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Review of the Quality of Population Estimates and Projections at Subnational Level in India Using Principles of Applied Demography

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Abstract

The projected population based on the 2011 census published by Ministry of Health and Family Welfare (MoHFW), Government of India (2020) has been used as the basic input data for generating the projections of population for districts by Dhar (2022) ; Esri India (2022)) and studying the long-term population growth scenarios for large states by Kulkarni (2021a, 2023). It is, therefore, necessary to review the quality of the latest population projections by the Government of India. The goal of this paper is to review the quality of the MoHFW population projections as follows: (1) describe the principles of applied demography, (2) apply these principles to review the quality of the technical report for the population and urban population projections for States, Union Territories and India, 2011-2036, (3) describe the tasks for updating the existing population projections by the technical committee of the population projection and applied demographers to serve the needs of clients for better quality of population projections, and (4) discuss the feasibility for developing population projections for districts in India using the cohort component method. This paper presents some weaknesses in the existing projected population by MoHFW (2020), which have affected the quality of district wise population projection by Dhar (2022) and Esri, India (2022). In addition, it is found that the projected numbers by MoHFW (2020) are not comparable to other sets of projections developed by United Nations, Population Division (2022), United states Census Bureau (2023), Kulkarni (2021a) and Chaurasia (2023) for India over the periods 2021-2025, 2026-2030, 2031-2036. In order to provide better quality of data for users, the existing population projection by the Government of India (2020) needs to be updated based on the population projection by United Nations (2022). Further work on the development of district wise population projection using the cohort-component method is suggested in the paper.

Introduction

India does not publish annual population estimates after the year of the population census year as is the practice in countries like United States of America, Canada, United Kingdom, Australia, and New Zealand. The reason is that there is a high level of incompleteness in the registration of births and deaths under the civil registration system. Although, it is mandatory under the Registration of Births and Deaths Registration Act of

1969 that every birth and every death is registered under the civil registration system, yet the deficiencies of the civil registration system in India are well-known. For example, births and deaths registered under the civil registration system in the year 2019 have been published 2021 only (Government of India, 2021).

The Government of India, however, has been producing population projections by age and sex for India and for its constituent States and Union Territories for 25 years, since 1958 after every population census. The latest of these projections have been carried out by the Registrar General of India based on the data available through the 2011 population census and published by the National Commission on Population (Government of India, 2020). These projections provide annual projected population of the country and its constituent States and Union Territories for the period 2011 through 2036, although they were published in 2020, almost 9 years after the 2011 population census (Government of India, 2020). The Government of India, however, makes no attempt to project the population of the districts of the country.

Dhar (2022) has carried out projections of the population of 640 districts of the country as they existed at the time of the 2011 population census by sex and age for the period 2011 through 2031 using the population projections prepared by the Government of India. He has used the ratio method to project the population of the district based on the projected population of the State/Union Territory to which the district belongs. This is a top-down method which does not take into consideration the district-level variation in population growth. The limitation of this method is that the projected population of the district is controlled by the projected population of the concerned State/Union Territory prepared by the Government of India.

Chaurasia (2023), on the other hand, has forecasted the population of each of the 640 districts of the country by modelling the population growth pattern in the district during the period 1951-2011 as revealed through the decennial population census since 1951. He has modelled the population growth in a district by fitting the logistic growth curve. Based on the forecasted population of each district, population forecast of different States and Union Territories and population forecast of the country has been obtained by simply summing the population forecast of the districts within the State/Union Territory. In this approach, the forecasted population of the district and hence States and Union Territories is not controlled by the population projected by the Government of India.

The ESRI India has also produced district-wise population projections for the period 2011-2036 by calculating a factor of projected population of a state for the year (t+K) and the base year (t). These factors are calculated for the period 2012-2036 and then they are multiplied to the population of the district enumerated at the 2011 population census (ESRI India, 2022). These projections, however, are not available in the public domain. They are available for the registered users of ArcGIS software only.

Kulkarni (2021a; 2021b; 2023) has projected the population of the country and its large states up to the year 2100 based on certain assumptions on future changes in demographic parameters using the country level population projections prepared by the United Nations Population Division (United Nations, 2022). He has, however, made no attempt to project the population of the districts of the country.

The population projections prepared by the Government of India are the basic input data for projecting district population by Dhar (2022) and by ESRI India (2022) and for studying the long-term population growth scenarios for large states of the country by Kulkarni (2021; 2023). In this context, it is important to review the quality of the population projections prepared by the Government of India. It is in this perspective that the present paper aims at (1) describing some principles of applied demography that may be used to analyse the quality of projections; (2) using these principles to review the quality of the population projections prepared by different researchers and agencies; (3) describing the task of updating the current population projections prepared by the Government of India; and (4) discussing the feasibility of projecting district population using the cohort component method. The paper also reviews the projections prepared by Chaurasia (2023), Dhar (2022), ESRI India (2022) and Kulkarni (2021a; 2023).

