POPULATION AGING AND DEMOGRAPHIC TRANSITION IN KENYA

BY

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DECLARATION

This PhD thesis is my original work and has not been presented for an award of a degree in this or any other university.

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Prof. Lawrence Ikamari

DEDICATION

To my sons Joel Nabibia, Abel Nato and Noel Wekesa

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I give glory to our Almighty God for the awesome grace, provision and favour while undertaking this PhD thesis. Indeed, He saw me through all the challenges and I praise His Holy name.

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ABSTRACT

Population aging has far reaching social, economic and political consequences and has led to a number of countries responding by increasing retirement age and investing heavily in pension schemes and social welfare for the aged. Despite the enormous implications of population aging, its measurement has received little attention in Kenya. This study demonstrates population aging in Kenya as a consequence of the demographic transition. Specifically, the study projects the population of Kenya to the year 2050, establishes an implied demographic transition scenario for Kenya, and establishes trends in population aging indicators. The study uses data drawn from the Kenya population and housing census reports and selected national surveys. Linear and non-linear regression models are used to generate age specific fertility rates (ASFRs) and age specific mortality rates (ASMRs). The matrix projection method is used to project the population by varying the elements of the projection matrix after five years. Past and projected crude birth rates (CBRs) and crude death rates (CDRs) are used to illustrate demographic transition underway in the country. Similarly, the aging indicators are computed and trends established from 1969 to 2050. The study establishes that the exponential model best fits Kenya's ASFRs and ASMRs and is, therefore, used in the projection of these rates. The results show a decline in the natural rate of increase, indicating that Kenya is undergoing a demographic transition that is causing population aging. The total population is projected to increase from 42.88 million in 2015 to 72.74 million in 2050. The proportion of the population aged 65 years and above increases from 3.4 percent in 2015 to 8.1 percent in 2050, the median age increases from 19.04 years in 2015 to 27.53 years in 2050, while the aging index increases from 8.4 percent in 2015 to 29.3 percent in 2050.The study provides exponential model as an alternative to the traditional deterministic approach of obtaining TFRs and the use of Lee - Carter model for mortality projections. The study also relaxes the stability assumption by varying vital rates in the projection matrix after every five years. Additionally, the study shows prospects of population aging in Kenya. This calls for strengthening of existing programmes for the aged especially the monthly stipends, provision of universal healthcare, and pension expenditure to ensure their effectiveness and sustainability.

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List of Acronyms and Abbreviations

ASFRs	Age Specific Fertility Rates
ASMRs	Age Specific Mortality Rates
CBS	Central Bureau of Statistics – Kenya
CBRs	Crude Birth Rates
CDRs	Crude Death Rates
FF	Female Fraction
GDP	Gross Domestic Product
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome
JICA	Japan International Cooperation Agency
KCPS	Kenya Contraceptive Prevalence Survey
KDHS	Kenya Demographic and Health Surveys
KLRC	Kenya Law Reporting Council
KNBS	Kenya National Bureau of Statistics
KFS	Kenya Fertility Survey
NCPD	National Council for Population and Development
NSNP	National Safety Net Programme
OADR	Old Age Dependency Ratio
PSA	Population Situation Analysis
POADR	Prospective Old Age Dependency Ratio
RCM	Random Country Model
TFR	Total Fertility Rate
UN	United Nations
UNPD	United Nations Population Division

CHAPTER ONE

INTRODUCTION

1.1 Background

Population aging, which has emerged as a major demographic phenomenon worldwide, is the process by which older persons form a proportionately larger share of the total population of a country (United Nations [UN], 2002a; Dorson, 2005).[1] It is also a summary term for shifts in the age structure of a population toward older ages as a consequence of demographic transition (Gavrilov & Heuveline, 2003; Lisenkova, 2009).[2]

Developed countries have undergone the demographic transition while many developing countries are experiencing a significant decline in their rate of natural population increase (Kinsella & Velkott, 2001).[3] This is due to tremendous improvement in public health, sanitation, medical care, education status and general economic development that consequently increase the chances of survival of the new-born as well as life expectancy (Kinsella & Velkott, 2001).[4] During the demographic transition, fertility decline is a major contributor to the ageing of the population, while mortality decline especially in old ages accelerates the aging of the population by increasing the numbers of the aged (Hermalin, 1966; Keyfitz, 1968; Preston, Himes, & Eggers, 1989; Grigsby & Olshansky, 1989; Rowland, 2003; Miller, 2006).[5]

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[1]UN (2002a) defines older persons as the population aged 60 years and over, a definition that is consistent with the retirement age of most countries.

[2] Demographic ttransition is the gradual evolution from high birth and death rates to low birth and death rates in response to the social and economic changes brought about by industrial modernization (Caldwell, 2006).

[3] Rate of natural population increase is the excess of births over deaths per 1000 of the population or the difference between the crude birth rate and crude death rate.

[4] Life expectancy at a specific age is the average number of additional years a person of that age could expect to live if current mortality levels observed for ages above that age were to continue for the rest of that person's life. In particular, life expectancy at birth is the average number of years a new-born would live if current age specific mortality rates were to continue.

[5] The population aged is people with 65 years and above. The aged has three sub-populations commonly referred to as the young old (65 - 74 years), the old (75 - 84 years) and the oldest old (85 years and above).

The decline in fertility and mortality rates has resulted in rapid increase in the numbers and proportion of the aged in developing countries, similar to what occurred previously in most industrialized nations (Kinsella & Velkott, 2001). The United Nations Population Division (UNPD) (2011) medium variant estimates, for instance, show that the percentage of the population 60 years and above for the world was 8 percent in 1950, 11 percent in 2010 and is projected to be 22 percent in 2050. According to UNPD (2015) the elderly population of 60 years and above was 12 percent of the global population (about 901 million) in 2015. This number is projected to reach 1.4 billion by 2030 and 2.1 billion (about 21.5 percent of the global population) by 2050.

The increase in the proportion of the population aged has economic, social and political consequences (UN, 2002a). The increase, especially in developed countries, has resulted in increased cost of medicare, pensions and taxation as well as decreased labour input, which suppresses economic growth potential and puts pressure on public finances and households (Kinsella & Velkott, 2001; Oizumi, Kajiwara, & Aratame, 2006; UN, 2002a).

Furthermore, population aging increases the demand for health care, distorts family composition, living arrangements and housing, while in the political arena it influences voting patterns and representation (UN, 2002a). Most countries are currently being governed by old people (gerontocracy) as a result of their numbers and economic influence, while in countries with youthful populations, especially African countries the situation has resulted in youths demanding leadership positions (Kinsella & Velkott, 2001; Lee, Mason, & Cotler, 2010).

A number of developed countries have responded to the increase in the aged population by investing heavily in pension schemes and social welfare for the aged (Lee et al., 2010). Other countries have increased retirement age of its workers. Taxes have also been increased to raise funds to pay for pension costs. Additionally, private sector has been involved in providing pensions and health care (Pettinger, 2013). For instance, the Kenya Government increased retirement age of civil servants from 55 years to 60 years in 2009 due to budgetary constraints in paying pension (Mwendo, 2009).

The elderly population has also become a subject of legislation. In Kenya, for instance, the rights of the elderly people have been entrenched in the 2010 Constitution. Article 57(d) of the Constitution recognizes the elderly as a special interest group for protection and provides for the elderly to receive reasonable assistance from their families and the state to enable them live in dignity and respect (Kenya Law Reporting Council [KLRC], 2010; National Council for Population and Development [NCPD], 2013).[6]

In spite of the responses that have been instituted in many countries, policy makers continue to struggle with the economic, social and political challenges of population aging (Kinsella & Velkott, 2001). In Kenya, the challenges posed by population aging are compounded by inadequate information and lack of country specific data on population aging. This study, seeks to fill this gap in knowledge in Kenyan context.[7]

1.2 Problem Statement

Measurement of population aging in Kenya has received little attention despite the enormous implications it has for the economy and the fact that Kenya has been conducting population censuses since 1948. For instance, the future estimates of population aging indicators for Kenya are only those prepared by UN, which has been providing global trends of population aging indicators (Keilman, 2001; UNPD, 2011; 2015).[8] These indicators can also be computed from Kenya Population and Housing Census Reports. However, currently no aging indicators from the Kenyan census data reports have been computed. There is, therefore, a need to compute these indicators for Kenya. This study is a step in this direction.

Reliability and usefulness of projections depend on the assumptions made during their preparation and how these assumptions are close to reality (Pandey & Singh, 2015).The UN has been making deterministic projections using the cohort component method by making assumptions on fertility, mortality and migration (Preston et al., 1989; Keilman, 2001; Alkema et al., 2011). Kenya National Bureau of Statistics (KNBS), just like UNPD, has also

[6] NCPD (2013) prepared the Population Situation Analysis (PSA) Report for Kenya to document incisively the overall situation of the well being of Kenyan society, and to inform the citizens, civil society, government and wider stakeholder community of the challenges and opportunities that Kenya has with respect to population and development to support efforts towards a strong information base.

[7] The 2013 Kenya PSA Report identifies the following areas as lacking requisite data and information: migration and its determinants and consequences, maternal mortality at sub-national levels, causes of death data to determine burden of disease as well as data and information that link poverty, inequality, population and reproductive health indicators. However, the Report fails to acknowledge lack of information on the elderly population in the country.

[8]Population aging indicators include number of persons aged 60 or 65 years and above, proportion of the total population 60 or 65 years and above, proportion of persons 85 years and above, aging index, life expectancy at the age of 65, median age, old age dependency ratio and potential support ratio (UN, 2002a)

been using the cohort component method to prepare population projections for the country (Kenya National Bureau of Statistics [KNBS], 2011c). However, Keilman (2001) found that the accuracy of the UN projections is better for short than for long projection durations; is better for large than small countries and regions; projections of the old and the young tend to be less reliable than those of intermediate age groups; and there are considerable differences in accuracy between regions.

Probabilistic projections have been developed to address weaknesses of the deterministic projections. Miller (2006) developed Random Country Model (RCM), which uses the collective experience of UN member countries as the basis for projecting future demographic trends and measuring uncertainty about these trends. However, each country has a unique experience. Alkema et al. (2011) and UNPD (2015) used the Bayesian projection model to produce country specific projections of total fertility rate (TFR) for all countries based on both the country's TFR history and the pattern of all countries. The Bayesian projection model assumes that fertility will eventually fall below replacement level. Further improvements have been done by Pandey and Singh (2015) who used the Bayesian model by examining the past and futuristic trends in age specific fertility rate (ASFR) to project ASFR for each age group separately instead of TFR.

Projection of mortality has always been based on the Lee - Carter model which assumes that the time index in the model for age specific mortality (in log form) follows a random walk with drift process, the expectation of which is linear in time. Girosi and King (2007) have criticized the Lee - Carter model as producing age profiles that are less and less smooth over time no matter what trends exist in the empirical data. Consequently, Li and Chan (2007) recommend the use of a more general class of non-linear time series model for a more rigorous examination of the linear mortality index of the Lee - Carter model.

Furthermore, the assumptions that have been made by UNPD (2011) and KNBS (2011c) in preparing population projections for Kenya differ significantly. The difference can be best illustrated by the assumptions on fertility levels as fertility decline makes a major contribution to population ageing (Rowland, 2003; Miller, 2006). UNPD (2011) projections estimate that the elderly population of Kenya will reach 9 percent in 2050, with the assumption that the TFRs are 4.8 in 2010, 4.62 in 2015, 4.34 in 2020, 4.01 in 2025, 3.46 in 2030, and 2.89 in 2050. On the other hand, KNBS (2011c), which has projected the population to the year 2030, has made assumption that the TFR are 4.4 in 2010, 4.1 in 2015, 3.7 in 2020, 3.4 in 2025, and 3.2 in 2030.

The UNPD (2011) fertility estimates are higher across the period than those of the KNBS (2011c). Kenya Demographic and Health Survey (KDHS) (2015) shows that the TFR was 3.9 in 2014, which is even lower, indicating that fertility transition is taking place faster than what UNPD (2011) and KNBS (2011c) have estimated. On the other hand, Kenya has a policy objective of attaining a TFR of 2.6 by 2030 (NCPD, 2013). This is much lower than UNPD (2011) TFR estimate of 3.46 and KNBS (2011c) TFR estimate of 3.2. The varying assumptions results in different projected populations.

This study seeks to overcome the above-mentioned challenges by using non-linear models and the modified projection matrix which allows the ASFRs and age specific mortality rates (ASMRs) to be varied at specified interval in projecting the Kenyan population. The study also uses the projected population to compute the population aging indicators for Kenya.

1.3 Research Questions

The study seeks to answer the following questions:

i. What is the projected population of Kenya to the year 2050 based on modelled fertility and mortality rates?
ii. What is the implied demographic transition scenario for Kenya?
iii. What trends are formed by the population aging indicators computed from the projected population of Kenya to the year 2050?

1.4 Objectives of the Study

The general objective of the study therefore, is to demonstrate population aging in Kenya as a consequence of demographic transition. The specific objectives are:

i. To project the population of Kenya to the year 2050 based on modelled fertility and mortality rates;
ii. To establish an implied demographic transition scenario for Kenya; and
iii. To establish trends in the population aging indicators computed from projected population of Kenya to the year 2050.

1.5 Justification for the Study

This study seeks to enhance knowledge on the measurement of population aging, which has received little attention in Kenya. Modelling of ASFRs and ASMRs to obtain the best models that best fit the rates has not been undertaken in the country. This study models these rates that are then used in population projections, illustrates demographic transition for Kenya, and demonstrates population aging.

The deterministic approach of establishing fertility and mortality rates based on expert opinion is likely to result in biased estimates. This study seeks to overcome the expert biases in the projections by modelling the past fertility and mortality rates of Kenya.

Population projections are necessary for allocation and distribution of resources; advocacy, especially where there is a negative impact of a particular phenomenon on population; research to estimate the likely demographic impact of planning decisions; policy changes; and monitoring and evaluation to assess whether the country is on track in achieving national and international development targets (KNBS, 2011c). Indeed, projections are helpful in highlighting the immediate and future policy challenges for governments posed by demographic trends (European Commission, 2014). Often, each age group in a population behaves differently, with distinct economic consequences and effects of changing age structure must be factored in any analysis of economic and human development relationships (Pool & Wong, 2006; Pool, 2006; 2007).[9]

Currently, the point of focus both in terms of studies and policies is the issue of youth bulge and demographic dividend. However, the flip-side of the youth bulge, which is population ageing is often ignored. This is the case in Kenya as we have inadequate population aging indicators. This study seeks to provide the indicators and lay the foundation for further studies, especially on the implications of population aging in the country.

Kenya can no longer ignore the aged population as the rights of the elderly have been entrenched in Article 57(d) of the 2010 Constitution (KLRC, 2010). The manner in which the Kenyan Government responds to population aging challenges now would be a deciding factor in the well-being of not only the current young and elderly population, but also for future generations. This is because different policy responses and institutional settings are required

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[9] The age structure is the way in which population is distributed across different age groups at any given point in time, regularly referred to as Age-Structural Transitions (ATSs) (Pool & Wong, 2006; Pool, 2006; 2007).

to deal with the aged depending on the current and expected levels of population aging indicators (Pettinger, 2013).

Countries which are experiencing a large increase in the proportion of the aged population face the possibility of a decline in economic productivity and slower aggregate Gross Domestic Product (GDP) growth or stagnation and will be forced to undertake cost-effective reforms of their retirement and health care programmes. Such countries will also need to allocate funds to adequately support retirees, while maintaining the living standards of those families and tax payers who support them (National Intelligence Council, 2012).

1.6 Scope and Limitations of the Study

The study uses secondary data. The data is obtained from population and housing census reports of 1969, 1979, 1989, 1999 and 2009, census analytical reports on fertility and mortality, and selected national surveys. The surveys whose data are used include Kenya Fertility Survey (KFS) of 1977/78, Kenya Contraceptive Prevalence Survey (KCPS) 1984, and Kenya Demographic and Health Surveys (KDHS) of 1988, 1993, 1998, 2003, 2008 and 2014.

The fertility and mortality rates are modelled separately by exploring both linear and non-linear models under regression analysis to obtain the models that best fit each age specific rate. The modelled rates are then used in the projection of the population and in deriving the implied demographic transition scenario for Kenya.

Stable population model is applied to project the population of Kenya to the year 2050 by using the matrix projection method. In this study, the vital rates are held constant over a five-year period then varied to incorporate the expected changes instead of holding them constant for the entire period of projection.

