Irrigation and the Great Indian Rural Database

Vignettes from South India

The census offers an irreplaceable dataset to examine local settings and study them on various scales, from a global perspective contrasting regional trends down to villagewise variations. This paper seeks to demonstrate that irrigation data from the Indian census has been severely underutilised in this regard, and also offers a view on the issues that can be researched using village level statistics.

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It is more common in India to lament over the lack of accurate sources of information than to deplore the underuse of existing ones. It is therefore not surprising to read in a recent assessment of irrigation statistics in West Bengal [Rawal 2001] that these data remain unreliable and incomplete, in spite of the numerous sources that are scrutinised. Most data users are familiar with this type of situation and have to struggle with incomplete or discordant data to study the dynamics of agricultural change. What looks more puzzling is that this survey of irrigation statistics leaves out one of the richest sources for irrigation studies in India, which appeared in the 1990s. This omission is unfortunately quite common and does not concern only the domain of irrigation statistics. The rural database derived from the census is probably the most underused source in the study of contemporary Indian economy.

This brief paper will endeavour to give a rapid survey of the wealth of data that lies unused in the census publications. The salient points of the argumentation will rely on the examination of the irrigation data, which constitutes but a small fraction of the database. Materials used in this paper, collected in the course of a research project on south India, will provide a sample of possible applications of these data for description, exploration, identification, analysis and synthesis. Beforehand, I shall offer a brief overview of the nature of these vastly ignored data.

Villages, Irrigation and the Census of India

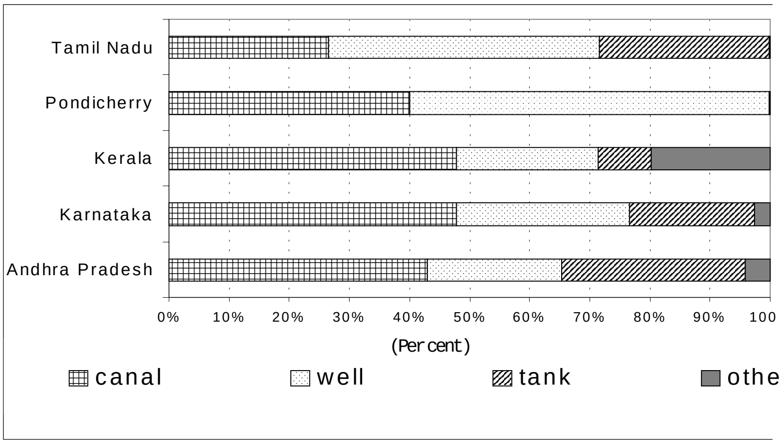
Since 1951, the Census of India has been collecting and publishing data about all revenue villages in India.[1] Data include most notably social and demographic particulars assembled from individual records collected at the household level. The type of data tabulated at the village level have not changed so much over the censuses and cover some of the most familiar census data: households, population, dalit and tribal components, literates, workers and occupational categories. The 1991 Census published not less than 42 such figures (also known as *Primary Census Abstract*) for the 5,80,781 inhabited villages of India. What is surprisingly less known is the fact that information is also collected at the village level on infrastructure and land use. These data are collected prior to the population census day and cover a very wide gamut of information such as educational, health, communication and market facilities, as well as many other amenities(water and electricity supply, etc). Moreover, when a given facility is not locally available, the distance to the nearest locality where this facility exists is given. As part of this exercise, the census also collects village level data on land use and irrigation pattern. These infrastructure data (also known as *Village Directory*) constitute another 96 variables that are available for all inhabited villages.

In view of the size of this single source, it would not be exaggerated to call the village census data the Great Indian Rural Database (hereafter the GIRD). The GIRD has thus long included decennial estimates of irrigation down to the village level. Though yearly estimates of irrigation would be preferable in view of fluctuations in land use in rural India, the census data carry the advantage of identifying all individual villages and offering for each of them irrigation estimates. No other source provides such a fine geographical picture of the rural scene.[2] Landuse data are detailed in five categories (forest land, irrigated land, unirrigated, cultivable waste, area not available for cultivation) apart from the village total area. As for irrigated areas, they are subdivided into 11 irrigation types (Table 1). Although many useful dimensions of irrigation are missing from the census (such as cropping intensity or cultivated crops), no less than 13 irrigation statistics are provided for all Indian villages.

