Estimation and Projection of the Fertility at Bagmati Province

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Received: March 27, 2022 Accepted: May 28, 2022 Published: December 24, 2022

Abstract

Information on fertility levels and patterns can assist to formulate and evaluate policies related to population change (Brass, 2015). Policy on fertility can affect the population change. Fertility relies upon accepted practices and desired family size (Bongaart, 2017). Fertility provides positive contribution to population growth if it is above the replacement level. The negative contribution occurs if it is below replacement level (Pressat, 1973). So, actual scenario of fertility data is essential for policy formulation. Fertility decline in Nepal has been tested and tried with different studies gives different figures like demographic health survey and national census data but varies data in provincial level. This study describes number of children ever born and number of births before 12 months who were given birth by reproductive (15-49) age group of women. The study has utilized census data from CBS that were conducted in 2001 and 2011. From census data files 1156521 and 1583063 number of reproductive age group (12.5% of the sample data) of women were identified through analysis. It was used to the Arriaga method and changing P/F ratio method in the estimation of Bagmati Province. The TFR values of Bagmati Province exact years 2016, 2021, 2026 and 2031 were obtained by linear interpolation and extrapolation by 2031, it will too low TFR replacement level.

Key Words: estimation, projection, arriaga, brass, bagmati province

Introduction

Fertility levels and patterns provide an important demographic information regarding the population change, as well as socio-economic development and human well-being. There are very few specific studies in Nepal that estimate and project fertility among the national level. When the practice of vital registration system was incomplete during 1960s and 1970s, indirect estimation of demographic variables of population was crucial and widely

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used method (Brass, 2015). Indirect techniques mostly rely on demographic theory and modelling applications, and these used to consider ingenious combinations of demographic data. The methods were robust and used to minimize the common errors. The demography of Tropical Africa (Caldwell & Okonjo, 1968) and United Nations (Coale & Demeny, 1968) were developed as the indirect estimation. A second generation of demographers developed the estimation techniques further. The indirect estimates for demographic characteristics were among the pioneering tasks practiced by the United States of America (USA) established back in 1977. These attempts ultimately lead; publication of the United Nations (UN) Manual X (United Nations, 1983; Schmertmann et al., 2013).

The world fertility survey and its successor surveys provided reliable data. The surveys not only estimated fertility, but also mortalities for infants and children (Brown & Guinnane, 2002). The survey also provided the impetus for data collection, but the indirect estimation remained in practice (Cleland, 1996). Due to non-availability of complete and reliable data, a large number of indirect techniques have been developed to estimate the demographic parameters. The new variant of indirect methods, for example, use of small area estimation has been widely used to estimate fertility at sub-national levels. Some of these techniques are based on indirect estimation while others are based on the statistical modeling in which the parameters are estimated (Brass & Coale, 1977) and thus limits the understanding of population dynamics in the developing country (Hobcraft & Little, 1984).

Many demographers agree that the Brass techniques are the most significant advancement in measuring of vital rates throughout the post-war period (Coale & Demeny, 1968). Brass methods detect and correct common reporting problems found in demographic data from developing nations (Brass, 1996). With the popularity gained by the indirect methods, demographers have reexamined these techniques which have upgraded these approaches (Moultrie et al., 2013). The census conducted during 1961-2011, estimates the fertility data only at national level and does not cover different geographical area. Myre's, Whipple's and UN age sex accuracy index have shown irregularities in the fertility estimations and trends, therefore, indirect techniques have been used in this study. This study shows that census data are not actual scenario of real field. So, Indirect estimation is necessary

This knowledge gap in fertility data within the from various researches is fulfilled by estimation and projection of fertility. The demographic health survey 2011 reveals that Bagmati Province has shortest birth interval (30 months) and the total fertility rate (TFR) is 2.3 children per woman highest among the provincial level (Ministry of Health, 2016) and applying the estimation and projection of fertility in Bagmati Province.

