Population Projection of Pakistan: What is there in 2028?

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ABSTRACT

Pakistan has been facing a massive population upheaval for the past three decades which needs to be tackled through a comprehensive, effective, and resourceful plan. This study aimed to build a methodology for population projection as an imperative step to address the population concerns for an inclusive socioeconomic development planning. The projections made in this study are based on three data sets of Pakistan Demographic and Health Surveys (PDHS) and Pakistan Census Reports (PCR). Cohort Component Method is employed for projecting total population and population aggregates of young, working, and old aged people, women (in childbearing age)and sex ratio, crude birth and crude death rates, and population growth for the period 1998 to 2028. The empirical results exhibited that due to continuous drop-in total fertility rate, proportion of young and old aged group would likely to reduce, whereas working age population appeared to be increased. The percentage of reproductive women is projected to be increased, whereas sex ratio, crude birth and death rates are predicted to be decreased over time. A carefully drawn population policy must be focused on awareness about family planning programs to control an immense population growth in Pakistan.

Keywords**:** Population problem, Population projection, Cohort Component Method, Population Census.

JEL Classification:J10, J11, J13, J19, O22

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1. INTRODUCTION

The word 'Population' refers to a total number of males, females, boys, and girls of various ages, residing in a distinct locality which can be a city, region, district, or country at some definite point in time. Age structure of population is usually shown with the help of graphs commonly known as population-pyramid. It consists of two back-to-back bar graphs; one bar illustrates number of males while other portrays number of females in five-year age cohorts. An extensive information could be interpreted from a population pyramid to elucidate the degree of population growth. The broad base designates large numbers of children, however; fast tightening on the way to top demonstrates smaller number of people living when age increases. The specific type of pyramid represents a population facing higher birth and death rates with small life-expectancy. This classical pattern of population pyramid illustrates less developed countries. When population projections are made, it can be easily approximated what a population will look-like at some point in future. The assumptions of drop-in infant mortality and fertility rates cause bottom few bands of projected population in 2028 comparatively equivalent. The population projection can be described as the estimated numeral of people projected to be living in future. The projection is mainly the approximation of population for upcoming days. It exemplifies reasonable course of future population variations based upon the assumptions of future births, deaths, national and international migrations. The projected statistics is based upon an anticipated population with census, and forwarded by a modification of cohort component method. At the same time, as projections and estimates may possibly come out analogous, there exist a few distinct dissimilarities between two measures. The estimates normally employ accessible data, collected from different sources, whereas projections suppose the future demographic trends. Therefore, population projections form only a reflection of plausible population trends, based on a set of assumptions regarding fertility, mortality, and life expectancy.

Population projections not only produce concern for future demographics and stimulating-strategies for progress but rejuvenate decision makers to formulate suitable policies and programs, planned to modify population growth rate and promote socioeconomic development. Population projections can also illustrate possible population growth and structural out-turns of social and economic advancement. These projections are usually used in two dissimilar categories of planning. First, preparations for different services of education, health and employment which are required for different fields in upcoming time. Secondly, proper program of family planning, provisions of contraceptive, laws on age at the time of marriage and abortions etc. Hence, population projections provide twin purpose of supporting the policy makers in preparing policies which function as a foundation for development arrangements and assisting in planning for varying the route of population trends towards the preferred direction. Population projections are also valuable for many reasons and assist stakeholders' strategies equally for near and distant future. An information about the number of people living in a country or region allows the policy makers to evaluate the requirement of new employment, educators, educational institutes, doctors, housing, foodstuff, and necessities for various resources and their allocations. In addition, population projections assist in approximating the size of future population. It also plays a significant role in elevating attentiveness of different matters among policymakers. The population projections could help to point out the influences of an increased population on the utilizations of resources and their potential risks associated with forests, or call for the reasonable housing projects to provide accommodation for the rapidly growing population. The study also provides a guideline to long term renaissance in economic research along with innovative practice while projecting population which is expected to formulate outcome more constructive. The study used latest ideas to highlight the state vagueness, going on to new-fangled methodological methods of projections, and expected future fertility rate as well as life expectancy.

Pakistan at its inception in 1947 recorded fertility as 7.50 per women with 4.50 percent per annum growth, in 1990s, both condensed to 5.10 and 2.90 respectively. Currently, 41 percent of total population belong to less than 15 years of age. Excess of young people is ready to go in their reproductive phase almost assuring sustained speedy population growth for the predictable future. The population of Pakistan is projected to 260 million by the year 2035

(UNPF[5], 2018). More than fifty years have gone now, millions of United States dollars have been used up, many resources have been worn-out but Pakistan keeps adding 4,000,000 people annually. The practice of contraceptive has gone up from 6 percent in 1969 to 18 percent in 1995 (Rosen et al., 1996) and further to 50 percent in 2018 (PDHS, 2017-18). Pakistan's population density is 169/km^2 as compared to 28/km^2 of the USA. Pakistan faces many deterring challenges nowadays, with current population of 221 million, it became world's sixth biggest nation and third largest provider of global population expansion. With the projections of the United Nations, Pakistan's population will reach to 380 million in 2050 after surpassing the United States, Brazil, Indonesia, and Russia, and get 3rd spot after India and China. By means of uppermost growth rate of population, Pakistan will indeed experience remarkable turn down in per capita accessibility of agricultural land, water, and forest resources (Samina, 2007). Abovementioned sketch revealed unsuccessful family planning program, though it was the oldest programs of the world. Changeable political encouragement is another main cause for the program failure. Recurrent change in management has added to continuous shifting strategies together with feeble execution. Population programs lack enough environmental coverage and society outreach (Rehman et al., 1994).The main aim of this study is to build a methodology and some assumptions for projecting population. A vital step to incorporate the population concerns into inclusive social and development planning of Pakistan. A few additional specific objectives are to calculate the projected population size of Pakistan using Cohort Component Method (CCM) from 1998 to 2028, using census statistics (1998) to calculate the young, working, and old aged population (65 and above), women who are in childbearing ages, sex ratio, crude birth and death rates and population growth rate, over a projected time of 1998 to 2028.This study is structured in a way as section 2 discusses different theories and usage of projection approaches related to the estimates of population. Section 3 highlights long-term projection methodology (CCM) for estimating Pakistan's population from 1998-2028. Section 4 gives the details about the key assumptions, fundamental for projecting population, baseline demographic data and trends of future fertility rate, mortality, and migration in conjunction with many other demographic formulations and

[5]United Nations Population Fund

their computations. Section 5 exhibits the projection outcomes, discussions, and comparisons among results of projected population size, age structure and distribution. Last segment provides conclusion and policy implications.