Before examining these in detail, one may wonder why these data have not been used more systematically to study agricultural development at the local level. The main explanation may lie in the fact that these data are found only in the district level volumes published for individual states. These volumes (*District Census Handbooks*) are usually published many years after the census and it is not uncommon for some of them to be published while the next census is being launched. These volumes, which otherwise contain invaluable material on villages and include detailed district or taluk information, are not easy to locate themselves and with the exception of patient PhD students, they usually do not reach out to the potential audience (planners, administrators, NGOs, research scholars). Moreover, the printed data scattered in dozens of volumes are almost impossible to compile to get a larger picture for taluks, districts or states. Or so they were till the 1991 Census.

In fact, the 1991 Census introduced a radical change in the dissemination set-up by offering data in a computer format right from the mid-1990s. Village data were actually provided on floppies long before most of the district handbooks were pub-

Figure 1: Irrigation Types for Individual States, 1991 Census Village Data



lished. Data from the *Primary Census Abstract* and *Village Directory* are given at the district level in two separate files, with an additional file containing location codes and village names. With a little patience, it is actually possible to combine these two sets of population and infrastructure files into a single register of village data for entire districts. As raw data entered in computer format are not scrutinised, inconsistencies and deficiencies are frequent.[3] The infrastructure characteristics of villages can then be compared with their social and economic composition. Once compiled for entire states, the database becomes a powerful tool to investigate rural issues from social, demographic or economic perspectives. The GIRD has no match to describe and monitor several features of rural development at the most decentralised level.[4]

Data and Their Quality

In this paper, we will illustrate the usefulness of this database by using a sample derived from a project on fertility decline. This sample consists of the entire village database for south India, that is, Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Pondicherry union territory. It includes a total of 70,984 inhabited villages. The number of villages actually used in the analysis may vary according to the data examined because of the statistical deficiencies encountered (missing or erroneous data). There is no doubt that comments and examples provided here are probably applicable to similar studies that could be conducted in other areas of the country. However, in view of the large variety of information included in the GIRD, we shall focus here solely on irrigation data as a specific topic for disaggregated analysis.[5] These irrigation data happen to be dramatically under-exploited in view of their potential in a country where irrigation is estimated to have increased fourfold since independence.

A crucial question about these data concerns their quality, which depends on the care with which village records were collected and compiled during the census. It must be stressed at the outset that lack of comparable village data prevents any attempt at assessing the precise quality of the data. Like other census demographic estimates, irrigation data are simply the only systematic source of information at the village level. What can, however, be examined is the internal consistency of the data and here our experience with these data inspires confidence. Using a sample of 70,260 villages with cultivated areas[6], we checked the quality of the data and found only a negligible number of erroneous or incomplete records. We also noted that in some cases, the reported total irrigated area is different from the total of individual irrigation categories. However, in our south Indian sample, we identified only 116 villages (that is, less than 0.2 per cent of the sample) where the difference between these two totals was greater than 0.1 ha.[7]