- To estimate and verify the validity logistic curve function using the projection in Bagmati Province.

  The next section deals with methods followed by result, discussion and finally the study presents the conclusion section.

2. Data and Methods

Indirect demographic estimation covers a wide variety of procedures many of which solely utilize information obtained from single round surveys (United Nations, 1983). The estimation of vital rates using national registers in developing countries is problematic and NDHS has limited sample size. These censuses suffer from coverage and content errors (Kpedekpo, 1982) used in idirect estimation. Nepal, the proposed analysis has used available on census data set (2001 and 2011) focused on Bagmati Province in Nepal. This study describes number of children ever born and number of births before 12 months who were given birth by reproductive (15-49) age group of women. Applied Arriaga method and changing P/F ratio for reliable and accurate information in indirect estimation (Schmertmann et al., 2013). Feeney (1996) presented a reinterpretation of P/F adjustment that similar logic (Feeney & Noller, 1996), however, proposed time based on the difference between current age and past and future mean time of cohort childbearing used logistic curve function rather than others mathematical model.

The Arriaga fertility method (1994) is used for the estimation of fertility levels by comparing two or more sets of average CEB. This method was designed to be useful for those cases where the Brass P/F ratio method could not be appropriate due to the changing fertility level. The method was implemented as part of the population analysis system used in demographic software. This analysis has reviewed the Arriaga method from the theoretical perspective and is based on simulations and addresses the performance of the method, as implemented, under different assumptions such as fertility change, the effect of fertility under age 15, the impact of the number of decimal places and sample variation in the average parity data.

The preliminary simple simulation of a rapid linear decline in age specific fertility rates (ASFRs) indicates that the method tends to measure the average ASFRs over the period between the two sets of CEB data. It is based on the mean value theorem, the slope of any continuous function connecting two points will at some point be equal to the slope of the straight line connecting them linearly. Thus, the method might work best near the midpoint between the dates of the two sets of CEB data, rather than near the endpoints. The method is estimating ASFRs based on differences in CEB data, it seems logical that the number of decimal places of the CEB data may affect the results (Arriaga, 1994).

The Brass changing P/F ratio method is hypothetical inter-survey cohort is logical relationship in this context is that, as a cohort of women moves through life, the average parity at each age equals the cumulated ASFRs to that age, provided that the fertility of surviving women is equal to that of women dying during the interval. The indirect method of demographic assement aviable to date are frequently insufficient to predict levels. However, the use of hypothetical cohort-based measurements is used to reduce the impacts of trends and estimate period levels in different caste/ethnic groups. If fertility rate changes, lifetime fertility and cumulative period fertility rates will not be same and hence an adjustment factor should be used to deterrmine it on the basis of comparison, that will refelect not only probable data mistake but also the impacts of changes over time. Instead of lacking age specific rates of end points for the given period, a set of rates corresponding to the period's mid-point could be utilized and in case of hypothetical inter- survey cohort method two dates of number of CEB and number of births before 12 months according to reproductive age groups of women can also be taken (United Nations, 1983). In any case, the best P/F ratio to use for adjustment will be that for the youngest useable age group, 20-24.

In projection, logistic equation is describing the self-limiting growth of demographic processes such as nuptiality, fertility, and mortality and migration population. These models have been used in studies of all these issues and diffusion processes are often modeled by logistic curve function. The logistic function is:

$$f(x) = \frac{1}{1+e^{-x}}$$

Where e is Euler's number and x-values in the real range from -∞ to +∞ are S-curves. Due to the nature of the exponential function e−x, it is often sufficient to compute x over a small range of real numbers, such as [−6, +6]. Biology, Biomathematics, Demography, Economics, Chemistry, Mathematical Psychology, Probability Theory, Sociology, Political Science and Statistics (Willekens & Rogers, 1978).

