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MAPPING OUT FERTILITY IN SOUTH INDIA: METHODOLOGY AND RESULTS[1]

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Recent progress made in Computer Aided Cartography (CAC) and in the GIS, supported by the power of computers, today warrants a consideration of statistical units in their spatial dimensions and with reference to their environment. Geographic databases[2] containing several tens of thousands of units, with which more than a 100 variables are linked, can now be created.

It therefore becomes possible—and necessary—to envision social change in India in its spatial dimension. A study of fertility in south India will provide us with an eloquent example. In effect, the analytical cartography[3] of data concerning 70,000 villages comprising the four states and the union territory in the south calls for a new perception of fertility, freed of the a priori divisions constituting the administrative grid of *taluks* and districts. One can thus embark on a veritable 'exploratory spatial data analysis, in which it is desired to let the data "speak for themselves"' (Martin, 1996:113).

The SIFP, establishing as it does a geographic database on the village scale throughout south India, is integrated in this context. This chapter

[1] I wish to thank Christophe Z. Guilmoto for his help in the preparation of this chapter.

[2] The particularity of geographic databases is that they take into account the position of individual statistics in space by a system of referencing of the X and Y type (generally in longitude and latitude).

[3] This is the name given to this approach, taken from an article of that title by Tobler (1976).

presents the cartographic approach followed by this project, as well as various results derived from the consequent analytical cartography. The first section corresponds to the presentation and methods of data treatment. It is devoted to a brief discussion of our requirements of quality, spatiality and exhaustiveness and is required before beginning any spatial analysis. Diverse methods are also available to treat the information, the volume alone of which (by reason of the number of statistical units employed) precludes an exhaustive cartography.

The second section is devoted to the presentation of the remarkable results attained on the scale of south India. The maps obtained illustrate the interest of such technical investments. At the end of this article, and by way of example, we compare the fertility map with other maps derived from this database, so as to offer trails of reflection for interpreting the rapid demographic change observed in this region.

THE CARTOGRAPHIC REPRESENTATION OF FERTILITY ON A MICRO SCALE

WHAT ARE THE DATA FOR MAPPING FERTILITY?

In order to bring to light the geographic structure of fertility in south India, a cartography based on small numbers on a narrow scale is required. There are four main sources of national statistics enabling the study of fertility in India: civil registration, the SRS and surveys such as the NFHS and the Census of India.

MUCH DATA, BUT FEW POSSIBILITIES

Civil registration,[4] although an Indian demographic source as old as the census, is not of sufficient quality to enable macro-regional studies on fertility. The quality of the data is, in fact, quite unequal from region to region because of a sometimes very pronounced rate of under-registration. It is nevertheless, still a source to which one can refer to complement one's study.

[4] Every year, the Registrar General of India publishes civil registration statistics in the *Vital Statistics of India*, collected at the district level (differentiating rural and urban) and towns of more than 30,000 inhabitants.

The SRS follows the evolution of the population in the states on the basis of a population sample of villages and of representative towns around them.[5] The SRS is without doubt, one of the best sources for describing demographic movements (fertility and mortality) and, notably, annual and inter-regional variations. Unfortunately, the data issued by the SRS are not available at the district level and, consequently, sometimes conceal profound demographic differentials existing within the regions.

After independence, the Indian government began a large survey which is repeated annually, namely the NSS. Unfortunately, this source no longer provides regular information pertaining to birth rate. There is, however, also the NFHS,[6] a large demographic survey begun in 1992–93 and repeated in 1998–99. Representative of Indian fertility and mortality, it certainly constitutes the best source of demographic information that India has produced until now. However, all the data of the different NFHS surveys, although pertinent from a demographic point of view, are not available at the district level (Bhat and Zavier, 1999). Once again, these sources do not allow a geographical study on a detailed scale, but they do enable one to keep the major tendencies of a region in mind and to perceive therein particularities respective of the rest of the nation.

The census does not directly correspond to the necessities of a study on fertility; neither the number of decennial births nor the age structure of the population is provided on a satisfactory scale. It only allows us to approach the phenomenon by various indirect methods. Our interest here is to identify the most disaggregated indicator available, for which numerical estimates have already been made.[7] Considering that the districts on the average comprise several million inhabitants, we wanted to operate on the basis of smaller units of observation. Moreover, the 1991 census for the first time provides information on the distribution by age, ('population below 7 years') on the smallest possible level, that is to say, rural village or urban ward.

As has been shown elsewhere, an indicator of fertility can be inferred from the 1991 census information using the CWR. This indirect indicator is of very good quality, for the potential effect of the differentials of infant mortality on the calculation by the CWR is minor. Moreover, it allows

[5] The statistics are published twice yearly in the *SRS Bulletin* and in recapitulative publications.

[6] *National Family Health Survey (MCH and Family Planning)*, India 1992–93, International Institute for Population Science (IIPS), Bombay, 1995. The publications of the NFHS-II are now available at www.nfhsindia.org.

[7] See for example Murthi et al., (1995); Bhat (1996); Guilmoto and Rajan (2001).

such an analysis on the smallest census level, which had not been possible in the past.

A Geographic Database for the Analysis of Fertility

The database established by the SIFP is based on village data. The data, available in numerical form, were systematically subjected to a series of tests relating to both internal logic and external controls. The outliers and other erroneous data were thus detected and corrected, using the printed publications of the census when they were available. This leads to an improvement in the statistics, which in turn make the SIFP database a source of very good quality. There are, however, villages for which the census estimates give rise to doubt, as well as some which could not be precisely located.

The other aspect of a geographic database is to determine the exact situation of the different units in space. As there is but one available source (the Survey of India is the only producer of maps in India) and because the publications of the 1991 census were belated (the last volumes were published in 2000), the spatialization of data has been made more complex. It was at times necessary to use older maps (1981 census, old toposheets) and to combine all the available cartographic sources to identify and locate the census villages. Various tests have shown that local errors in localization do not exceed 500 metres, which on the scale of south India, is negligible. In the same way, comparison of our data with other geographic databases[8] has confirmed the considerable accuracy of the SIFP base.

Using this database, 69,700 villages can be analyzed representing a rural population of 134,571,811 persons (Table 2.1).