The paper is organised as follows. The next section of the paper outlines the basic principles of applied demography that may be used to analyse the quality of population projections. The third section of the paper reviews the population projection prepared by the Registrar General of India from the applied demography lens. Section four of the paper discusses the factors that may influence the quality of population projections. Section five reviews the district level population projections prepared by Dhar (2022), ESRI India (3022) and Chaurasia (2023).

Method

This paper uses the principles of applied demography to review the population projections prepared by the Registrar General of India and projections and forecasts prepared by Chaurasia (2023), Dhar (2022), ESRI India (2022) and Kulkarni (2021a; 2023). Applied demography is intrinsically distinct from basic demography. Applied demography exhibits the value-orientation and empirical characteristics of a decision-making science whereas basic demography exhibits the value-orientation and empirical hallmarks of a basic science (Swanson et al, 1996). Applied demography is based on the context and, therefore, its substantive problems are largely exogenously defined. By contrast, the substantive problems of basic demography are largely endogenously defined. Basic demography primarily offers explanations of demographic phenomena whereas applied demography focusses on what is necessary to support practical decision-making while minimising time and resources. There are nine principles of applied demography (Swanson and Tayman, 2012):

1. Need of estimates and projections
2. Time
3. Resources
4. Method(s)
5. Input data quality
6. Developing estimates and projection scenarios
7. Error assessment
8. Review process
9. Transparency

Projections Prepared by the Government of India

The population projections of the Government of India (2022) are prepared by a Technical Committee comprising of 19 experts including senior demographers from India: technical staff of the Office of the Registrar General, India and representative of the Ministry of Health and Family Welfare, the nodal ministry of the Government of India for population related matters. The Technical Committee includes only Indian experts whereas technical committees constituted by many western countries include international experts. For example, Statistics Canada has two advisory committees for different subject matters. The advisory Committee on Demography and the Federal-Provincial Statistical Advisory Committee are responsible to evaluate the quality of demographic products such as population estimates and projections for Canada, provinces and territories and sub provincial areas. The demography committee includes experts from other countries. The United States Bureau of Census also has similar committees. Similarly, the Office of National Statistics (ONS) of the United Kingdom collaborates with many international and national experts to determine the methods, data and assumptions which underpin population estimates and projections. (United Kingdom, 2021). There is, however, no doubt that the report prepared by the Technical Committee has taken care of the issues related to methods of projection and adjustment of input data quality for all states and union territories. The projections prepared by the Technical Committee for 25 years (2011 to 2036) appear to be more accurate than 50- and 100-years projection prepared by the United Nations (United Nations, 2022).

The technical Committee uses the cohort component method for projecting the population of the country. However, the Committee has followed different methods for projecting population of the States and Union Territories because of data constraints. It has used the cohort component mothed for some States and Union Territories of Chandigarh and National Capital Territory of Delhi. For the northeastern states of the country the population projections prepared by the Committee are based on the cohort component method and the ratio method. For the Union Territories and Goa, the Committee has used the exponential rate of growth for projecting the population. This is quite in contrast to the western countries which adopt consistent approach of projecting the population at all administrative levels. It is also not clear from the Technical Committee report how has the projected population of northeaster states, Goa and Union Territories has been distributed by age and sex.

There are ambiguities in the input data and their quality used by the Technical Committee also. For example, it is not clear how the conventional five-year age specific fertility rates are split into single-year age specific fertility rates. The Statistics Canada uses the Pearson Type III curve has been used to convert the five-year age specific fertility rates into single year of age specific fertility rates (Verma and Loh, 1996; 2008). Similarly, it is not clear how five-year age specific probability of death has been converted into single-year age specific probability of death necessary for the application of the cohort component method of population projection.

The Technical Committee has assumed for the purpose of projection that the international migration in zero. This assumption is questionable as the emigration from India to other countries is quite substantial. At the same time, there is immigration to India

also, although the immigration is small compared to emigration. This means that there is net emigration from the country. The Technical Committee should have at least discussed the size of immigration and emigration and may then have assumed that the international migration, is zero. The technical Committee has also assumed that within country, net inter-state migration during the period 2011-2036 is the same as the net inter-state migration during the period 2001-2011 as revealed through the 2011 population census. This assumption is also questionable and would have affected the population projected for the period 2011-2036. It may also be pointed out that there has been very significant decline in inter-state migration because of the Covid-19 pandemic so that the assumption that inter-state migration will remain constant during the period 2011-2036 is contentious.