It has used derivative:

$$\frac{d}{dx} f(x) = f(x).(1 - f(x)).$$

This variant is used to project TFR for both population of census. The logistic is defined in terms of the complement of the TFR; that is, of the difference between TFR in year and the lower bound of the logistic. The specification ensures that proportionate changes in provincial and local level proportionate changes that TFR projected. Medium variant is used to project TFR estimation and projection. These data were processed in computer were using SPSS, Mort Pak 4.3 and MS excel programmed.

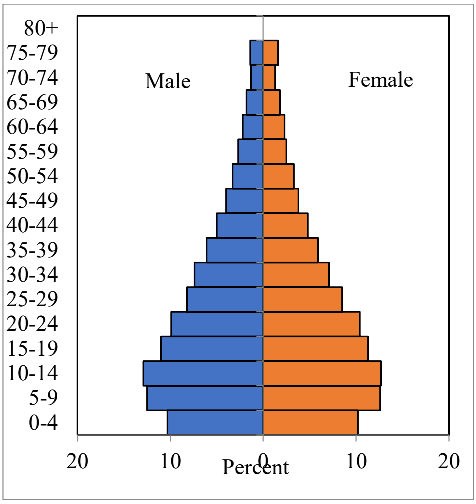
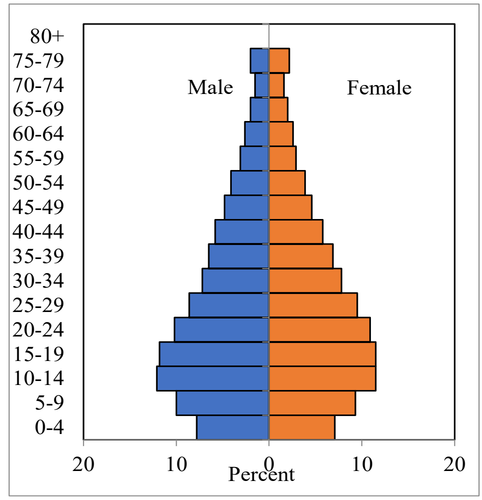
3. Results

This study has attempted to estimate fertility change by applying latest indirect techniques of fertility estimation at Bagmati Province, from 2001 and 2011 census data. The fertility estimates which are based on children ever born, last year birth according to reproductive age group of women.

3.1 Household Population by Age and Sex

The age-sex pyramids of household population clearly represents the population structure of specific time frame. The age-sex pyramid of Bagmati Province for census 2001 and 2011 are presented in Figure 3.1. Age sex structure analysis of census for Bagmati Province, 2001 has the highest proportion is 10-14 and followed by 5-9 and 0-4 age groups. Hence, the data clearly indicates declining fertility and mortality. Age 0-4 age group has lower than (5-9, 10-14 and 15-19). In other hand, 2011 census shows that highest proportion is 10-14 followed the 15-19 and 20-24 age groups. Age group 0-4 The has lower than subsequent (5-9, 10-14, 15-19 and 20-24) respectively presented in Figure 3.1.

Figure 3.1: Age sex pyramid 2001 at Bagmati Province

Age sex pyramid 2001	Age sex pyramid 2011
	

Source: Census dataset, 2001 and 2011.

The Figure 3.1 shows that aging index increases from 19.2 to 28.6 accordingly. This means there was significant increase in life expectancy and decrease in sex ratio at reproductive age group. The child dependency ratio has decreased from 62 to 46, working ratio has increased from 58 to 63, ageing dependency ratio has increased from 12 to 13, child- aged ratio has decreased from 74 to 59, sex ratio has decreased from 102 to 99 and women ratio has increased from 0.402 to 0.260 during census 2001 to 2011. The sex ratio of the study population shows that male population with the age group between 15 to 40 years has declined sharply in comparison to other age groups. It might be the effect of absentee population.

3.2 Estimation of fertility Arriaga method at Bagmati Province

This study is based on CEB according to reproductive age group of women at using 2001 and 2011 census data set at Bagmati Province. Table 3.1 is based on age specified data of reproductive age span of women at Bagmati Province for 2001 census; the adjusted values were estimated on the basis of cumulative ASFR and cumulative ASFR pattern.