Table 2.1: Descriptinve Data for the Villages of the SIFP Database

	Mean	Standard Deviation	Minimum	Maximum
Village Populations	1,930 inhabitants	2,890	1 inhabitant	32,566 inhabitants
Village Areas	800 ha	1,440	0.8 ha	83,077 ha

[8] In particular, the various layers of the *Digital Chart of the World* (ESRI, 1993) were superimposed on those of the SIFP. The level of generalization and imprecision of the former prove to be greater than that of the latter.

How to Process the Data

A Complex Approach

Cartography is not a minor operation and, as it is a question of dealing with 70,000 units, it is best to reflect upon the methods employed. The first thing which one notices when observing the size of the database, is the number of units which can be presented on one page. The representation of all the villages of Tamil Nadu alone in a simplified areal form (like the polygons of Thiessen, for example), on an A4 (21 cm × 29.7 cm) page is already no longer possible.

There are three solutions that are suggested.

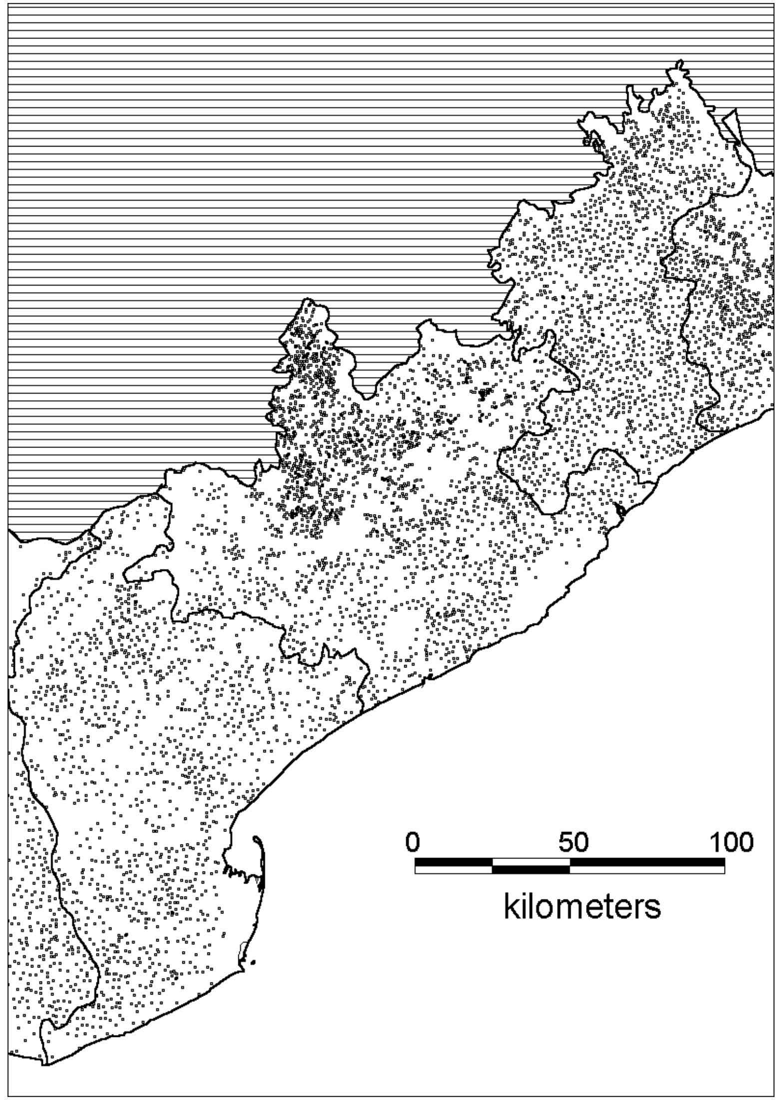
- The use of a broader administrative definition, as for example, *taluks*.
- The controlled aggregation of data according to spatial or statistical constraints.
- The use of a continuous range of values, rather than of points and polygons. This makes it possible to leave these representational problems by forming a continuous grid of pixels which eliminates direct references to villages.

As we shall see, the choice of the graphic method is not neutral from a statistical point of view. Although the first solution is by far the simplest, it can nevertheless not be employed. On the one hand, and this is its most serious limitation, the administrative structure (village-*taluk*-district) is very imprecise, for a *taluk* can comprise more than a 100 village units. On the other hand, the administrative division imposes a pre-defined form on the analysis of the form of the phenomena, and one can refer, for example, to Map 2.5 to convince oneself that the administrative boundaries do not coincide with the spatial distribution of demographic phenomena.

The second solution consists in aggregating the data according to a defined spatial procedure. That is to say, one creates a new point situated at the centre of gravity of the concerned points, defined according to a spatial rule. For example, all the original villages less than 5 kilometres will be aggregated and their data combined to form a new statistical unit.[9] Maps 2.1, 2.2, and 2.3 given below illustrate this procedure for the districts

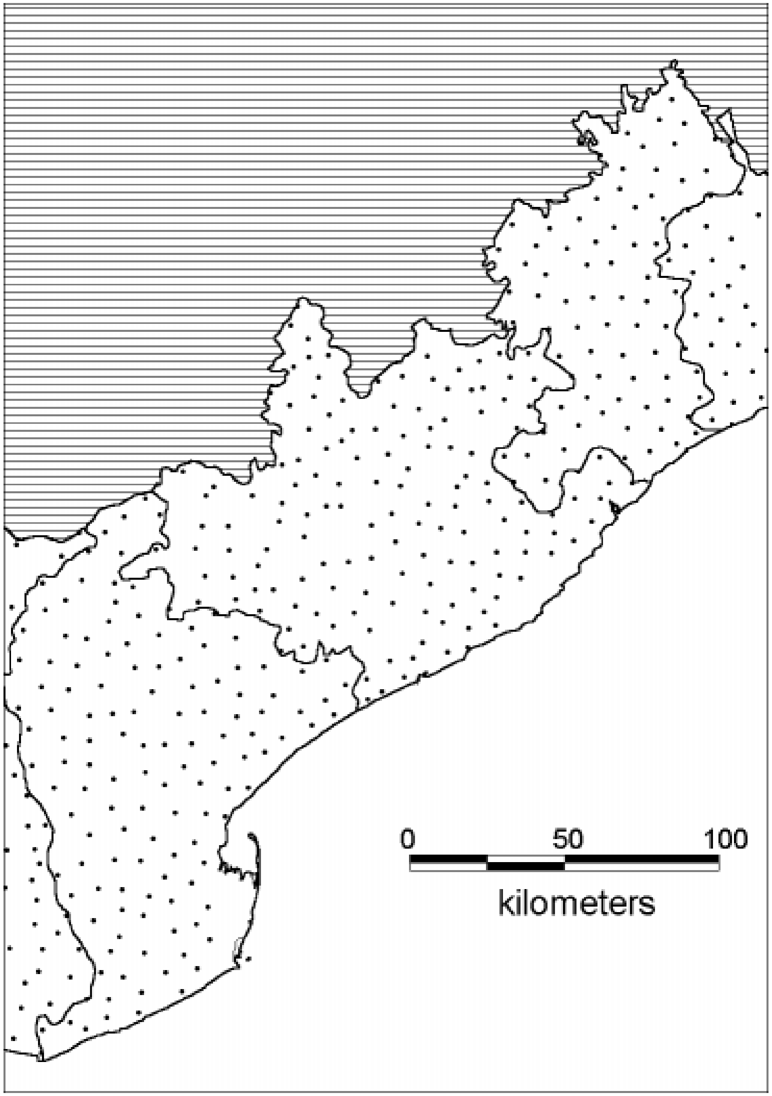
[9] This spatial aggregation procedure has been devised by C.Z. Guilmoto and is also used in other chapters of the book for both statistical analysis and cartography. For a detailed presentation of the methodology see Guilmoto et al., 2004.