The Covid-19 pandemic during the period 2019-2021 has also influenced the pace of fertility and mortality transition at the national level as well at state/Union Territory level. For example, Chaurasia (2023) has observed that the pandemic has resulted in a loss of almost 3.7 years in the life expectancy at birth and accounted for at least 4 million excess deaths in the country. The loss in the life expectancy at birth in India associated with the pandemic has been amongst the highest across countries for which estimates are prepared by the United Nations Population Division. Moreover, there have been more male that female excess deaths due to the pandemic. The Population Reference Bureau (2001) has observed that" incorrect assumptions about fertility and mortality have a greater effect at older and younger ages". The Technical Committee has also not adjusted the population enumerated at the 2011 population census for under coverage. At the national level, the post-enumeration check after the 2011 population census has revealed the under enumeration of 20 per 1000 population and this error is different in different states and Union Territories of the country. This is a big source of the difference across the projected population of the country carried out by different organisations. Population Reference Bureau (2001) has stressed that "In short-term projections, inaccuracies in the population count at the beginning of the projection period are the most important sources of error whereas in the long-term projections, assumptions about the future trends in fertility, mortality, and migration matters the most."

The Government of India released the report of the Technical Committee in the year 2020 only, almost 9 years after the 2011 population census without any note about the inordinate delay in the release of the report. This is in contrast to the projection report based on the 2001 population census which was released in 2006 in which it was clearly mentioned that the report was delayed because the migration data of the 2001 population census could be released in 2005 only (Government of India, 2006).

The official population projections released by the Government of India are associated with the caution that the projected population may be wrong in the future. There is, however, no analysis that how the projections carried out for the period 2011-2026 differ from the projections for the same period based on the 2001 population census and what are the sources of the difference. It would have been useful if the Technical Committee would have provided the error of closure between the projected population and the enumerated population from 1961 census onward.

The population projections prepared by the Technical Committee are limited to one scenario only whereas the United Nations produces population projections under

different scenarios. Traditionally, United Nations projects population under three scenarios – low, medium, and high – depending upon the pace of fertility decline whereas the pace of mortality decline is assumed to be the same in all the three scenarios and the medium variant is assumed to be the most likely scenario. It would have been more appropriate if the Technical Committee would have produced population projections under alternative scenarios of the future trend in fertility, mortality, and migration.

Table 1: Population (000) of India projected by different agencies and authors, 2011-2036.

Year	Government of India		United Nations 2022	US Census Bureau 2023	Kulkarni 2021	Chaurasia 2023
	2011	2001				
2011	1210855	1192506	1257621	1236352	1211000	1324262
2012	1226901	1208116	1274487	1251839		1338635
2013	1242942	1223581	1291132	1267220		1352419
2014	1258985	1238887	1307247	1282483		1365617
2015	1275030	1254019	1322867	1297588		1378235
2016	1291074	1268961	1338636	1312486	1292000	1390280
2017	1305463	1283600	1354196	1327127		1401761
2018	1319844	1298041	1369003	1341471		1412690
2019	1334235	1312240	1383112	1355597		1423079
2020	1348616	1326155	1396387	1369541		1432944
2021	1363006	1339741	1407564	1380722	1368000	1442298
2022	1375586	1352695	1417173	1389637		1451159
2023	1388163	1365302	1428628	1399180		1459543
2024	1400744	1377442	1441720	1409128		1467467
2025	1413324	1388994	1454607	1419317		1474950
2026	1425908	1399838	1467231	1429700	1437000	1482009
2027	1436478		1479579	1440259		1488662
2028	1447051		1491671	1450913		1494928
2029	1457628		1503471	1461595		1500825
2030	1468194		1514994	1472251		1506369
2031	1478775		1526209	1482896	1496000	1511579
2032	1487471		1537108	1493392		1516472
2033	1496175		1547690	1503552		1521064
2034	1504878		1557920	1513365		1525372
2035	1513578		1567802	1522819		1529410
2036	1522288		1577303	1531918	1544000	1533194

Source: Government of India (2006; 2020); United Nations (2022); United States Census Bureau (2023); Kulkarni (2021a); Chaurasia (2023).

The report of the Technical Committee has not been externally reviewed by independent experts either within or outside the country as is the practice in western countries. The review by external independent experts and agencies provides credibility to the projections prepared by the Technical Committee. Such a review also helps in improving the quality and hence relevance of the projected population. An attempt, therefore, has

been made in this paper to compare the population projected by the Government of India based on the 2001 population census (Government of India, 2006) with the population projected by the Government of India based on the 2011 population census (Government of India, 2020) for the period 2011-2026. In addition, we have also compared population projections prepared by the Government of India based on 2011 population census with the population projections prepared by the United Nations (2022), United States Census Bureau (2023), Kulkarni (2021a) and Chaurasia (2023).