Table 3.1: Estimation of ASFR based on 2001 census at Bagmati Province

Age	ASFR from CEB	Cum. ASFR	ASFR Pattern	Cum. ASFR pattern	Adj factors	Adj. Fertility f*
15-19	0.066	0.066	0.025	0.025	2.589	0.055
20-24	0.160	0.226	0.099	0.125	2.211	0.219
25-29	0.136	0.362	0.080	0.204	1.773	0.177
30-34	0.075	0.437	0.049	0.254	1.722	0.108
35-39	0.037	0.474	0.029	0.283	1.676	0.064
40-44	0.019	0.493	0.014	0.296	1.665	0.031
45-49	0.006	0.499	0.005	0.301	1.658	0.011
TFR						**3.328**

Source: Census dataset, 2001 and 2011.

The adjusting factor of P_2/F_2 values (2.211) has resulted adjusted ASFR for all age group and the adjusted TFR value was 3.3 in December 2001. The mean age of childbearing was 27.8 years. The TFR value (3.3) was lower than national census value 4.1 (Central Bureau of Statistics, 2003).

Table 3.2: Estimation of ASFR based on 2011 census at Bagmati Province

Age	ASFR from CEB	Cum. ASFR	ASFR Pattern	Cum. ASFR pattern	Adj factors	Adj. Fertility f*
15-19	0.035	0.035	0.018	0.018	2.024	0.031
20-24	0.123	0.158	0.075	0.093	1.703	0.128
25-29	0.113	0.271	0.070	0.163	1.664	0.119
30-34	0.059	0.330	0.038	0.200	1.646	0.065
35-39	0.027	0.357	0.016	0.217	1.648	0.027
40-44	0.009	0.366	0.007	0.224	1.634	0.012
45-49	0.002	0.368	0.002	0.226	1.627	0.003
TFR						**1.924**

Source: Census dataset, 2001 and 2011.

Table 3.2 is based on age specified data of reproductive age span of women at Bagmati Province for 2011 census; the adjusted values were estimated on the basis of cumulative ASFR and cumulative ASFR pattern. The adjusted value for age group was found in decreasing trends with increasing the age group. The adjusting factor of P_2/F_2 values (1.703) has resulted adjusted ASFR for all age group and TFR value was 1.928 in December 2010. The mean age of childbearing was 27.8 years. The TFR value estimated (1.9) was found lower than national census value 2.6 (Central Bureau of Statistics, 2014).

3.3 Estimation of fertility for hypothetical inter- survey cohort

The data of censuses 2001 and 2011 were used for the calculation of changing P/F ratio at Bagmati Province. The changing reported average parities P (i, s) were calculated from the reported average parities of 2001 and 2011 censuses obtained from ASFR datasheet of 2001 and 2011 censuses. It was based on medium variant estimation, changing reported parities methods with P (i, s)/F (i) ratios applied.

Table 3.3a: Estimation of ASFR based on inter- survey cohort at Bagmati Province

Age	2001P(i)	2011P(i)	Δ P(i)	P(i,s)	2001 f(i)	2011 f(i)
15-19	0.114	0.054	0.054	0.054	0.025	0.018
20-24	0.815	0.528	0.528	0.528	0.099	0.075
25-29	1.803	1.357	1.243	1.297	0.080	0.070
30-34	2.588	2.027	1.212	1.741	0.050	0.038
35-39	3.145	2.527	0.724	2.021	0.029	0.016
40-44	3.613	2.912	0.324	2.064	0.014	0.007
45-49	3.922	3.254	0.108	2.129	0.005	0.002

Source: Census dataset, 2001 and 2011.