The population aging indicators computed include; absolute numbers of the aged, proportion or percentage of the total population that is aged, median age, aging index, and life expectancy at birth, age 60, age 65 and age 80.[10] Dependency ratios and potential support ratio, which are affected by the population aging, are also computed since they help in planning.

[10] Median age of a population is that age that divides a population into two groups of the same size, such that half the total population is younger than this age, and the other half older. Aging index is calculated as the number of persons 65 years old and above per hundred persons under age 15

Population aging has many implications, especially on social welfare programmes of pension expenditure and medicare. This study does not consider these implications as they involve different methodological approach. However, the implication of monthly cash payments of KShs. 2000 to population 70 years and above under the National Safety Net Programme (NSNP) is considered.

The limitation of the study is that the modelling of the past age specific fertility and mortality rates to obtain the future rates assumes that the past trends continue to operate in the future. Additionally, projecting age specific rates separately runs the risk of distorting the age patterns of fertility and mortality. Modelling past rates ignores interventions that may be initiated by the government to influence the trends of fertility or mortality rates. In order to avoid significant variations that may occur as a result of interventions that may be made, short range projections have been undertaken to the year 2050.

The other limitation of the study is the assumption that there is zero international migration during the projection period. The percentage of international migration in Kenya in all the seven censuses taken in the country has been less than one percent, hence an insignificant factor in population change.

1.7 Organization of the Thesis

The thesis is organized in six chapters. Chapter one on the introduction to the study includes the background, problem statement, research questions, objectives of the study, justification for the study and scope and limitation.

Chapter two reviews literature in four sections. Section one presents the concepts of population aging and demographic transition. The second section reviews population projections of fertility, mortality and total population. The third section reviews indicators or measures of population aging, examples of aged populations, implications of population aging, and responses to population aging by governments. The final fourth section gives a summary of literature reviewed.

Chapter three discusses the methodology used in obtaining population projections and aging indicators. It describes the methods for generating input data for population projections; projection matrix and population projections; generating of crude birth rates (CBRs) and crude death rates (CDRs); and computing of aging indicators.

Chapter four presents projections of the input data and the projected population to the year 2050. The projections obtained are compared with the existing ones made by UN and KNBS. A summary of the projections is also presented.

Chapter five presents projected CBRs, CDRs and aging indicators. CBRs and CDRs are used to demonstrate demographic transition. Aging indicators are computed and compared with the existing ones from UN and KNBS. Additionally, implications of cash payments to the aged are given.

The final chapter six gives a summary of the study findings, conclusions and recommendations both for policy and further research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In this chapter, pertinent literature is reviewed. It is presented in four sections. The first section reviews demographic transition as a cause of population aging. The second section reviews population projections of fertility, mortality and total population. The third section reviews indicators or measures of population aging, examples of aging populations, implications of population aging, and responses to population aging by governments. The final fourth section gives a summary of the literature reviewed.

2.2 Population Aging and Demographic Transition

Population aging is the process by which older persons form a proportionately larger share of the total population of a country (UN, 2002a; Dorson, 2005). It is a summary term for shifts in the age structure of a population toward older ages as a consequence of demographic transition (Grigsby & Olshansky, 1989; Gavrilov & Heuveline, 2003; Lisenkova, 2009). Population aging is also referred to as demographic ageing and entails an increase in the percentage of the population in older ages, often taken as 65 years and over (Rowland, 2003). An increase in the population's mean or median age, a decline in the fraction of the population less than 15 years, or a rise in the fraction of the population that is elderly are all aspects of population aging **(**Weil, 2006).

Demographic transition is a process whereby demographic variables change in a systematic way from one state to another (Jones et al., 2004). It is the gradual evolution from high birth and death rates to low birth and death rates in response to the social and economic changes brought about by industrial modernization (Caldwell, 2006). Demographic transition has been the cause of population aging in developed countries, most of which underwent the transition over a long period, and in developing countries, which are rapidly going through the transition (Lisenkova, 2009). During the demographic transition, fertility decline is a major contributor to the ageing of the population as it increases percentage in older ages, while mortality decline in old ages accelerates the aging of the population by increasing the numbers of the aged (Hermalin, 1966; Keyfitz, 1968; Preston et al., 1989; Grigsby & Olshansky, 1989; Rowland, 2003).

In Africa, population aging has been occasioned by a sharp decline in the fertility rates due to socio economic development, uptake of contraceptives, and declining infant and child mortality as a result of improvement in health care systems, especially in middle income countries such as Mauritius, Tunisia, Morocco, Algeria and Egypt. However, in countries such as South Africa, Botswana, Lesotho, Zimbabwe and Swaziland, the increase of the elderly population has been attributed to the shrinking adult age cohort due to a high prevalence of HIV/AIDS (Nabalamba & Chikoko, 2011).

In Kenya, the crude birth and death rates have been on a decline as shown in Figure 2.1. However, the crude death rates have been declining faster than the crude birth rates, indicating that Kenya is in the second stage of demographic transition. NCPD (2013) recommended for acceleration of demographic transition in Kenya through decline in fertility by increasing contraceptive use and reduction in mortality, especially infant and child mortality by enhancing female school enrollment.

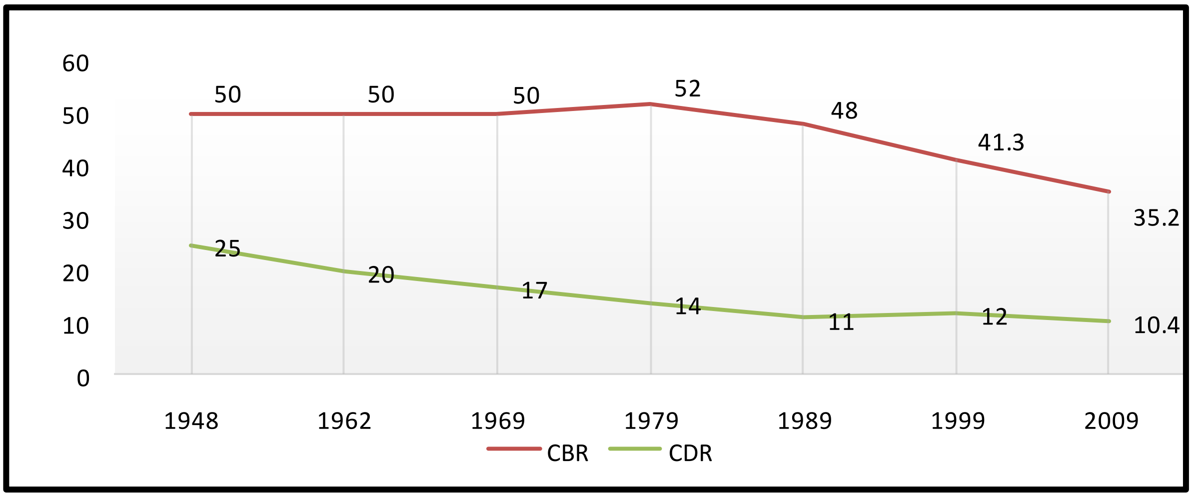


Figure 2.1: Transition of crude birth rate (CBR) and crude death rate (CDR) for Kenya

Source: Generated by the Author from CBS (1970b; 1981b; 1996a; 1996b; 2002a; 2002b) and KNBS (2011a; 2011b)

2.3 Population Projection

Population projection is an estimate of future population that entails considering changes in a population due to fertility, mortality and migration (KNBS, 2011c). The demographic trends obtained from population projections help in highlighting the immediate and future policy challenges for governments (European Commission, 2014). The population projections are also necessary for distribution of resources, advocacy, policy change, research and monitoring and evaluation to assess whether the country is on track in achieving national and international development targets (KNBS, 2011c). Different methods are used in the projection of fertility and mortality which are discussed below.

2.3.1 Fertility Projections

Projected levels of fertility have important implications for the age structure of future populations, including the pace of population aging (Alkema et al., 2011). The UN produces deterministic total fertility rate (TFR) projections. It then decomposes the projected TFR into ASFRs using fertility schedules. These are finally combined with projections of mortality and international migration using the cohort-component projection method (Alkema et al., 2011). Such deterministic projections are based on expert opinion, which is often biased, about the likely future course of mortality, fertility and immigration (Miller, 2006). Experts using deterministic projections have consistently overstated future mortality rates, resulting in underestimation of the elderly population. They also forecast high fertility when the recent past fertility rates are high and low fertility when the recent past fertility rates are low (Miller, 2006).

Improvement on the deterministic approach has been made by Miller (2006) who developed the Random Country Model (RCM). The RCM model uses the collective experience of UN member countries as the basis for projecting future demographic trends and measuring uncertainty about these trends. The model stresses the shared experience of countries and purposively attempts to restrict expert knowledge about the country being forecast.

Further improvement has been made by Alkema et al. (2011) who used the Bayesian projection model to produce country specific projections of TFR for all countries and decomposed the evolution of the TFR into three phases: pre-transition high fertility, the fertility transition and post-transition low fertility. It is used to project future TFR based on both the country's TFR history and the pattern of all countries. The Bayesian model was extended by Fosdick and Raftery (2014) to allow for probabilistic projection of aggregate TFR for any set of countries by modelling the correlation between country forecast errors as a linear function of time invariant covariates.

The recent strategy in the projections of fertility has focused on ASFR instead of TFR. Pandey and Singh (2015) examined the past and futuristic trends in ASFR of Uttar Pradesh, a state of India and used the Gompertz model in the Bayesian framework to project ASFRs for each age group separately.

2.3.2 Mortality Projections

The current gold standard of mortality trend fitting and projection is the Lee - Carter model (Li & Chan, 2007). The model assumes that the dynamic of mortality trends over time is only determined by a single parameter, the mortality index, which is extrapolated through the selection of an appropriate time series model (Lee & Carter, 1992).

The Lee - Carter model essentially describes the logarithmically transformed age-specific rate of death $(m_{x,t})$ as a sum of an age-specific component that is independent of time (a_x), and the product of a time varying parameter (k_t), the mortality index, that summarizes the general level of mortality and an additional age specific component (b_x) that represents the rate of change of mortality index. The mathematical representation of the model is given below.

$$ln(m_{x,t}) = a_x + b_x k_t + \mathcal{E}_{x,t}$$

The final term, $\mathcal{E}_{x,t}$, is the error term, which reflects the age specific influences not captured by k_t (Li & Chan, 2007).

The appeal of the Lee - Carter model is the long-term linearity of its time series component, the mortality index, k_t (Li & Chan, 2007). However, Girosi and King (2007) have criticized the Lee - Carter model. They claim that the model ignores all but the first and last data points, thereby producing age profiles that are less and less smooth over time no matter what trends exist in the empirical data, and eventually deviate from any given baseline.

Lee and Carter developed their approach specifically for U.S. mortality data, 1933-1987. The key recognition by Lee and Carter is that U.S. national log mortality data have, with few exceptions, followed a fairly linear age path over recent history. Different age groups are, also, highly correlated over time. The method is now being applied to all cause and cause specific mortality data from many countries and time periods, all well beyond the applications for which it was designed (Girosi & King, 2007).

Li and Chan (2007) performed a systematic outlier analysis of the mortality index built in the Lee- Carter model using the United States and Canada mortality data. They found that linearity holds despite the detection of outliers in the mortality levels caused by pandemics and wars. However, they recommend for the use of a more general class of non-linear time series model for a more rigorous examination of the mortality index, k_t in future mortality analysis.

2.3.3 Stable Population Model

A stable population is formed when the age-specific fertility rates and age-specific death rates remain constant for a long period of time and the population experiences no gains or losses through migration (Keyfitz, 1968a; Miur, 2002). The stable population model was developed by Alfred Lokta in 1922 who considered the special case in which the age-specific vital rates of fertility and mortality are constant year after year (Keyfitz, 1968b).

The limitation of the stable population is that it is unrealistic to hold the vital rates constant as birth and death rates tend to fall over time (Lisenkova, 2009). However, the theoretical relationships between fertility, mortality and age structure in stable populations contribute to understanding the growth and structure of historical populations, and can be used to make demographic estimates when empirical data are incomplete or of poor quality (Keyfitz, 1985).

UNPD has been applying the stable population model to make population projections (Keilman, 2001). Many countries and scholars have equally applied the stable population model to make population projections (Bernardelli, 1941; Leslie, 1945; Euler, 1960; Keyfitz, 1968a; Wekesa, 1989; Rafig, 1992; CBS, 2002c; Bwila, 2004).

2.3.4 Cohort Component and Matrix Projection Methods

Cohort component method is the most widely used method for population projections (Wekesa, 1989; Rafig, 1992; UN, 2002a; 2010; CBS, 2002c; KNBS, 2011c). The method is based on the stable population model. However, the method does not necessarily assume constant rates for survival and fertility, nor net migration numbers (Preston, Hauveline, & Guillot, 2001).

The disadvantage of using the cohort component method is that it is highly dependent on reliable birth, death and migration data and assumes that survival rates, birth rates and estimates of net migration will remain the same throughout the projection period (Goldstein & Stecklov, 2002).

Various assumptions on the growth rate are also made, which are high, medium and low rates in anticipation of future changes, which give wide disparities (Miur, 2002). The accuracy for the projections has also been in question, especially for the UN projections. Keilman (2001) found that the accuracy of the UN projections is better for short than for long projection durations; is better for large than small countries and regions; projections of the old and the young tend to be less reliable than those of intermediate age groups and they are considerable differences in accuracy between regions.

The specification of the pattern and path of age-specific rates is also complicated, resulting in projections that are hard to replicate without access to proprietary computer software used by the team that prepared the projections (Goldstein & Stecklov, 2002).

Matrix projection method is a specific notation for the expression of Cohort component method (Preston, Hauveline, & Guillot, 2001). The matrix projection method has been widely used in demography (Bernardelli, 1941; Leslie, 1945; Euler, 1960; Keyfitz, 1968a; Caswell, 2001; Preston, Hauveline, & Guillot, 2001; Bwila, 2004; Picard & Liang, 2014). Matrix population models were introduced in the 1940s by Bernardelli (1941), Lewis (1942), and especially Leslie (1945 and 1948) who developed the use of matrices fully. Matrix models were largely neglected until the mid-1960s, when both ecologists and human demographers rediscovered them (Keyfitz & Caswell, 2005).

Keyfitz (1968a) simplified the projection matrix. For the second row onwards, it contains non-zero elements only in the sub-diagonal, which are the probabilities of passage from one age group to the next. The first row contains combinations of probabilities of fertility at different ages and of survival for infants born in the projection interval. Over time, the projection matrix has been improved by using the probability of surviving instead of zero as the last element in the final, open-ended age group (Caswell, 2001; Preston et al., 2001; Picard & Liang, 2014). The limitation of the matrix projection method is that it assumes zero migration during the projection period.

2.4 Measurement of Population Aging

There is no single demographic measure that qualifies as the best measure of population aging (Grigsby & Olshansky, 1989). There are several demographic indices of population aging. These include: number of persons aged 65 years and above, proportion of the total population aged 65 years and above, proportion of persons aged 85 years and above, aging index, life expectancy at the age of 65, median age, old-age dependency ratio (OADR), and potential support ratio (UN, 2002a).[11]

In many countries, population aging is measured by an increase in percentage of either people reaching 60 years of age or elderly people of retirement age, which may be aged 60 or aged 65 (UNPD, 2011). The percentages are important because of their bearing on the question of dependency, sometimes measured as the ratio of the elderly to other adults or the ratio of pensioners to taxpayers (Rowland, 2003). The numbers of the older people are also important in the demographic study of the aged, because major concerns arise from how many will require support in terms of pension, housing, health and welfare services (Rowland, 2003).

The median age is often used as a basis for describing a population as young or old or as aging. Population with median less than 20 years is described as young, 20 years to 29 years as intermediate, while 30 years or over as old (Hobbs, 2004). The median age has an intuitive appeal for summarising the age structure and is used to compare age structures of two or more populations. It also allows measurement of population aging without having to define what age is old (Grigsby & Olshansky, 1989).

Shryock and Siegel (1980) suggest that aging index, also referred to as the aged-to-youth ratio, may be the best measure of population aging because this measure includes two sub-groups which change the most during the demographic transition, that is the population aged less than 15 years and 65 years and above.

Cuaresma (2014) states that the most commonly used aging indicator is OADR as it has important implications for the solvency of social security systems, including pensions and public health, as well as for the demand of private transfers from working age population to older family members. The inverse of the OADR is the potential support ratio. The ratio describes the burden placed on the working population by the non-working aged population.

