Estimation and Projection of the Fertility in Different Caste/ethnic Groups, Nepal

Bijaya Mani Devkota

Lecturer at Central Department of Population Studies (CDPS),

Tribhuvan University (TU), Kathmandu, Nepal

Email: devkotabm2006@gmail.com

https://orcid.org/0009-0005-1533-2678

Suresh Acharya

Lecturer at Department of Rural Development Padmakanya Multiple Campus

Tribhuvan University (TU), Kathmandu,

Nepal Email: sureshrdpk@gmail.com

https://orcid.org/0009-0002-4034-1603

Abstract

This study focuses on estimating recent fertility levels in Nepal across different caste/ethnic groups, employing various methods with a particular emphasis on the Arriaga method. The extensive data assessment and corrections of individual variables were undertaken to obtain optimal fertility estimates. The study identifies a strong indication of fertility decline in Nepal, supporting previous studies findings. The hypothetical inter-survey cohort is employed to estimate fertility levels from December 2000 to December 2010 using the logistic method. This study analyzing the census data from 2001 and 2011, the study reveals variations in Total Fertility Rate (TFR) values among different caste/ethnic groups. For instance, the Newar, Tarai Janajiti, and Madheshi Brahman exhibit lower TFR values compared to the national census, while Hill Janajati, Brahman/Chhetri, Madheshi Other Caste, Hill Dalit, Madhesi Dalit, Muslim, and Others Minor Caste show higher values. The study applies hypothetical inter-survey analysis, indicating that Muslim, Hill Janajati, Madhesi Dalit, Madheshi Other Caste, Hill Dalit, Madhesi Dalit, and Others Minor Caste are expected to have fertility rates exceeding replacement levels by 2031. In contrast, Newar, Tarai Janajiti, and Brahman/Chhetri are projected to have fertility rates below replacement levels. This study contributes valuable insights into fertility trends and disparities among caste/ethnic groups in Nepal, emphasizing the need for targeted interventions and policy considerations based on these variations.

Key words: *Estimation, Projection, Different, Caste/ Ethnic, Arriaga method*

Introduction

Fertility levels and patterns play a central role in understanding population dynamics, socioeconomic development, and human well-being. In Nepal, there is a scarcity of specific studies estimating and projecting fertility at the national level. The utilization of indirect estimation methods became imperative due to the inadequacies in the vital registration system during the 1960s and 1970s, which was incomplete. This approach was widely adopted to address the limitations of the registration system (Brass, 2015). These methods, relying on demographic theory and modeling applications, ingeniously

combined demographic data to ensure robustness and minimize common errors. Indirect estimation, as illustrated in the demographic analysis of Tropical Africa by Caldwell and Okonjo (1968) and the models developed by the United Nations, serves as an example (Coale & Demeny, 1968), advanced by a subsequent wave of demographers, this progress reached its peak with the release of the United Nations Manual X in 1983, as documented by Schmertmann et al. in 2013.

The World Fertility Survey and its follow-ups played a pivotal role in supplying dependable data, encompassing not only fertility rates but also estimates of infant and child mortalities, as highlighted (Brown & Guinnane, 2002). Despite the impetus for data collection, indirect estimation persisted due to incomplete and unreliable data (Cleland, 1996). A range of indirect methods, such as small area estimation, have been devised to estimate demographic parameters at sub-national levels. While certain techniques rely on indirect estimation, others utilize statistical modeling to estimate parameters, potentially constraining the comprehension of population dynamics in developing countries (Brass & Coale, 1977; Hobcraft & Little, 1984).

Demographers recognize Brass techniques as a significant post-war advancement in measuring vital rates (Coale & Demeny, 1968). These approaches identify and rectify common issues in the reporting of demographic data in developing countries (Brass, 1996). Despite census data covering national fertility estimates from 1961 to 2011, irregularities in trends, as revealed by Myre's, Whipple's, and the UN age-sex accuracy index, necessitated the use of indirect techniques in this study. It underscores that census data may not accurately represent real-world scenarios, emphasizing the necessity of indirect estimation.

Addressing the knowledge gap in fertility data, this research utilizes estimation and projection techniques. As per the 2011 Demographic Health Survey, there are disparities in birth intervals, and the Total Fertility Rate (TFR) stands at 2.3 children per woman, with the highest rates observed at the provincial level among various caste/ethnic groups (Ministry of Health, 2016). The use of strong fertility estimation and projection techniques is the important to solving the gaps in data and the explanation of fertility differentials in a heterogeneous population. This analysis estimates the process of fertility change and determines the feasibility of the logistic curve model in projecting fertility in caste and ethnic groups to determine whether the model is suitable in accounting for group selective fertility and in the dynamics of group transitions.