Map 2.1: Villages in Three Districts of North-East Andhra Pradesh



of eastern Andhra Pradesh. The spatialization of the phenomena will be given greater consideration if the data are aggregated under application of a spatial constraint than if a pre-defined grid is employed (and control over the size of the final units can be retained). Underlying this operation

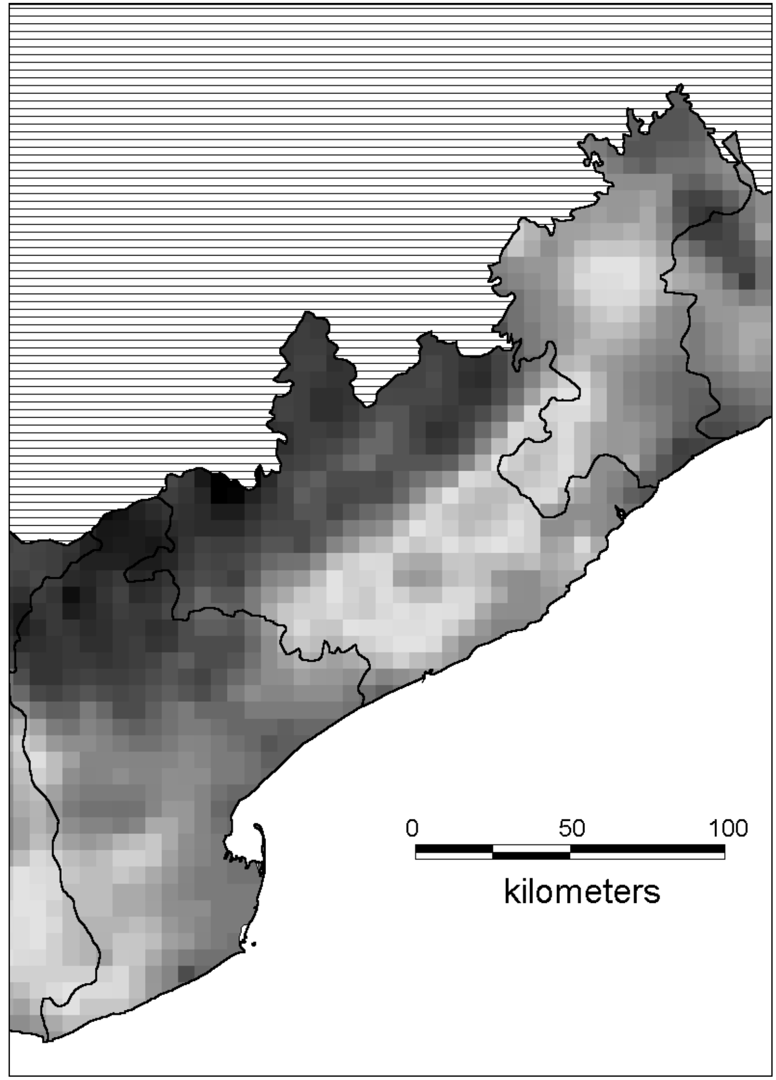
Map 2.2: Clusters of 5 km



is the geographic rule that the objects closest to each other have the greatest resemblance (this is the principle of spatial autocorrelation).

Although this procedure is not always expedient, it has two reasons for being so in our case. On the one hand, the aggregation of data is legitimate,

Map 2.3: Smoothed Fertility Values Obtaind by Kriging Cluster Values



insofar as fertility is very highly autocorrelated in space.[10] In combining neighbouring villages, there is no risk of eliminating a strong heterogeneity

[10] A series of spatial autocorrelation tests on different levels was carried out on diverse variables using the Moran Coefficient. Here, fertility emerges as the most spatially

of demographic characteristics. On the other hand, and this is an important point, the aggregation allows the reduction of the statistical noise produced by the small units. It is, in fact, hazardous to use villages whose populations are too low to calculate the indices, and our computation of fertility is tenuous at best, taking the effect of small size into consideration.[11]

In addition, this solution renders the units of the different states more comparable. Thus, the administrative definition of villages in Kerala makes them much larger than villages in the three neighbouring states. A village in Kerala can easily have a population a 100 times greater than that of a village in the region of Mysore. The application of an aggregation according to clusters of 5 kilometres facilitates comparison by reducing the problem of difference in the sizes of spatial units (better known under the term MAUP[12]) which distort the comparisons. Although the spatial grouping which we have made, leads to clusters of comparable area, it does not entirely eliminate variations in size. In fact, significant variations in population density exist, for example, between the less populated arid regions of the Deccan plateau and the denser regions of coastal Kerala. However, these differences are much less than those observed on the basis of village of origin.

The third solution tends to eliminate references to the administrative framework of the existing habitat. The grid obtained represents the variations of the studied phenomenon in a continuous manner in space; one moves, in fact, from a territorial approach to a spatial approach, which is much richer in information.