2. LITERATURE REVIEW

This section highlights different concepts and types of population projections which are very important for understating the significance of this study. Population projections are basically related with future population growth that might be set for total population of a country, geographical region or a district. A projection may be termed as projection which is preferred the most possible way to give a precise forecast about population (Shryock, 1976). It characterizes a precise point of view about the strength of underlying data and its assumptions. Based upon these projections, one can easily take perception about the causes of population changes such as what influence would a twenty percent decrease in birth rate have on population size plus age structure of a county during the next 50 years. It could also be used to give information on feasible future situations as nobody can investigate the future (Tom, 2011). Usually, population projections are taken as forecasts, therefore, never be regarded as the ultimate population. Projections often supposed to be assessed for verifying the extent to which it consents by current demographic changes. In case of differences between the projections and final events are noteworthy, it must be discovered due to the quality of input data and applied methodology (Mehta, 1994). Population projections are utilized for an extensive diversity of planning and financial statements. In various cases, projections about demographic distinctiveness are very imperative for projecting total population. Age has very imperative characteristic and is usually employed at the time of projecting births, enrolment in school, housing care for children, services of hospitals, labor force, social security, incomes and spending, and numerous additional policy related variables (Lapkoff, 1993; Fishlow, 1994; Dunton, 1994; Rives, 1994; Lee and Tuljapurkar, 1997). Smith et al. (1995) and Smith (2003) lengthened the prediction errors tests by means of age cohorts in various sub-national regions. Bongaarts et al. (1999) tried to measure fundamental involvements of fertility, mortality, migration and age structure in projections for all the countries of the world. For attaining this, they made four projection sets. First, creating a drive projection, reducing mortality was included to present a replacement projection, afterward, non-replacement fertility was included for presenting natural projection, eventually, the net immigration was integrated for creating standard projection. Sets of these four projections allowed the involvements of every constituent to be evaluated. Bouvier and Poston (1997) utilized simulations for emphasizing misleading notion of conjecture of zero net worldwide migration in population projections means no worldwide migration. Dissimilarities take place because of differentiated age reports about immigration and emigration. O'Neill et al. (1999) used projections to find-out the effect of fertility transition levels and their ultimate long-run extents on population size of existing fertility. Their work recorded that present long-standing projections entail comparatively negligible role in fertility transition. Alho (1990) stated that population projections are vague by their own characteristics. No one can recognize accurately what the size of population will be after one year from now on, in less than ten, twenty or thirty years. The precision in a projection is enhanced by building up stochastic projection models; connect clear declarations about the likelihood of population projections. An old debate in demography is whether multifaceted projection methods make more precise projection as compared to simple methods or not (Keyfitz, 1981; Long 1995; Rogers 1995; Smith and Sincich, 1992). To project the total population, it is deliberated that empirical facts are obvious; compound methods do not constantly make more exact prediction compared to simple extrapolation methods (Smithet al., 2001). Smith and Ahmed (1986) considered migration as a main determinant of population development. It is believed to be the most complex constituent of growth to predict precisely because national and local migration rates are topic to larger instability compared to fertility and mortality rates (Kulkami, 1994). As migration rates differ noticeably by age, estimated errors are expected to be bigger in favor of few age cohorts. As a rule, migration rates are comparatively higher for young children, decrease for teens, and increase to a climax for adults and turn down progressively afterward. Changes in the composition and size of population have numerous socio-economic, political, and environmental inferences.

The most widespread sub-regional projection methods of non-components include Trend Extrapolation, ARIMA[6], Comparative, Regression, Economic Base, Housing Unit, Land use allocation, APSCM[7]. Component projection methods consist of Simple Component, CCM[8], and MSIPM[9]. CCM proposed by Whelpton (1936), formalize in matrix form during the mid century (Leslie, 1945; 1948) and began to be used in country's projections via nationwide (Shaw, 2004) and worldwide statistical organizations (United Nations, 2004). Rogers and Willekens (1986) systematized its use to various nations. They differentiate models by means of extrapolation of projection drivers from models trying elucidation about projection drivers. Schoen (1988) studied equivalent efforts on the multistate model. Imhoff (1990) explained how multistate model could be classified presuming exponential instead of linear changes in demographic powers by age. Many existing projections fit into the previous class and usually do better as compared to explanatory models when comparative tests are executed (Wilson et al., 2002; van-der-Gaag et al., 2003). Smith et al. (2001) being supporters of SCM[10] disagreed that it owns theoretical benefits of fragmenting population by groups, therefore, present age specific projections need small key in data. Necessities for minimum data are two populations by means of age and sex of five years separately. Its effortlessness signifies that this could be cleanly computed in any spreadsheet, thus, somewhat inexpensive, and speedy to be executed. It is failed to model the mortality, internal migration, and external migration, individually, therefore; complex to put together the assumptions concerning how cohort change ratios may trend in future.

3. PROJECTION METHODOLOGY

Although, various methods are used to project the population of a country, a few projects total population directly, by providing the original population size and assumptions related to the future population growth rates like algebraic method, geometric projection method, and shares method.