However, Sanderson and Scherbov (2005; 2008; 2010) argue that OADR compares the same chronological age across periods, maintaining the hypothesis that a person aged 65 today has the same characteristic as a person aged 65, say 50 years ago. They opine that OADR ignores the role played by increase in life expectancy in the global aging process and propose the use

[11]Old-age dependency ratio (OADR) is usually defined as the ratio of the number of people 65 years and older to the number of people in the working age groups of 15 to 64 years, while potential support ratio is the number of persons aged 15 to 64 per every person aged 65 or older.

of prospective old age dependency ratio (POADR), which takes into account the remaining lifetime (prospective age) instead of chronological age.[12] Nevertheless, POADR has been criticized by Bloom et al. (2010) who argue that despite the increase in life expectancy, people generally do not work to later ages and if they do, they are less productive.

Grigsby and Olshansky (1989) examined the dependency ratio as a useful indicator for policy purposes but not as an indicator of population aging.[13] They argue that dependency ratio is only affected by population aging and that since age is not a perfect indicator of economic activity, the dependency ratio tends to perpetuate the negative stereotype that persons over age 65 are dependent on persons aged 15 to 64.

2.4.1 Aging Populations

The world population has been aging over time as illustrated by the elderly population, population 60 years and above. UNPD (2011) estimates show that the percentage of the elderly population for the world was 8 percent in 1950 and 11 percent in 2010. The latest estimates by UNPD (2015) show that the same population was 12.3 percent in 2015 and is projected to be 16.5 percent in 2030 and 21.5 percent in 2050.

The percentage of the elderly population in the world has been increasing except in Africa which remained constant at 5 percent between 1950 and 2010 (UNPD, 2011). However, it increased to 5.4 percent in 2015 and is projected to increase to 6.3 percent in 2030 and 8.9 percent in 2050 (UNPD, 2015). The same population in Asia was 7 percent in 1950 and 10 percent in 2010 (UNPD, 2011). Asian elderly population increased to 11.6 percent in 2015 and is projected to be 17.2 percent in 2030 and 24.6 percent in 2050. On the other hand, Europe elderly population was 12 percent in 1950 and 22 percent in 2010 (UNPD, 2011). European elderly population increased to 23.9 percent in 2015 and is projected to increase to 29.6 percent in 2030 and 34.2 percent in 2050 (UNPD, 2015).

UNPD (2015) identifies Japan as the country with the most elderly population in the world with 33 percent in 2015. Japan is followed by Germany (28 percent), Italy (28 percent) and Finland (27 percent). Japan's elderly population is projected to reach 37.3 percent in 2030 and 42.5 percent in 2050.

[12]The prospective old age dependency ratio (POADR) is defined as the ratio of the population whose age is such that the remaining life expectancy is 15 years or less (the old-age threshold) to the number of people of age 20 to that old-age threshold.

[13] Dependency ratio is the ratio of the number of people below 15 years and 65 and above to the number of people in the working age groups of 15 to 64 years.

The elderly populations of the most populous countries of the world, China and India, are also projected to increase. China had an elderly population of 15.2 percent in 2015 and is projected to be 25.3 percent in 2030 and 36.5 percent in 2050 (UNPD, 2015). India had an elderly population of 8.9 percent in 2015 and is projected to be 12.5 percent in 2030 and 19.4 percent in 2050 (UNPD, 2015). Translating these percentages into numbers yields huge elderly populations due to the populous nature of these countries.

In Africa, the most aged country in 2015 was Mauritius with an elderly population of 14.7 percent and is projected to have 23.3 percent in 2030 and 30.6 percent in 2050. It is followed by Tunisia with 11.7 percent in 2015 and is projected to be 17.7 percent in 2030 and 26.5 percent in 2050 (UNPD, 2015). For Kenya, the elderly population was 6 percent in 1950, decreased to 4 percent in 2010 (UNPD, 2011). It was 4.5 percent in 2015 and is projected to be 5.5 percent in 2030 and 9.6 percent in 2050 (UNPD, 2015).

Life expectancy at birth has also been increasing over the years and this is an indication of population aging. UNPD (2015) shows that in 1995 life expectancy at birth, both sexes combined, for the world was 64.5 years, while 57.3 years for Kenya. By 2010, life expectancy at birth had increased to 68.8 years for the world, while for Kenya decreased slightly to 56.5 years. In 2015, life expectancy for the world was 70.5 years, while for Kenya was 60.6 years (UNPD, 2015). Life expectancy at birth for the world is projected to be 71.7 years in 2020, 73.7 years in 2030 and 77.1 years in 2050, while for Kenya to be 63.3 years in 2020, 66.0 years in 2030 and 71.7 years in 2050 (UNPD, 2015).

2.4.2 Implications of Population Aging

Clark and Spengler (1980) state that the problem with population aging is provision of adequate economic security for the aged. On the other hand, Oizumi et al. (2006) argues that population aging suppresses growth potential through a decreased labour input, lowered domestic savings, and puts pressure on public finances and households as a result of increase in medical expenses and expansion of pension burden.

American National Intelligence Council (2012) argues that countries which are experiencing a large increase in the proportion of the aged face the possibility of a decline in economic productivity and slower aggregate GDP growth or stagnation. Cipriani (2013) states that population aging, as a result of fertility decline and longevity, undermines the solvency of the pay-as-you-go pension system by increasing the capital labour ratio thereby increasing output per capita and pension pay-outs. Pettinger (2013) summaries the impact of population aging as increase in dependency ratio, increased government spending on health care and pensions, increased taxes for those working, shortage of workers, bigger market for goods and services linked to older people, and reduced capital investment due to higher savings for pensions.

Walker (1990) argues that the growing concern of policy makers, particularly in the United States and the United Kingdom, over the implications of demographic aging have been exaggerated by an ideological dislike of public expenditure on pensions and health care in general, which may also exacerbate intergenerational conflict if it is used as a basis for the development of social policy. Bloom et al. (2011), however, give some hope that population aging poses challenges that are formidable but not insurmountable. They note that various behavioural responses can mitigate these age structure effects.

In Kenya, extended family within which the needs of the elderly are usually met is slowly disintegrating, despite most elderly persons living with family members (Kithinji, 1988; Waweru, 2002; Omoke, 2008; NCPD, 2013). Elderly persons in Kenya suffer from various health problems but are unable to afford medicare, even to those who receive pension due to meagre amounts (Kithinji, 1988; Waweru, 2002; NCPD, 2013). Consequently, NCPD (2013) considers the elderly in Kenya as a vulnerable group that needs to be taken care of.

2.4.3 Responses to Population Aging by Governments

Sustained growth of the elderly populations poses myriad challenges to policy makers in many societies (Kinsella & Velkott, 2001). These challenges have led to creation of various instruments to address them at international, regional and national levels.

The first international instrument that guides the thinking and formulation of policies on ageing is the Vienna International Plan of Action on Ageing of 1982. It was adopted by the first World Assembly on Aging held in Vienna, Austria from 26 July to 6 August 1982. It aims to strengthen the capacities of governments and civil society to deal effectively with the ageing of populations and to address the developmental potential and dependency needs of older persons, besides promoting regional and international cooperation (UN, 1983a). However, population ageing at this point in time was mostly a concern of developed countries.

The Madrid International Plan of Action on Ageing (MIPAA) of 2002 is the second international instrument on ageing which was adopted during the second World Assembly on

Ageing held in April 2002 in Madrid, Spain. MIPAA marks the turning point in how the world addresses the key challenge of building a society for all ages, with the main objective of promoting a developmental approach to population ageing through mainstreaming of older persons into international and national development plans and policies across all sectors (UN, 2002b). It focuses on three priority areas: older persons and development; advancing health and well-being into old age; and ensuring enabling and supportive environments (UN, 2002b).

After the adoption of the MIPAA, the African Union in the same year, in July 2002, came up with African Union Policy Framework and Plan of Action on Ageing, 2002. The policy framework require the member states to recognize the fundamental rights of older persons and commit themselves to abolish all forms of discrimination based on age; and undertake to ensure that the rights of older persons are protected by appropriate legislation (HelpAge International & African Union, 2003). As a follow-up to the African Union 2002 Action Plan on Ageing, the twenty sixth ordinary session of the African Union assembly was held in Addis Ababa, Ethiopia, in 2016 and adopted the Protocol to the African Charter on Human and Peoples' Rights on the Rights of Older Persons in Africa. The Protocol calls for the implementation of the tenets of various international declarations, conventions and instruments that deal with the issues of ageing (African Union, 2016).

Kenya has since domesticated the United Nations and African Union instruments on ageing. Parliament in February 2009 enacted the National Policy on Older Persons and Ageing to provide a comprehensive framework for guiding issues of older persons and ageing in development processes, programmes and also to inform other sectoral policies (Ministry of Gender, Children and Social Development, 2009). In 2010, the rights of the elderly were entrenched in Kenya's 2010 Constitution. Article 57(d) of the Constitution recognizes the elderly as a special interest group for protection and provides for the elderly to receive reasonable assistance from their family and the state to enable them live in dignity and respect (KLRC, 2010; NCPD, 2013). In January 2014, the Policy on Older Persons was reviewed and aligned with the 2010 Constitution through a consultative process in conformity with the Constitutional requirement. The policy provides a comprehensive framework to address the unique challenges that older persons in Kenya face, and recognition of their rights, as distinct right holders and participants as per Article 57 of the Constitution (Ministry of Labour, Social Security and Services, 2014).

Among the policy direction that Kenya has taken to address population aging in the country include the increase in retirement age of civil servants from 55 years to 60 years due to budgetary constraints in paying their pension (Mwendo, 2009). This was done in the year 2009. Equally, the current non-contributory civil service pension schemes are being converted to contributory retirement schemes (Chirchir, 2010; Kipanga, Were, & Toroitich, 2013). The Government initiated a welfare programme from July 2012 to pay the aged poor a monthly stipend of KShs.2,000 across the country (National Gender and Equality Commission, 2014). The programme has since been enhanced under the National Safety Net Programme (NSNP) to pay monthly stipend as non-contributory social pension to registered persons 70 years and above (Igadwah, 2018).

2.5 Summary of Literature Reviewed

Population aging is a summary term for the shifts in the age structure of a population towards older ages (Grigsby & Olshansky, 1989). It is a consequence of demographic transition where fertility and mortality rates decline in response to social and economic changes (Lisenkova, 2009). Eventually, life expectation of the population increases, resulting in more numbers and proportions of the older ages of the population (Kinsella & Velkott, 2001).

The commonly used measure/indicator of population aging is the proportion or percentage of the total population aged 60 and above (or 65 and above) (UNPD, 2011). Other measures are; absolute numbers of the aged, median age and aging index. Dependency ratio and potential support ratio, which are affected by population aging, are also calculated to help in planning purposes (Grigsby & Olshansky, 1989).

Measures of population aging in most countries are based on the UN projections. However, the UN projections of the old and the young tend to be less reliable than those of intermediate age groups (Keilman, 2001). The UN uses the deterministic approach in projecting TFRs, which are then decomposed into ASFRs using fertility schedules. They are finally combined with the age - specific projections of mortality and international migration using the cohort component projection method to yield the medium variant population projections (Alkema et al., 2011).

Deterministic projections are based on expert opinion, which is often biased about the likely future course of mortality, fertility and immigration (Miller, 2006). Probabilistic projections have been developed to address expert biases, especially the Bayesian models (Miller, 2006;

Alkema et al., 2011). Modelling of age specific fertility and mortality rates has also been suggested to overcome the deterministic biases as well as the use of nonlinear time series models (Lee & Carter, 1992; Li & Chan, 2007, Pandey & Singh, 2015). This study models ASFRs and ASMRs for Kenya and establishes the model that best fits the rates.

The stable population model is mostly applied in making population projections, especially the use of cohort component method (Preston et al., 1989; Keilman, 2001; Alkema et al., 2011). However, it is unrealistic to hold the vital rates constant as birth and death rates tend to fall over time and cohort component method is complicated as it involves many assumptions which make it difficult to replicate (Goldstein & Stecklov, 2002; Lisenkova, 2009). The use of matrix projection is preferred in this study as it allows the projection matrix to be replicated with variation in the vital rates (Keyfitz & Caswell, 2005).

Population aging has implication on all facets of human life including; economic, social, cultural and political (UN, 2002a). It suppresses growth potential through decreased labour input, lowered domestic savings, increased medical expenses and expansion of pension burden (Oizumi et al., 2006). Various protocols, policies and programmes on older persons at international, regional and national levels have been developed to address the challenges. Governments have mainly responded by increasing retirement age and taxes, heavy investment in pension schemes and social welfare for the aged (Lee et al., 2010; Pettinger, 2013).

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter presents the methodology used in order to achieve the objectives of the study, i.e. obtaining population projections and aging indicators. It discusses the quality of data used and the methods for generating input data for population projections. It further describes how the projection matrix is used to make the population projections; methods of generating CBRs and CDRs; and computation of aging indicators.

3.2 Methods of Generating Input Data for Population Projections

The input data required for population projections are the ASFRs, ASMRs and the base population. The ASFRs and ASMRs are generated by modelling of the past rates.

3.2.1 Modelling of ASFRs

ASFR is conventionally defined as the number of live births per 1000 women in a specific age group per year. The data required for modelling of ASFRs are the past ASFRs. The data was obtained from population and housing census analytic reports on fertility and national surveys, namely; the KFS of 1977/78, KCPS of 1984, and KDHS of 1988, 1993, 1998, 2003, 2008 and 2014.

3.2.1.1 Quality of ASFR data from Census Reports

Seven censuses have been undertaken in Kenya, two in pre-independence Kenya in 1948 and 1962 and five post-independences in 1969, 1979, 1989, 1999 and 2009. However, censuses of the non-African population had been held earlier in 1921, 1926, and 1931 in which no count for Africans was made (CBS, 1970a).

Fertility has been measured in different ways throughout the history of census taking in Kenya. Fertility data was not collected in 1948. The 1962 and 1969 censuses used probability samples of 10 percent to collect data on fertility on women, while 1979, 1989, 1999 and 2009 censuses included complete enumeration on fertility (KNBS, 2011a).

Kenyan censuses, just like those of other developing countries, suffer from both content and coverage errors in spite of efforts to collect complete and accurate data on fertility (CBS, 1996a). Content errors result from younger women over reporting live births, older women under reporting live births, age misreporting and wrong dating of births and marital status. On the other hand, coverage errors emanate from double counting, omission of enumeration area units or population sub-groups (CBS, 1970b; 1981b; 1996a; 2002a; KNBS, 2011a).

Consequently, CBS and KNBS have been correcting and adjusting the reported fertility data using various methods. Brass method was used to obtain fertility estimates for 1969 and 1979 censuses by comparing cumulated current fertility with average parity (CBS, 1970b; 1981b). Equally, El-Badry method was used to correct the average parities and fitted with Relational Gompertz Fertility Model for the 1989, 1999, and 2009 censuses fertility data (CBS, 1996a; 2002a; KNBS, 2011a). Published ASFRs for Kenya from census data is given in Table 3.1.

Table 3.1: ASFRs from Census Data (1969 – 2009)

Age Group	**YEAR**				
	1969	**1979**	**1989**	**1999**	**2009**
15 -19	0.132	0.182	0.160	0.145	0.085
20 - 24	0.331	0.368	0.334	0.254	0.230
25 - 29	0.337	0.372	0.322	0.236	0.243
30 - 34	0.294	0.311	0.251	0.185	0.200
35 - 39	0.223	0.226	0.167	0.127	0.133
40 - 44	0.135	0.105	0.069	0.056	0.057
45 - 49	0.068	0.014	0.008	0.007	0.012
TFR	**7.600**	**7.890**	**6.559**	**5.050**	**4.800**

Source: CBS (1970b; 1981b; 1996a; 2002a) and KNBS (2011a)

3.2.1.2 Quality of ASFR data from Selected National Surveys

The national surveys whose ASFR data is used are the KFS of 1977/78, KCPS of 1984, and KDHS of 1988, 1993, 1998, 2003, 2008 and 2014. One of the objectives of KDHS is to provide reliable estimates of fertility levels. This is done using representative sample of women aged 15 - 49 and men aged 15 - 54 in selected households. Northern part of the country was excluded from 1978 to 1998 surveys due to challenges in accessibility and insecurity. However, the surveys conducted since 2003 have included all the areas of the country. The ASFRs are shown in Table 3.2.