For this purpose, the map must be transformed into an orthogonal grid formed of elementary cells (pixels). The smaller the pixel, the finer will be the grid and the database will be correspondingly large. In each pixel, the corresponding value will be calculated by weighting the values of the villages which are present within the pixel, or by interpolating the value of the surrounding villages. A spatial smoothing is thus carried out which eliminates the punctual representation of each value to give the regional tendencies of the phenomenon. The resulting map is much easier

autocorrelated variable. Moreover, the works of Michael Feng (1996) on China also show a strong spatial autocorrelation of fertility.

[11] In an unpublished note on village size and computation of CWRS, C.Z. Guilmoto shows that the statistics for villages of less than 500 inhabitants are subject to large variations and that from 2,000 inhabitants, this variation has become negligible. This means that the aggregation of data under statistical constraints is also a solution to be considered.

[12] This phenomenon is well explained in Green and Flowerdew, 1996.

to read because it erases the micro-variations which would not be legible (Map 2.3).

Our procedure combines the two latter solutions. First a spatial aggregation is carried out, which significantly reduces the number of demographic units. The aggregation makes it possible to remove the majority of units, the sizes of which are too low.[13] Second, a spatial smoothing makes it possible to reconstitute regional tendencies.

Altered Solutions

As we have just seen, the cartographic approach, to be efficacious, goes through a number of particular procedures. It is therefore, always advisable to specify which procedures have been used, so that the reader (as well as the designer) of the maps would not be misled by the final result. In this case, our results will be determined by the level of aggregation and the method of smoothing.

The level of aggregation retained is 5 kilometres, as it allows us to compare all the southern states, and satisfactorily increases the soundness of the variables. Fewer than a 100 clusters have a population of less than 1,000 inhabitants. Another not insignificant advantage is that the number of units to be analyzed is considerably decreased, becoming somewhat less than 7,000.

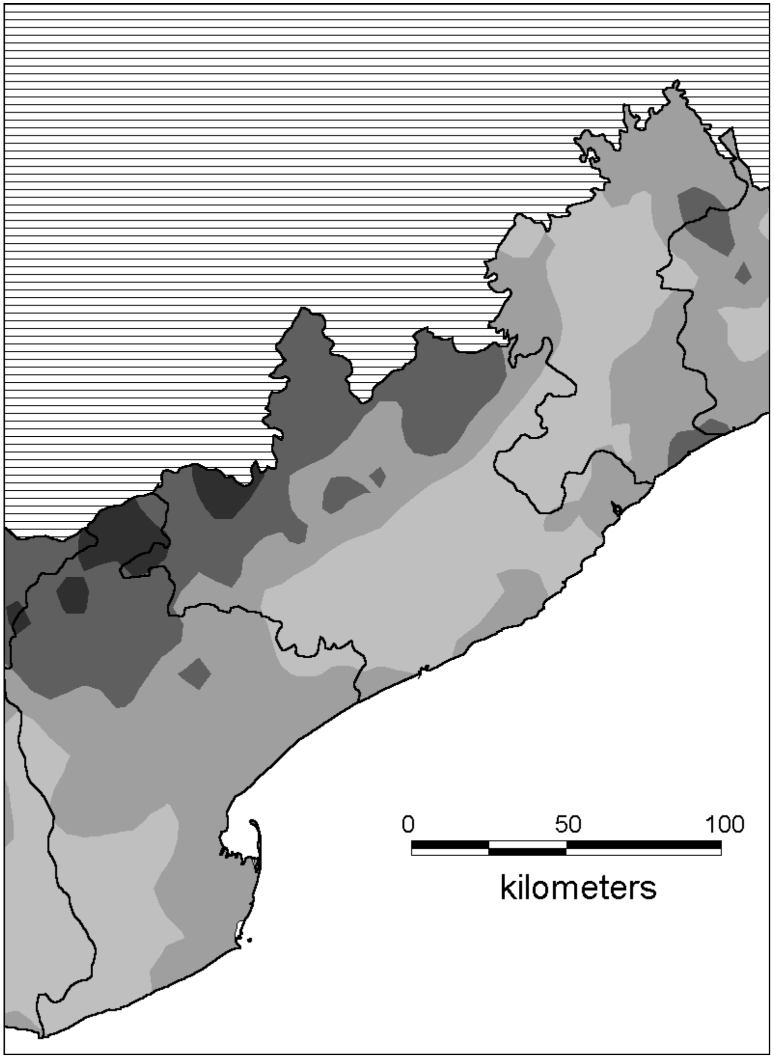
This reduction makes it possible to carry out the method of smoothing in a reasonable period of time, as the volume of calculations naturally corresponds to the number of geographic units considered. For the smoothing of data we shall use the kriging method, which is well-adapted to spatially autocorrelated data such as fertility. This method is based on a model of spatial autocorrelation and, as such, rests upon quite weighty calculations.[14]

We finally obtain a continuous series of values representing the variation of fertility in south India. A contouring can be applied so as to bring certain zones to the fore (see Map 2.4). However, although the contouring appreciably improves the reading, it sets a trap for the reader: by doing

[13] In a few rare regions with very low density, for example the southern Ghats, the aggregation is sometimes not sufficient to create new demographic units with meaningful numbers.

[14] Although sometimes criticized (Grasland et al., 2000), the method of kriging is still essential, for it provides the best possible means of estimating punctual data. In strictly statistical terms, the method of kriging is superior to any other method of smoothing constructed by interpolation of nearby villages. See Bailey and Gatrell (1995).

Map 2.4: Fertility Contours Obtained from Kriged Cluster Values



away with the continuous aspect of the variation, it gives the impression of a division between each zone and of creating classes of values which can be arbitrary.