Data and methods

Indirect demographic estimation encompasses various procedures, many relying on information from single-round surveys (United Nations, 1983). Vital rate estimation using national registers in developing countries is challenging due to issues like limited sample size in the Nepal Demographic and Health Surveys (NDHS) and errors in censuses regarding coverage and content (Kpedekpo, 1982). This study utilizes census data from 2001 and 2011, focusing on different caste/ethnic groups in Nepal. The Arriaga method, incorporating changing P/F ratios, is applied for accurate indirect estimation, as proposed by Schmertmann et al. (2013) and Feeney (1996). Feeney (1996) suggests a time-based adjustment using logistic curve functions.

The Arriaga fertility method, introduced in 1994, gauges fertility levels by contrasting the average Children Ever Born (CEB) over distinct time periods. This method proves valuable when the Brass P/F ratio approach is unsuitable due to fluctuating fertility levels. Theoretical scrutiny and simulations have reviewed the method's performance under various assumptions, including fertility shifts, the influence of fertility below age 15, considerations of decimal places, and variations in sample data for average parity.

Simulations suggest the Arriaga method measures average Age-Specific Fertility Rates (ASFRs) over the period between two sets of Children Ever Born (CEB)data, with optimal results near the midpoints. The number of decimal places in CEB data can influence the estimates. The Brass changing P/F ratio method, a hypothetical inter-survey cohort, establishes a logical relationship where average parity equals cumulated ASFRs at each age. Hypothetical cohort-based measurements help mitigate trends' impacts and estimate period levels in different caste/ethnic groups.

In projections, logistic equations describe self-limiting growth in demographic processes. The logistic function, involving Euler's number (e), models S-curves in various fields like biology, demographics, and sociology (Willekens & Rogers, 1978). The derivative is used to project Total Fertility Rate (TFR) for both census populations. Proportional changes in TFR are ensured by the logistic's specification. The medium variant is utilized in the estimation and projection of Total Fertility Rate (TFR), employing SPSS, Mort Pak 4.3, and MS Excel for processing.

This comprehensive methodology integrates various demographic estimation techniques and projection models, emphasizing their application to diverse caste/ethnic groups in Nepal for a nuanced understanding of fertility dynamics.

Result

Nepal, characterized by its rich diversity, encompasses numerous ethnicities with diverse languages, religions, and cultural traditions. The significance of the 1991 census lies in its pioneering inclusion of data on caste/ethnicity, population size, and socioeconomic attributes across different groups. As of the 2011 census, Nepal is home to 125 distinct caste/ethnic groups and 207 religious groups. This represents a notable shift from the 2001 census findings, which reported fewer than 350 caste/ethnic groupings and eight religious groupings in the country (Central Bureau of Statistics, 2014).

Fertility estimation by Arriaga method in different caste/ethnic groups

The Arriaga fertility method was employed in this study to gauge fertility levels by comparing average Children Ever Born (CEB) across various caste/ethnic groups. The Population Analysis System (PAS) was implemented on two different dates, utilizing the Arriaga approach for both theoretical analysis and simulations. These estimates were used to adjust observed fertility patterns, akin to the changing Brass P/F ratio method. In instances of missing or insufficient crucial event registrations, the Total Fertility Rate (TFR) can be estimated using age and gender distribution data. In the context of Nepal, where evidence suggests a decline in fertility rates, the applicability of Arriaga's method

becomes crucial in discerning the extent of this trend across diverse caste/ethnic groups. The study focuses on CEB within the reproductive age group of women, utilizing data from the 2001 and 2011 census datasets.

