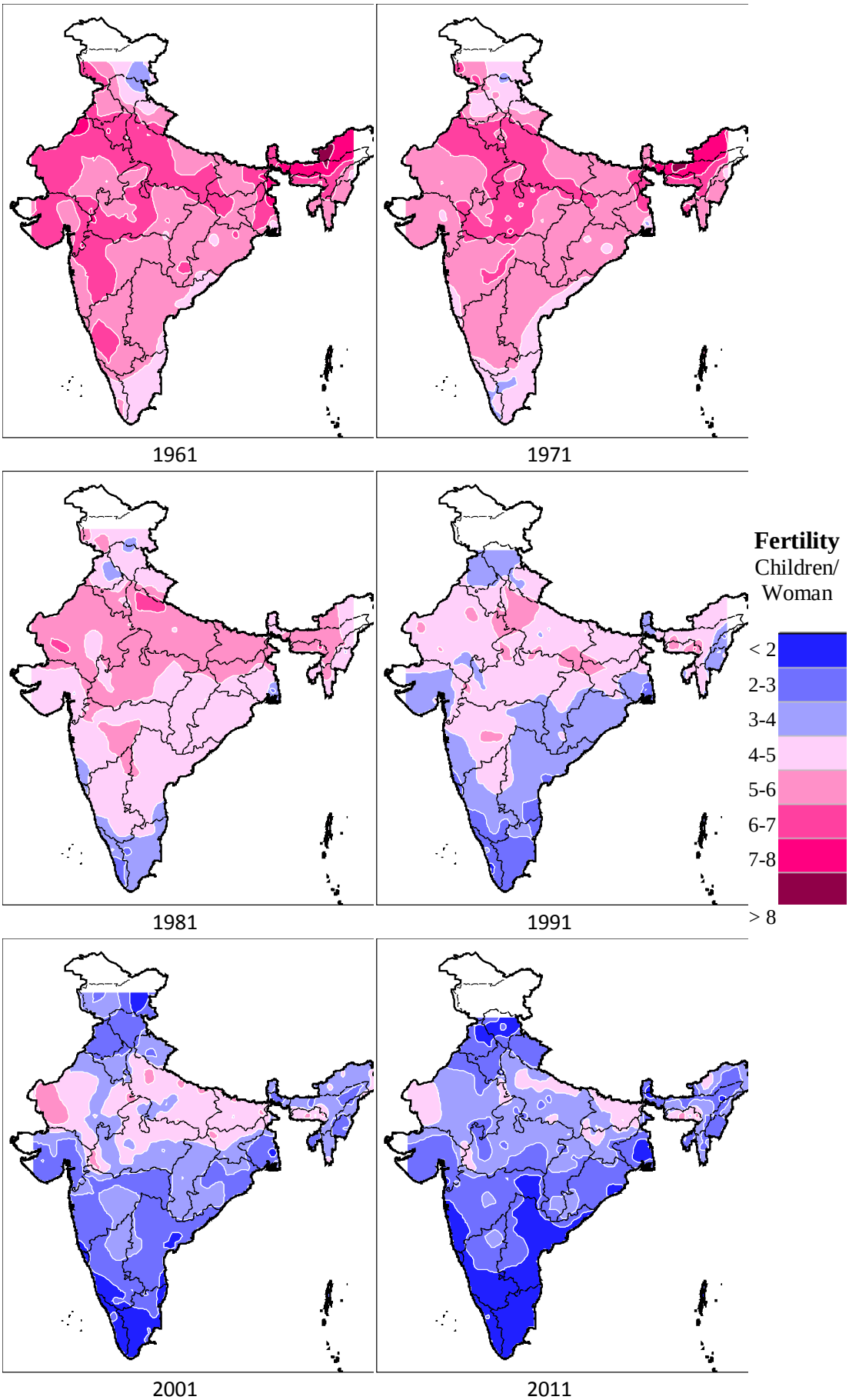


Figure 5: Total fertility rates at district level, India, 1961-2011

It is only during the subsequent period, from 1971 to 1981, that the fertility decline reshapes India's demographic map. This may, as we have seen, be partly associated with the effects of the Emergency period, although the more pronounced decrease is observed in South India, a region less affected by changes in family planning policies than North India. During this decade, districts with fertility below 5 children see their number triple and the reduction of fertility now clearly affects all of South India and many other coastal regions, from Gujarat to West Bengal. Fertility is now below 4 children in most of the advanced districts of Kerala and Tamil Nadu and fertility estimates below three are even reported for some areas. In addition, another hotspot of fertility decline has now emerged in Northwest India, centered on the state of Punjab. At the same time, the highest TFR values reported in the past become less frequent. In North India, there are for instance no more than a handful of isolated districts left in 1981with fertility above 6 children.

The spatial progression of moderate fertility levels (2-3 children per woman) continues unabated in South India during the 1980s. But according to the 1991 map, fertility has also fallen significantly in the north and values above five children have become quite rare. The spatial character of the changes in reproductive behaviour is quite pronounced during this period: we distinguish not only the regular extension of blue areas with moderate fertility, but also the gradual decomposition of the large blocks of high fertility that once covered most of North and West India.

Ten years later, the 2001 map indicates that a few districts have already crossed the replacement level, mostly in Kerala, Tamil Nadu and in Southwest Karnataka. The other node of fertility reduction in Northwest India remains active and now encompasses Punjab's neighboring states of Himachal Pradesh, Haryana, and Jammu and Kashmir, as well as North Rajasthan, and Uttarakhand. The spatial advance of moderate fertility into West Bengal and Orissa proceeds independently from other regional trends. Traces of the former princely state of Hyderabad across Maharashtra, Andhra Pradesh and Karnataka are still visible and they represent a large area of resistance to rapid fertility decline in the Deccan. In North India, the Indo-Gangetic plain (the so-called "cow belt") corresponds to a larger high-fertility region, where women still have more than four children on average. This regional assemblage made of Uttar Pradesh, Bihar, and of parts of Madhya Pradesh and Rajasthan gave rise to the acronym of "Bimaru states" introduced by the famous Indian demographer Ashish Bose. 3