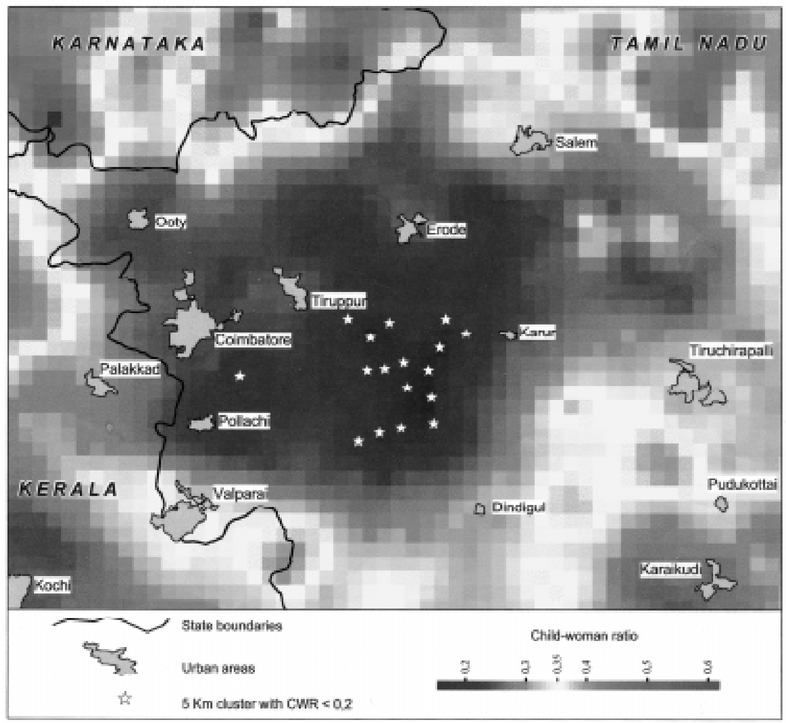
It is, therefore, necessary to keep in mind that the data obtained appear in a distinctive and continuous manner, whereas the choice of values for

the contouring is arbitrary. In the same way, one cannot 'look for one's village' on the map. The variations which are expressed are local tendencies, based on averages, and sometimes conceal more complex local situations.

Results

The cartographic treatment of the SIFP database is confined to the rural zones, because the introduction of urban zones would bring with it a very pronounced spatial discontinuity on this scale. This treatment was applied to different indicators, and the first map allows a comprehensive spatial view of fertility in south India (see Map 2.5 and Plate 3). The previously introduced indicator is used here, that is, the number of children

Map 2.5: Low Fertility Areas in Rural Tamil Nadu, 1991



below six years of age in relation to the female population over six years (CWR).

This map of the CWR is to be compared with the mapping of other phenomena. We have retained certain indicators which appeared to give suggestions for interpreting the variations in fertility. Only the CWR of the corresponding maps has been prepared according to the same procedure (aggregation, then kriging). We have chosen to present the map of the general literacy rate of the population, which represents the social characteristic most closely correlated to the fertility level. Also represented is the inequality between the sexes as regards education, an indirect measurement of gender inequalities. Finally, a map of the distribution of the tribal population completes this triptych, casting an original light on the phenomenon.

Analysis of Fertility on the Micro-level

A Global Analysis Revisited

The map of the CWR illustrates a contrasting situation in south India, the main lines of force of which are known in existing cartography on the district level.[15] Certain hypotheses pertaining to regional particularisms or urban effects are confirmed.

The index calculated ranges from 0.15 in Tamil Nadu to 1.1 in Andhra Pradesh. It goes without saying that the variations within states can be very pronounced, as one will observe in the case of Karnataka, for example. It will, however, be noted that the division by state only plays a very minor role in the global mapping. Administrative boundaries do not in general constitute perceptible barriers on the map and the differences in fertility seem negligible along the borders between Andhra Pradesh and Tamil Nadu, or again, between Andhra Pradesh and Karnataka. However, when fertility goes together with physical barriers, the state borders can be significant. This is the case between Tamil Nadu and Kerala (Ghats), and between Tamil Nadu and Karnataka (Deccan marches).

The district-level map, the only one presently available, shows a clearly structured situation. It seems caricatured today when compared to the mapping carried out on the village level. Abandoning the administrative frame of districts, the analysis of the decrease in fertility is moving from a perspective in terms of population towards a perspective in terms of space.

[15] See various maps in Census of India (1999), Guilmoto (2000), Bhat (1996).

In fact, mapping on the micro level brings out the regions of low population, but over a vast area, while diminishing the importance of very populated but reduced space. This enables a closer approach, and causes certain phenomena, until now only outlined, to appear more distinctly (the positive role of communication axes, negative role of mountainous zones).

Thus, the emphasis on the high fertility areas, centred on the Hyderabad Karnatak (part of Karnataka which formerly came under the State of Hyderabad) and resisting a wave of innovation coming from the coast, makes way for a more differentiated analysis. Low fertility extends from the sub-regions along the 'routes of decline', cutting pockets of resistance. Isolated pockets of low fertility, such as in Telengana around Nizamabad and Karimnagar, are destined to develop and upset the simplifying image of a Deccan plateau lagging behind the coastal zones.

Another example would be the pioneer position of Kerala in the decline of fertility in India. The fertility observed is in fact very moderate in this state, and more precisely in the former princely states of Travancore and Cochin. Included in this zone will be the southern point of Kanyakumari, which was united with Tamil Nadu in the 1950s, but which still relates to the historical geography of Travancore. However Map 2.5 also shows the deepest 'trough' in Tamil Nadu, in the region of Kongu Nadu. This is an industrially very advanced region, resultant of the exceptional development of Coimbatore and of its epigones Tirupur and Erode. In addition, it will be noted that this absolute trough is located in the south of Periyar district (Erode), that is to say, in a lightly urbanized part of the district.

Even if our methods can have a significant smoothing effect on the micro level, the global mapping nevertheless sometimes shows pronounced gradients between zones of high and low fertility. They can be abrupt, representing veritable 'fault lines' which divide the adjacent regions. An example, which will be taken up below, is that of north-eastern Andhra Pradesh, details of which are provided by mapping on a narrower scale. However, other acute differentials appear on our map, as on the border between Karnataka and Tamil Nadu, or around more isolated regions which are often pockets with Muslim or tribal dominance.

As was already observed, fertility is a phenomenon having a very high spatial auto-correlation. It is actually organized in homogeneous sub-regions in the middle of the south. On the map of fertility decline in Tamil Nadu (Map 2.5), one notes the extreme concentration of low and high fertilities and the steep gradient separating them. More precisely, 16 of the 17 clusters in which the CWR is lower than 0.19, are found in a circle with a radius of 30 kilometres[16] located in the south of Periyar district in Tamil Nadu (the failing cluster is located only 30 kilometres from the others). The whole of the zone studied is itself much larger, covering more than 1,100 kilometres from west to east and more than 1,300 kilometres from north to south, but the zones with very low fertility are extremely close together.