[6] Auto-Regressive Integrated Moving Average
[7] Averaged Projections and Shortcut Cohort Method
[8] Cohort Component Method
[9] Micro Simulation And Integrated Projection Model
[10] Shortcut Cohort Method

3.1. Cohort Component Method (CCM)

Algebraic method accession of population means more parents producing children and a proportionate increase in the size of succeeding absolute increment. A constant percentage is used for the current size of population each year. It assumes that factors and conditions which produce population growth in past will have the same effects in future. Therefore, this method become less reliable when used for long term projections such as more than 10 years. Cohort Component Method (CCM) is superior to algebraic method as it involves separate analysis about changes that effects each component of population. A simple version of CCM was developed by Hamilton and Perry (1962) who entails data from two successive censuses along with sets of easy computations. CCM can project population by age groups and sex by using original age and sex structure of population in conjunction with different assumption regarding constituents of future population changes like fertility, mortality, and life expectancy[11]. The results it generates, include age and sex structure of population in addition to various summary indicators related to population size; examples of these indicators are population size, broad age group, number of births and deaths, crude birth and death rates and population change due to these birth and deaths. The main power of this method is its aptitude to project a population in simple and explicit manners. It gives projection outcome which are crucial to any planning exercise looking for future population changes. Such characteristics make this method essential for incorporating population factors into growth planning. The inputs required by CCM and output that it generates in conjunction with a series of steps involved in computing the projected population are discussed briefly. For projecting a country's population, various inputs are required.

i. Original age and sex structures.
ii. Assumptions lying on mortality which include the survival ratios by age and sex, expectations of life at birth by sex, infant mortality rates by sex and expectations of life at age five by sex.

[11] See Annex A.1 (Figure 1.1)

iii. Assumptions lying on fertility consist of fertility rates by age, total fertility rates and proportionate fertility rates by age.

CCM is employed for projecting country's population, kinds of outcome may comprise subsequent projections.

i. Age and sex structures of population.
ii. Different population aggregates comprise size of population, broad age population, size of mid-interval population, number of individuals lived (years), population growth, and number of total births and deaths.
iii. Measures of population structure contain proportions by broad age groups, percentage of women (who are reproductive or in childbearing ages) and sex ratios of population.
iv. Rates of population change due to crude birth and death rates, natural increase, and population growth.

Projections have done for the period 1998-2028 and included population projections by five years of age and sex using assumptions regarding fertility. For hypothetical population projections, it is assumed that fertility remains constant from 1998 onward. The series of population projections is launched from 1998 census which is considered as a base population for all related calculations. The projection of population by means of CCM entails a series of computational steps which reiterated for succeeding projection intervals of five years. These steps apply assumptions on demographic conditions of future for transforming age and sex structure of population for developing different measures (indicators) about the size, structures, and changes of population. These steps brought projected age and sex structures, designed to end for projection intervals through various kind of indicators relating to parallel time. A projection by CCM would be required to repeat series of steps meant for numerous projection intervals of five years. The subsequent section consists of various steps engaged in developing age and sex structure through more outcomes that can be attained in projecting national population (closed to international migration). The method entailed in projecting nationwide closed population, over a projection interval of five years (t to t+5); consisting of many steps required for developing age and sex structure of population at interval's ending. The steps could easily separate out into two sets: firstly, population structure at age five or above, and secondly population structure below ages five. The method consists of various steps for computing different population aggregates and indicators of population structure for five years' projection interval. The steps are stated below:

Step 1 utilizes the mortality assumptions for getting survival ratios via age and sex intended for five years 'interval.

Step 2 employs survival ratios to age and sex structure of population at interval's start to get the age and sex structure of population at five years of age or over at the end of interval.

Step 3 utilizes fertility assumptions for getting the fertility rates by age for five-year time interval.

Step 4 utilizes fertility rates, numbers of women who are in childbearing ages at starting and at end of the interval, along with sex ratio at birth for calculating statistics of births by sex, taking place all through interval.

Step 5 employs suitable survival ratios to numbers of births by sex for achieving age and sex structure less than five years of age at interval's ending.

Step 6 obtains different population aggregates, for example, size of population, wide age groups of population along with numbers of births and deaths.

Step7 estimates various indicators of population structure, for example, population proportions in different broad age groups in addition to sex ratio of population.

Step 8 estimates different rates of population change, crude birth rate, crude death rate and growth rate.

4. DATA SOURCES, VARIABLES DESCRIPTION AND COMPUTATION

Different sources of data are used for projecting Pakistan's population including Pakistan Census Report (1998, 2017), PDHS (1990-91, 2006-07, 2012-13 and 2017-18) and different reports of Pakistan Economic Surveys. This section also provides detailed structures along with complete descriptions about formulae and calculations used in population projection process.

4.1. Population Structure at Age Five and More

Survival Ratios (SR)

Step involved to derive age and sex structure relies on the assumptions of mortality prepared in terms of survival ratios that are life expectancy at birth.[12] These may be employed directly like inputs into the projection procedure, revealed into equations (2), (3) and (8). In case, when mortality assumptions have made, survival ratios can be computed as hereunder.

$$\mathrm{SR}\ (\mathrm{a}, \mathrm{s}) = \mathrm{T}\ [\mathrm{eb}\ (\mathrm{s})] \qquad 1$$

where;

a	Five years' age group (0-4, 5-9… 75-75+)
s	Males and females' sexes (1, 2)
$\mathrm{SR}\ (\mathrm{a}, \mathrm{s})$	Likelihood of surviving over the interval amongst people who fit in an age group (a) and sex (s) at interval's end.
T	Transformation of life expectancy at birth by sex into survival ratios
eb (s)	Life expectation at birth of both sexes stated for the interval.