Table 1 gives data on projected population of India prepared by the Technical Committee based on 2011 population census for different years of the period 2011-2036 along with the population projected by United Nations (2022), United States Census Bureau (2023), Kulkarni (2021a) and Chaurasia (2023). The population projected by the Government of India based on 2011 population census is consistently higher than the population projected by the Government of India based on the 2001 population census and one reason is that the population enumerated at the 2011 population census was higher than the population projected for the year 2011 based on the population enumerated at the 2001 population census. On the other hand, population projected by the United Nations (2022), United States Census Bureau (2023), Kulkarni (2021a), and Chaurasia (2023) is consistently higher than the population projected by the Government of India based on the 2011 population census throughout the period 2011-2036, although the difference is not large.

The difference in the population of India projected by different agencies and authors may be attributed to different methods used for projection. Three of the five projections, except Government of India (2020) and Chaurasia (2023), are based on the estimated population of the country as on July 1, 2021. The projections by the Government of India (2020) are based on the population enumerated at the 2011 Census. Chaurasia (2023), on the other hand, has prepared population projections for India and states based on population projections for 640 districts, using the logistic growth model. All projections, except by Chaurasia (2023) are based on the cohort component method. but assumptions about projected trend in the components of population growth (fertility, mortality, and migration) are different. The United Nations and United States Census Bureau have also adjusted the base population for census undercount and net international migration.

Despite differences in methodology, population projected by different agencies and authors for the year 2036 is at the comparable level ranging from 1520 million (Government of India, 2020) to 1577 million (United Nations, 2022). The population projected by United Nations, United States Census Bureau and Chaurasia are higher by 2 to 4 per cent over the population projected by the Government of India whereas the population projected by Kulkarni is lower than that projected by the Government of India for the years 2021 and 2026 but higher by about 3 per cent for the year 2036. United Nations (2022) has projected the total fertility rates using the Bayesian probabilistic approach whereas the United States Census Bureau (2023) has projected the total fertility rate by modelling the trend in total fertility rate in 240 countries through the logistic curve. The Government of India (2020) has used the Gompertz Curve. United Nations and United States Census Bureau have estimated net international migration rates using the residual method. Untied Nations (2022), United States Census Bureau (2023, and Kulkarni (2021a) have projected that the total fertility rate will decline from 2.4 during 2011-2015 to 1.9 children

per woman in during 2031-2036 whereas the Government of India (2020) has projected that the total fertility rate will decline to 1.77 children per woman by the period 2031-2036. On the other hand, Kulkarni (2021) has projected lower life expectancy at birth as compared to that projected by the Government of India (2020). The United States Census Bureau has also projected lower life expectancy at birth for 2021-2025, 2026-2030 and 2031-2036 whereas United Nations (2022) has projected the life expectancy at birth which is similar to that by the Government of India. Chaurasia (2023) has derived the projected population for India based on the population projections for 640 districts using the logistic curve fitted to the population enumerated at the previous seven census years by inflating the parameter K, (maximum population size) of the model by 10 per cent. Modelling population growth by logistic curve is less affected by the problem of census undercount. Kulkarni (2021a) has produced the population projection for three scenarios (high, medium, and low). The projected population under medium scenario is lower than that projected by United Nations (2020) for all years but marginally higher than that prepared by the Government of India (2020). Kulkarni has not adjusted the base population for the census undercount and has assumed that the net international is zero. There is also a difference in the base population between Kulkarni and Government of India (2020).

We have also calculated the error of closure, mean absolute per cent error (MAPE), and the relative difference in the projected and the enumerated population for the year 2011. The error of closure is defined as the difference between the projected and the enumerated population divided by the enumerated population. If the projected population is less than the enumerated population, then the error of closure is negative, otherwise positive. The higher the error of closure, the higher the inaccuracy in the projection exercise.

The error of closure between the projected population for the year 2011 based on the 2001 population census and the population enumerated at the 2011 census is estimated to be -1.5 per cent for India. The projected population by age and sex for the year 2011 was obtained by the cohort-component method with the population at the 2001 census as the base. The net international migration was assumed to be zero over the projection period. The uncertainty in the assumptions about assumed changes in the components of population growth during 2001-2011 explains major share of the error of closure (Table 2). The difference between the projected total fertility rate and the total fertility rate obtained from the official Sample Registration System was 1.0 and 1.1 respectively during the period 2001-05 and 2006-10. Similarly, the projected life expectancy at birth was consistently higher than the life expectancy at birth obtained from the Sample Registration System for both males and females. Other factors may also lead to the discrepancy between projected and enumerated population for the year 2011. These include effect of HIV/AIDs, quality of the population data from 2001 and 2011 census, and net international migration. While projecting the population for the year 2011, the data available from the 2001 population census were not adjusted for undercount and the net international migration was assumed to be zero. On the other hand, the impact of HIV/AIDS on the projected population was published in the technical report based on the 2001 census during the period 2001-2026 (Government of India, 2006). HIV/AIDS is estimated to have reduced the projected population in 2011 from 1193. million to 1188 million so that the error of closure increased to -1.9 per cent.