This high degree of spatial patterning is expressed by the presence of easily identifiable regions. In terms of low fertility, the Coimbatore plateau (which contains the core of 16 clusters with very low fertility) and the coast of Kerala (as far as southern Tamil Nadu), connected by the Palakkad Gap, stand out. The regional particularism of Telengana is more distinct here than in the case of cartography on the scale of districts, the gradients which contrast it to the neighbouring regions with a very high fertility being very pronounced.

The diffusion of fertility seems to follow the main roads (the Bangalore–Hyderabad axis, for example), as well as the railways (from Chennai to Nagpur and Calcutta via Vijayawada). Also to be noted is an effect on the hinterland of certain towns, such as Chennai or Vijayawada, and more generally along the coasts of Karnataka and Andhra Pradesh.

As observed by Ramachandran (1989: 147) in regard to other phenomena, the city of Hyderabad does not appear to influence the surrounding countryside, despite its large size. Let us add that, except for the cases mentioned above, the urban effect often remains moderate, indeed imperceptible. It is true that in regions such as Kerala, the difference between town and countryside is not great, the consequence of which is that the fertility rates of urban and rural zones are in the main comparable. Moreover, it should be underscored that the effect of the largest cities (Bangalore, Coimbatore, Madurai, Mysore, Hyderabad, etc.) on the surrounding fertility is often weak.

Although fertility is low in numerous regions, two major zones of high fertility are to be distinguished. The first is located in the extreme south of the Deccan plateau (Hyderabad, Karnatak) and the second at the northern border of Andhra Pradesh (with Orissa and Madhya Pradesh). They are complemented by numerous other pockets, less extensive, but also all noteworthy in their contrast to their environment.

[16] A GIS makes it possible today to very easily carry out this kind of calculation. We have selected the clusters in which the CWR is lower than 0.19 and have drawn a circle circumscribing all of them. The circle encompasses 28 clusters constituting a zone with 460,000 inhabitants and an average CWR of 0.18.

A diffusionist interpretation will view them as zones of resistance to change, protected by 'invisible barriers' (Guilmoto, 2000: 49). This interpretation is justified here, for the zones of high fertility are located in areas with particular cultural and social characteristics (see below).

A Detailed Analysis

The global approach to fertility in south India must not cause one to forget that an approach on a more detailed scale is possible by magnifying the view, that is, by increasing the scale. In effect, the cartography of which we avail enables us to consider only certain zones of lesser extent, to see in detail what takes place.

We thus return to two figures presented in this article. The first highlights three districts in north-east Andhra Pradesh (Map 2.3). To be noted first is the steep gradient that, over some 50 kilometres, opposes the low fertility rates on the coast to the high fertility rates in the border regions. The crown surrounding Vizianagaram can then be observed.

It seems, in effect, that low fertility radiates from Vizianagaram towards the rural world around it and extends at the same time to the coast, that is, by following the orientation of the main roads, and notably of the railway, to Orissa. A gap in fertility can be also discerned, leading north, in the district of Vizianagaram. This zone corresponds to the road axis linking coastal Andhra Pradesh to Orissa (Koraput), passing by way of Vizianagaram and the region of Bobbili.

On the other hand, the populations located along the western part of the border to Orissa, north of the districts of East Godavari and Visakhapatnam, have an excessively high fertility rate. This could express a spatial remoteness, reinforced by the hilly relief in this region (Northern Circars), because the roads are parallel to the coast and the regions located 20 kilometres away are, in fact, poorly linked. However, this relative isolation corresponds above all to the tribal specificity of the population of remote zones. To the proper geographical distance existing between these areas, one should add the district social discontinuity that separates tribal and non-tribal groups.

For the second map (Map 2.5), the presence of a high fertility rate at least 50 kilometres from the region where the CWR is scarcely 0.2 induces us to directly place in the foreground the predominant role of the relief which completely isolates the tribal populations from the populations in rest of the plain. This zone with minimum fertility, perhaps the rural region where fertility is the lowest in India,[17] merits a more detailed investigation because its social profile in terms of population and social and economic development has nothing exceptional in the regional context.

Thus, the study of the cartography of fertility in a global, or in a more precise manner, leads us to analyses which are much more detailed and often to a renewed questioning of the circumstances framing the decline in fertility. The contribution of new information by the mapping of other variables is a necessary tool for the improvement of our understanding of the demographic mechanisms under study.

Comparison for Better Understanding

Truly Comparable Maps

Beyond the description of the map of the CWR, the SIFP database enables us to map other social indicators and to undertake comparisons. We can therefore envisage the spatial distribution of different phenomena in terms of similarity and dissimilarity and put forward new hypotheses.

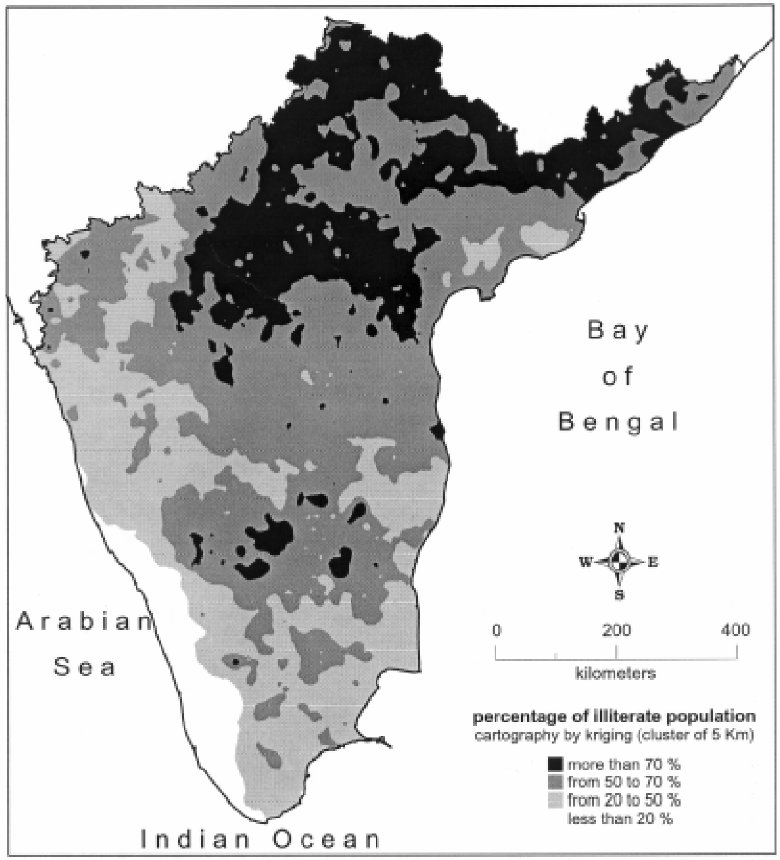
The first study will be done by comparing the map of the CWR to two new maps: that of the literacy rate (Map 2.6) and that of the index of gender inequality as regards literacy (Map 2.7).