For each sex, initial survival ratio achieved by transformation which is indicated in eq. (1) as if ($\mathrm{a} = 1$), signifies a possibility of survival among births taking place throughout interval and age 0-4 at its ending. Left over ratios showed survival chances among agesi.e.,0-4, 5-9…75 and 75+ at beginning and respective ages of 5-9, 10-14, 75-75+ at interval's end.

Population Aged Five and Above

Those survivors belonging to different five year of age cohorts at age five and above at ending of five-year projection intervals are estimated by employing survival ratios to several people, fitting into equivalent five-year age groups at interval's beginning.

$$\mathrm{Pop}(\mathrm{a}, \mathrm{s}, \mathrm{t} + 5) = \mathrm{Pop}(\mathrm{a} - 1, \mathrm{s}, \mathrm{t}) * \ \mathrm{sr}(\mathrm{a}, \mathrm{s}) \qquad 2$$

where,

[12] Average numbers of years a person of birth cohorts is anticipated to live,if groups be subjected to mortality condition stated through a distinctive set of age specific mortality rates.

t	Year of projected time
$\text{Pop}(a, s, t + 5)$	Population who are survivors of age cohorts (a) and sex (s) at interval's ends
$\text{Pop}(a - 1, s, t)$	Population of age cohorts (a-1) and sex (s) at interval's openings

Number of survivors who are present in an open (oldest) age cohort at ending of projection interval (five years) can be achieved by employing survival ratios to the people who fit (at interval's beginning) either to an open age group or else age group prior.

$$\text{Pop}(16, s, t + 5) = [\textstyle\sum_{a=15}^{16} \text{Pop}(a, s, t)] * \text{sr}(16, s) \qquad 3$$

By combing eq. (2) and (3), population structure at age five and over will be produced at the end of interval.

4.1.1. Population Structure below Age Five

Number of people below age 5 at ending of projection intervals (five years) contains survivors of children born throughout the interval. So, for obtaining these figures, numbers of births by sex, taking place during intervals are calculated and then multiplied everyone's numbers through appropriate survival ratios. Numbers of births are determined from fertility rates based on fertility assumptions, number of women who are in childbearing ages[13] and sex ratio[14] at birth.

Fertility Rates

The fertility assumptions are stated through Age Specific Fertility Rates (ASFR), for example, Total Fertility Rate (TFR) together with Proportionate Age Specific Fertility Rates (PASFR). If assumptions are stated in ASFR, these rates could be fitted in projection, directly, as revealed into eq. (6). When fertility assumptions are developed via summary measures, ASFR should be calculated from those measures. Therefore, if assumptions are given in TFR and PASFR, derivation of ASFR designed for specified five-year projection interval, number for extending proportionate rates through a factor which equals TFR divided by five years' projection intervals.

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[13] Age length in which women are capable to produce children, normally started from age 15 to age 49.
[14] Number of male births to every female birth, conservatively multiplied by hundred.

$$\mathrm{FR(a)} = \left(\frac{\mathrm{TFR}}{5}\right) * \mathrm{PASFR(a)} \qquad 4$$

FR(a)	Average annual fertility rate of age group (a) for an interval.
TFR	Total fertility rate specified for an interval.
PASFR(a)	Proportionate fertility rate of age group (a) for an interval.

Births

For computing the number of births which are taking place during interval by ASFR, it is required to derive number of women from different five-year age cohort at the midpoint of interval and this is done by estimating geometric mean number of women at beginning and at ending of time interval.

$$\mathrm{MPop}\ (\mathrm{a}, 2) = [(\mathrm{Pop}\ (\mathrm{a}, 2, \mathrm{t}) * \mathrm{Pop}(\mathrm{a}, 2, \mathrm{t}+5)]^{\frac{1}{2}} \qquad 5$$

where,

MPop (a, 2) Mid interval number of women of age cohort (a)

Due to ASFR and MPop of women at childbearing age, number of births occurring throughout interval as;

$$\mathrm{Births} = [5 * \textstyle\sum_{a=4}^{10} \mathrm{FR(a)} * \mathrm{MPop}\ (\mathrm{a}, 2)] \qquad 6$$

Births Number of births taking place throughout five years' interval.

So, number of births for a given five-year projection interval equals summation of outcomes of ASFR and MPop, multiplied by length of interval that is five. For computing the number of children successfully survives at interval’s end, it seems very essential that total numbers of births are separated by sex and this could be made via proportions of births of both sexes, resulting from a supposed sex ratio at birth that is105.

$$\text{Total number of Births(s)} = \mathrm{Births} * \mathrm{PBS}\ (\mathrm{s}) \qquad 7$$

$$\mathrm{PBS}\ (\mathrm{s}) = \left\{ \begin{matrix} \left(\frac{\mathrm{SRB}}{100} + \ \mathrm{SRB}\right) \mathrm{s} = 1 \\ \left(\frac{100}{100} + \ \mathrm{SRB}\right) \ \mathrm{s} = 2 \end{matrix} \right\}$$

where,

Births(s) Total number of births of both sexes (s) taking place all through the interval.

PBS (s)	Proportion of births of sex (s)
SRB	Sex ratio at birth

Population Less Than Age Five

In favor of both sexes, population aged 0-4 at interval's ending is achieved by employing survival ratios to number of births.

$$\mathrm{Pop}(1,2,t+5) = \mathrm{Births} * \mathrm{SR}(1,s) \qquad 8$$

The above step is comprehensive for deriving age and sex structure of closed population at the ending of interval.

4.1.2 Further Outcomes

After derivation regarding age and sex structure of population, it is quite possible to calculate different indicators that are helpful for planning and policy making.