Table 2: Error of closure in India and states, 2011.

India, States and Union Territories	Projected population as of March 2011 (000)	Census count 2011 (000)	Difference (000)	Error of closure (%)
India				
1.1 Projected population without HIV/AIDS	1192516	1210855	-18,339	-1.5
1.2 Projected population with HIV/AIDs	1187533	1210855	-23,322	-1.9
1.3 Projected population with net international migration and HIV/AIDS	1182251	1210855	-28,604	-2.4
1.4 Difference in undercount in 2001 and 2011 census	45404	42527	2,877	
1.5 Adjusted projected population and census count for 2011	1182251	1253382	-25,727	-2.1
States and Union Territories (Projected population is without adjustment)				
Andhra Pradesh and Telangana	84735	84581	286	0.3
Assam	30508	31206	-698	-2.2
Bihar	97720	104099	-6,379	-6.1
Chhattisgarh	24258	25547	-1,289	-5.0
Delhi	18451	16788	1,663	9.9
Gujarat	59020	60440	-1,420	-2.3
Haryana	25439	25351	88	0.3
Himachal Pradesh	6728	6865	-137	-2.0
Jammu & Kashmir including Ladakh	11718	12541	-823	-6.6
Jharkhand	31472	32988	-1,516	-4.6
Karnataka	59419	61095	-1,676	-2.7
Kerala	34563	33406	1,157	3.5
Madhya Pradesh	72200	72627	-427	-0.6
Maharashtra	112660	112374	286	0.3
Odisha	40750	41974	-1,224	-2.9
Punjab	27678	27743	-65	-0.2
Rajasthan	67830	68548	-718	-1.0
Tamil Nadu	67944	72147	-4,203	-5.8
Uttar Pradesh	200764	199812	952	0.5
Uttarakhand	9943	10086	-143	-1.4
West Bengal	89499	91276	-1,777	-1.9
Other states, and Union Territories	18196	18196	82	0.5
Total	1191495	1209690	-17,981	-1.5
Mean absolute per cent error (MAPE)				2.8
Number of states with higher projected population over 2011 census count				6

Source: Author's calculations. Projected population for 2011 is from Government of India (2006). Census count for 2011 is from Government of India (2020).

According to the United Nations (2022), about 5.282 million Indians emigrated to other countries during the period 2001-2011. This means that the projected population of India in 2011 decreased from 1,187,533 million (with HIV/AIDs) to 1,182,251 million when the net international out migration is considered, and the error of closure increased to -2.4 per cent. On the other hand, the figures about the census undercount are derived by taking the difference from the population estimated by the United Nations for 2001 and 2011 from

the difference in the population enumerated in 2001 and 2011 population census. As the result of this difference, the error of closure decreased marginally to -2.1 per cent. Although, this error of closure is higher than the error of closure of -1.50 per cent obtained without making any corrections due to HIV/AIDS, net international out migration, and the difference in the undercount in 2001 and 2011 population census, yet it is quite small and suggests that the quality of the population projection prepared by the Technical Committee constituted by the Government of India is acceptable.

Among different states and Union Territories of the country, the population projected by the Government of India is lower than the population enumerated at the 2011 population census in all but 6 states - Andhra Pradesh (including Telangana), Delhi, Haryana, Kerala, Maharashtra, and Uttar Pradesh (Table 2). The mean absolute per cent error (MAPE) across all states and Union Territories between the projected population for the year 2011 and the population enumerated at the 2011 census is estimated to be 2.8 per cent which is comparable to MAPE for states in the United States of America (Swanson and Tayman, 2012). The table also shows that the error of closure varies across the states and Union Territories of the country. The error of closure is based on the projected population for the year 2011 which does not consider the extent of international migration from states, impact of HIV/AIDS and the difference in the undercount of population at 2001 and 2011 population census.

As discussed earlier, different methods have been used by the Technical Committee of the Government of India for projecting the population of different states and Union Territories. For states for which relevant information about fertility and mortality is available through the official Sample Registration System, the cohort component method has been used for projecting the population. In these states, the error of closure is mainly due to the difference in the projected and the observed trend in fertility and mortality (Tables 3 and 4). In Delhi, Bihar and Tamil Nadu, the error of closure for the year 2011 is estimated to be more than 5 per cent. The error of closure in Delhi is positive and close to 10 per cent, the highest in all states and Union Territories of the country. This means that the projected population of Delhi in 2011, based on the 2001 population census was higher than the population enumerated at the 2011 population census. The positive error of closure for Delhi may be attributed to higher net in-migration rate assumed in the projection exercise.