Numerous zones common to all three maps can, of course, be distinguished. The poles of low male–female disparities and of high literacy correspond to zones with low fertility, in absolute terms, as in Kerala, or in relative terms, as on the coasts of Karnataka. Conversely, the poles of high fertility correspond to zones of marked inequalities and of low literacy. This correspondence underscores the partial superimposition of demographic behaviour with the social development illustrated by literacy, notably female literacy. It will, however, be noted that this link is not invariable, particularly since in south India progress is much more rapid in terms of fertility than in literacy.

However, numerous counter-examples prevent us from being satisfied with this first analysis. Thus, the district of Malappuram stands out—in Kerala, where low fertility is the rule—although it does not appear in the cartography relating to literacy. This is, therefore, another factor which enters the picture and is linked to the singular demographic behaviour of the Muslim community, which is very concentrated in the region

[17] The absence of disaggregated data on north India prevents us from formally confirming this hypothesis.

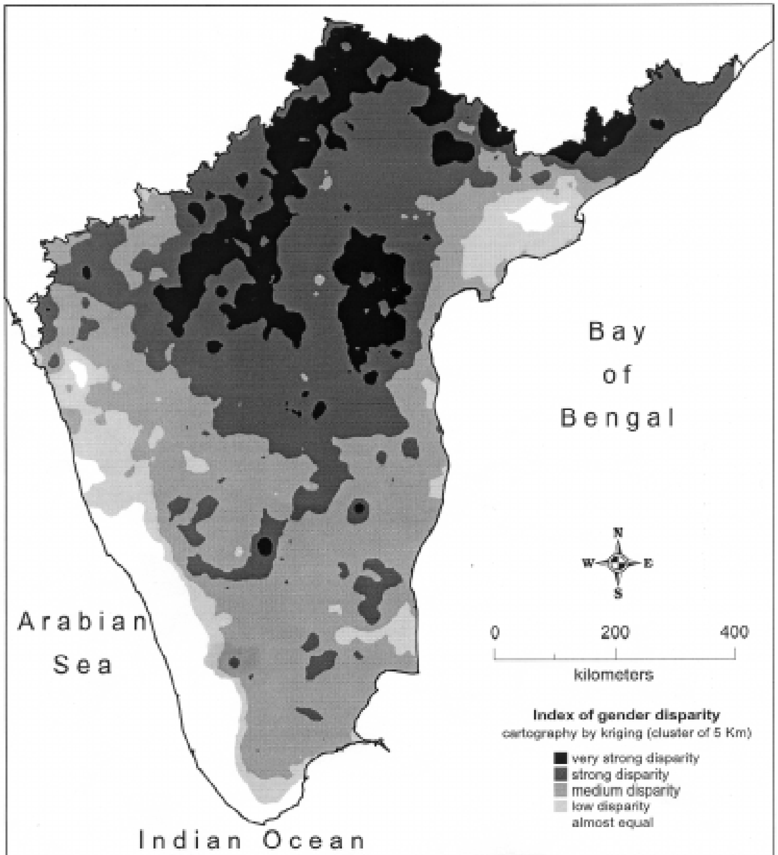
Map 2.6: Smoothed Literacy Estimates in Rural South India, 1991



(Guilmoto, 2000). A closer examination would similarly reveal a local peak in fertility on the west coast of the Konkan region, around the very Muslim town of Bhatkal (in the south of Uttar Kannada district, Karnataka).

Examining the distribution of tribal populations in south India (Map 2.8), it is seen that some zones are marked by the presence of particular groups within the population. A major characteristic of the tribal population is its concentration: the tribal population generally represents a very weak minority in the villages (frequently less than 0.2 per cent of the population), or an absolute majority of the population. It is to be observed that numerous local (and absolute) peaks in fertility coincide

Map 2.7: Smoothed Gender Index of Literacy in Rural South India, 1991

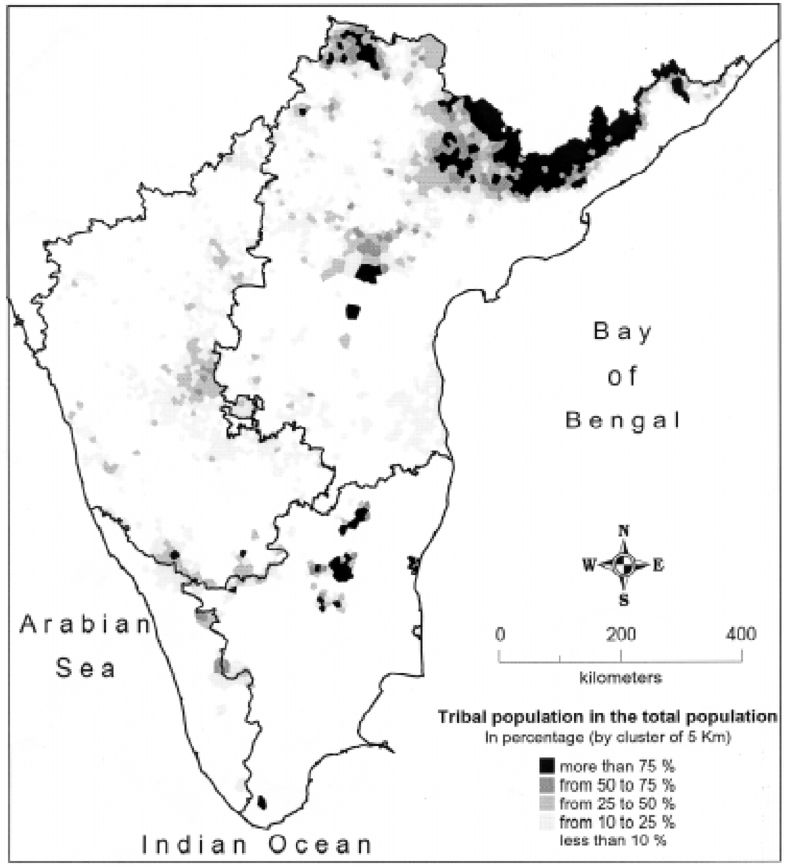


directly with the presence of tribal populations.[18] We shall take as example the Tamil situation in the western and, above all, eastern Ghats (notably in the Yelaghiri and Shevaroy hills).