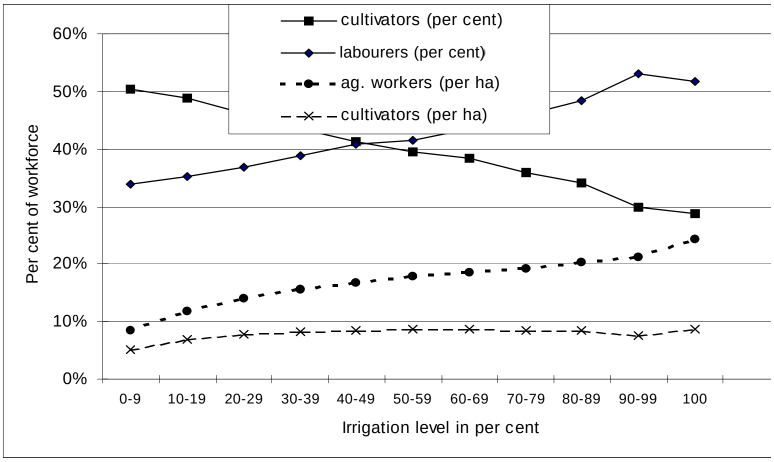
The classification of cultivated land for south India is given in Table 1. As can be seen, some irrigation categories correspond to negligible areas, while some other categories (well and tubewell irrigation) have been subdivided according to power sources. There remain, however, two main open questions that our global analysis cannot answer. First, are irrigation data systematically collected and included in the census records? Overall, the answer seems to be positive. The state total does match available data from other sources for corresponding years. On the micro level, we have also tried to locate villages reporting no irrigation in areas with the highest irrigation levels (for example, along the Kaveri, Godavari and Krishna deltas). These villages happen to be very few and they are usually clustered in distinct zones, suggesting that local factors such as terrain account for the absence of irrigation facilities. Nevertheless, close comparison with other aggregated data (at the block or district level) would probably allow a more accurate assessment of these estimates for specific regions.

The second question relates to the proper identification of irrigation categories. The 11 available categories for classifying irrigation (shown in Table 1) may be responsible for some amount of overlap or confusion. For instance, the difference between private and government canals, between tubewells with and without electricity, or between lake and tank may be at times spurious. It is probably safer to aggregate irrigation figures into broader categories as we have done for the state totals, as shown in Figure 1. All well and tubewell categories have been clubbed together, while lake irrigation has been merged with tank. Similarly, river irrigation is here combined with government

Table 1: Irrigated Land by Categories in South India, 1991 Village Census Data

Irrigation Type	Total Area (ha)	Share of Irrigated Area (Per Cent)
Government canal	30,49,351	32.7
Private canal	22,934	0.2
Tank	23,96,798	25.7
Well with electricity	14,32,114	15.4
Well without electricity	9,62,210	10.3
Tubewell with electricity	3,77,250	4.0
Tubewell without electricity	60,278	0.6
River	6,08,300	6.5
Lake	98,184	1.1
Waterfall	6,897	0.1
Other sources	3,15,355	3.4
Total	93,29,671	100.0

Figure 2: Agricultural Workforce Composition and Density According to Irrigation Levels, 1991 Census Village Data



and private canal irrigation. Another possible drawback is the fact that many areas may be irrigated from more than one source of irrigation.

As a conclusion about the quality of the data, it is safe to say that this would require a separate assessment at the state or district level in order to compare the census data with other survey statistics on irrigation. Besides, careful comparison with in-depth surveys conducted in specific areas would also offer a more precise evaluation of the reliability of the dataset. While such an exercise is beyond the scope of this paper, the quality of data seems to be reasonably good in our sample and the possibility of any systematic bias preventing cross-regional comparisons as attempted in this paper is unlikely.

Statistical Analysis of Irrigation Linkages

The GIRD lends itself to all possible statistical examinations in view of its computer format. While data acquisition was previously difficult from published sources, computerised census data can be easily processed. This allows systematic description of irrigation features and a more elaborate statistical analysis. In this section, we have performed a correlation analysis of irrigation level using other variables derived from the GIRD. This analysis uses population as statistical weights as average village size is extremely variable in the different social and ecological regions of south India.[8] The average village size is indeed an important feature to take into account before any serious analysis, as more than 17 per cent of villages in India have a population below 200 for which census estimates are likely to be fragile.[9]

As Table 2 shows, all indicators tested against irrigation turn out to be significantly correlated because of the sheer size of our sample. However, this statistical analysis indicates some interesting correlates of higher irrigation levels. Thus, the percentage of irrigated area is strongly associated with canal- and river-based irrigation. Conversely, the share of tank or well irrigation is greater when irrigation level is moderate. We shall come back below on this dimension of the irrigation system, which is crucial in understanding the role of various irrigation types in Tamil Nadu's agricultural development.