On the other hand, the error of closure in Bihar and Tamil Nadu is found to be negative. The large negative error of closure in Bihar may be attributed to the fact that the decrease in both fertility and mortality in the state was slower than the projected one, In Tamil Nadu, the large negative error of closure may be attributed to the relatively slower decrease in mortality compared to the decrease in mortality assumed in the projection exercise and the assumption about the migration out of the state. In other states and Union Territories of the country, the error of closure is not large. There are only 6 states and Union Territories where the population projected based on the 2001 population census by the Government of India is found to be larger than the population enumerated at the 2011 population census. In other states and Union Territories, population projected for the year 2011 based on 2001 population census is smaller than the population enumerated at the 2011 population census.

Table 3: Projected and estimated total fertility rate (TFR) in India and states.

India/States	Projected TFR		Estimated TFR		Difference between projected and estimated TFR	
	2001-05	2006-10	2001-05	2006-10	2001-05	2006-10
India	2.9	2.6	3.0	2.6	-0.1	0.0
Andhra Pradesh and Telangana	2.1	1.9	2.3	1.8	-0.2	1.0
Assam	2.9	2.6	2.9	2.6	0.0	0.0
Bihar	3.9	3.3	4.2	3.9	-0.3	-0.6
Chhattisgarh	3.3	2.9	3.1	3.0	0.2	-0.1
Delhi	2.0	1.8	2.1	2.0	-0.1	-0.2
Gujarat	2.6	2.3	2.8	2.5	-0.2	-0.2
Haryana	2.8	2.4	3.0	2.5	-0.2	-0.1
Himachal Pradesh	2.1	1.9	2.1	1.9	0.0	0.0
Jammu & Kashmir	2.8	2.4	2.4	2.2	0.4	0.2
Jharkhand	3.3	2.8	3.5	3.2	-0.2	-0.4
Karnataka	2.2	2.0	2.3	2.0	-0.1	0.0
Kerala	1.8	1.8	1.8	1.7	0.0	0.1
Madhya Pradesh	3.7	3.2	3.8	3.8	-0.1	-0.6
Maharashtra	2.4	2.2	2.3	2.0	0.1	0.2
Odisha	2.5	2.2	2.6	2.4	-0.1	-0.2
Punjab	2.3	2.1	2.3	1.9	0.0	0.2
Rajasthan	3.6	3.1	3.8	3.3	-0.2	-0.2
Tamil Nadu	1.9	1.9	1.9	1.7	0.0	0.2
Uttar Pradesh	4.4	4.0	4.4	3.8	0.0	0.2
Uttarakhand	3.2	2.8	2.3	2.5	0.9	0.3
West Bengal	2.2	1.9	2.3	1.9	-0.1	0.0
Northeastern states	2.2	2.0	na	na	na	na

Source: Projected values are from Government of India (2006). Estimated values are from Government of India (2013).

Population Projection at the District Level

There are few attempts to project district population in India (UNFPA, 2016; Sinha et al, 2009). These are based on the 2001 census. The is a need for district population projections based on 2011 census for planning and assessing progress towards Sustainable Development Goals. Dhar (2022) has argued that cancer registration authorities in India indispensably require annual estimate of district population. Chaurasia (2023) has also argued that updating and forecasting district population is the need of the time as they are required for many purposes including district development planning and programming, provision of welfare services such as health and education services, infrastructure development, and making decisions about investments in the district, and assessing the future development and welfare needs of the people.

Table 4: Projected and estimated life expectancy at birth in India and states.