This approach, however, does not resolve all the questions raised by the spatial distribution of reproductive behaviour. In fact, although the tribals constitute a particular population in south India, there are large tribal zones in the north-east of Andhra Pradesh where fertility, literacy and gender inequalities are contrasting and do not correspond to what has

[18] See in this regard the map of tribal minorities in India in De Golbéry and Chappuis (2000).

Map 2.8: Smoothed Tribal Share in South India, 1991

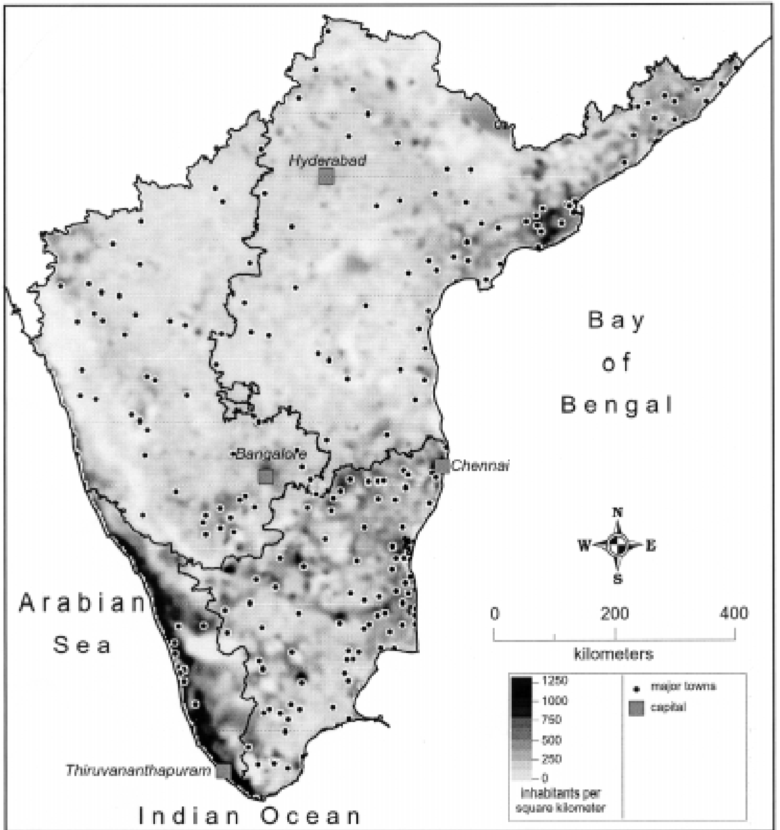


been described above. Tribal membership, the Muslim religion or literacy are not absolute criteria of fertility behaviour.

New Trails to Explore

We are thus led to reflect upon the different explanations for the spatial organization of fertility. Observing the map of urban densities and of networking (Map 2.9), a new hypothesis can be considered as regards the role of accessibility (Nagaraj, 2000). Assuming a diffusionist perspective, regions with low fertility are seen as zones where demographic change

Map 2.9: Urban Densities and Networking in Rural South India, 1991



and behaviour has already taken place, and zones of high fertility as zones of resistance to innovation where change is taking place or has not yet begun.[19]

Thus, densely populated and often highly urbanized zones possessing a denser road network have a greater chance of seeing new modes of behaviour rapidly spreading. Regions in which the population is well-educated—and more particularly women as concerns change in demographic behaviour—are the milieus in which one would think that the

[19] Refer here to the now classic work of Hägerstrand (1967).

vectors of social change would be more efficient and more rapid, all the more so as the access to information would be assured. Kerala constitutes a good example from this point of view: the density of the population, together with the level of education and the quality of access to information (whether by political mobilization or the Malayalam press), would define an extremely favourable environment for the diffusion of changes in behaviour and in value systems.

It is therefore advisable to re-read all the maps from this perspective. The two large regions of low fertility are densely populated areas, characterized by a well-developed road network, an extensive urban networking and the reduced role of agriculture in the local economy. On the other hand, regions of higher fertility are much less dense, less urbanized, more agricultural and poorly connected.

This explains, moreover, the relationship existing between areas with a high tribal concentration which are often located in marginal regions (elevated regions of the western Ghats, the edge of the Mysore plateau, southern extremities of the eastern Ghats, etc.). The Deccan plateau is also interesting to consider from this point of view, as the densities there are lower, while the urban networking and the road network are but little developed. On the other hand, the passage of the Bangalore–Hyderabad and Bangalore–Mumbai axes seems to erode the zone with high fertility.

Conclusion

The approach on the micro-level has allowed a more precise and exact view of demographic phenomena. It also shows the limitations of the classic approach on the aggregated scale of district or state.

Thus, taking up examples given in this chapter, the organization of fertility along the coastal strip is clearly defined and the low fertility of the Coimbatore plateau better circumscribed. Having made this observation, it will be noted that Tamil Nadu, notwithstanding a significant internal heterogeneity, which is no doubt related as much to its geographic diversity as to its social history, is the state that has the lowest local fertility. Similarly, this micro-spatialized approach shows us the behaviour of numerically weak populations dwelling in marginal spaces, such as tribal populations, which vanish entirely from the usual aggregated statistics.

However, the objective of this chapter was above all to present the methods employed to develop the central map of estimated fertility in south India. We have provided a few observations as to the results obtained, without attempting to be systematic. The examination on a more regional scale of the differentials which became prominent in this mapping would have led, in fact, to a discussion much too extensive to be included in this chapter. This approach raises new questions for researchers, notably in terms of local situations to be explored. We shall refer to, for example, the pioneering areas in the decline in fertility, the pockets of resistance to local change, or to the zones of high discontinuity.

This work also suggests that new factors be considered, such as the role of accessibility to villages. It encourages a more systematic questioning of factors, accounting at the same time for the spatial concentration of demographic behaviour in a period of rapid change, by putting forward new methods of observation and analysis.

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