Population Aggregates

Age and sex structures could possibly employ to compute different population aggregates, for instance population size and number of people in specific age intervals, young, working, old and school age population and number of reproductive women. Other aggregates can be determined which include mid interval population size and total people lived during the five-year projection interval. However, an additional collection of aggregates comprising of total births, deaths and growth of population can also be calculated.

Size of Population

Size of population can probably be attained by summing number of people projected for the ending of interval across different age cohort and sexes.

$$\mathrm{Pop}(t+5) = \sum_{a=1}^{16} . \sum_{s=1}^{2} \mathrm{Pop}(a,s,t+5) \qquad 9$$

$\mathrm{Pop}(t+5)$	Population size at interval's end

Population of Young Age

Population of young age people can be easily determined by summing up entire people under age fifteen (15).

$$\mathrm{YAP}(t+5) = \sum_{a=1}^{3}. \sum_{s=1}^{2} \mathrm{Pop}(a, s, t+5) \quad 10$$

$\mathrm{YAP}(t+5)$ Young age population at the end of interval

Population of Working Age

In general, working age population described as a population surrounded by an interval of 15-64 age cohorts and can be computed as:

$$\mathrm{WAP}(t+5) = \sum_{a=4}^{13}. \sum_{s=1}^{2} \mathrm{Pop}(a, s, t+5) \quad 11$$

$\mathrm{WAP}(t+5)$ Working age population at the ending of interval

Population of Old Age

Population of old aged group, predictably takes account of people aged sixty-five (65) and above and may be calculated;

$$\mathrm{OAP}(t+5) = \sum_{a=14}^{16}. \sum_{s=1}^{2} \mathrm{Pop}(a, s, t+5) \quad 12$$

$\mathrm{OAP}(t+5)$ Population of old age at the ending of interval

Population of School Age

Population of school age, normally defined as people inside age series of 5-24, attained by totaling up of entire population surrounded by this age interval;

$$\mathrm{SAP}(t+5) = \sum_{a=2}^{5}. \sum_{s=1}^{2} \mathrm{Pop}(a, s, t+5) \quad 13$$

$\mathrm{SAP}(t+5)$ Population of school age at interval's end

Women who are in Childbearing Ages

Number of women between 15 and 49 years described as women in childbearing or reproductive ages and can be computed by the following formula;

$$\mathrm{WCA}(t+5) = \sum_{a=4}^{10} \mathrm{Pop}(a, s, t+5) \quad 14$$

$\mathrm{WCA}(t+5)$ Number of women in childbearing ages at ending of interval.

Population Size of Mid-Interval

Population size of mid-interval can be computed by taking geometric mean of population size at starting and ending of interval.

$$\text{MIPop} = [(\text{Pop}\ (\text{t}) * \text{Pop}(\text{t}+5)]^{1/2} \qquad 15$$

MIPop Population size of mid interval

Total Number of People Lived (Years)

Total number of people lived (years), can be gained as a product of mid-interval population size and duration of five years' interval.

$$\text{TNPY} = \text{MIPop} * 5 \qquad 16$$

TNPY Total number of people who lived in years all through five years of interval.

Population Growth

Growth of population equals to a difference between population sizes at ending and starting of intervals.

$$\text{PG} = \text{Pop}(\text{t}+5) - \text{Pop}(\text{t}) \qquad 17$$

PG Population growth over a period of five years' interval.

Total Numbers of Births

Number of total births taking place throughout intervals is calculated in same manners of equation 7.

Total Numbers of Deaths

Number of deaths can be calculated by taking a difference between number of births and population growth.

$$\text{Total Deaths} = \text{Total Births} - \text{PG} \qquad 18$$

Total Deaths Number of deaths taking place all through the interval.

Different Measures of Population Structures

Proportions of Broad Age Groups

Proportions of broad age groups are computed by dividing the number of people belonging to age groups (0-14, 15-64, 65-75+) by the size of population as;

Proportion of Young Age Population

$$\text{PYAP}\,(t+5) = \frac{\text{YAP}\,(t+5)}{\text{Pop}\,(t+5)} \qquad 19$$

$\text{PYAP}\,(t+5)$ Proportion of young age (0-14) population at interval's ending

Proportion of Working Age Population

$$\text{PWAP}(t+5) = \frac{\text{WAP}\,(t+5)}{\text{Pop}\,(t+5)} \qquad 20$$

$\text{PWAP}(t+5)$ Proportion of working age (15-64) population at interval's ending

Proportion of Old Age Population

$$\text{POAP}(t+5) = \frac{\text{OAP}\,(t+5)}{\text{Pop}\,(t+5)} \qquad 21$$

$\text{POAP}(t+5)$ Proportion of old age (65-75+)population at interval's ending

Proportion of Women who are in Childbearing Ages

Proportion of women who are in childbearing ages can be calculated as a ratio of reproductive aged women to population size.

$$\text{PWCA}(t+5) = \frac{\text{WCA}\,(t+5)}{\text{Pop}\,(t+5)} \qquad 22$$

$\text{PWCA}(t+5)$ Proportion of women who are in reproductive ages at interval's ending.

Population Sex Ratio

Population sex ratio can be computed by taking a ratio of male number present in population to the existing females and then multiplied by 100.

$$\text{SRP}\,(t+5) = [(\frac{\sum_{a=1}^{16} \text{Pop}\,(a,1,t+5)}{\sum_{a=1}^{16} \text{Pop}\,(a,2,t+5)})] * 100 \qquad 23$$

$\text{SRP}\,(t+5)$ Population Sex Ratio at interval's ending

Rates of Population Change

Population projections can also help in deriving subsequent average annual rates of change in populations including crude birth and death, natural increase, and population growth.