The last fertility mapping presented here is based on the 2011 census results. More than half of South India now reports fertility levels below replacement levels and other large pockets of low fertility are visible in Punjab, Himachal Pradesh and West Bengal. Yet, fertility decline is now stagnating in Tamil Nadu and Kerala and there are only very few cases of ultra-low fertility (below 1.5 children per woman). The high-fertility region in the North continues to disintegrate and there are only a few isolated districts in North Uttar Pradesh and Bihar or in West Rajasthan with 2011 TFR estimates above four children per woman.

[3] This nomenclature has been now been changed into "Empowered Action Group states", a regional grouping that exactly matches the former BIMARU states but for the recent addition of Odisha.

It is interesting to note that high fertility has obviously become a spatially peripheral phenomenon in India over the years: most areas reporting the highest TFR levels are tucked away along the borders with Pakistan (in Rajasthan), Nepal (in Uttar Pradesh and Bihar) or Bangladesh (in Meghalaya), i.e. adjacent to countries or regions that have higher fertility rates than India. However, this peripheral spatial patterning of delayed fertility transition does not correspond to a concentration of below-replacement districts around metropolitan areas – areas usually regarded as the spearheads of India's social modernization and economic development. In fact, as our maps clearly demonstrate, the history of fertility decline over the last 50 years does not at all involve the showcases of "shining India", be it New Delhi, Mumbai or Bangalore (Bengaluru). Today, these large cities may exhibit low fertility levels, but this is a somewhat recent development. In no way did they play any visible role in the spread of fertility decline over the last five decades. On the contrary, the core areas of fertility decline themselves lie on the outskirts of India, located along the coasts of Kerala and Tamil Nadu with a gradual extension towards Goa and Maharashtra on the west and towards Andhra Pradesh on the east. Other isolated seats of fertility decline can be found along the border of Punjab and Himachal Pradesh and in West Bengal. With the exception of Kolkata where traces of fertility decline are observable early on, no major metropolis appears to have had a significant impact on the diffusion of small family size in its own subregion. This remains true if we extend our scrutiny to the other largest Indian cities such as Chennai, Pune, Hyderabad, Ahmedabad, Surat or Jaipur.[4] They do not constitute hotspots of fertility decline and are almost invisible on our maps.