As expected, irrigation appears also to be positively associated with higher demographic density. Irrigated villages support larger populations, most notably because the workforce engaged in agriculture (including dalits) is significantly larger as will be shown below. The analysis shows also that higher irrigation goes along with closer proximity to urban areas, following the general pattern of Von Thunen's model. While the dalit is positively associated with irrigation, mainly through the demand for agricultural labour, tribal settlements are obviously deprived of irrigation facilities. Further analysis of qualitative data on infrastructure development would also show the positive association of irrigation on a large array of collective amenities. Surprisingly, the positive link between literacy and irrigation appears to be almost negligible. Obviously, many factors are simultaneously at play and a more comprehensive statistical analysis would be called for in order to disentangle the specific associations between irrigation, social composition and various dimensions of social development such as literacy, health, and schooling facilities.

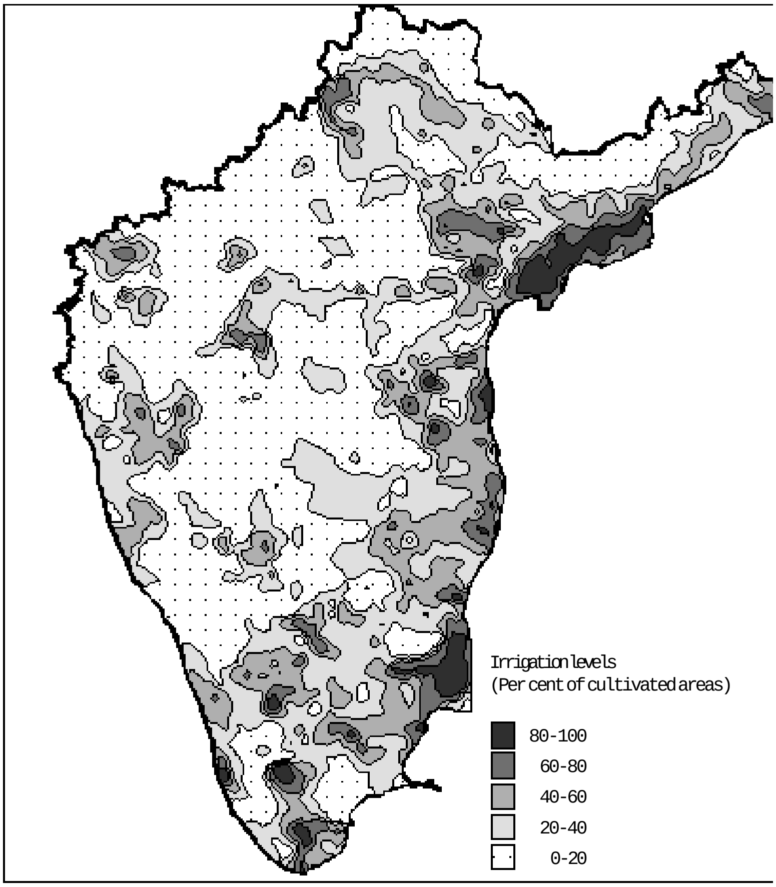
An important result of our analysis is the negative correlation of irrigation with the proportion of cultivators. On the contrary, the proportion of agricultural labourers in the total workforce is much higher in irrigated villages. This phenomenon is better captured on the data plotted in Figure 2. Here, we have divided villages into 10 irrigation classes, starting from 0-10 per cent of irrigated areas to 100 per cent. Unweighted averages have been computed for each class in order to display the changing composition of the agricultural

Table 2 : Correlates of Irrigation Level with other Village Characteristics, South Indian Villages, 1991