Table 1: *Estimation of Asfr using Arriaga in Different Caste/Ethnic Groups (2001)*

Age	Hill Ja-najati	Newar	Tarai Janajiti	Brah-man/ Chhetri	Mad-heshi Brah-man	Mad-heshi Other Caste	Hill Dalit	Madhe-si Dalit	Muslim	Others
15-19	0.075	0.036	0.093	0.058	0.056	0.101	0.095	0.104	0.075	0.090
20-24	0.258	0.170	0.248	0.276	0.218	0.263	0.260	0.252	0.249	0.229
25-29	0.222	0.153	0.190	0.214	0.145	0.207	0.230	0.217	0.262	0.197
30-34	0.176	0.087	0.120	0.124	0.098	0.138	0.148	0.143	0.227	0.139
35-39	0.112	0.044	0.060	0.069	0.030	0.084	0.097	0.088	0.140	0.102
40-44	0.064	0.017	0.030	0.035	0.012	0.039	0.049	0.058	0.092	0.056
45-49	0.020	0.005	0.016	0.012	0.002	0.017	0.023	0.025	0.047	0.016
TFR	4.633	2.563	3.788	3.940	2.810	4.242	4.508	4.437	5.468	4.149

Source: Census data files, 2001 and 2011.

Table 1 presents age-specific data from the 2001 census for the reproductive age span of women. Adjusted values are derived through cumulative Age-Specific Fertility Rates (ASFR) and their patterns. The adjusting factor for age groups exhibits a decreasing trend with increasing age. The adjusted ASFR and Total Fertility Rate (TFR) values for December 2000 are as follows: Hill Janajati (4.6), Newar (2.6), Tarai Janajiti (3.8), Brahman/Chhetri (3.9), Madheshi Brahman (2.8), Madheshi Other Caste (4.2), Hill Dalit (4.5), Madhesi Dalit (4.4), Muslim (5.5), and Others Minor Caste (4.1). Variations in mean ages of childbearing are observed among different caste/ethnic groups. Notably, Newar, Brahman/Chhetri, Tarai Janajiti, and Madheshi Brahman exhibit TFR values lower than the national census (4.1), while Hill Janajati, Madheshi Other Caste, Hill Dalit, Madhesi Dalit, Muslim, and Others Minor Caste have higher TFR values than the national average (Central Bureau of Statistics, 2003).

Table 2 : *Estimation of ASFR using Arriaga in Different Caste/Ethnic Groups (2011)*

Age	Hill Jana-jati	Newar	Tarai Janajiti	Brah-man/ Chhetri	Madheshi Brahman	Madheshi Other Caste	Hill Dalit	Madhesi Dalit	Muslim	Others
15-19	0.049	0.019	0.043	0.036	0.019	0.045	0.079	0.063	0.061	0.054
20-24	0.172	0.108	0.188	0.191	0.146	0.202	0.232	0.227	0.219	0.225
25-29	0.150	0.104	0.142	0.174	0.134	0.166	0.176	0.176	0.206	0.214
30-34	0.095	0.072	0.079	0.086	0.067	0.085	0.109	0.111	0.153	0.095
35-39	0.055	0.025	0.029	0.044	0.029	0.044	0.071	0.072	0.092	0.058
40-44	0.026	0.008	0.014	0.017	0.005	0.021	0.037	0.035	0.048	0.035
45-49	0.008	0.002	0.007	0.010	0.002	0.009	0.019	0.012	0.025	0.011
TFR	2.772	1.691	2.516	2.610	2.130	2.864	3.615	3.473	4.020	3.459

Source: Census data files, 2001 and 2011.

Table 2, based on age-specific data from the 2011 census for women of reproductive age, presents adjusted values using cumulative Age-Specific Fertility Rates (ASFR) and patterns. Adjusting factors for age groups follow a decreasing trend. Adjusted ASFR and Total Fertility Rate (TFR) values for December 2010 are reported: Hill Janajati (2.8), Newar (1.7), Tarai Janajiti (2.6), Brahman/Chhetri (2.6), Madheshi Brahman (2.1), Madheshi Other Caste (2.9), Hill Dalit (3.6), Madhesi Dalit (3.5), Muslim (4.0), and others (3.5). Mean ages of childbearing vary across caste/ethnic groups. Notably, Newar, Tarai Janajiti, and Madheshi Brahman exhibit TFR values lower than the national census (2.6), while Hill Janajati, Brahman/Chhetri, Madheshi Other Caste, Hill Dalit, Madhesi Dalit, Muslim, and others have higher TFR values (Central Bureau of Statistics, 2014).

Estimation of fertility for hypothetical inter- survey cohort

This study utilizes caste/ethnic-based data at the national level in Nepal. Conventional indirect demographic assessment methods often prove insufficient for predicting levels, prompting the use of hypothetical cohort-based measurements. To account for changes in fertility rates, adjustments are made based on comparisons, reflecting not only potential data errors but also the impacts of temporal changes. The study employs a hypothetical inter-survey cohort method using data from censuses in 2001 and 2011, calculating changing P/F ratios in various caste/ethnic groups.