India/ Major Large States	Life expectancy at birth by sex								Difference between projected and estimated life expectancy at birth			
	Projected				Estimated							
	Male		Female		Male		Female		Male		Female	
	2001-05	2006-10	2001-05	2006-10	2001-05	2006-10	2001-05	2006-10	2001-05	2006-10	2001-05	2006-10
India	63.8	65.8	66.1	68.1	63.1	64.6	65.6	67.7	0.7	1.2	0.5	0.4
Andhra Pradesh & Telangana	63.4	65.4	67.9	69.4	62.8	63.5	67.5	68.2	0.6	1.9	0.4	1.2
Assam	59.6	61.6	60.8	62.8	58.4	61.0	60.3	63.2	1.2	0.6	0.5	-0.4
Bihar	65.6	67.1	64.7	66.7	64.2	65.5	64.1	66.2	1.4	1.6	0.6	0.5
Chhattisgarh	58.5	61.0	62.0	64.0	na	na	na	na				
Delhi	70.6	71.4	73.8	74.8	na	na	na	na				
Gujarat	64.9	67.2	69.0	71.0	63.7	64.9	67.8	69.0	1.2	2.3	1.2	2.0
Haryana	66.4	67.9	68.3	69.8	65.0	64.9	68.2	69.5	1.4	3	0.1	0.3
Himachal Pradesh	68.8	69.8	72.1	73.3	na	na	na	na				
Jammu & Kashmir	63.0	65.8	64.5	67.0	na	na	na	na				
Jharkhand	64.0	66.0	62.0	64.0	na	na	na	na				
Karnataka	64.0	66.5	69.6	71.1	63.9	64.9	68.5	69.7	0.1	1.6	1.1	1.4
Kerala	70.8	72.0	76.0	76.8	70.5	71.5	76.7	76.9	0.3	0.5	-0.7	-0.1
Madhya Pradesh	60.5	62.5	61.3	63.3	58.9	61.1	60.5	63.8	1.6	1.4	0.8	-0.5
Maharashtra	66.4	67.9	69.8	71.3	66.3	67.9	69.7	71.9	0.1	0.0	0.1	-0.6
Odisha	60.3	62.3	62.3	64.8	59.6	62.2	62.1	63.9	0.7	0.1	0.2	0.9
Punjab	67.7	68.7	70.4	71.6	67.5	67.4	70.2	71.6	0.2	1.3	0.2	0.0
Rajasthan	64.1	66.1	67.2	69.2	63.0	64.7	66.0	68.3	1.1	1.4	1.2	0.9
Tamil Nadu	66.1	67.6	69.1	70.6	65.7	67.1	65.7	70.9	0.4	0.5	3.4	-0.3
Uttar Pradesh	62.0	64.0	61.9	64.4	60.6	61.8	61.1	63.7	1.4	2.2	0.8	0.7
Uttarakhand	62.0	64.0	66.0	68.0	na	na	na	na				
West Bengal	66.7	68.2	69.4	70.9	65.7	67.4	68.9	71.0	1.0	0.8	0.5	-0.1

Source: Projected life expectancy at birth is from Government of India (2006). Estimated life expectancy at birth is from Government of India (2013).

Recently, Dhar (2022), ESRI India (2023) and Chaurasia (2023) have prepared district level population projections using different methods. Dhar (2022) has used the ratio method, ESRI India (2023) has used the ratio of population change and Chaurasia (2023) has used the logistic curve to project district population. This section discusses, in brief, the approach adopted by the authors for projecting district population.

The ESRI India (2023) has projected district population by calculating a factor based on the projected population and the base year population of the state. Subsequently, this factor is calculated for each year using the projected values provided by the Government of India. It is; however, not clear which derived values are being compared. The methodology needs to be elaborated further. This approach is a top-down approach which does not considers the variation in population change due to internal migration among districts within a particular state. It is suggested to generate the projected population for districts for the year 2011 using the factor based on the population projections for India, States and Territories from 2001 to 2026 and to compare the projected population for each district for the year 2011 with the population enumerated at the 2011 population census. Such analysis would provide the error of closure for each district and would give an estimate of the accuracy of the projection.

Dhar (2022) has used the ratio method for projecting district population based on the population projected by the Government of India (2022) for the states and Union Territories of the country. This approach is also a top-down approach and district projection is contingent upon the population projected at the state/Union Territory level. This method also does not consider the district level variation in population growth while projecting population. The author has observed that the method is more accurate than other methods in majority of districts by calculating the accuracy of the method relative to other methods using data from 1991 and 2001 population census for those districts which did not have boundary changes during 1991-2011.

Chaurasia (2023) has produced population projection by sex for 640 districts of India from 2011 to 2041 using the logistic model of population growth. For each district, the model was fitted to the population of the district enumerated in 1951, 1961, 1971, 1981, 199, 2001, and 2011 population census. Unlike the approaches used by ESRI India (2022) and Dhar (2022), the approach adopted by Chaurasia (2023) is the bottom-up approach in which the project population of the state/Union Territory and the country is contingent upon the projected population of districts of the state/Union Territory or country. The model provided good fit to population growth during 1951-2011 in all but 12 districts which are flagged as outliers. Two measures of the goodness of the fit – mean absolute per cent error (MAPE) and R^2 are used. About 90 per cent districts had MAPE under 0.05 per cent for males and females. Similarly, in more than 95 percent districts, the R^2 is estimated to be at least 0.90 for both males and females. The fitted logistic curve has been used for projecting population for 30 to 40 years based on the assumption that growth curve of the population follows an exponential path for 30-40 years only. Consequently, when it comes to projecting population for a longer period, a provision for population stabilisation is required exogenously (Mahmood and Kundu, 2001). Chaurasia (2023) has estimated population at stabilisation in each district by inflating the parameter *K* of the logistic growth curve by 10 per cent. This has not affected the projected population from

2011 to 2036 which are considered in this paper. Chaurasia (2023) has, however, not estimated the closure error for the districts. The approach adopted by Chaurasia (2023) for projecting district population is recommended as they are based on historical data on population growth in the district. The logistic curve provides relatively more accurate population projection for the country, states, and small areas. However, the projected population for districts based on the logistic curve is not available by age. This may be done by multiplying the projected population by their percentage distribution by age using the ratio method.