Our geographical analysis suggests that fertility decline has proceeded in a somewhat unique manner across Indian districts and that it has followed a typical diffusional pattern. This does not mean that small family size is something which spreads over contiguous areas like viruses, but rather that social change progresses along socially homogeneous areas that tend invariably to be geographically adjacent. The lack of advanced metropolitan areas at the core of the maps of fertility decline in India suggests that spatial proximity and cultural homogeneity are better predictors of impending fertility change than social and economic characteristics of “modernity” such as higher incomes or educational levels associated with urban contexts.

Yet we may still wonder if the pioneer regions that were at the origin of the decline in India have been more affected by the process of fertility decline than "laggard regions" in North India. In other words, is the spatial patterning of fertility decline in India reflected in different paces of fertility reduction across regions? The map shown in Figure 6 tries to answer this question. This map depicts the difference between local fertility decline computed at district-level and the average decline observed in India over 1961-2011. We distinguish areas with faster fertility decline shown in red (dark red for declines faster by more one child) and with slower fertility decline shown in blue (dark blue when the decline has been lower than the national average by more one child per woman).

[4] These are cities with more than 3 million inhabitants in 2011. Coimbatore, located in the middle of western Tamil Nadu, is a special case. The city does lie in the middle of one of the pioneer areas of fertility decline in India, but fertility stated to fall there in the 1960s at the same rate as in the neighboring Tamil countryside. The city then had no more than 300,000 inhabitants (it is still only the 39th largest India city today).

As the map demonstrates, the reduction in TFR is almost identical to the national average for more than half of India's territory, i.e. variations in fertility decline over these fifty years are less than 0.5 children per woman in these areas. This suggests that the fertility landscape has not changed appreciably in relative terms after five decades of fertility change: regions with the lowest TFRs today were to a large extent already characterized by lower fertility in the 1960s. This persistent fertility differential has only been eroded by the recent stalling of fertility reduction in South India below replacement-level.

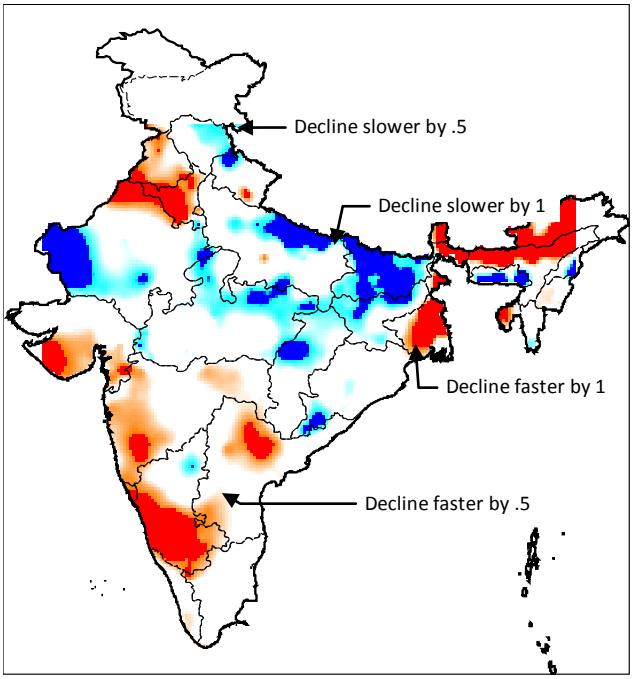


Figure 6: Differences between fertility decline in Indian districts and in India as a whole, 1961-2011