Table 3: *Estimation of ASFR Based on P/F Hypothetical Inter- survey Cohort*

Age	Hill Ja-najati	Newar	Tarai Janajiti	Brah-man/ Chhetri	Mad-heshi Brah-man	Mad-heshi Other Caste	Hill Dalit	Madhe-si Dalit	Muslim	Others
15-19	0.068	0.032	0.085	0.057	0.050	0.091	0.109	0.107	0.088	0.091
20-24	0.191	0.129	0.210	0.216	0.180	0.234	0.251	0.250	0.257	0.235
25-29	0.157	0.111	0.151	0.166	0.128	0.177	0.197	0.196	0.250	0.198
30-34	0.112	0.067	0.089	0.088	0.073	0.104	0.124	0.127	0.193	0.111
35-39	0.069	0.028	0.040	0.047	0.027	0.060	0.082	0.079	0.118	0.077
40-44	0.035	0.010	0.020	0.022	0.008	0.027	0.041	0.044	0.070	0.041
45-49	0.009	0.002	0.008	0.006	0.002	0.011	0.017	0.016	0.033	0.011
TFR	**3.205**	**1.886**	**3.014**	**3.007**	**2.333**	**3.523**	**4.106**	**4.097**	**5.015**	**3.818**

Source: Census data files, 2001 and 2011.

This study calculates changing reported average parities and period Age-Specific Fertility Rates (ASFR) at the national level based on 2001 and 2011 census data in diverse caste/ethnic groups. Using a medium variant estimation, the changing reported parities method, and the United Nations Manual X procedure, adjustments are made. The adjustment factor (K) for registered births is determined by summing births from 2001-2011 in Nepal. Adjusted values for 2001 and 2011 in various caste/ethnic groups are obtained, and the adjusted Total Fertility Rate (TFR) for December 2005 is presented. Notably, Newar, Tarai Janajiti, Brahman/Chhetri, and Madheshi Brahman exhibit lower TFR values than the national census (3.1), while Hill Janajati, Madheshi Other Caste, Hill Dalit, Madhesi Dalit,

Muslim, and Others Minor Caste show higher values (Ministry of Health, 2006).

Projection of fertility in different caste/ethnic groups (reference date 2010)

The Arriaga method and changing P/F ratio methods were employed for fertility estimation, proving effective for declining fertility and mortality rates. Caste/ethnic-based Total Fertility Rate (TFR) estimates for December 2010 were validated using logistic curve functions with data from December 2000 and December 2005. Both Arriaga and changing P/F ratio methods were utilized to derive TFR values. Trend extrapolation models, focusing on past growth patterns to predict future trends, acknowledge the demographic transition's phases, where fertility initially changes slowly, accelerates, and eventually decelerates. The demographic scenario of various caste/ethnic groups in Nepal aligns with the phases of demographic transition.

Table 4: *Estimated TFR Values in Different Caste/Ethnic Groups, Nepal*

Age	Hill Janajati	Newar	Tarai Janajiti	Brah-man/ Chhetri	Mad-heshi Brah-man	Mad-heshi Other Caste	Hill Dalit	Madhesi Dalit	Muslim	Others
Dec2000	4.633	2.563	3.788	3.940	2.810	4.242	4.508	4.437	5.468	4.149
Dec2005	3.205	1.886	3.014	3.007	2.333	3.523	4.106	4.097	5.015	3.818
Dec2010	2.772	1.691	2.516	2.610	2.130	2.864	3.615	3.473	4.020	3.459
Trends	-0.161	-0.268	-0.151	-0.284	-0.197	-0.132	-0.055	-0.040	-0.062	-0.038

Table 4 displays the adjusted Total Fertility Rate (TFR) values for December 2000, 2005, and the verified value for 2010, along with their respective slopes and intercepts. The parameters and TFR values derived from the logistic curve method validate its application. Consequently, this method can be similarly applied to project TFR values for the reference dates of December 2015, 2020, 2025, and 2030.