Table 3.3b: Estimation of ASFR based on inter- survey cohort at Bagmati Province

Age	f(i)	□ (i)	F(i)	K	f+	f*(i)
15-19	0.021	0.107	0.029	1.833	0.028	0.048
20-24	0.087	0.544	0.320	1.654	0.090	0.153
25-29	0.075	0.917	0.742	1.748	0.071	0.122
30-34	0.044	1.135	1.036	1.680	0.041	0.070
35-39	0.023	1.249	1.196	1.689	0.021	0.036
40-44	0.010	1.300	1.273	1.621	0.010	0.016
45-49	0.004	1.318	1.312	1.623	0.003	0.005
TFR						**2.242**

Source: Census dataset, 2001 and 2011.

The adjusted value 1.701 (mean value of P_2/F_2 = 1.654 and P3/F3 =1.748) was estimated based on data in 2001 and 2011 censuses (Table 5.17a and 5.17b). Finally adjusted TFR value of Bagmati Province was calculated 2.2 for December 2005. Hence, the TFR value (2.2) was found lower than the national value 3.1 (Ministry of Health, 2006).

3.4 Projection of fertility at Bagmati Province (reference date 2010)

For declining fertility and mortality rate Arriaga method and changing P/F ratio methods are suitable in estimating fertility. The estimation of provincial groups based TFR in December 2010 was verified by using logistic curve function on the basis of the data of December 2000 and December 2005. Arriaga and changing P/F ratio methods were used to estimate the TFR values. A trend extrapolation model is a simplistic model that uses the historical growth pattern to project the future growth pattern and the observation incorporates the demographic transition, in which fertility first changes slowly; it accelerates first then decelerates gradually.

The phase of demographic transition in Nepal has reflected by the demographic scenario of diffrent provincial groups. The demographic scenario of Bagmati Province reflects the phase of demographic transition. Bagmati Province adjusted TFR value was 3.33 in December 2000 and 2.24 in December 2005. The estimate of TFR obtained December 2010 was 1.92. The estimation curve shows decreasing trend (slope = -0.373). The parameter and TFR was obtained from the same value and hence the logistic curve method was validated. So, similar method can be applied to project the TFR of reference date December 2015, 2020, 2025 and 2030.

3.5 Projection of fertility at Bagmati Province (reference date 2031)

Generally, the population growth rates are calculated from historical data by using certain mathematical formulas to predict the future size of the population. Population predictions at Bagmati Province are necessary for development planning. The estimates could be accurate for accurate data use and assumptions made in true reality. Prior to the projection, data must be adequately reviewed and adjusted for mistakes and the logistic curve being the most likely assumption. The ASFR is the modification of the general fertility rate in which fertility rates for each 5-year age cohort of women is calculated with the starting age group of 15 to 19 years and continuation up to the age group of 40 to 44 years. Most of the projection approaches extrapolate previous or current trends into the future to some degree. The estimated TFR values of Bagmati Province for December 2000, 2005 and 2010 by using logistic function has projected the TFR value up to December 2030.

It was used same slope for future projection. The model in spreadsheet TFRLGSTNew.xls interpolates and extrapolates of TFR. Finally, 2015, 2020, 2025 and 2030 data were used to interpolate point estimation with medium variant in groups, Bagmati Province. Fertility decline has been a primary determinant of population ageing and projected levels of fertility have important implications on the age structure of future population, including on the pace of population ageing. On these basis trends of TFR values projected (Table 3.4).

Table 3.4: Projected TFR values at Bagmati Province

Year	TFR Values
December 2000	3.33
December 2005	2.24
December 2010	1.92
December 2015	1.90
December 2020	1.90
December 2025	1.90
December 2030	1.90

These dates based on census 2001 and 2011 points are estimated by linear interpolation and projection is based on time series logistic method. In fact, this research was used point estimation with medium variant interpolation in different groups, Bagmati Province. TFR values were estimated on December 2000 and 2010 by using Arriaga method on December 2005.