The 1961-2011 comparison points, however, to a few regions where fertility declined especially fast such as south Karnataka, central West Bengal, Haryana, and north Assam. We also distinguish regions characterized by a slow pace of fertility reduction: Bihar, north Uttar Pradesh, west Rajasthan. These areas where the decline has been faster or slower by more than one child than the national average constitute distinct clusters of a few districts. But they remained small, isolated and somewhat peripheral. Moreover, they correspond to no more than 20% of the territory.

In other words, this map confirms what the previous examination of state-level trends had suggested, i.e. that on balance, fertility decline has been almost parallel across India over the last 50 years. A finer spatial disaggregation fails to unveil a significant level of regional diversity in the profile of fertility decline within the country.

5 Conclusion:

There is no obvious explanation for the slow pace of fertility decline in India. Structural explanations relating fertility decline to specific drivers such as overall economic development, family planning efforts, educational achievements or decline in infant mortality are not particularly convincing since India is a medium position with regard to all these factors compared to the rest of India. Once it started, fertility decline has proportionally been faster in several countries of South Asia such as Nepal, Bangladesh or Pakistan, where social and economic conditions are not necessarily more favorable than in India and where the population policies have probably been less vigorous than in India.

The examination of spatially disaggregated data has failed similarly to highlight distinct fertility trajectories within India, measured at state as well as at district level. To a large extent, fertility decline has proceeded across India at a similar pace over the last fourty years. The main source of the vast variations observed on fertility maps is the related to the date of

the onset of fertility decline rather to its rate. The comparison of successive maps of fertility variations points to a gradual spread of moderate and low fertility across the country, spreading from a few original hot spots of fertility decline in South, Northwest and Northeast India. The potential impact of structural variables such as urbanization or economic growth appears limited while fertility maps better coincide initially with the maps of educational levels. Such findings tend to emphasize the role of purely diffusional mechanisms in accounting for the gradual decrease in fertility, in which spatial proximity may be have played a larger role in facilitating changes in demographic behavior than other trends in social and economic development.

The maps also suggest that future fertility decline will bring replacement level fertility in more than half of India before the end of the present decade. If the decrease in TFR levels continues to proceed along spatial lines, only a few states stretching from Rajasthan to the West to Jharkhand and Bihar to the East may be able to maintain fertility levels above two children by the time of the next census, contradicting some bleaker scenarios (Haub 2011). At the same time, the relative stagnation in TFR levels observed in South India at levels close to 1.7 children per woman suggest that only a few areas are likely to plunge into ultra-low fertility by the end of the decade.

6 References:

Basu, Alaka Malwade, 2009. On The Prospects For Endless Fertility Decline In South Asia, in *Completing the Fertility Transition*, Population Bulletin of the United Nations, United Nations, New York, 554-561.

Bhat, P. N. Mari, 1996. “Contours of Fertility Decline in India: A District Level Study Based on the 1991 census” in K Srinivasan (ed.). *Population Policy and Reproductive Health*. Hindustan Publishing Corporation, New Delhi, 96-179.

Bhat, P.N. Mari, 2009. India’s Changing Dates with Replacement Fertility: A Review of Recent Fertility Trends and Future Prospects, in *Completing the Fertility Transition*, Population Bulletin of the United Nations, United Nations, New York, 376-391.

Census of India, 2011a. *Provisional Population Totals*, Paper 1 of 2011 India, Series-1, Office of the Registrar General & Census Commissioner, New Delhi.