Projection of fertility in different caste/ethnicity (reference date 2031)

Population growth rates are typically derived from historical data and employed in mathematical formulas to predict future sizes. The Age-Specific Fertility Rate (ASFR) extends fertility rate calculations to 5-year age cohorts of women, from ages 15 to 19 through 40 to 44. Projection approaches generally extrapolate existing trends into the future. Utilizing the logistic function, estimated Total Fertility Rate (TFR) values for various caste/ethnicities from December 2000 to 2010 project TFR values up to December 2030, employing the same slope for future projections. The TFRLGSTNew.xls spreadsheet model interpolates and extrapolates TFR, using 2015, 2020, 2025, and 2030 data for point estimation with a medium variant in different caste/ethnicities. Projected TFR trends (Table 5) highlight the pivotal role of fertility decline in population aging and its implications for future age structures.

Table 5: *Projected TFR Values in 2001-2031 in Different Caste/Ethnic Groups*

Age	Hill Ja-najati	Newar	Tarai Janajiti	Brah-man/ Chhetri	Mad-heshi Brah-man	Mad-heshi Other Caste	Hill Dalit	Madhe-si Dalit	Muslim	Others
Dec2000	4.7	2.6	3.8	3.9	2.8	4.2	4.5	4.4	5.5	4.2
Dec2005	3.2	1.9	3.0	3.1	2.3	3.5	4.1	4.1	5.0	3.8
Dec2010	2.8	1.7	2.5	2.6	2.1	2.9	3.6	3.5	4.0	3.5
Dec2015	2.5	1.6	2.3	2.5	2.0	2.6	3.2	3.1	3.5	3.2
Dec2020	2.4	1.6	2.1	2.3	1.9	2.4	2.9	2.8	3.0	2.9
Dec2025	2.3	1.6	2.1	2.2	1.9	2.3	2.6	2.5	2.6	2.7
Dec2030	2.3	1.6	2.0	2.1	1.8	2.2	2.4	2.3	2.4	2.5

Using census data from 2001 and 2011, this research employs linear interpolation for estimated points and a time-series logistic method for projections. The study utilizes point estimation with medium variant interpolation across different caste/ethnicities. Total Fertility Rate (TFR) values for December 2000 and 2010 are estimated using the Arriaga method in December 2005, validated by the logistic curve. The projected TFR for precise dates through linear interpolation is 2016, 2021, 2026, and 2031. Findings suggest that Hill Janajati, Madhesi Dalit, Madheshi Other Caste, Hill Dalit, Madhesi Dalit, Muslim, and Others Minor Caste will exceed replacement-level fertility by 2031, while Newar, Tarai Janajiti, and Brahman/Chhetri will fall below replacement levels.

Discussion

The estimated number of global births, covering 156 countries and areas, is approximately 230 million, significantly surpassing the reported 129 million births by 81 percent (Liu, 2015). Projected Total Fertility Rates (TFR) for Hill Janajati in December 2015, 2020, 2025, and 2030 are 2.5, 2.4, 2.3, and 2.3, respectively, as presented in Table 4.9. Other major castes, including Newar, Tarai Janajiti, Brahman/Chhetri, Madheshi Brahman, Madheshi Other Caste, Hill Dalit, Madhesi Dalit, Muslim, and Others Minor Caste, exhibit varying TFR values for the same period. In December 2010, different caste/ ethnic groups in Nepal demonstrated lower fertility compared to the national TFR of 2.6 (Central Bureau of Statistics, 2014). The challenge of unmet contraceptive needs and the persistence of unintended pregnancies and high abortion rates are significant issues, particularly in impoverished countries like Nepal. The country's demographic data quality remains a concern, contributing to controversies in fertility estimates. Various studies on fertility decline in Nepal have yielded conflicting conclusions, partially attributed to the limitations of national census data. The broader demographic landscape of the SAARC region has undergone substantial changes in the past century, with India, Pakistan, and Bangladesh ranking among the most populous countries globally. The SAARC countries exhibit diverse fertility rates, from Afghanistan's highest at 5.4 to Sri Lanka's replacement-level TFR of 2.1. In Nepal, indirect estimates using Arriaga's method indicate a decline in TFR from 4.1 in 2001 to 2.6 in 2011, aligning with the demographic and health survey data. The recorded TFR in the 2011 census closely

matches the 2011 demographic and health survey, while the current TFR in Nepal is reported as 2.3 (Ministry of Health, 2016).