Table 3.2: ASFRs from Selected National Surveys (1978 - 2014)

Age Group	**1978** KFS	**1984** KCPS	**1988** KDHS	**1993** KDHS	**1998** KDHS	**2003** KDHS	**2008** KDHS	**2014** KDHS
15 – 19	0.168	0.143	0.152	0.110	0.111	0.114	0.103	0.096
20 – 24	0.342	0.358	0.314	0.257	0.248	0.243	0.238	0.206
25 – 29	0.357	0.338	0.303	0.241	0.218	0.231	0.216	0.183
30 – 34	0.293	0.291	0.255	0.197	0.188	0.196	0.175	0.148
35 – 39	0.239	0.233	0.183	0.154	0.109	0.123	0.118	0.100
40 – 44	0.145	0.109	0.099	0.070	0.051	0.055	0.050	0.038
45 – 49	0.059	0.066	0.035	0.050	0.016	0.015	0.012	0.009
TFR	**8.015**	**7.690**	**6.705**	**5.395**	**4.705**	**4.885**	**4.560**	**3.900**

Source: CBS (1984) and KNBS (2010; 2015)

ASFRs from census data in Table 3.1 and national surveys in Table 3.2 have been combined in Table 3.3.

Table 3.3: ASFRs from both Census Data and National Surveys

Age	YEAR												
Group	**1969**	**1978**	**1979**	**1984**	**1988**	**1989**	**1993**	**1998**	**1999**	**2003**	**2008**	**2009**	**2014**
15 -19	0.132	0.168	0.182	0.143	0.152	0.160	0.110	0.111	0.145	0.114	0.103	0.085	0.096
20 - 24	0.331	0.342	0.368	0.358	0.314	0.334	0.257	0.248	0.254	0.243	0.238	0.230	0.206
25 - 29	0.337	0.357	0.372	0.338	0.303	0.322	0.241	0.218	0.236	0.231	0.216	0.243	0.183
30 - 34	0.294	0.293	0.311	0.291	0.255	0.251	0.197	0.188	0.185	0.196	0.175	0.200	0.148
35 - 39	0.223	0.239	0.226	0.233	0.183	0.167	0.154	0.109	0.127	0.123	0.118	0.133	0.100
40 - 44	0.135	0.145	0.105	0.109	0.099	0.069	0.070	0.051	0.056	0.055	0.050	0.057	0.038
45 - 49	0.068	0.059	0.014	0.066	0.035	0.008	0.050	0.016	0.007	0.015	0.012	0.012	0.009
TFR	**7.600**	**8.015**	**7.890**	**7.690**	**6.705**	**6.555**	**5.395**	**4.705**	**5.050**	**4.885**	**4.560**	**4.800**	**3.900**

Source: Table 3.1 and Table 3.2

3.2.1.3 Method of Modelling ASFRs

Modelling of ASFRs borrows from the work of Pandey and Singh (2015) that used the past trends in ASFRs to project the future ASFRs for each age group separately for the Uttar Pradesh state in India. However, excel based extrapolation are used in the modelling of ASFRs. Data from Table 3.1, Table 3.2 and Table 3.3 are tabulated separately in an excel spread sheet for each of the seven reproductive age groups of women: 15-19, 20-24, 25-29, 30-34, 35-39, 40-44 and 45-49. Single year scale from 1969 to 2050 is used. Scatter chart is selected by using the insert option in the excel spread sheet. Scatter with smooth lines and markers, and the design layout with grid plot area and trendline is picked. The default option of the trendline is linear. The trendline is formatted by right clicking on the trendline, which gives options of trend / regression type, namely; exponential, linear, logarithmic, polynomial, power and moving averages. The option to display equation on chart and R- squared value is also added. The model that best fits the data with the highest R-squared value is chosen. The ASFRs values over the projection period are obtained by checking the intersection points on the trendline and the year.

3.2.2 Modelling of ASMRs

The principal way of measuring variation in mortality by age is in terms of ASMRs, which is conventionally defined as the number of deaths of persons in a given age during a year per 1000 of the mid-year population at that age. This measure is very important in that it singles out the ages that are vulnerable to death relative to others (CBS, 1970b).

3.2.2.1 Quality of ASMR data from Census Reports

ASMR data were obtained from census reports. However, census data often suffer from errors of under reporting of infant deaths, age misreporting and wrong dating of deaths (CBS, 1996b). Indirect methods of estimation of mortality have been used to correct these errors using model life tables. The Brass two-parameter model life tables is mostly used as it performs the dual function of linking the estimates of child mortality with those of adult mortality and smoothen irregularities of adult mortality (CBS, 1996b).

Mortality is gender and age specific with wide variations over the age pattern (CBS, 1996b). As a result, model life tables are constructed separately for males and females on the basis of mortality estimates in the first two years of life and of the expectations of life for adults at various ages. The ASMRs have been extracted from the life tables that have been constructed for Kenya and are summarized in the Table 3.4.

Table 3.4: Age Specific Mortality Rates from Life Tables (1969 - 2009)

AGE GROUP	MALES					FEMALES				
	1969	1979	1989	1999	2009	1969	1979	1989	1999	2009
0	0.1382	0.1021	0.0743	0.0869	0.0632	0.1215	0.0880	0.0664	0.0768	0.0501
1 - 4	0.0241	0.0190	0.0139	0.0111	0.0067	0.0199	0.0166	0.0119	0.0105	0.0055
5 - 9	0.0085	0.0062	0.0046	0.0045	0.0030	0.0069	0.0053	0.0038	0.0037	0.0023
10 - 14	0.0032	0.0025	0.0018	0.0018	0.0029	0.0025	0.0021	0.0015	0.0014	0.0024
15 - 19	0.0054	0.0042	0.0031	0.0031	0.0025	0.0042	0.0035	0.0025	0.0026	0.0018
20 - 24	0.0070	0.0057	0.0043	0.0043	0.0035	0.0056	0.0048	0.0034	0.0051	0.0030
25 - 29	0.0072	0.0059	0.0045	0.0059	0.0048	0.0060	0.0050	0.0035	0.0070	0.0056
30 - 34	0.0075	0.0062	0.0047	0.0085	0.0077	0.0062	0.0052	0.0037	0.0079	0.0107
35 - 39	0.0084	0.0071	0.0054	0.0103	0.0122	0.0067	0.0059	0.0042	0.0083	0.0138
40 - 44	0.0101	0.0085	0.0065	0.0116	0.0132	0.0081	0.0070	0.0051	0.0086	0.0110
45 - 49	0.0128	0.0108	0.0084	0.0132	0.0140	0.0101	0.0089	0.0065	0.0093	0.0101
50 - 54	0.0167	0.0144	0.0113	0.0156	0.0133	0.0137	0.0119	0.0087	0.0108	0.0090
55 - 59	0.0226	0.0202	0.0160	0.0198	0.0146	0.0184	0.0167	0.0123	0.0138	0.0102
60 - 64	0.0329	0.0293	0.0238	0.0274	0.0203	0.0267	0.0243	0.0182	0.0195	0.0146
65 - 69	0.0464	0.0441	0.0367	0.0408	0.0300	0.0390	0.0369	0.0282	0.0296	0.0231
70 - 74	0.0718	0.0678	0.0586	0.0638	0.0466	0.0670	0.0577	0.0457	0.0473	0.0378
75 - 79	0.1074	0.1059	0.0957	0.1023	0.0750	0.0872	0.0924	0.0768	0.0786	0.0631
80+	0.1893	0.1915	0.1850	0.1606	0.2495	0.1758	0.1789	0.1663	0.1302	0.2128

Source: CBS (1970b; 1996b; 2002b) and KNBS (2011b)

3.2.2.2 Method of Modelling ASMRs

Modelling of ASMRs is based largely on the recommendation of Li and Chan (2007) to consider nonlinear models in the projection of mortality. ASMRs for males and females from data in Table 3.4 are projected separately since mortality is sex and age specific. Just like in the modelling of ASFRs described in Section 3.2.1.3, ASMRs data are tabulated separately for each of the eighteen age groups, starting from age 0 to the last open age group of 80+ in an excel spread sheet using single year scale from 1969 to 2050. Modelling is undertaken in a similar way as in the case of ASFRs and the model that best fits the ASMRs with the highest value of R-squared is chosen.

3.3 Methods of Population Projections

Population projection is based on projecting the female population since females are the ones who give birth. The corresponding male population is obtained by multiplying the projected female population with the sex ratio.[14]

3.3.1 Introduction to Population projections

Population projections help in answering the question, 'given the current population, what could be the future population?' The sets of data required for the population projection are: ASFRs, ASMRs (to give survival rates) and the base population.[15] The ASFRs and ASMRs are obtained from the generated rates as described in Section 3.2. The base population is obtained from smoothed 2009 population, which is projected to the mid-year 2010 (KNBS, 2011c).[16] The smoothed population is given in Table 3.5.

[14] Sex ratio is the number of males to the number of females.

[15] Base population is the starting population on which future population projections are speculated to increase from.

[16] Smoothed population is the population that has been adjusted for errors on age due to misreporting to give a more fitting demographic pattern.

Table 3.5: 2010 Population by Age and Sex- Base Population

Age Group	Male	Female	Total	*Sex Ratio (Male/Female)
0 - 4	3,036,260	2,996,900	6,033,160	1.0131
5 - 9	2,751,137	2,678,618	5,429,755	1.0271
10 - 14	2,433,120	2,349,758	4,782,878	1.0355
15 - 19	2,119,052	2,120,355	4,239,407	0.9994
20 - 24	1,800,433	2,017,920	3,818,353	0.8922
25 - 29	1,518,683	1,722,576	3,241,259	0.8816
30 - 34	1,268,075	1,284,748	2,552,823	0.9870
35 - 39	1,023,636	1,002,818	2,026,454	1.0208
40 - 44	777,974	777,404	1,555,378	1.0007
45 - 49	600,723	603,103	1,203,826	0.9961
50 - 54	472,669	476,058	948,727	0.9929
55 - 59	363,767	369,964	733,731	0.9832
60 - 64	275,407	291,832	567,239	0.9437
65 - 69	203,759	224,305	428,064	0.9084
70 - 74	151,629	173,700	325,329	0.8729
75 - 79	109,502	129,904	239,406	0.8429
80+	159,780	223,897	383,677	0.7136
Total	**19,065,606**	**19,443,860**	**38,509,466**	

Source: KNBS (2011c)

3.3.2 Matrix Projection Method

Matrix projection method is used to project the population to the year 2050 in five year intervals. The method entails obtaining the 17 x 17 projection matrix which is detailed in Keyfitz (1968a) with further improvements as used in Caswell (2001), Preston et al. (2001) and Picard and Liang (2014). A section of the method is repeated here for easy of reference.

Let ${}_nK_x{}^{(t)}$ be the population at time t whose ages are between x and x + n, where the age interval n is taken as 5. Among those alive at t = 0 survivors to t = 1 are calculated as

$$
\left.\begin{aligned}
(L_5/L_0)\,K_0^{(0)} &= K_5^{(1)}, \\
(L_{10}/L_5)\,K_5^{(0)} &= K_{10}^{(1)}, \\
(L_{15}/L_{10})\,K_{10}^{(0)} &= K_{15}^{(1)}, \\
&. \\
&. \\
&. \\
(L_{80+}/L_{75})\,K_{75}^{(0)} &= K_{80+}^{(1)}
\end{aligned}\right\} \quad \textbf{(1)}
$$

The typical age interval is from age x at last birthday to x + 4, where x is a multiple of 5. Equation **(1)** may be written as

$$(L_{x+5}/L_x)\,K_x^{(0)} = K_{x+5}^{(1)}, \quad \textbf{(2)}$$

x = 0, 5, 10… ω-5, ω being the maximum possible age taken as a multiple of 5.

Equation **(2)** above projects the populations already alive at time zero, and to it must be added births subsequent to that date that constitute the first age group in every projection. The ASFR is obtained by observing the number of births to mothers x to x + 4 years of age at last birthdays and dividing this by the average number of women in the same age group over the period of observation.

To follow the female population, the number of births of girl babies is required and it is assumed that the female fraction (FF) is the same for all ages of the mothers. FF is the ratio of female births to total births. This ratio is multiplied by the births in each age group of the mothers to obtain the female birth in each age group. To obtain the age specific female birth rate, F_x, we divide the female births in each age group by the number of mothers in each age group.

The ratio F_x is multiplied by the arithmetic mean of the initial population of ages x to x + 4 taken from **(1),**

$$(K_x^{(0)} + K_x^{(1)}) / 2 = ½\,(K_x^{(0)} + (L_x/L_{x-5})K_{x-5}^{(0)}) \quad \textbf{(3)}$$

and since this number is exposed for 5 years, we multiply also by 5.

The women aged x to x + 4 together with those x + 5 to x + 9 at last birthday will make a contribution to the number of births during the 5-year time period from 0 to 1 of

$5/2\ \{K_x^{(0)} + K_x^{(1)}\}F_x\ +\ 5/2\ \{K_{x+5}^{(0)} + K_{x+5}^{(1)}\}F_{x+5}\ + \ldots$ **(4)**

Adding through all ages and rearranging gives

$$\frac{5}{2}\sum_{\alpha-5}^{\beta-5}\{F_x + \left(\frac{L_{x+5}}{L_x}\right)F_{x+5}\}\ K_x^{(0)} \qquad \textbf{(5)}$$

Where α is the youngest age of childbearing and β is the oldest, both being multiples of 5.

The last step is to survive the births in 5-year interval. The proportion of survivors among children born throughout the interval is

$$_5L_0/5l_0 \qquad \textbf{(6)}$$

Multiplying **(5)** and **(6)** gives $\mathbf{K_0^{(1)}}$, which is the term needed to complete the population projection in equation **(1)**. The relation between the population at time t + 1 and at time t (where t is in multiples of 5 years) is a set of linear, first-order, homogeneous differential equations with constant coefficients given as

$$\left.\begin{array}{l}
L_0/2l_0[\{K_{15}^{(t)} + K_{15}^{(t+1)}\}\ F_{15} + \{K_{20}^{(t)} + K_{20}^{(t+1)}\}\ F_{20} + \ldots + \{K_{45}^{(t)} + K_{45}^{(t+1)}\}F_{45}] = K_0^{(t+1)}, \\
(L_5/L_0)K_0^{(t)} = K_5^{(t+1)}, \\
(L_{10}/L_5)K_0^{(t)} = K_{10}^{(t+1)}, \\
\quad . \\
\quad . \\
\quad . \\
(L_{80+}/L_{75})K_{75}^{(t)} = K_{80+}^{(t+1)}
\end{array}\right\} \textbf{(7)}$$

where the childbearing span is taken as 15 to 49.

The entire set above can be compactly written as

$$\mathbf{L\ \{K^{(t)}\} = \{K^{(t+1)}\},} \qquad \textbf{(8)}$$

Where $\mathbf{\{K^{(t)}\}}$ is the vertical vector of the age distribution at time t, given as

$$\mathbf{K^{(t)}} = \begin{pmatrix} K_0^{(t)} \\ K_5^{(t)} \\ K_{10}^{(t)} \\ . \\ . \\ . \\ K_{80+}^{(t)} \end{pmatrix}$$

and **L** is the matrix of the coefficients of $K_x^{(t)}$ in **(7)** after the $K_x^{(t+1)}$ are eliminated on the left, given as

$$\mathbf{L} = \begin{pmatrix} 0 & 0 & 0 & L_0/2l_0\left(\frac{L_{15}}{L_{10}}\right) F_{15} & L_0/2l_0\left(\frac{L_{20}}{L_{15}}\right) F_{20} & \cdots & 0 & 0 \\ L_5/L_0 & 0 & 0 & 0 & 0 & \cdots & 0 & 0 \\ 0 & L_{10}/L_5 & 0 & 0 & 0 & \cdots & 0 & 0 \\ . & . & . & . & . & \cdots & . & . \\ . & . & . & . & . & \cdots & . & . \\ . & . & . & . & . & \cdots & . & . \\ 0 & 0 & 0 & 0 & 0 & \cdots & L_{80+}/L_{75} & 0 \end{pmatrix} \quad \textbf{(9)}$$

The required projection matrix is given as equation **(9)** above. In summary, the projection matrix is a 17 x 17 matrix consisting of first row values, sub-diagonal values and zero values in the rest of the matrix.

The first-row values are obtained as $L_o/2l_o\ (F_{x-5} + (L_x/L_{x-5})\ F_x\ )$. The l_x and L_x values are the female life table values.[17] The F_x values are obtained by multiplying the modelled ASFRs with FF of the base population. The sex ratio at birth of the 2010 base population is 103, which gives a female fraction of 0.4926 (100/203).