Crude Birth Rate (CBR)

Crude birth rate is achieved after dividing average annual number of births to a mid-interval population which then multiplied by 1000.

$$CBR = \left(\frac{\frac{Births}{5}}{MIPop}\right) * 1000 \qquad 24$$

CBR Crude Birth Rate

Crude Death Rate (CDR)

Crude death rate is computed after dividing average annual number of deaths to a mid-interval population which then multiplied by 1000.

$$CDR = \left(\frac{\frac{Deaths}{5}}{MIPop}\right) * 1000 \qquad 25$$

CDR Crude Death Rate

Rate of Natural Increase

Average annual rate of natural increase can be obtained by taking a difference between crude birth rates and crude death rates.

$$NIPop = CBR - CDR \qquad 26$$

NIPop Rate of natural increase in population

Population Growth Rate

Average annual rate of population growth can be achieved by using the following formula;

$$RPG = [\ln(\frac{\frac{Pop\ (t+5)}{Pop\ (t)}}{5}] * 1000 \qquad 27$$

RPG Average Annual Growth Rate of Population

ln Natural Logarithm

5. RESULTS AND DISCUSSION

Fifth population census was held in March 1998, the recorded statistics showed that total population of Pakistan was 129,175,948, out of which 67,221,639 were males and 61,954,309 were females. The structures of age and sex of projected time intervals are depicted in Figure 1 and Figure 2. The Table A.1, Table A.2 and Table A.3(see annex) showed that Pakistan is expected to grow from a total of 247,137,420 to 344,491,140 out of which males would be 128,242,884 to 178,729,235 and females would be 118,894,540 to 165,761,910 from 2018 to 2028 (Figure 3). This means Pakistan has copious economically active human resource. Thus, for a high number of human-being, availability of natural resources, required to sustain this huge population, the quality of peoples' lives and mass poverty eradication, essentially be increased. Nevertheless, issues of scarce natural resources can also be handled by the progression in technology and human resource development in education, health, and training facilities. The results in terms of future projections of population size under assumptions are given in Table A.4 that provides projections for the next ten years with five-year intervals: future size of population through five year intervals; broad age distribution, including young, working and old age population and women who are in child bearing ages, total number of people lived (years), population growth, total number of births and deaths; proportions by broad age groups (young, working and old age; women of child bearing ages and sex ratio of population); rates of population consist of crude birth rate, crude death rate, average annual rate of natural increase and rate of population growth. Growth of population size for the projected time (1998-2028) is showed in Figure 4. Due to an ongoing reduction in total fertility rate, percentage of young, aged group (children between 0 to 14 years of age) would likely to decrease from 47.90 percent to 45.60 percent whereas working aged population seems to increase from 50.10 percent to 52.50 percent from 2018 to 2028 respectively. The young aged group is economically unproductive, and demand more for food, clothing, education, and primary medical care. They usually hinge on working population for their provisions. The working population (adult between 15-64 years of age) is considered as capital of a nation in terms of human resource because they are economically very productive. If such demographic dividend is yoked and expertise are communicated to youth for encountering internal and global market requirements, it would help in raising the productivity of domestic industries and better remittances from overseas. Therefore, Government needs to emphasize on employment generation through skill development in the country. The percentage of population aged 65 and above would decreases considerably from 2.02 percent in 2018 to 1.84 percent in 2028.