Village Characteristics	Units	Correlation Coefficient
Tank irrigation	per cent of total irrigation	-0.1413
Canal irrigation	per cent of total irrigation	0.3649
Well/tubewell irrigation	per cent of total irrigation	-0.1993
Other irrigation	per cent of total irrigation	-0.0692
Density	Inhabitants/ha	0.1495
Distance from nearest town	km	-0.1418
Dalit	per cent of population	0.1225
Tribe	per cent of population	-0.1366
Literacy	per cent of population above 6	0.0485
Cultivators	per cent of workforce	-0.2009
Agricultural labourers	per cent of workforce	0.2421
Livestock, fishing, forestry	per cent of workforce	-0.1313
Mining, quarrying	per cent of workforce	-0.0832
Household industry	per cent of workforce	0.0696
Non-household industry	per cent of workforce	0.0359
Construction	per cent of workforce	-0.0413
Trade and commerce	per cent of workforce	0.0415
Transportation	per cent of workforce	0.0126
Other services	per cent of workforce	0.0467

Notes: Correlation computed on 70,260 villages with total population used as weights; All coefficients significant at 1 per cent level; Data from the SIFP database.

Figure 3: Irrigation Levels in South India, 1991 Census Data



workforce with rising irrigation. Moreover, a simple index of agricultural density (total agricultural workforce per hectare of cultivated land) has also been added. The data of Figure 2 demonstrates that increasing irrigation causes a sizeable, gradual decline in the share of cultivators among the peasantry, going from 51 per cent in the driest villages down to 29 per cent in completely irrigated areas. At the same time, the share of agricultural labourers records a regular increase and is greater than that of cultivators when more than half of the cultivated areas are cultivated. Interestingly, the increase of agricultural labour does not entirely offset the decline in cultivators, as an increase in non-agricultural activities (industry and service) is also noticeable.

At the same time, these irrigation data indicate that irrigation is strongly connected to agricultural density. Because of multiple cropping, irrigation has a direct impact on the gross area cultivated and therefore on labour demand. This is captured in Figure 2, where the average agricultural workforce is plotted against village irrigation levels. Dry villages with, say, 10 hectares of cultivated land supports only 8.5 workers in agriculture (cultivators and labourers). The number of workers in agriculture doubles when the irrigation level increases to 50 per cent and almost triples to 24.5 workers when the village is completely irrigated. This difference is primarily due to the increasing agricultural labour per cultivated hectare. The number of cultivators per hectare, also shown in Figure 2, increasing at a much slower pace when the irrigation level is less than 50 per cent and remains constant thereafter. This means that when irrigation has crossed 50 per cent, the addition to the agricultural workforce is entirely due to the number of landless labourers and marginal farmers. These observations indirectly confirm that irrigation tends to worsen land inequality – for which we can use the ratio of labourers to cultivators as a proxy.