The sub-diagonal values of the projection matrix are the survival ratio (${}_nSR_x$) values which are calculated as ${}_nSR_x = {}_nL_x/{}_nL_{x-5}$. Some exceptions are, however, made in the calculation of the survival ratios of the first and the last age groups. The life tables have ASMRs for the age groups 0 and 1 - 4 and not the age group 0 - 4. The ${}_5L_0$ value for the age group 0 - 4 is obtained by summing ${}_1L_0$ and ${}_4L_1$ values (UN, 1983b). The survival ratio for the last age group, SR_{80+} is calculated as $SR_{80+} = T_{80+}/T_{75+}$ (Preston et al., 2001).[18] The life table value of L_{80+} is usually more than that of L_{75+} which gives a survival ratio of more than 1 when computed as $SR_{80+} = L_{80+}/L_{75+}$.

The last element in the projection matrix, equation **(9),** is zero. This is based on the stable population model assumption that all the people die in the last age group of 80+. This is true to the extent that eventually, all the people in the last age group die. However, in the five-year

[17] l_x is the number of persons from a radix say of 1,000 births who reach the beginning of the age interval, while ${}_nL_x$ is the number of persons in the populations who at any moment are living within the indicated age interval

[18] T_x – Total number of persons alive up to the age interval

interval in which the projections are made, not all the people in the last age group die. Over time, the projection matrix has been improved by using the probability of surviving instead of zero as the last element in the final, open-ended age group (Caswell, 2001; Preston et al., 2001; Picard & Liang, 2014). The life table probability of surviving, $P_{80+} = 1 - q_{80+}$ where q_{80+} is the probability of dying obtained from the ASMR (given as M_{80+}), as $q_{80+} = 5 * M_{80+} /(1+5 * M_{80+} * 0.5)$. In this study, the M_{80+} is obtained from the modelled ASMRs in Section 3.2.2.2.

The resultant projection matrix that is used in this study is given as equation **(10)** below

$$
\mathbf{L} = \begin{pmatrix}
0 & 0 & 0 & L_0/2l_0\left(\frac{L_{15}}{L_{10}}\right) F_{15} & L_0/2l_0\left(\frac{L_{20}}{L_{15}}\right) F_{20} & \cdots & 0 & 0 \\
L_5/L_0 & 0 & 0 & 0 & 0 & \cdots & 0 & 0 \\
0 & L_{10}/L_5 & 0 & 0 & 0 & \cdots & 0 & 0 \\
. & . & . & . & . & \cdots & . & . \\
. & . & . & . & . & \cdots & . & . \\
. & . & . & . & . & \cdots & . & . \\
0 & 0 & 0 & 0 & 0 & \cdots & T_{80+}/T_{75} & P_{80+}
\end{pmatrix} \quad \textbf{(10)}
$$

In this study, equation **(10)** is not held constant over the projection period. Instead, it is varied after every 5 years to use the modelled ASFRs and ASMRs

3.4 Methods of Generating CBRs and CDRs

CBR is the total number of live births occurring among the population during a given year, per 1000 mid-year total population. It is crude measure because the denominator (mid-period population) used to derive it usually includes all the population, some who are not at risk of giving birth such as men, children and old people (CBS, 2002a). CDR is the number of deaths occurring during the year, per 1000 population.

Trends in CBRs and CDRs are used to demonstrate the demographic transition. The past CBRs and CDRs are obtained from population and housing census analytic reports on fertility and mortality. The past CBRs and CDRs are given in Table 3.6.

Table 3.6: CBRs and CDRs (1969 – 2009)

Variable	YEAR				
	1969	**1979**	**1989**	**1999**	**2009**
CBR	50	52	48	41.3	35.2
CDR	17	14	11	12	10.4

Source: CBS (1970b; 1981b; 1996a; 1996b; 2002a; 2002b) and KNBS (2011a; 2011b)

The projected rates are generated from the modelled ASFRs, ASMRs and the projected population as per Sections 3.2 and 3.3. CBRs are calculated by dividing the total births by total population. The total annual births are calculated by multiplying the ASFRs by the number of women in reproductive age groups.

Deaths are obtained separately for males and females since mortality is gender and age specific. The male deaths are obtained by multiplying the projected male ASMRs with the projected male population while the female deaths are obtained by multiplying the projected female ASMRs with the projected female population.

Some adjustment, however, are made to the ASMRs to obtain the ASMR for the age group 0 - 4, ${}_5M_0$, which is not given in the life tables. ${}_5M_0$ is obtained as ${}_5M_0 = (d_0 + {}_4d_1)/ {}_5L_0$ in both male life tables and female life tables. The male and female deaths are summed and total deaths are divided by the total population to obtain the CDRs.

3.5 Computation of Population Aging Indicators

Population aging indicators to be computed are; number of persons 60 years and above (older population), number of persons 65 years and above (aged population), proportion of the total population 60 years and above, proportion of the total population 65 years and above, aging index, median age, life expectancy at the age of 65, old age dependency ratio and potential support ratio.

Computation of aging indicators requires total population in age groups. To establish trends in population aging indicators, past and projected population is required. The projected population is obtained as per Section 3.3, while the past population is given in Table 3.7.

Table 3.7: Graduated and Corrected Population by Age and Sex

Age Group	1969			1979		
	Male	**Female**	**Total**	**Male**	**Female**	**Total**
0 – 4	1,058,102	1,046,380	2,104,482	1,730,341	1,686,871	3,417,212
5 -9	916,599	893,359	1,809,958	1,369,382	1,343,156	2,712,538
10 – 14	714,707	663,808	1,378,515	1,092,215	1,083,199	2,175,414
15 – 19	560,152	544,847	1,104,999	821,478	822,981	1,644,459
20 – 24	428,015	450,096	878,111	648,691	661,504	1,310,195
25 – 29	349,594	411,245	760,839	513,464	537,401	1,050,865
30 – 34	280,948	299,241	580,189	416,230	439,730	855,960
35 – 39	252,136	264,819	516,955	340,408	360,034	700,442
40 – 44	193,936	201,936	395,872	276,497	294,290	570,787
45 – 49	172,508	163,852	336,360	223,394	245,117	468,511
50 – 54	132,466	139,072	271,538	177,894	192,136	370,030
55 – 59	114,669	102,235	216,904	139,140	151,804	290,944
60 – 64	102,466	94,508	196,974	104,806	116,310	221,116
65 – 69	74,611	63,307	137,918	74,036	84,075	158,111
70 +	131,472	121,619	253,091	88295	106480	194775
Total	**5,482,381**	**5,460,324**	**10,942,705**	**8,016,271**	**8,125,088**	**16,141,359**

Age Group	1989			1999		
	Male	**Female**	**Total**	**Male**	**Female**	**Total**
0 – 4	2,114,721	2,075,278	4,189,999	2,342,576	2,366,559	4,709,135
5 – 9	1,922,630	1,899,058	3,821,688	1,987,900	2,028,015	4,015,915
10 – 14	1,654,482	1,649,883	3,304,365	1,995,510	2,034,447	4,029,957
15 – 19	1,201,639	1,206,528	2,408,167	1,740,730	1,820,619	3,561,349
20 – 24	957,523	971,269	1,928,792	1,379,948	1,560,951	2,940,899
25 – 29	775,424	791,182	1,566,606	1,124,732	1,280,910	2,405,642
30 – 34	638,776	654,005	1,292,781	885,768	940,088	1,825,856
35 – 39	529,619	544,969	1,074,588	703,401	728,140	1,431,541
40 – 44	439,299	454,540	893,839	534,186	551,737	1,085,923
45 – 49	361,197	376,284	737,481	418,546	431,630	850,176
50 – 54	290,909	305,753	596,662	322,763	334,748	657,511
55 – 59	226,223	240,954	467,177	254,342	270,412	524,754
60 – 64	167,004	181,249	348,253	199,299	227,383	426,682
65 – 69	113,940	127,323	241,263	155,091	180,878	335,969
70 +	124,387	153,553	277,940	297,417	354,298	651,715
Total	**11,517,773**	**11,631,828**	**23,149,601**	**14,342,209**	**15,110,815**	**29,453,024**

Source: CBS (1970b; 1981b; 2002c)

The proportion or percentage of the total population aged 65 years and above is computed as persons aged 65 years and above divided by total population multiplied by 100 percent. Population with 10 percent or more of its population is considered old while that with less than 5 percent is considered young.

Aging index is computed as persons aged 65 years and above divided by persons aged less than 15 years multiplied by 100 percent. Population with aging index under 15 percent is considered young while that with the index over 30 percent as old.

Median age is computed as:

$$L_m + \left[\frac{\frac{N}{2} - Fm - 1}{fm}\right] * c$$

Where;

L_m = the lower limit of the class containing the median,

N = the sum of all the frequencies (If there is a category of age not reported, N would exclude the frequencies of this class),

F_{m-1} = the sum of the frequencies in all classes before the median class,

f_m= frequency of the median class, and

c = size of the median class.

Populations with medians less than 20 years are described as young, those with medians 20 years to 29 years as intermediate and those with medians 30 years or over as old.

Dependency ratio is computed as population less than 15 years plus population 65 years and above divided by population in the working age groups of 15 to 64 years multiplied by 100 percent. On the other hand, old-age dependency ratio (OADR) is computed as population 65 years and above divided by population in the working age groups of 15 to 64 years multiplied by 100 percent. Conversely, potential support ratio is computed as population 15 to 64 years divided by population 65 years and above.

CHAPTER FOUR

POPULATION PROJECTIONS

4.1 Introduction

This chapter presents projections of the input data and the projected population to the year 2050 as described in Chapter Three Sections 3.2 and 3.3. The projections are also compared with existing ones prepared by UN and KNBS. A summary of the projections is also given.

4.2 Input Data for Projections

The input data for population projections is obtained from projected ASFRs and ASMRs, which are presented in this section. A comparison of the projected TFRs from various sources is also given.

4.2.1 Projected ASFRs

Modelled ASFRs are obtained as described in Section 3.2.1.3. ASFR data from Table 3.1, Table 3.2 and Table 3.3 are fitted into regression models of exponential, linear, logarithmic, polynomial and power. The modelling of age group 15-19 from Table 3.1 (census data) is used as an illustration of the rest of the age groups. The various models are shown in Figures 4.1 to 4.5.