All the existing district population projections do not provide any information about the future tend in the components of population growth. It is therefore not possible to explain the growth of population in the district. There is, therefore, a need to project the population of the district using the cohort-component method to explain the determinants of population growth. This issue will be discussed in the following section of the paper.

Projection of the Urban Population

The Government of India (2020) has used the urban rural growth difference (URGD) approach proposed by the United Nations to project the urban population in the country and in its states/Union Territories. The URGD for the period 2001-2011 has been assumed to be the same up to the year 2036. This exercise suggests that the urban population in the country will increase from about 31 per cent in 2011 to around 39 per cent in 2036. The same method has been used by the United Nations (United Nations, 2018). According to the United Nations, more than 43 per cent population of India will be living in the urban areas by the year 2035. This proportion is substantially higher than that projected by the Government of India and the difference may be due to the use of population adjusted for census undercount as base population for projecting the population. It is, however, well-known that the URGD method over projects the urban population, especially, in the developing countries (Bocquier 2005). Alternative to URGD method includes the polynomial method (Bocquier, 2005). Application of the polynomial method suggests that the URGD method may overestimate the urban population in the world for the year 2030 by almost one billion. The overestimation will be more pronounced in the developing countries and may exceed 30 per cent in Africa, India, and Oceania. The logistic growth model has also been used to project the population of metropolitan cities in India (Dey et al, 2021) for the period 2011-2051.

Updating the Projections of Government of India

The terms of reference for the Technical Committee on Population Projections constituted by the Government of India clearly states that the Committee may give guidance to adjust the existing population projections based on 2011 population census to meet the requirements relating to use of population projections in the intervening period, both before and after the release of the data from the 2011 population census. It has also been

mentioned that the group may also give guidance for similar adjustments in population projections of intervening periods, when results of the 2021 population census become available. (Government of India, 2020). It is in the above context that the following recommendations are put forward to address the weaknesses in the existing projections:

(a) Following the tradition followed by the United Nations, projections may be prepared under three scenarios – high, medium, and low – depending upon the future trend in fertility.

(b) The distribution of the projected population across states/Union Territories may be obtained and this distribution may be applied to the projections to provide the updated projected population for subnational level in India.

(c) Generate the distribution of projected population by age and use this distribution to update the population by age and sex for the states/Union Territories.

District Level Projections Using Cohort-component Method

Projecting district population using cohort-component method is required to understand the determinants of district population growth. This responsibility may be undertaken by 18 Population Research Centers in the country and the activity may be coordinated by the International Institute for Population Sciences. The Hamilton -Perry method, which requires only population data by age for males and females separately from two points of time may be used for the purpose (Hamilton and Perry, 1962). This method is based on cohort change ratios which combine the effects of mortality and migration and using the child-woman ratio to estimate the youngest age group. This method has been recommended for small areas which lack the input data necessary for cohort-component method (Swanson and Tayman, 2012). The district level census data by age may be adjusted for digit preference.

Concluding Remarks

Some reasons for the low representation of applied demography work (estimating and projecting) population for small areas in India in comparison to the western countries are discussed in this paper. The first and the most important reason is that the civil registration system of the country still suffers from high level of incompleteness and lack of timeliness at the district level. Moreover, users are not aware of the weaknesses in the existing population projections produced by the Government of India. There has not been any publication by any external reviewer with respect to quality of the latest population projection based on the 2011 population census. The review of the latest population projections produced by the Government of India based on the principles of applied demography has outlined some weaknesses that need to be addressed by making alternative sets of projections for planning and for making business decisions. The Technical Committee on Population Projections constituted by the Government of India is mandated

to update current population projections and report any updated projections to the National Commission on Population. As regards projecting the district population, we recommend the projections prepared by Chaurasia (2023) based on the population growth modelling approach. These projections are based on the historical data on population growth in each of the 640 districts that existed at the time of the 2011 population census. For each district, these projections are available for males and females separately. These projections may serve the basis for projecting district population by age following the ratio method or by using other appropriate methods. An applied demographer can carry out this task and update population projections for the country and for its constituent states and Union Territories. This is the need of the time as the Government of India has placed the emphasis on decentralised district level planning, programming, and monitoring and evaluation of development and welfare activities. At the same time, the Population Research Centers of the country, under the stewardship of the International Institute for Population Sciences, may bear the challenging responsibility of projecting district population using the cohort-component method.

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