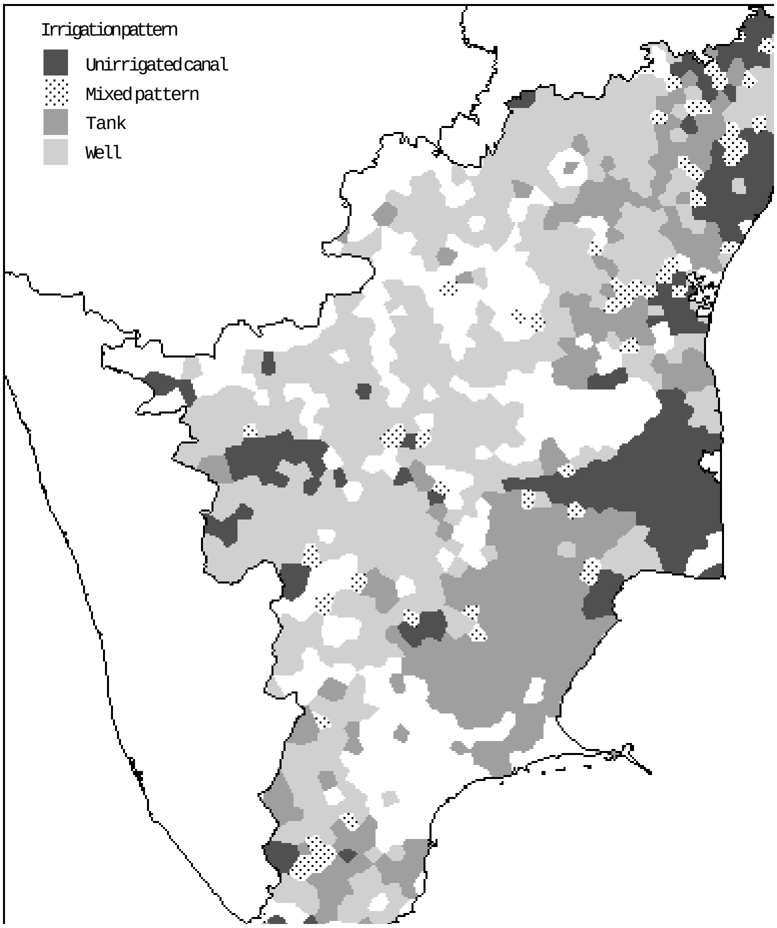
Our models also suggest that any increase in irrigation levels may determine an increasing local labour demand. On the contrary, labour absorption in areas where irrigation remains stagnant may be more difficult. Using the data derived from this stylised model, we can deduce what increase in irrigation level would be necessary for absorbing the growing labour population during the 1991-2001 period. An increase of 8.5 per cent in irrigation level would be sufficient to generate a parallel increase of 13.2 per cent in agricultural labour demand, where 13.2 per cent is the population increase measured from the last census in south India.[10] This, of course, remains a very simplified model that takes no account of crop values, agricultural wages or productivity. Nevertheless, it illustrates the potential of irrigation in terms of rural labour absorption, especially in the context of increasing population pressure in the semi-arid areas of Andhra Pradesh, Karnataka and western Tamil Nadu. During 1968-92, the decadal progression of irrigation in these areas has been of 6.3 per cent [Gulati and Kelley 1999], which is not far below the required 8.5 per cent increase from our model.

These features would, of course, require further analysis in order to determine the nature of the causal links between village characteristics. However, agricultural prosperity has undoubtedly many direct and indirect effects on the village structure that could be examined using such data. Contrary to other sources on irrigation, the GIRD includes both agricultural and socio-demographic characteristics of villages. The analysis can therefore focus not only on selected regions, where linkages between irrigation and population figures would be admittedly more meaningful than for the whole of south India, but also on other specific issues. For instance, based on the same dataset, our own research has shown the sizeable role played by irrigation in fertility reduction.[11] Demographic data used to investigate the determinants of fertility decline rarely incorporate direct information on agricultural development such as irrigation patterns.

Mapping Census Data: Contours of Irrigation

Mapping village-level data represents a further improvement in the GIRD. While most district-level information is now provided in a cartographic format, there is almost no attempt to map local data. However, as most census district handbooks offer maps to locate village units, it is also possible to draw maps of rural localities. As part of our original project on south India, we prepared such villagewise maps for south Indian rural localities.[12] From

Figure 4: Irrigation Patterns in Tamil Nadu, 1991 Census Data



this source, we have prepared two irrigation maps that we present in this section. As rivers in south India are mostly seasonal and the climate overall semi-arid (except for the western coast), irrigation has been, during the recent period, a crucial factor in agricultural prosperity.[13]

The first map (Figure 3) covers the whole of south India and consists of a contour map of irrigation levels.[14] Irrigation is a highly localised phenomenon, the map of south India offers a clear picture of regional divisions. The map shows the eastern gradient of irrigation in south India. Apart from pockets along the western coast of Karnataka and Kerala, where rainfall is otherwise abundant, irrigation is mainly concentrated in Andhra Pradesh and Tamil Nadu. This is chiefly related to major rivers such as Godavari or Kaveri, which flow eastwards into the Bay of Bengal. The basins and delta determinate large irrigated areas that are clearly discernible on the map.