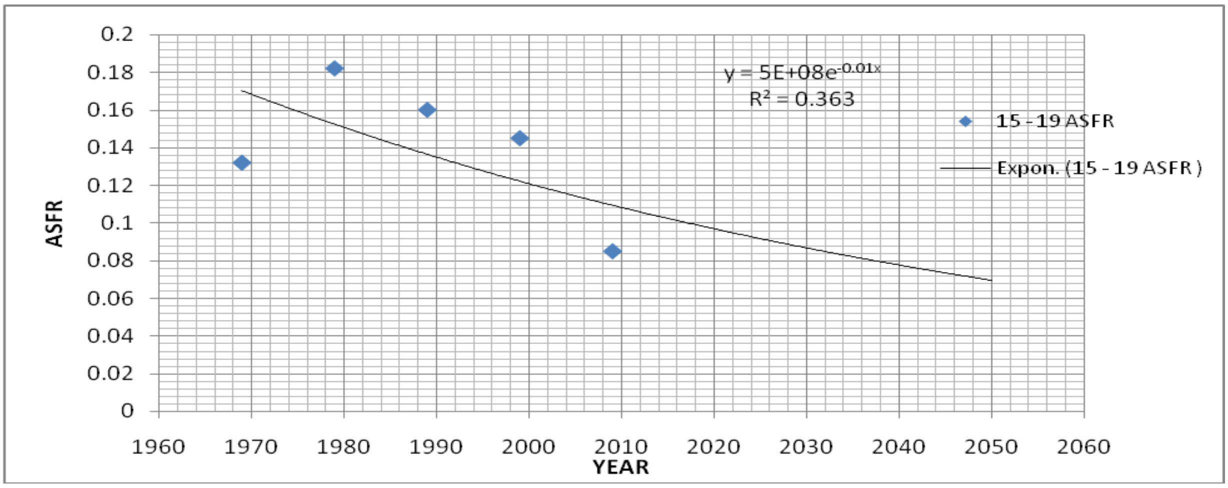


Figure 4.1: Exponential Model for ASFR of Age Group 15-19

Source: Table 3.1

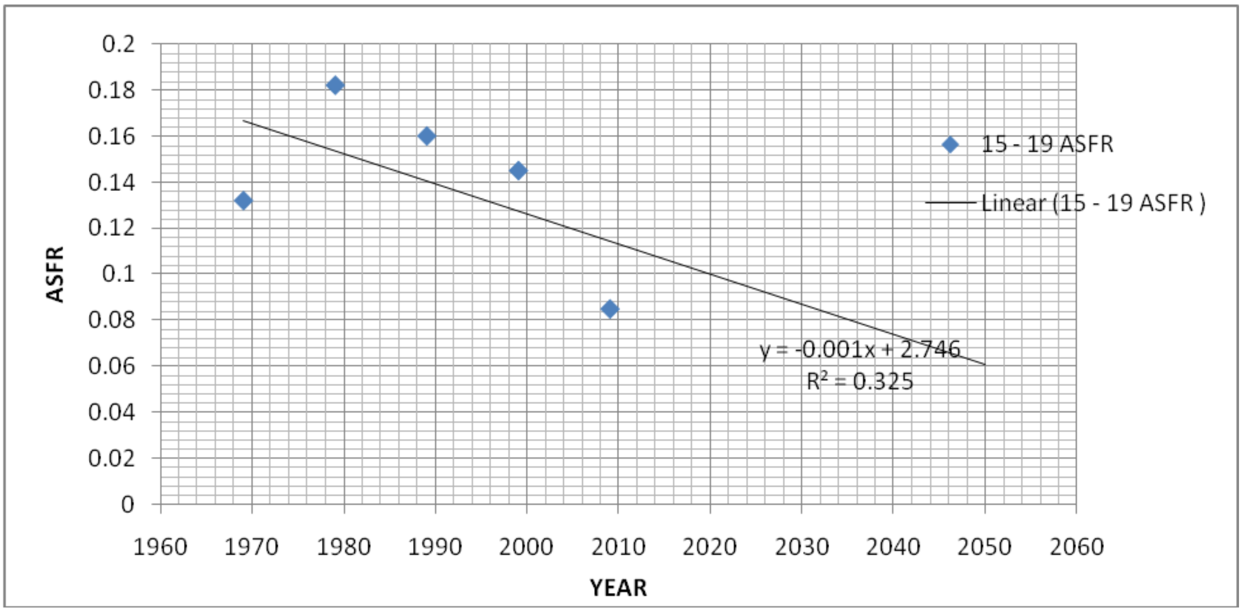


Figure 4.2: Linear Model for ASFR of Age Group 15-19

Source: Table 3.1

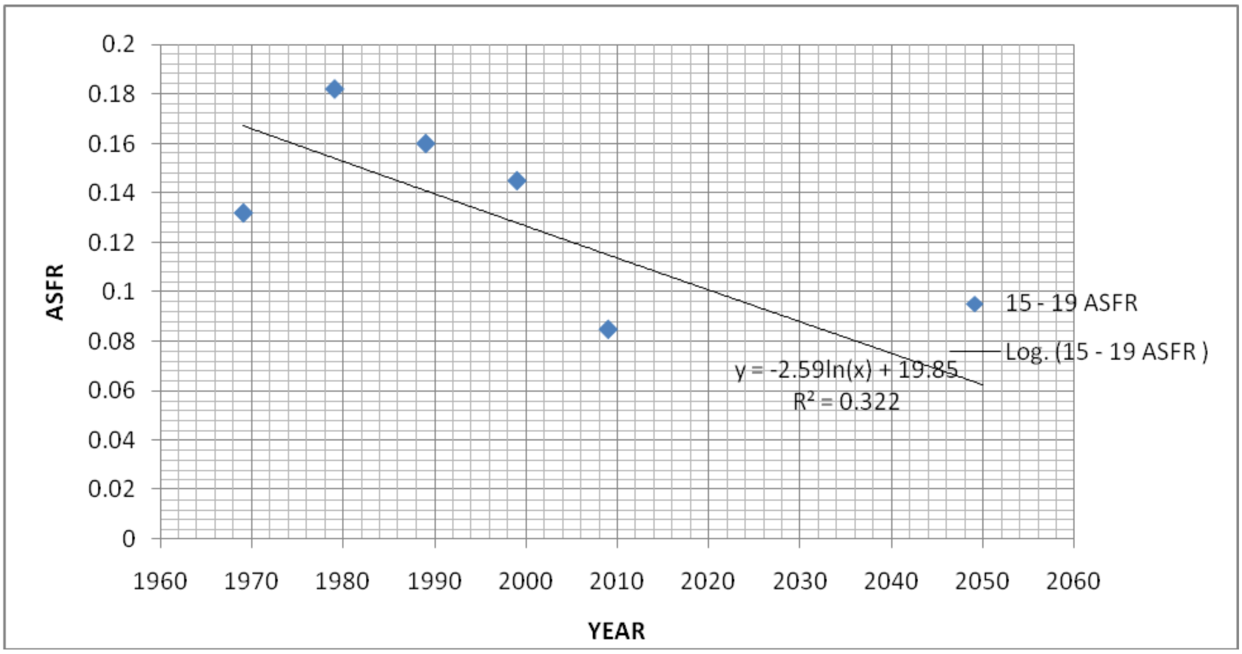


Figure 4.3: Logarithmic Model for ASFR of Age Group 15-19

Source: Table 3.1

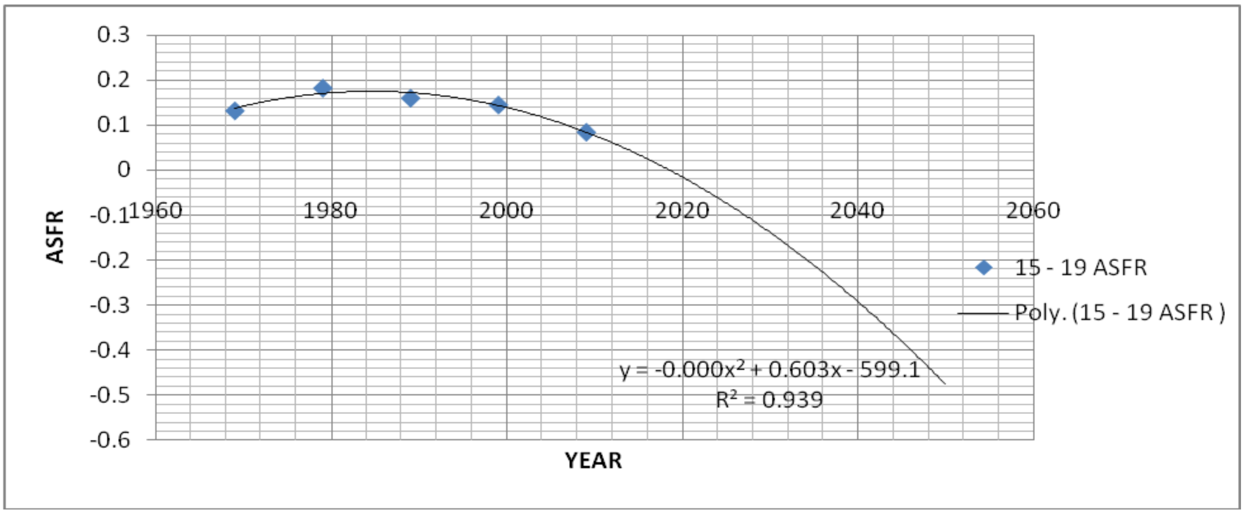


Figure 4.4: Polynomial Model for ASFR of Age Group 15-19

Source: Table 3.1

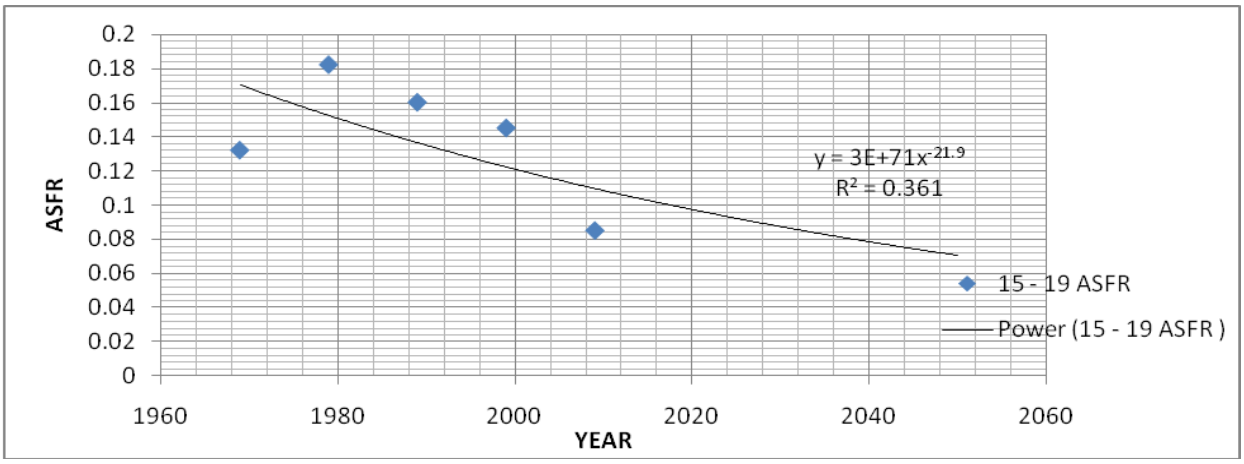


Figure 4.5: Power Model for ASFR of Age Group 15-19

Source: Table 3.1

The exponential model and power model result in almost the same fit. However, the R^2 value of exponential model of 0.363 is slightly higher than that of power model of 0.361. The linear, logarithmic and polynomial regression models progress to negative values, which do not represent the reality. Exponential model best fits the ASFRs and is therefore adopted and used in the study. Projected ASFRs from census data (Table 3.1) are presented in Table 4.1, while those from national survey (Table 3.2) are presented in Table 4.2. Modelled ASFRs from all the censuses and surveys (Table 3.3) are presented in Table 4.3.

Table 4.1: Projected ASFRs from Census Data (2010 - 2050)

Age Group	Year 2010	2015	2020	2025	2030	2035	2040	2045	2050
15 – 19	0.1082	0.1026	0.0968	0.0918	0.0867	0.0820	0.0778	0.0735	0.0695
20 - 24	0.2370	0.2242	0.2126	0.2010	0.1904	0.1800	0.1706	0.1615	0.1528
25 - 29	0.2355	0.2229	0.2105	0.1995	0.1885	0.1785	0.1687	0.1595	0.1511
30 - 34	0.1852	0.1748	0.1630	0.1526	0.1432	0.1343	0.1258	0.1180	0.1107
35 – 39	0.1212	0.1118	0.1032	0.0951	0.0880	0.0810	0.0748	0.0690	0.0637
40 - 44	0.0484	0.0430	0.0383	0.0340	0.0303	0.0268	0.0239	0.0212	0.0189
45 – 49	0.0061	0.0049	0.0040	0.0032	0.0026	0.0021	0.0017	0.0014	0.0012
TFR	**4.708**	**4.421**	**4.142**	**3.886**	**3.6485**	**3.4235**	**3.2165**	**3.0205**	**2.8395**

Source: Modelled from Table 3.1

Table 4.2: Projected ASFRs from National Surveys (2010 - 2050)

Age Group	Year 2010	2015	2020	2025	2030	2035	2040	2045	2050
15 – 19	0.0985	0.0915	0.0847	0.0784	0.0728	0.0676	0.0624	0.0580	0.0537
20 - 24	0.2185	0.2030	0.1882	0.1746	0.1617	0.1505	0.1392	0.1294	0.1200
25 - 29	0.1955	0.1785	0.1625	0.1482	0.1350	0.1232	0.1124	0.1025	0.0934
30 - 34	0.1612	0.1461	0.1329	0.1210	0.1097	0.0995	0.0905	0.0825	0.0746
35 – 39	0.1034	0.0907	0.0796	0.0696	0.0615	0.0540	0.0474	0.0417	0.0366
40 - 44	0.0418	0.0349	0.0291	0.0244	0.0203	0.0169	0.0141	0.0118	0.0098
45 – 49	0.0108	0.0081	0.0059	0.0044	0.0033	0.0025	0.0018	0.0014	0.0010
TFR	**4.1485**	**3.764**	**3.4145**	**3.103**	**2.8215**	**2.571**	**2.339**	**2.1365**	**1.9455**

Source: Modelled from Table 3.2

Table 4.3: Projected ASFRs for Censuses and Surveys (2010 - 2050)

Age Group	Year 2010	2015	2020	2025	2030	2035	2040	2045	2050
15 – 19	0.1020	0.0954	0.0892	0.0834	0.0779	0.0729	0.0681	0.0638	0.0596
20 - 24	0.2255	0.2112	0.1976	0.1852	0.1734	0.1624	0.1518	0.1422	0.1332
25 - 29	0.2084	0.1932	0.1788	0.1653	0.1530	0.1415	0.1312	0.1217	0.1125
30 - 34	0.1695	0.1562	0.1437	0.1327	0.1220	0.1125	0.1034	0.0955	0.0878
35 – 39	0.1103	0.0992	0.0893	0.0805	0.0723	0.0652	0.0586	0.0528	0.0475
40 - 44	0.0448	0.0388	0.0335	0.0249	0.0249	0.0215	0.0186	0.0162	0.0138
45 – 49	0.0100	0.0082	0.0066	0.0053	0.0043	0.0035	0.0028	0.0023	0.0018
TFR	**4.3525**	**4.0110**	**3.6935**	**3.3865**	**3.1390**	**2.8975**	**2.6725**	**2.4725**	**2.2810**

Source: Modelled from Table 3.3

The projections from census data gives higher values of ASFRs compared with those from national surveys. When all the ASFRs from censuses and surveys were projected, the projections were moderate. These projections are illustrated in the Figure 4.6 using TFRs. Consequently, the projections of ASFRs from all the censuses and surveys (Table 4.3) are used in the projections of the population. The figures of exponential models used to obtain values for Table 4.3 have been presented in Appendix 1.

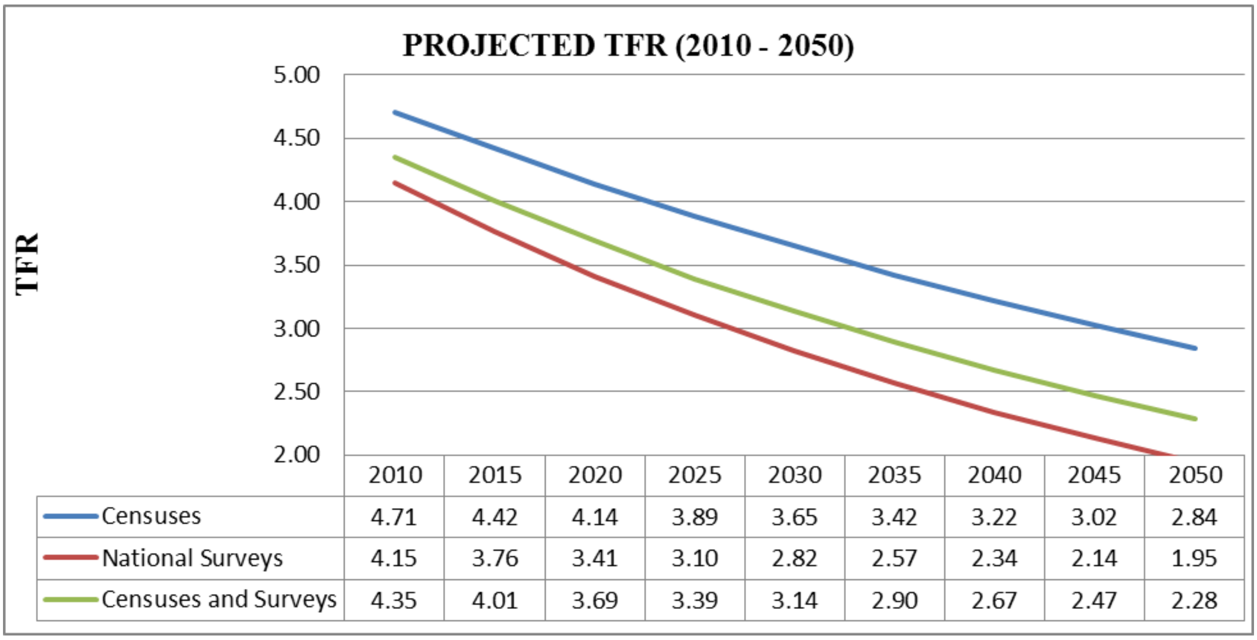


Figure 4.6: Projected TFR (2010 - 2050)

Source: Computed from Table 4.1, Table 4.2 and Table 4.3

4.2.2 Comparison of Projected TFRs from Various Sources

Table 4.4: Projected TFRs from Various Sources

Year	Total Fertility Rate (TFR)				
	Study	KNBS (2011c)	NCPD (2011)	UNPD (2011)	UNPD (2015)
2015	4.01	4.1		4.62	4.44
2030	3.14	3.2	2.6	3.46	3.56
2050	2.28			2.89	2.85

Source: The Study, KNBS (2011c), NCPD (2011) and UNPD (2011; 2015)

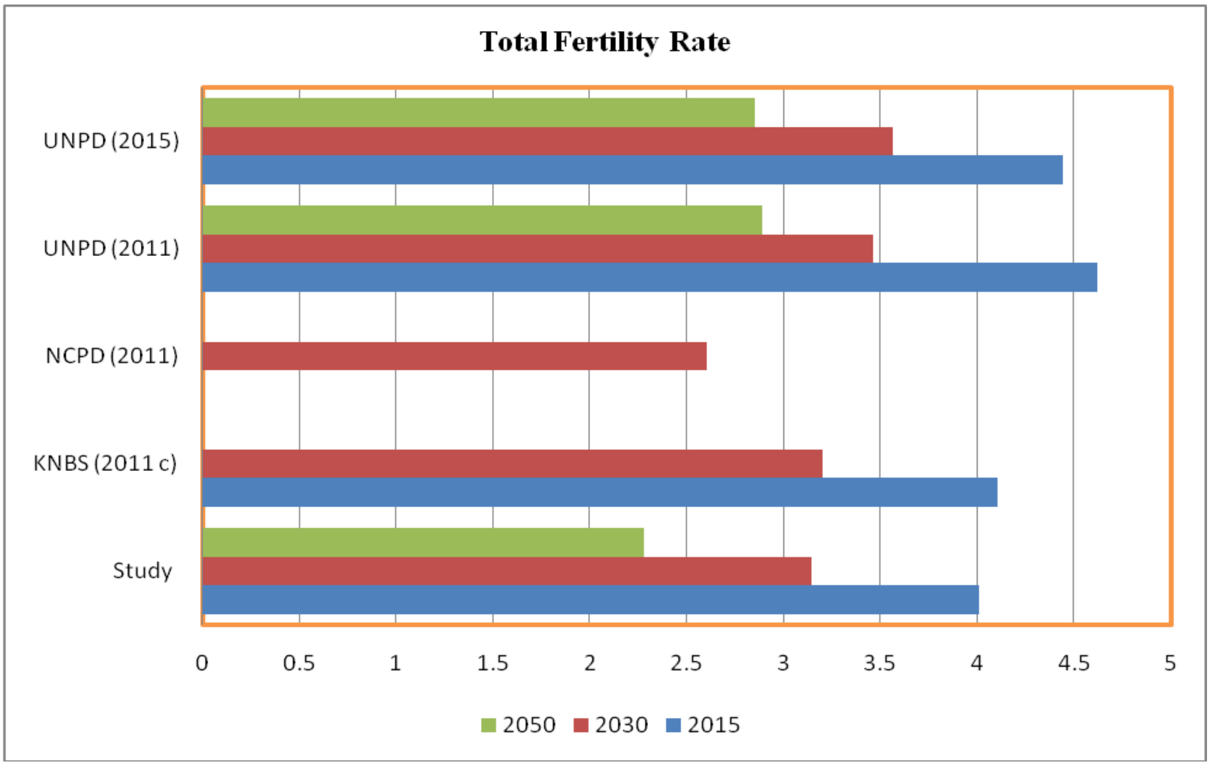


Figure 4.7: Comparison of the Projected TFRs from Various Sources

Source: Table 4.4

The projections from the study for the year 2015 are lower than those of KNBS (2011c) and UNPD (2011; 2015). The UNPD (2015) revised the TFR downward from 4.62 to 4.44. For the year 2030, the projected TFR in the study is lower than those of KNBS (2011c) and UNPD (2011; 2015). However, the study TFR of 3.14 is higher than that of the Kenyan Government policy objective of 2.6 by 2030. By 2050, the study projects TFR of 2.28 which is lower than that of UNPD (2011; 2015). The UNPD (2015), however, revised the UNPD (2011) TFR slightly downwards from 2.89 to 2.85. Generally, the study TFRs are lower over the period than those of the KNBS (2011c) and UNPD (2011; 2015).