These dates based on census 2001 and 2011 which can be obtained by linear interpolation. In fact, this research was used point estimation with medium variant interpolation. TFR values were estimated December 2000 and 2010 by using Arriaga method and December 2005 by using hypothetical inter survey cohort. The obtained values were verified and valid by using logistic curve. The projected Bagmati Province TFR of December 2015, 2020, 2025 and 2030 were obtained 1.9 as a constant ratio r (Table 3.4). However, exact date of projected TFR using linear interpolation are 2016, 2021, 2026 and 2031 respectively. The TFR value was lower than the national value in all estimated dates. In Bagmati Province will be below the replacement level in 2031.

4. Discussion

It is very crucial, critical and important and noted that 156 countries and areas around the world, the estimated number of births that the estimates of the approximately 230 million, which is more than the estimated 129 million births that actually 81 percent variants (Liu, 2015). This study shows that the Bagmati Province has low fertility rate to compare national level

TFR (4.1) in December 2001 (Central Bureau of Statistics, 2003). Similarly, Bagmati Province has low fertility rate in comparison of national TFR (2.6) in December 2005 (Ministry of Health, 2006). In December 2010 shows that Bagmati Province has low fertility in compare to national TFR (2.6) (Central Bureau of Statistics, 2014). Significant numbers of women say that they do not want another child but are not using any method of contraception (Casterline, 1989). Reducing unmet need and serving current users of contraceptive scan help in reducing unintended pregnancies that lead to abortions and unwanted births both of which are unacceptably high in many countries (Becker, 1999). Nepal is among the poorest countries in the world and the quality of its demographic data is no different either. Data that is meager and defective limits understanding of population dynamics in the country. The controversy arising from fertility estimates in many developing countries is mainly due to the poor data quality. For instance, fertility decline in Nepal has been tested and tried with different studies coming up with contradictory conclusions national census data. The demographic landscape of the SAARC region has seen unprecedented changes over the last 100 years. The population growth rate accelerated and India (which accounts for three-fourths of the region population) doubled its population between 1961 and 1991 and crossed one billion marks in 2001. India, Pakistan and Bangladesh are respectively the second, seventh and ninth most populous countries of the world. The highest fertility rate (TFR) 5.4 in Afghanistan and lowest fertility rate (TFR) 2.1 which reached the replacement level in Sri Lanka world population data and NDHS give same TFR 2.6 in Nepal which is medium change of fertility in SAARC countrieswich is resemale indirect estimates of the TFR calculated using Arraiga's method in 2001 and 2011. The TFR is approximately 4.1 in 2001, which declines to 2.6 in 2011, a decline of slightly less than one child per woman over a decade (Central Bureau of Statistics, 2014). The value of the TFR recorded by the population and housing census of 2011 at 2.52, is much closer to the value of the TFR obtained by the demographic and health survey of 2011 of 2.6 in 2009, that is during the period 2008 to 2010. The TFR in Nepal is 2.3 children per woman (Ministry of Health, 2016).

5. Conclusions

This study has presented substantial defectiveness in Nepal fertility data, hence the usefulness of indirect estimation of the total fertility rate using Bagmati Province in Nepal. This research has main strength of study of point estimation of fertility by Arriaga's method and changing P/F ratio method in Bagmati Province is justified which is new contribution study in Nepal. The changing P/F ratio, the Arriaga's methods were quite powerful in indirectly estimating fertility levels. If the degree of data errors is enormous, then the techniques can also be sources of errors themselves (Feeney & Noller, 1996). This study was used point estimation with medium variant interpolation. TFR values were estimated December 2000 and 2010 by using Arriaga method and December 2005 by using hypothetical inter survey cohort. The obtained values were verified and valid by using logistic curve. The projected national level TFR of December 2015, 2020, 2025 and 2030 were obtained constantly at 1.90 which is below the replacement level. The TFR values will near to reach national TFR replacement level. At last, using linear interpolation project the TFR exact date 2016, 2021, 2026 and 2031 respectively.

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