Moreover, old and new forms of alternative irrigation through tanks and tubewells allow irrigation in other areas in the interior, most notably in entire Tamil Nadu and coastal Andhra, where irrigation levels are rarely below 20 per cent of cultivated areas. The Deccan plateau, which cuts across the Karnataka-Andhra Pradesh border, appears as a uniform region in terms of irrigation. Most villages enjoy no irrigation at all, except in isolated tracts clustered around major dams (Krishnaraja Sagar, Nizam Sagar, Nagarjuna Sagar) or along some of the tributaries of the major rivers.

As the original database is extremely fine, contours do not follow district or even taluk boundaries. On the contrary, they divide administrative boundaries, including state boundaries. Many isolated pockets appear on the map, identifying specific sub-regions with distinct irrigation system. This suggests that the ecological zoning of irrigation patterns in south India does not conform to the usual administrative classification. This map could be fruitfully enlarged in order to "zoom in"on smaller regions. As the database is extremely detailed, such mapping could be restricted to areas the size of a district.

While the previous map offered a synthetic description of irrigation in south India, the next one attempts a more analytical presentation of a region. It is based on the classification of irrigation types already shown in Figure 1 and is restricted to Tamil Nadu, where irrigation levels are the highest in rural South India.[15] Irrigation in Tamil Nadu corresponds chiefly to paddy cultivation, while important irrigated cash crops are groundnut and sugarcane.

We first performed a thorough statistical analysis of irrigation patterns and identified five categories of villages, namely, unirrigated (irrigation accounts for less than 20 per cent of cultivated land); where canal irrigation accounts for more than 50 per cent of all irrigated areas; well irrigation accounts for more than 50 per cent of all irrigated areas; tank irrigation accounts for more than 50 per cent of all irrigated areas; mixed pattern corresponds to areas where no single irrigation type account for more than 50 per cent of all irrigated areas.

Data for the 15,000-odd villages in Tamil Nadu were first merged into 1,442 spatial clusters before the cartographic analysis. For each of these clusters, the irrigation pattern has been computed along the formula given above. Unirrigated tracts (less than 20 per cent of the cultivated area) are shown as a blank on the map.

As mixed areas are few in number and irrigation types spatially concentrated, the map provides a coherent division of Tamil Nadu into compact irrigation zones. The canal type predominates in the Kaveri delta, from Tiruchirapalli down to the ocean, as well as along in other isolated pockets along the coast and in western Tamil Nadu. The main area of tank irrigation is found to the south of the Kaveri river, in an area that stretches from Pudukkottai to Ramanathapuram. Smaller tank-irrigated pockets are also visible along the coast. Well irrigation covers most of the inland tracts, which are characterised by red and black soils. Several large-scale pockets of dry areas are also found in different parts of the state, be it on the coast or along the Karnataka border.

This patterning of irrigation as obtained in Tamil Nadu closely reflects geophysical dimensions such as the drainage system, the soil map as well as rainfall distribution. Moreover, because of the relationship of irrigation with the social and economic profile ofrural areas, the irrigation map has also important consequences on the settlement pattern and on labour absorption capacity as previously mentioned. Of late, excessive reliance on groundwater in Tamil Nadu has caused water levels to fall, while over irrigation is also responsible for soil salinisation.This means that both economic and environmental concerns warrant a detailed monitoring of the progress of irrigation.This type of irrigation map, which cannot be produced from any other source,[16] would therefore deserve a separate analysis of its own.

Conclusion

This overview has confirmed that irrigation data from the census have been severely underutilised so far. Even while other sourcescomprise important additional information, the census offers an irreplaceable dataset to examine local settings and study them on various scales, from a global perspective contrasting regional trends down to villagewise variations. The paper has tried to offer a general view of several research issues that can be fruitfully investigated with the village statistics.