Conclusions

This study emphasizes the substantial deficiencies in Nepal's fertility data, underscoring the significance of indirect estimation methods for the Total Fertility Rate (TFR) in Nepal. The research's main strength lies in the novel approach of point estimation using Arriaga's method and the changing P/F ratio method across different caste/ethnic groups. These methods prove powerful in indirectly estimating fertility levels, yet the potential for errors exists, especially with extensive data inaccuracies. The study employs medium variant interpolation and hypothetical inter-survey analysis, revealing variations in TFR values among caste/ethnic groups compared to national census and NDHS values. Notably, certain groups exhibit fertility rates above replacement levels by 2031, while others fall below. The TFR values are projected with linear interpolation for specific dates, highlighting the dynamic fertility landscape in Nepal.

References

Arriaga, E. E. (1994). *Bureau of the Census, USAID a Vol. I.*(1-22) : Bureau of the Census, USAID and UNFPA.

Devkota, B.M. (2022). *Estimation and Projection of the Fertility: National, Provincial and Local Level in Nepal.* An unpublished Ph. D. thesis, submitted to Tribhuvan University. Kathmandu: Tribhuvan University.

Bongaarts, J. (2017). The effect of contraception on fertility: Is sub-Saharan Africa different? *Demographic Research. 37*(6):129-146.

Brass, W. (1996). Demographic data analysis in less developed countries: 1946–1996. *Population studies, 50*(3), 451-467.

Brass, W. (2015). *Demography of Tropical Africa* (2141): Princeton University Press.

Brass, W., & Coale, A. J. (1977). Methods of analysis and estimation. In *Mathematical Demography* (307-313): Springer.

Brown, J. C. & Guinnane T.W.G (2002). Fertility transition in a rural, Catholic population: Bavaria 1880–1910. *Population Studies.* 56(1):35–50.

Caldwell, J. C., & Okonjo, C. (1968). The population of tropical Africa. *Studies in Family Planning, 1*(29), 10-12.

Casterline, J. (1989). *The state, social stratification and fertility transition.* Paper presented at the International Population Conference, New Delhi.

Central Bureau of Statistics. (2003). *Population Monograph of Nepal*. Kathmandu, Nepal: Central Bureau of Statistics.

Central Bureau of Statistics. (2014). *Population Monograph of Nepal*. Kathmandu, Nepal: National Planning Commission Secretariat.

Cleland, J. (1996). Demographic data collection in less developed countries 1946–1996. *Population Studies, 50*(3), 433-450.

Coale, A. J., & Demeny, P. (1968). *Methods of evaluating basic demographic measures from limited and defective data.* United Nations, New York.

Feeney, J. A., & Noller, P. (1996). *Adult attachment* (Vol. 14): Sage.

Feeny, G. (1997). *Estimates of Demographic Parameters from Census and Vital Registration Data.* Proceedings of the 1977 Mexico International Population Conference, (349-70). Liege: IUSSP.

Hobcraft, J., & Little, R.A. (1984). Fertility exposure analysis: A new method for assessing the contribution of proximate determinants to fertility differentials. *Population Studies. 36*(2):291-316.

Kpedekpo, G. M. (1982). *Essentials of demographic analysis for Africa.* Heinemann, London,UK.

Liu, A. M. (2015). *Research methods for construction*: John Wiley & Sons.

Ministry of Health. (2006). Nepal Demographic and Health Survey 2006. In. Kathmandu, Nepal and Calverton,: New ERA and ORC Macro, DHS+, Maryland, USA.

Ministry of Health. (2011). Nepal Demographic and Health Survey 2006. In. Kathmandu, Nepal and Calverton,: New ERA and ORC Macro, DHS+, Maryland, USA.

Ministry of Health. (2016). Nepal Demographic and Health Survey 2016. In. Kathmandu, Nepal

Moultrie, T. A., Dorrington, R. E., Hill, A. G., Hill, K., Timæus, I. M., & Zaba, B. (2013). *Tools for demographic estimation*: International Union for the Scientific Study of Population.

Pressart, R. (1973). *L'analyse démographique. Concepts, méthodes, résultats* (3rd ed.) :(175), Paris, PUF.

Schmertmann, C. P., Cavenaghi, S. M., Assunção, R. M., & Potter, J. E. (2013). Bayes plus Brass: estimating total fertility for many small areas from sparse census data. *Population Studies, 67*(3), 255-273.

United Nations. (1983). *Indirect techniques for demographic estimation* (81): New York: United Nations.

Willekens, F., & Rogers, A. (1978). *Spatial population analysis: methods and computer programs.* Retrieved from http://pure:ilasa.ac.at/880.