Dyson, Tim, 2009. On The Future Of Human Fertility In India, in *Completing the Fertility Transition*, Population Bulletin of the United Nations, United Nations, New York,392-408

Guilmoto, C. Z. and S. Irudaya Rajan, 2001. «Spatial Patterns of Fertility Change in Indian Districts», *Population and Development Review*, 27, 4, 713-738

Guilmoto, C. Z. and S. Irudaya Rajan, 2002. «District Level Estimates of Fertility from India's 2001 Census», *Economic and Political Weekly*, February 16, XXXVII, 7, 665-672.

Guilmoto, C.Z. and S Irudaya Rajan, 2013, "Fertility at the District Level in India. Lessons from the 2011 Census", *Economic and Political Weekly*, 48, 23, June 8, 59-70.

Haub, Carl, 2011, Future Fertility Prospects For India, Expert Paper, Population Division, United Nations, New York.

Säävälä, Minna, 2010. Below Replacement-Level Fertility in Conditions of Slow Social and Economic Development: A Review of the Evidence From South India, *Finnish Yearbook of Population Research*, XLV, 45–66.

United Nations Population Division, 2011. *World population prospects: The 2010 revision*, http://esa.un.org/unpd/wpp/index.htm

7 Appendix (methodology)

7.1 Source of data

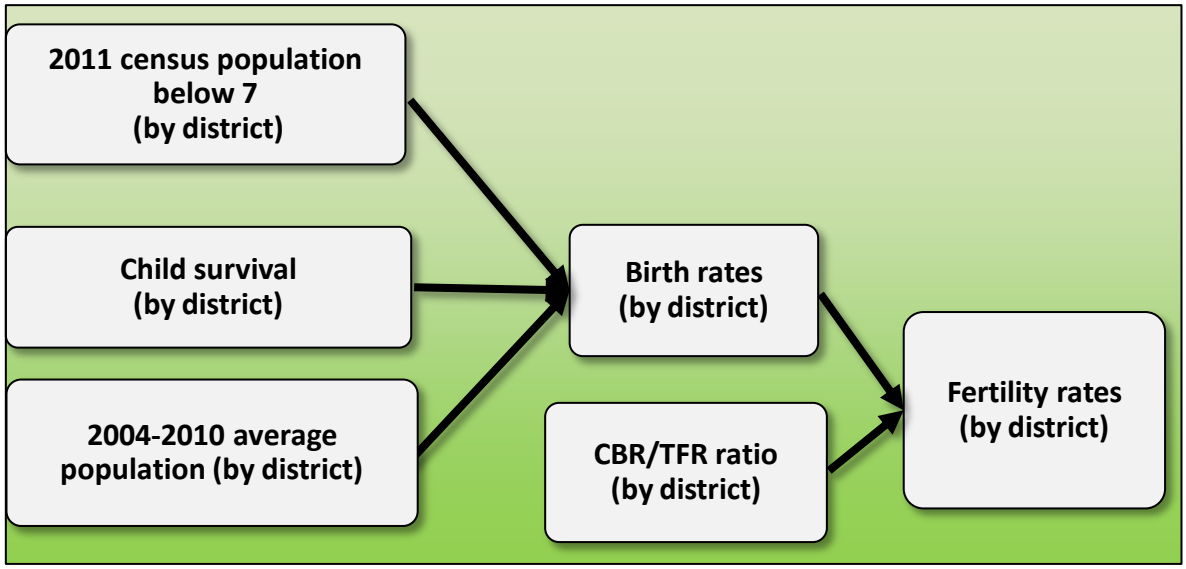
Analyses and maps here are based on several sets of TFR estimates derived from the Indian censuses. Till recently, the census has remained the only source for estimating fertility at local (district) levels. Figures at a higher administrative scale (state) are available from both the Sample Registration System (SRS, starting from 1991 in most states) and from regular national sample surveys (NFHS).