The sheer size of the information collected in the GIRD has prevented so far a systematic analysis by the Census of India. Analytical publications on infrastructure data are very rare and limited in their thematic and geographical scope. Scholars should contribute to the census enterprise by attempting a more systematic description and quality assessment of the village data. This can be followed by more detailed studies of various socio-economic or infrastructural features. In the case of irrigation illustrated in this paper, the analysis would probably start with the examination of irrigation patterns as exemplified in our presentation of the Tamil Nadu map. Linkages between irrigation on the one hand and labour composition, economic or social development, and local infrastructures on the other, may represent further topics for in-depth investigations based on the GIRD.

The 2001 Census has now been successfully completed and the preliminary results are already available in a variety of formats. When village level data become available, there is no doubt that they will be doubly interesting. Not only will they offer the best outline of the unequal impact of economic development in rural areas at the beginning of the 21st century, but combined with 1991 data, they will also minutely describe the dynamics of change during a decade that has witnessed some of the most important developments in India's economic history. It may become then difficult to study the development of irrigation and the redeployment of agricultural labour in rural areas without using census data to explore regional trajectories. It is hoped that this presentation of the GIRD will revive the scholarly interests in changing rural contexts while suggesting new tools for analysis. EPW

Notes

[The database and maps were prepared for the South India Fertility Project, a joint research programme conducted at the French Institute of Pondicherry, with support from the Wellcome Trust. The help from Zöé Headley, S Vingadassamy, R Amuda and Allah Pichay is gratefully acknowledged.]

1 For more information on the Census of India, see their efficient web site: www.censusindia.net.

2 As Rawal's paper reminds us, data from the agricultural census are often based on sample surveys and are not available below the district level.

3 Matching infrastructure and socio-demographic data for villages is not as easy as it seems. Users will often discover puzzling errors in village names or identification codes that prevent any automatic coupling of the two sources.

4 The large survey conducted by the NCAER in 1994 [Shariff 1999] covered only 1,765 villages and its findings cannot therefore be directly compared with the census.

5 However, research using the south India database has been already initiated on many other subjects such as female discrimination in Salem areas, deforestation in Kodagu district, and fertility decline, etc. See for example the analysis in Ramakrishnan et al (2000).

6 A good 724 villages, mostly located on forest land, report no cultivated land at all and cannot be used for the rest of our analysis.

7 Errors among other infrastructural data from theVillage Directory are much more frequent than among acreage estimates.

8 Due to its peculiar ecological and administrative features, the average population of Kerala's villages is of 15,000 inhabitants, that is, 10 times more than in the rest of south India. Conversely, census villages in some areas like the Mysore plateau or the tribal areas of the northern Circars have often populations lesser than 500 inhabitants.

9 For regional comparisons, see Census of India (1997).

10 To compute this 8.5 per cent value, we first regressed agricultural density against irrigation levels. From this model, we deduced the irrigation increase corresponding to a 13.2 per cent increase in the workforce; 13.2 per cent is the total population increase between 1991 and 2001 for the entire region of south India.

11 Villagewise fertility levels are negatively correlated with irrigation levels, even after controlling for the effects of a large number of other fertility determinants. See Chakrabarty and Guilmoto (2001).

12 The map and database for Tamil Nadu have been subsequently published in CD format. See Guilmoto et al (2000). However, village boundaries have not been digitised.

13 Yields in irrigated areas are on average twice that of rain-fed agriculture. See Gulati and Kelley (1999) for a disaggregated analysis of agricultural growth in semi-arid areas.

14 As the number of village units was huge, villages lying within a 5-km radius were aggregated, resulting in a simplified database of 6,986 spatial units. More detail on the preparation of maps in this paper is available from the author.

15 The map has been prepared in relation to a research project on tank irrigation conducted by Olivia Aubriot (CNRS/FIP). A trend map of irrigation levels in Tamil Nadu is also provided in Guilmoto et al (2000). More maps on our web site (http://members.rediff.com/sifp/).

16 Detailed maps of irrigation in Tamil Nadu based on administrative divisions may be found in Ramesh and Tiwari (1983).

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