4.2.3 Projected ASMRs

The projected ASMRs are obtained as described in Section 3.2.2.2. Male ASMRs and female ASMRs data from Table 3.4 are fitted to regression models of exponential, linear, logarithmic, polynomial and power. Exponential model gives the best fit to the data and is consequently used in the projections.

The male ASMR value of 0.2495 for the last age group 80+ for the year 2009 is found to be too high. This value is excluded in the plotting to get the trendline that represents the rest of the values. The fitted value for the age group 80+ for the year 2009 is then obtained as 0.1588. The projected male ASMRs are presented in Table 4.5.

Table 4.5: Projected Male ASMRs (2010 - 2050)

AGE GROUP	2010	2015	2020	2025	2030	2035	2040	2045	2050
0	0.0624	0.0572	0.0526	0.0480	0.0441	0.0405	0.0372	0.0340	0.0313
1 - 4	0.0071	0.0061	0.0052	0.0045	0.0038	0.0033	0.0028	0.0025	0.0020
5 - 9	0.0031	0.0027	0.0024	0.0021	0.0019	0.0017	0.0015	0.0013	0.0012
10 - 14	0.0021	0.0021	0.0020	0.0020	0.0019	0.0019	0.0018	0.0018	0.0017
15 - 19	0.0024	0.0022	0.0020	0.0018	0.0016	0.0015	0.0014	0.0013	0.0012
20 - 24	0.0034	0.0031	0.0029	0.0026	0.0024	0.0022	0.0020	0.0019	0.0017
25 - 29	0.0047	0.0045	0.0043	0.0042	0.0040	0.0038	0.0037	0.0035	0.0034
30 - 34	0.0073	0.0075	0.0076	0.0077	0.0079	0.0080	0.0082	0.0083	0.0085
35 - 39	0.0105	0.0112	0.0118	0.0125	0.0132	0.0140	0.0148	0.0156	0.0165
40 - 44	0.0116	0.0122	0.0126	0.0132	0.0137	0.0143	0.0149	0.0156	0.0162
45 - 49	0.0126	0.0129	0.0131	0.0134	0.0136	0.0139	0.0141	0.0144	0.0147
50 - 54	0.0131	0.0128	0.0126	0.0123	0.0121	0.0119	0.0117	0.0115	0.0112
55 - 59	0.0152	0.0146	0.0139	0.0134	0.0128	0.0122	0.0117	0.0112	0.0107
60 - 64	0.0212	0.0202	0.0192	0.0182	0.0173	0.0164	0.0156	0.0148	0.0140
65 - 69	0.0320	0.0306	0.0291	0.0278	0.0265	0.0253	0.0241	0.0230	0.0219
70 - 74	0.0503	0.0480	0.0458	0.0437	0.0417	0.0398	0.0380	0.0364	0.0347
75 - 79	0.0824	0.0793	0.0763	0.0735	0.0708	0.0683	0.0658	0.0633	0.0609
80+	0.1580	0.1538	0.1499	0.1460	0.1422	0.1384	0.1348	0.1313	0.1279

Source: Modelled from Table 3.4

The female ASMR value of 0.2128 for the last age group 80+ for the year 2009 is found to be too high, just like that of the male ASMR. This value is excluded in the plotting to get the trendline that represents the rest of the values. The fitted value for the age group 80+ is then obtained as 0.1264. The projected female ASMRs are presented in Table 4.6.

Table 4.6: Projected Female ASMRs (2010 - 2050)

AGE GROUP	2010	2015	2020	2025	2030	2035	2040	2045	2050
0	0.0517	0.0470	0.0426	0.0388	0.0352	0.0322	0.0293	0.0266	0.0241
1 - 4	0.0062	0.0053	0.0046	0.0039	0.0034	0.0029	0.0025	0.0022	0.0019
5 - 9	0.0024	0.0021	0.0018	0.0016	0.0014	0.0013	0.0011	0.0010	0.0009
10 - 14	0.0018	0.0017	0.0017	0.0016	0.0016	0.0015	0.0015	0.0015	0.0014
15 - 19	0.0018	0.0017	0.0015	0.0014	0.0013	0.0011	0.0010	0.0009	0.0008
20 - 24	0.0033	0.0031	0.0029	0.0028	0.0026	0.0025	0.0024	0.0023	0.0021
25 - 29	0.0055	0.0056	0.0056	0.0057	0.0057	0.0058	0.0058	0.0059	0.0061
30 - 34	0.0087	0.0094	0.0101	0.0109	0.0119	0.0127	0.0137	0.0148	0.0159
35 - 39	0.0105	0.0114	0.0125	0.0137	0.0149	0.0163	0.0178	0.0195	0.0213
40 - 44	0.0092	0.0094	0.0099	0.0104	0.0108	0.0112	0.0117	0.0122	0.0127
45 - 49	0.0089	0.0090	0.0090	0.0090	0.0090	0.0090	0.0091	0.0091	0.0091
50 - 54	0.0088	0.0084	0.0080	0.0076	0.0074	0.0069	0.0066	0.0063	0.0060
55 - 59	0.0105	0.0098	0.0091	0.0085	0.0080	0.0074	0.0070	0.0065	0.0060
60 - 64	0.0150	0.0140	0.0130	0.0121	0.0113	0.0105	0.0098	0.0091	0.0085
65 - 69	0.0236	0.0222	0.0208	0.0195	0.0183	0.0173	0.0161	0.0151	0.0142
70 - 74	0.0378	0.0352	0.0331	0.0309	0.0289	0.0270	0.0253	0.0236	0.0221
75 - 79	0.0667	0.0640	0.0615	0.0590	0.0567	0.0544	0.0523	0.0502	0.0482
80+	0.1255	0.1196	0.1138	0.1084	0.1033	0.0984	0.0937	0.0892	0.0850

Source: Modelled from Table 3.4

4.3 Population Projections

Population projections are undertaken as described in Section 3.3.2. It involved obtaining projection matrix values to be used in the projection of the female population. The male population is then obtained using the sex ratio of the base population and the total population is obtained by summing the male and female population.

4.3.1 Projection Matrix Values

The first-row values of the projection matrix, equation **(10),** are obtained as $L_0/2l_0$ (F_{x-5} + (L_x/L_{x-5}) F_x). The l_x and L_x values are the female life table values, which were constructed from projected female ASMRs in Table 4.6 and are presented in Appendix 2. The F_x, the age specific female birth rates, are obtained by multiplying the ASFRs in Table 4.3 with the female fraction (FF), the ratio of female births to total births, of 0.4926 (100/203). The sex ratio at birth has been assumed to be constant during the projection period. The first-row values of the projection matrices used over the projection period are presented in Table 4.7.

Table 4.7: First Row Values of the Projection Matrix (2010 – 2050)

Age	Year								
Group	2010	2015	2020	2025	2030	2035	2040	2045	2050
15 - 19	0.1173	0.1104	0.1038	0.0976	0.0916	0.0861	0.0807	0.0759	0.0711
20 - 24	0.3766	0.3549	0.3340	0.3144	0.2956	0.2779	0.2607	0.2451	0.2302
25 - 29	0.4981	0.4671	0.4372	0.4092	0.3828	0.3577	0.3343	0.3128	0.2920
30 - 34	0.4315	0.4011	0.3719	0.3450	0.3194	0.2959	0.2740	0.2541	0.2347
35 - 39	0.3186	0.2922	0.2676	0.2457	0.2245	0.2058	0.1879	0.1722	0.1573
40 - 44	0.1774	0.1588	0.1419	0.1225	0.1132	0.1013	0.0905	0.0811	0.0722
45 - 49	0.0631	0.0544	0.0467	0.0353	0.0343	0.0295	0.0254	0.0220	0.0186

Source: Author *(Appendix 2)*

The diagonal (survival, $_nSR_x$) values of the projection matrix are also obtained from the female life tables presented in Appendix 2. These values are presented in Table 4.8.

Table 4.8: Diagonal Values of the Projection Matrix (2010 – 2050)

Age Group	2010	2015	2020	2025	2030	2035	2040	2045	2050
5 - 9	0.9781	0.9810	0.9834	0.9856	0.9874	0.9888	0.9903	0.9913	0.9924
10 - 14	0.9897	0.9905	0.9914	0.9920	0.9926	0.9929	0.9935	0.9939	0.9942
15 - 19	0.9912	0.9915	0.9922	0.9925	0.9928	0.9934	0.9938	0.9941	0.9944
20 - 24	0.9874	0.9881	0.9891	0.9896	0.9903	0.9911	0.9916	0.9920	0.9928
25 - 29	0.9783	0.9786	0.9790	0.9790	0.9795	0.9795	0.9798	0.9798	0.9798
30 - 34	0.9653	0.9634	0.9617	0.9596	0.9573	0.9552	0.9529	0.9501	0.9471
35 - 39	0.9532	0.9494	0.9452	0.9405	0.9354	0.9303	0.9246	0.9182	0.9117
40 - 44	0.9519	0.9492	0.9454	0.9413	0.9374	0.9331	0.9283	0.9231	0.9176
45 - 49	0.9557	0.9550	0.9538	0.9526	0.9516	0.9506	0.9492	0.9479	0.9467
50 - 54	0.9567	0.9574	0.9583	0.9593	0.9597	0.9609	0.9614	0.9621	0.9628
55 - 59	0.9530	0.9556	0.9582	0.9606	0.9623	0.9649	0.9666	0.9685	0.9704
60 - 64	0.9386	0.9425	0.9465	0.9500	0.9531	0.9564	0.9590	0.9619	0.9645
65 - 69	0.9089	0.9143	0.9197	0.9247	0.9292	0.9334	0.9378	0.9417	0.9452
70 - 74	0.8598	0.8681	0.8755	0.8830	0.8900	0.8963	0.9027	0.9086	0.9140
75 - 79	0.7761	0.7862	0.7950	0.8041	0.8126	0.8209	0.8284	0.8361	0.8432
80+	0.5704	0.5841	0.5980	0.6113	0.6243	0.6372	0.6498	0.6622	0.6742

Source: Author *(Appendix 2)*

The last element (P_{80+}) values of the projection matrix, the probability of surviving in the last age group, are computed as described in Section 3.3.2. $P_{80+} = 1 - q_{80+}$; $q_{80+} = 5^* M_{80+} /(1+5^* M_{80+} {}^*0.5)$ and M_{80+} is obtained from the projected female ASMRs (2010 - 2050) in Table 4.6. These are presented in Table 4.9.

Table 4.9: Values of the Last Element of Projection Matrix (2010 - 2050)

Year	2010	2015	2020	2025	2030	2035	2040	2045	2050
ASMR	0.1255	0.1196	0.1138	0.1084	0.1033	0.0984	0.0937	0.0892	0.0850
q_{80}	0.4776	0.4604	0.4430	0.4264	0.4105	0.3949	0.3796	0.3647	0.3505
P_{80}	0.5224	0.5396	0.5570	0.5736	0.5895	0.6051	0.6204	0.6353	0.6495

Source: Computed from Table 4.6

4.3.2 Projection of Female Population

The projection matrices obtained by fitting the values in Table 4.7, Table 4.8 and Table 4.9 in equation **(10)** are multiplied by the female population to get the projected population. The first projection matrix is multiplied by the female population in Table 3.5, being the base population. Matlab software is used in the multiplication. These values form the projected female population for 2015, which subsequently form the base population for projection of the 2020 female population. The projected 2015 female population is then multiplied by the second matrix fitted by the values in Table 4.7, Table 4.8 and Table 4.9 corresponding to 2015. The process is repeated in five-year interval until the projected female population of 2050 is obtained. The projected female population is presented in Table 4.10.

Table 4.10: Projected Female population (2010 – 2050)

Age Group	2010	2015	2020	2025	2030	2035	2040	2045	2050
0 - 4	2996900	2916515	3139069	3274522	3363921	3421784	3396007	3324714	3241616
5 -9	2678618	2931268	2861101	3086960	3227369	3321536	3383460	3363065	3295789
10 - 14	2349758	2651028	2903421	2836496	3062265	3203486	3297953	3361468	3342551
15 - 19	2120355	2329080	2628494	2880774	2815222	3040216	3182343	3277505	3341635
20 - 24	2017920	2093639	2301364	2599844	2850814	2787915	3013159	3155612	3251285
25 - 29	1722576	1974131	2048835	2253035	2545247	2792372	2730762	2952293	3091868
30 - 34	1284748	1662803	1901878	1970364	2162013	2436565	2667274	2602143	2804973
35 - 39	1002818	1224622	1578665	1797655	1853128	2022347	2266737	2466162	2389288
40 - 44	777404	954582	1162411	1492470	1692133	1737122	1887052	2104212	2276514
45 - 49	603103	742965	911626	1108708	1421727	1610233	1651308	1791190	1994582
50 - 54	476058	576989	711315	873611	1063583	1364431	1547273	1587568	1723303
55 - 59	369964	453683	551370	681582	839191	1023486	1316540	1495594	1537559
60 - 64	291832	347248	427596	521872	647503	799833	978862	1262561	1438612
65 - 69	224305	265246	317489	393260	482575	601659	746564	917977	1188954
70 - 74	173700	192857	230260	277962	347249	429492	539267	673923	834074
75 - 79	129904	134809	151625	183057	223509	282175	352570	446729	563467
80 +	223897	191061	181838	191955	222008	270410	343427	442162	576730
Total	**19443860**	**21642526**	**24008358**	**26424128**	**28819456**	**31145064**	**33300558**	**35224878**	**36892801**

Source: Author

4.3.3 Projection of Male and Total Population

The projected male population is obtained by multiplying the projected female population in Table 4.10 with the sex ratio in Table 3.5. The sex ratio is held constant over the projection period. The projected male, female and total population is given in Table 4.11.