Figure 1. Total projected population by age and sex of Pakistan, 2018-2028

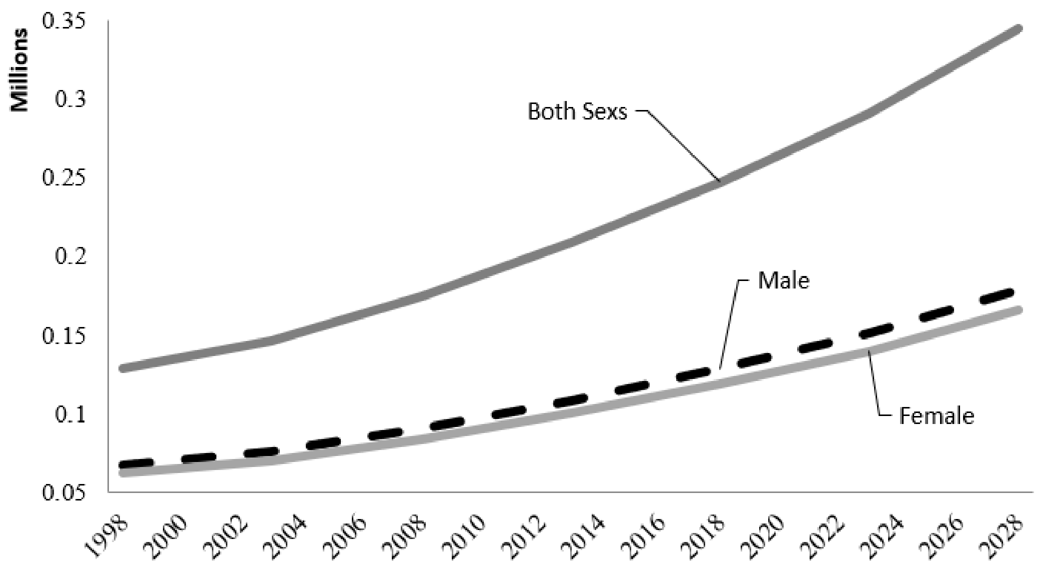


Figure 2. Age and sex structure of Pakistan's population in 1998

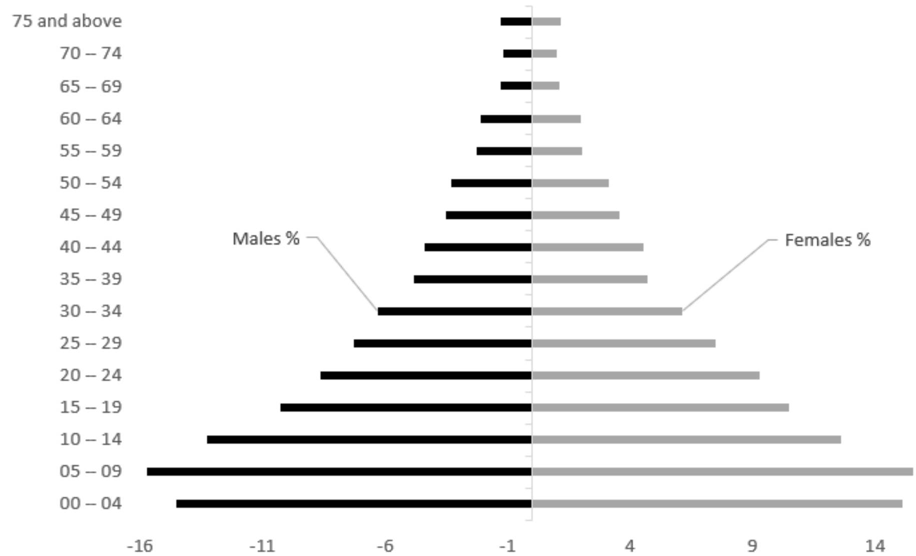
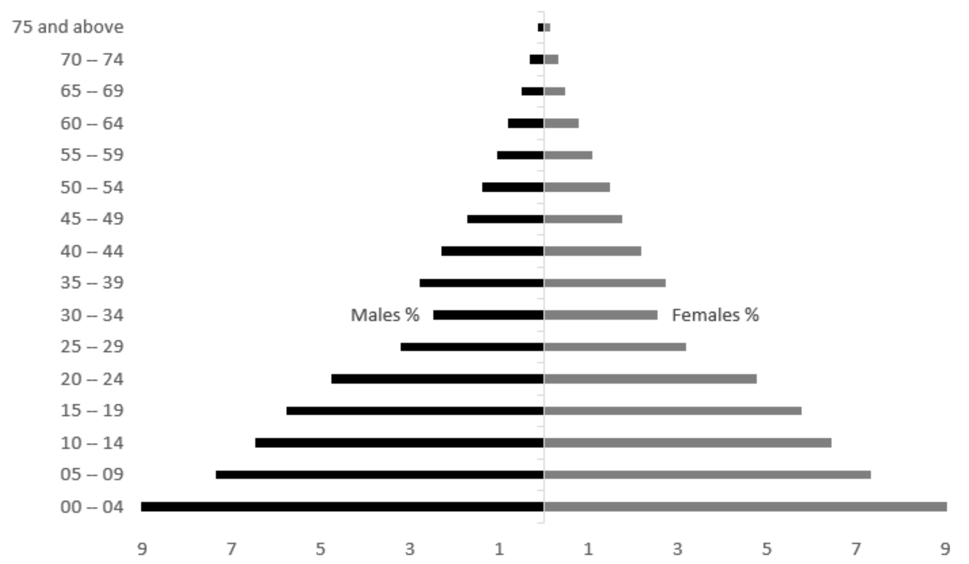


Figure 3. Projected age and sex structure of Pakistan's population in 2028



Pakistan has been facing numerous challenges since its inception including political variability, lack of economic growth, low savings of the ageing population, and a weak pension structure (turns the life of old aged people miserable). In future, the country requests to change a National health policy for the aging, which would certainly support in assimilating the old, aged population and grant them improved social security and health care facilities (Pakistan Economic Survey, 2018-19). The percentage of women belonging to childbearing ages would expect to increase from 21.10 percent (2018) to 22.10 percent (2028) whereas, sex ratio would probably decrease substantially over projected time explicitly from 107.86 (2018) to 107.82 (2028).

Figure 4. Projected population aggregates of Pakistan, 2018-2028

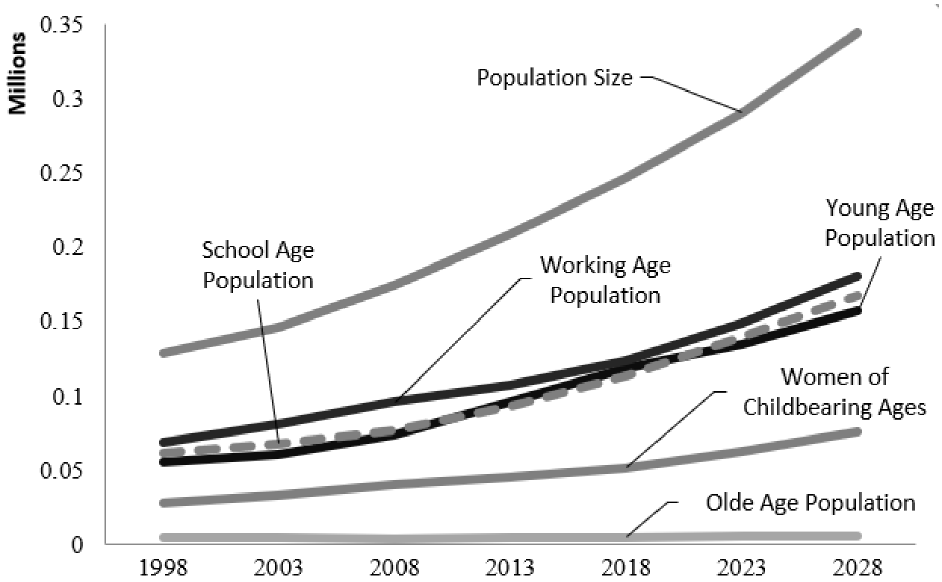
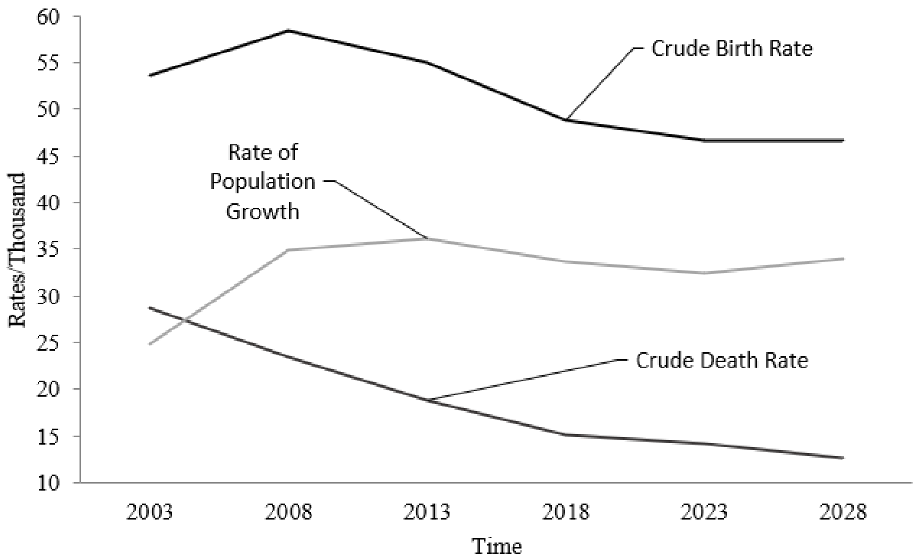