We use the provisional data on the child population available at district level from the 2011 census for estimating recent fertility levels. We also use previously available estimates of district-level fertility for 2001 (by Guilmoto and Rajan), 1981-91 (by Bhat) and 1961-91 (by Guilmoto and Rajan). Fertility trends from other Asian countries used in this analysis are taken from the 2011 World Population prospects (UN Population Division).

7.2 Fertility estimation for 2011

In a nutshell, the procedure followed here for evaluating 2011 fertility levels consists in using the available child population by district for estimating the corresponding number of births during the seven years preceding the census. This requires converting the child population into births after correction for infant and child mortality. This is done by estimating survival rates for the period 2004-11 at district level by combining state-level estimates from the SRS estimates and from district mortality differentials derived from the previous census. Adjustment is also made for all changes in administrative boundaries.

The district-level crude birth rates (CBR) are then derived by computing the ratio of births to the average district population during 2004-11. In order to convert birth rates into total fertility rates (TFR), a district-level ratio of birth rates to fertility rates is used. This ratio CBR/TFR depends mainly on the age distribution and the fertility schedule. The estimation method is summarized in the following figure:



Certain aspects of this procedure are be presented in more detail in a separate paper (Guilmoto and Rajan 2013).

7.3 India fertility: District-level estimates

A somewhat similar method to the one described above was used by Bhat (1996) for the 1981 and 1991 censuses and by Guilmoto and Rajan (2002) for the 2001 census. The Census of India prepared its own set of TFR estimates for 1991 (Registrar General of India 1997). An entirely different series exists for the eight five-period extending from 1956 to 1991, providing mortality-corrected fertility indices at district level (Guilmoto and Rajan 2001).

Several issues arise related to the use and consolidation of these series. We examine them separately:

Quality: The census of India estimates for 1991 based on the P/F method for estimating fertility are for instance been rather inconsistent with other sets of fertility estimates and were therefore disregarded (Registrar General of India, 1997). Similarly, TFR estimates are not available for Jammu and Kashmir districts as the 2011 census are deeply flawed due the over-reporting of the child population during the census operations in Kashmir (Guilmoto and Rajan 2013).

Comparability: The 1956-91 series of fertility indicators are not given in TFR. We therefore use them as local fertility indices and convert them into TFR by using national TFR estimates given by the United Nations Population Division.

Coverage: many series are incomplete, especially for the Northeast and from Jammu and Kashmir where census data may be missing for some years. The absence of census figures evidently precludes any attempt at estimating local fertility levels.

Boundary changes: The number of districts in India has regularly increasing over the years, starting from 310 districts in 1956 to 640 districts in 2011. This is a major source of concern

of intercensal comparison as it means that we do not have a longitudinal series of fertility estimates for a majority of 2011 districts. We have resorted therefore to a geostatistical procedure for estimating fertility in 2011 districts in the past (see detail below).

In order to prepare a consistent set of estimates for the largest number of districts, we have decided to combine the 1956-91 series and the 2001-2011 estimates. Fertility indicators were converted into TFR estimates by regression analysis. Mari Bhat's estimates were used to check the quality of our TFR estimates for 1981 and 1991. The resulting dataset used here covers most of India from 1956 to 2011.

7.4 Fertility maps

For mapping purposes, district-level estimates have been first transformed into surface values by using a standard geospatial interpolation method (ordinary kriging). This method uses local fertility observations at various census and autocorrelation models to provide fertility estimates for every cell of the Indian map grid (cell size: 15 km x 15 km). Fertility being characterized in India by a very high level of spatial dependence as assessed by spatial autocorrelation indices, ordinary kriging provides robust fertility estimates (except for border areas). From these local fertility estimates, we are able to compute fertility decrements over different intervals by "subtracting maps" (computing the net TFR difference between cell values of maps for different periods).

These surface estimates are later converted into isopleth maps with contours lines as used for 1061-2011 maps. These contour lines (or isolines) do not correspond to existing administrative boundaries (compare maps on Figures 4 and 5).