Figure 5. Projected rates of population change in Pakistan, 2018-2028



Childbearing at a very young age is related to increase hazards of pregnancy, labor, and high infant mortality. A proper usage of family controlling supports the parents to regulate not only the number of their children but a quality upbringing of them. Consequently, better access to education and job opportunities to women can give a change for more family-ties (through increased-median age of marriage from 19.50 years to 20.40 years among women aged 25-49 years) and having less children (PDHS, 2017-18). Crude birth rate and crude death rate would steadily decline from estimated levels of 48.86 and 15.11 in 2018 to 46.67 and 12.65 in 2028 respectively. Both statistics showed an educating trends on the population front. Decreasing birth and death rates (enhanced child survival rates) also indicate an improved life expectancy of people in the country. The projection directed that people may live longer due to high immunization, better health care, and prevention of epidemic diseases. The rate of natural increase equal to population growth rate in case of closed population, and this rate is projected to increase from 33.70 in 2018 to 34.00 in 2028 (Figure 5).

6. CONCLUSION AND POLICY IMPLICATIONS

The population of Pakistan is truly distressing as the projection seems to be 344,491,140 in 2028. The impact of over-population seems alarming because the country has no other option left except to address the issues as quickly as possible. Without taking corrective measures, the country would not be moving forward towards a better standard of living. Despite the efforts of the Government of Pakistan alongside with the United Nations Population Fund (UNFPA), the subject of family planning health services is considered a Taboo in Pakistan which adds insult to injury. Based on our empirical estimates, it is suggested that a women-centric population policy must be chalked-out after taking all stake holders on-board who can play their part in devising such policies targeting to control the population bomb such as the Government, UNFPA, national and International Non-Government Organizations, media, and some charismatic politico-religious leaders. An effective population policy must deal three main goals; drop-in rate and frequencies of unintended fertility, decrease in demand for bigger families, and better investment in young people to tackle massive population problem. The effective policy measures today can be a steppingstone for a better tomorrow in Pakistan.

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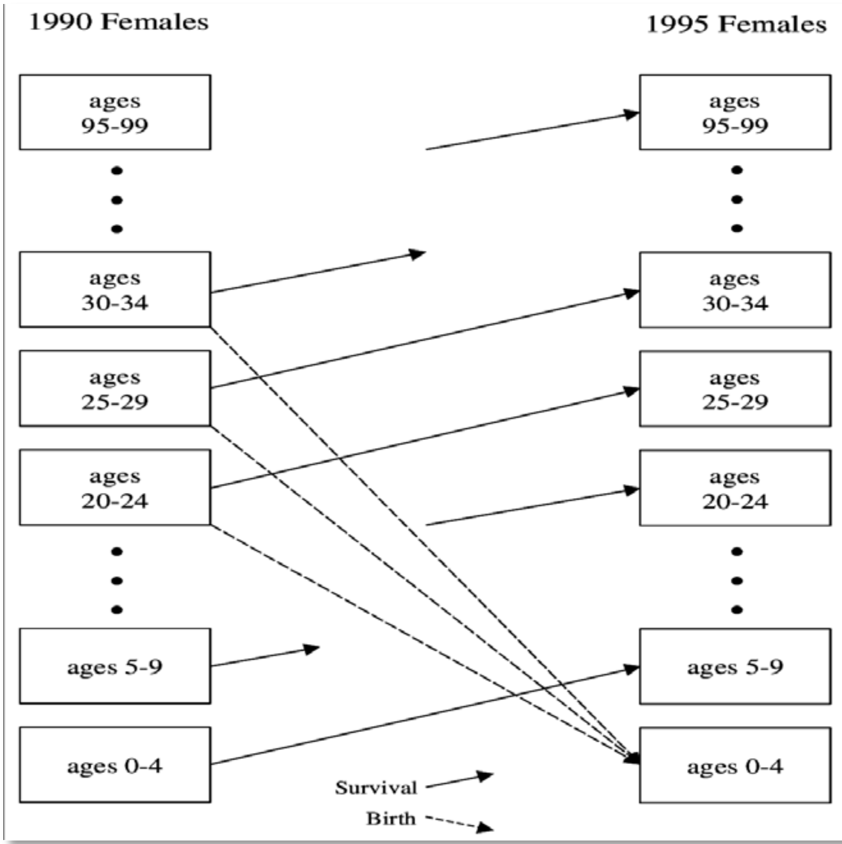
Annex A.1. A design of one-time step of Cohort Component Method (CCM) for a female population.[15]



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[15] After Cohen 1995, Figure 7.2