Table 4.11: Projected Population by Age and Sex, and in five-year period (2010 – 2050)

Age Group	2010			2015			2020		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
0 - 4	3036260	2996900	6033160	2954820	2916515	5871335	3180296	3139069	6319365
5 -9	2751137	2678618	5429755	3010627	2931268	5941895	2938561	2861101	5799662
10 - 14	2433120	2349758	4782878	2745078	2651028	5396107	3006425	2903421	5909846
15 - 19	2119052	2120355	4239407	2327649	2329080	4656729	2626879	2628494	5255374
20 - 24	1800433	2017920	3818353	1867991	2093639	3961629	2053328	2301364	4354692
25 - 29	1518683	1722576	3241259	1740463	1974131	3714594	1806324	2048835	3855159
30 - 34	1268075	1284748	2552823	1641223	1662803	3304026	1877196	1901878	3779074
35 - 39	1023636	1002818	2026454	1250044	1224622	2474666	1611437	1578665	3190102
40 - 44	777974	777404	1555378	955282	954582	1909865	1163263	1162411	2325674
45 - 49	600723	603103	1203826	740033	742965	1482998	908029	911626	1819655
50 - 54	472669	476058	948727	572881	576989	1149870	706251	711315	1417566
55 - 59	363767	369964	733731	446084	453683	899767	542135	551370	1093505
60 - 64	275407	291832	567239	327704	347248	674952	403530	427596	831127
65 - 69	203759	224305	428064	240950	265246	506196	288408	317489	605897
70 - 74	151629	173700	325329	168352	192857	361210	201002	230260	431263
75 - 79	109502	129904	239406	113636	134809	248445	127811	151625	279436
80 +	159780	223897	383677	136347	191061	327408	129765	181838	311603
Total	**19065606**	**19443860**	**38509466**	**21239165**	**21642526**	**42881692**	**23570641**	**24008358**	**47578999**

Age Group	2025			2030			2035		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
0 - 4	3317528	3274522	6592050	3408101	3363921	6772022	3466725	3421784	6888509
5 -9	3170535	3086960	6257495	3314744	3227369	6542113	3411461	3321536	6732996
10 - 14	2937126	2836496	5773622	3170904	3062265	6233169	3317136	3203486	6520622
15 - 19	2879004	2880774	5759778	2813492	2815222	5628715	3038348	3040216	6078565
20 - 24	2319638	2599844	4919482	2543560	2850814	5394374	2487439	2787915	5275354
25 - 29	1986355	2253035	4239390	2243979	2545247	4789226	2461853	2792372	5254225
30 - 34	1944794	1970364	3915158	2133955	2162013	4295968	2404944	2436565	4841509
35 - 39	1834973	1797655	3632628	1891598	1853128	3744725	2064330	2022347	4086676
40 - 44	1493564	1492470	2986034	1693373	1692133	3385506	1738396	1737122	3475517
45 - 49	1104332	1108708	2213040	1416116	1421727	2837843	1603879	1610233	3214113
50 - 54	867392	873611	1741004	1056012	1063583	2119595	1354718	1364431	2719149
55 - 59	670165	681582	1351747	825134	839191	1664326	1006342	1023486	2029829
60 - 64	492500	521872	1014372	611060	647503	1258562	754817	799833	1554650
65 - 69	357238	393260	750499	438372	482575	920947	546548	601659	1148208
70 - 74	242643	277962	520604	303126	347249	650375	374919	429492	804411
75 - 79	154307	183057	337364	188406	223509	411915	237858	282175	520032
80 +	136985	191955	328940	158432	222008	380440	192973	270410	463383
Total	**25909079**	**26424128**	**52333207**	**28210364**	**28819456**	**57029820**	**30462685**	**31145063**	**61607748**

Age Group	2040			2045			2050		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
0 - 4	3440608	3396007	6836615	3368379	3324714	6693093	3284190	3241616	6525805
5 -9	3475062	3383460	6858522	3454115	3363065	6817180	3385017	3295789	6680805
10 - 14	3414954	3297953	6712906	3480722	3361468	6842190	3461134	3342551	6803685
15 - 19	3180388	3182343	6362731	3275491	3277505	6552997	3339582	3341635	6681217
20 - 24	2688407	3013159	5701565	2815507	3155612	5971118	2900869	3251285	6152154
25 - 29	2407535	2730762	5138298	2602844	2952293	5555137	2725899	3091868	5817767
30 - 34	2632659	2667274	5299933	2568374	2602143	5170517	2768571	2804973	5573545
35 - 39	2313793	2266737	4580529	2517358	2466162	4983520	2438889	2389288	4828177
40 - 44	1888435	1887052	3775487	2105754	2104212	4209966	2278183	2276514	4554697
45 - 49	1644792	1651308	3296100	1784121	1791190	3575311	1986711	1994582	3981293
50 - 54	1536258	1547273	3083532	1576266	1587568	3163833	1711035	1723303	3434339
55 - 59	1294487	1316540	2611027	1470543	1495594	2966137	1511805	1537559	3049364
60 - 64	923769	978862	1902632	1191501	1262561	2454063	1357644	1438612	2796256
65 - 69	678180	746564	1424744	833892	917977	1751869	1080048	1188954	2269002
70 - 74	470746	539267	1010013	588292	673923	1262216	728093	834074	1562167
75 - 79	297197	352570	649767	376568	446729	823297	474972	563467	1038440
80 +	245080	343427	588507	315541	442162	757703	411573	576730	988303
Total	**32532351**	**33300558**	**65832909**	**34325268**	**35224878**	**69550146**	**35844213**	**36892802**	**72737015**

Source: Author

4.4 Comparison of Total Population Projections from Various Sources

The projections from this study have been compared with those of the *2015 Revision* of *World Population Prospect,* the twenty-fourth round of official United Nations population estimates and projections. These are prepared by the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat. The 2015 Revision builds on the previous revision by incorporating additional results from the 2010 round of national population censuses as well as findings from recent specialized demographic and health surveys that have been carried out around the world. UNPD (2015) gives medium variant estimates and projections for the years 1950, 2015, 2030, 2050 and 2100. The projections for the years 2015, 2030 and 2050 are used for comparison purposes with those of this study as the study projections and subsequent indicators are from 2010 to 2050.

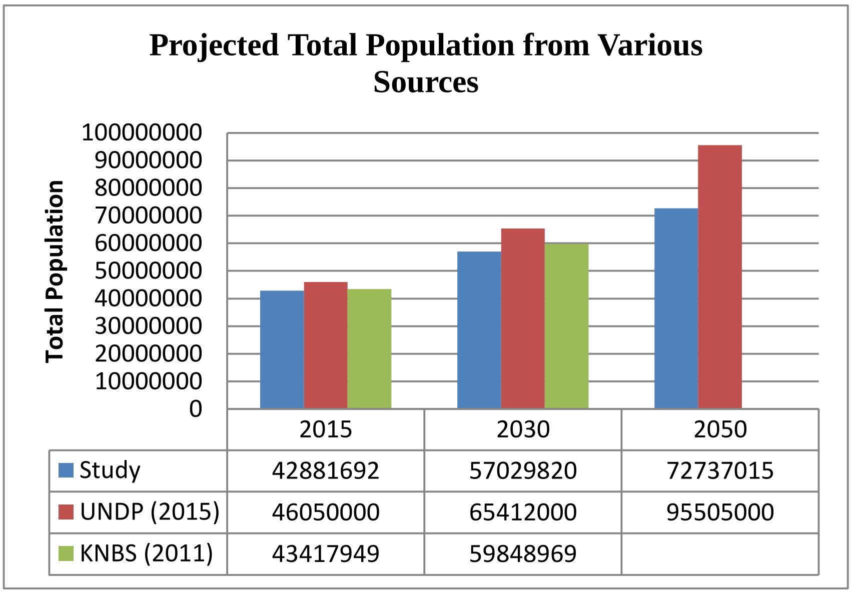


Figure 4.8: Comparison of Projected Total Population from Various Sources

Source: The Study, KNBS (2011c) and UNPD (2015)

The study projected population in 2015 is almost the same as that of KNBS (2011c), with KNBS (2015) being slightly more with about 0.5 million. However, the UNPD (2015) projection is higher by about 3 million for the same year. The 2030 projected population in the study is lower than that of KNBS (2011c) by about 3 million and lower by about 8 million of that of the UNPD (2015). The population projections of 2050 of UNPD (2015) are very high. They differ with those of this study by about 23 million.

4.5 Summary

The exponential model best fits both ASFRs and ASMRs. It had the highest value of R-squared compared with linear and power models under regression analysis. The model is therefore adopted and used in modelling of the rates. The study's projected TFR is 4.01 in 2015, 3.14 in 2030 and 2.28 in 2050. This is lower than KNBS (2011c) projected TFR of 4.1 in 2015 and 3.2 in 2030. It is also lower than UNPD (2015) projected TFR of 4.44 in 2015, 3.56 in 2030 and 2.85 in 2050. However, the study TFR of 3.14 is higher than that of the Kenya Government policy objective of TFR of 2.6 by 2030.

The study's projected population is 42.88 million in 2015, 57.03 million in 2030 and 72.74 million in 2050. This is almost the same as that of KNBS (2011c) projected population of 43.42 million in 2015 but less than the UNPD (2015) projected population of 46.05 million by about 3 million for the same year.

The study's projected population in 2030 of 57.03 million is lower by about 3 million of that of KNBS (2011c) of 59.85 million and lower by about 8 million of that of UNPD (2015) of 65.41 million. The projected population of 2050 of UNPD (2015) is very high at 95.51 million, differing with that of this study of 72.74 million by about 23 million. The huge difference may be attributed to the assumptions made on fertility rates. UNPD makes an assumption that by 2050 the TFR will be 2.85 while the projected TFR for this study is 2.28. This gives a significant difference of 0.57 births per woman.

CHAPTER FIVE

DEMOGRAPHIC TRANSITION AND AGING INDICATORS

5.1 Introduction

This chapter presents the projected CBRs, CDRs and aging indicators as described in Sections 3.4 and 3.5 of Chapter Three. The trends in CBRs and CDRs are used to demonstrate demographic transition, while trends in aging indicators are established to determine the status of population aging in the country. Additionally, the chapter discusses implication of population aging on the cash transfer programme in Kenya.

5.2 Demographic Transition

Demographic transition shows how fertility and mortality rates change over time. The past and projected CBRs and CDRs are used to demonstrate demographic transition for Kenya from 1969 to 2050.

5.2.1 Projected CBRs

The projected CBRs are obtained by dividing the total births by the total projected population. The total population is obtained from Table 4.11. The total annual births are calculated by multiplying the ASFRs in Table 4.3 by the number of women in reproductive age groups in Table 4.10. The results of the computations are presented in Appendix 3, while the projected CBRs are shown in Table 5.1.

Table 5.1: Projected CBRs (2010 – 2050)

YEAR	2010	2015	2020	2025	2030	2035	2040	2045	2050
CBR	36.34	34.28	31.84	29.49	27.16	24.65	22.49	20.62	18.90

Source: Appendix 3

The CBR declines over the projection period

5.2.2 Projected CDRs

Deaths are obtained separately for males and females since mortality is sex and age specific. The projected male ASMRs in Table 4.5 and female ASMRs in Table 4.6 are adjusted as described in Section 3.4 of Chapter Three. The tables have ASMRs for the age group 0 and age group 1 – 4 as given in the life tables. For projection purpose, the age group 0 and age group 1 – 4 were combined to have the first age group as 0 – 4 and its ASMR, $_5M_0$, obtained by the reconstruction of the life tables. $_5M_0$ was then obtained as $_5M_0 = (d_0 + {}_4d_1)/ {}_5L_0$ in both male life tables (presented in Appendix 4) and female life tables (presented in Appendix 5). The adjusted male ASMRs are presented in Table 5.2 while the adjusted female ASMRs are presented in Table 5.3.

Table 5.2: Adjusted Male ASMRs (2010 - 2050)

AGE GROUP	2010	2015	2020	2025	2030	2035	2040	2045	2050
0 - 4	0.0185	0.0166	0.0149	0.0134	0.0120	0.0109	0.0098	0.0089	0.0079
5 - 9	0.0031	0.0027	0.0024	0.0021	0.0019	0.0017	0.0015	0.0013	0.0012
10 - 14	0.0021	0.0021	0.0020	0.0020	0.0019	0.0019	0.0018	0.0018	0.0017
15 - 19	0.0024	0.0022	0.0020	0.0018	0.0016	0.0015	0.0014	0.0013	0.0012
20 - 24	0.0034	0.0031	0.0029	0.0026	0.0024	0.0022	0.0020	0.0019	0.0017
25 - 29	0.0047	0.0045	0.0043	0.0042	0.0040	0.0038	0.0037	0.0035	0.0034
30 - 34	0.0073	0.0075	0.0076	0.0077	0.0079	0.0080	0.0082	0.0083	0.0085
35 - 39	0.0105	0.0112	0.0118	0.0125	0.0132	0.0140	0.0148	0.0156	0.0165
40 - 44	0.0116	0.0122	0.0126	0.0132	0.0137	0.0143	0.0149	0.0156	0.0162
45 - 49	0.0126	0.0129	0.0131	0.0134	0.0136	0.0139	0.0141	0.0144	0.0147
50 - 54	0.0131	0.0128	0.0126	0.0123	0.0121	0.0119	0.0117	0.0115	0.0112
55 - 59	0.0152	0.0146	0.0139	0.0134	0.0128	0.0122	0.0117	0.0112	0.0107
60 - 64	0.0212	0.0202	0.0192	0.0182	0.0173	0.0164	0.0156	0.0148	0.0140
65 - 69	0.0320	0.0306	0.0291	0.0278	0.0265	0.0253	0.0241	0.0230	0.0219
70 - 74	0.0503	0.0480	0.0458	0.0437	0.0417	0.0398	0.0380	0.0364	0.0347
75 - 79	0.0824	0.0793	0.0763	0.0735	0.0708	0.0683	0.0658	0.0633	0.0609
80+	0.1580	0.1538	0.1499	0.1460	0.1422	0.1384	0.1348	0.1313	0.1279

Source: Appendix 4

The ASMRs for males decline over the period from 2010 to 2050 with exception of age groups 30 - 34, 35 - 39, 40 - 44 and 45 - 49 whose ASMRs increase over the period.

Table 5.3: Adjusted Female ASMRs (2010 - 2050)

AGE GROUP	2010	2015	2020	2025	2030	2035	2040	2045	2050
0 - 4	0.0155	0.0138	0.0123	0.0110	0.0099	0.0088	0.0079	0.0071	0.0064
5 - 9	0.0024	0.0021	0.0018	0.0016	0.0014	0.0013	0.0011	0.0010	0.0009
10 - 14	0.0018	0.0017	0.0017	0.0016	0.0016	0.0015	0.0015	0.0015	0.0014
15 - 19	0.0018	0.0017	0.0015	0.0014	0.0013	0.0011	0.0010	0.0009	0.0008
20 - 24	0.0033	0.0031	0.0029	0.0028	0.0026	0.0025	0.0024	0.0023	0.0021
25 - 29	0.0055	0.0056	0.0056	0.0057	0.0057	0.0058	0.0058	0.0059	0.0061
30 - 34	0.0087	0.0094	0.0101	0.0109	0.0119	0.0127	0.0137	0.0148	0.0159
35 - 39	0.0105	0.0114	0.0125	0.0137	0.0149	0.0163	0.0178	0.0195	0.0213
40 - 44	0.0092	0.0094	0.0099	0.0104	0.0108	0.0112	0.0117	0.0122	0.0127
45 - 49	0.0089	0.0090	0.0090	0.0090	0.0090	0.0090	0.0091	0.0091	0.0091
50 - 54	0.0088	0.0084	0.0080	0.0076	0.0074	0.0069	0.0066	0.0063	0.0060
55 - 59	0.0105	0.0098	0.0091	0.0085	0.0080	0.0074	0.0070	0.0065	0.0060
60 - 64	0.0150	0.0140	0.0130	0.0121	0.0113	0.0105	0.0098	0.0091	0.0085
65 - 69	0.0236	0.0222	0.0208	0.0195	0.0183	0.0173	0.0161	0.0151	0.0142
70 - 74	0.0378	0.0352	0.0331	0.0309	0.0289	0.0270	0.0253	0.0236	0.0221
75 - 79	0.0667	0.0640	0.0615	0.0590	0.0567	0.0544	0.0523	0.0502	0.0482
80+	0.1255	0.1196	0.1138	0.1084	0.1033	0.0984	0.0937	0.0892	0.0850

Source: Appendix 5

The ASMRs for females decline over the period from 2010 to 2050 with exception of age groups 25 - 29, 30 - 34, 35 - 39, 40 - 44 and 45 - 49. The ASMRs of the five reproductive age groups increase over the projection period.

The male deaths are obtained by multiplying the male ASMRs in Table 5.2 with the projected male population in Table 4.11, while the female deaths are obtained by multiplying the female ASMRs in Table 5.3 with the projected female population in Table 4.11. The results of CDRs computations are presented in Appendix 6, while the projected CDRs are shown in Table 5.4.

Table 5.4: Projected CDRs (2010 – 2050)

YEAR	2010	2015	2020	2025	2030	2035	2040	2045	2050
CDR	9.43	8.65	8.41	8.36	8.42	8.60	8.91	9.31	9.78

Source: Appendix 6

The CDR declines from the year 2010 to 2025 and starts to increase to 2050. It is expected that CDR would continue to decline over the period since most of the ASMRs in both males and females decline over the period. The increase in CDR may be attributed to the increase in the ASMRs for males in the four age groups from 30 years to 49 years (Table 5.2) and the five age groups in females from 25 years to 49 years (Table 5.3). Additionally, the deaths in the elderly population increase over the projection period despite the declining ASMRs due to increased population and dynamics in the age structure. The deaths are obtained by multiplying the ASMRs by the population in these age groups which consequently results in increased CDRs.

5.2.3 Illustration of Demographic Transition

Demographic transition in Kenya is illustrated using both the past CBRs and CDRs as presented in Table 3.6 and projected CBRs as presented in Table 5.1 as well as projected CDRs as presented in Table 5.4. These are combined in Table 5.5 and illustrated in Figure 5.1.

Table 5.5 CBRs and CDRs (1969 – 2050)

Year	1969	1979	1989	1999	2009	2010	2015	2020	2025	2030	2035	2040	2045	2050
CBR	50.00	52.00	48.00	41.30	35.20	36.34	34.28	31.84	29.49	27.16	24.65	22.49	20.62	18.90
CDR	17.00	14.00	11.00	12.00	10.40	9.43	8.65	8.41	8.36	8.42	8.60	8.91	9.31	9.78

Source: Table 3.6, Table 5.1 and Table 5.4

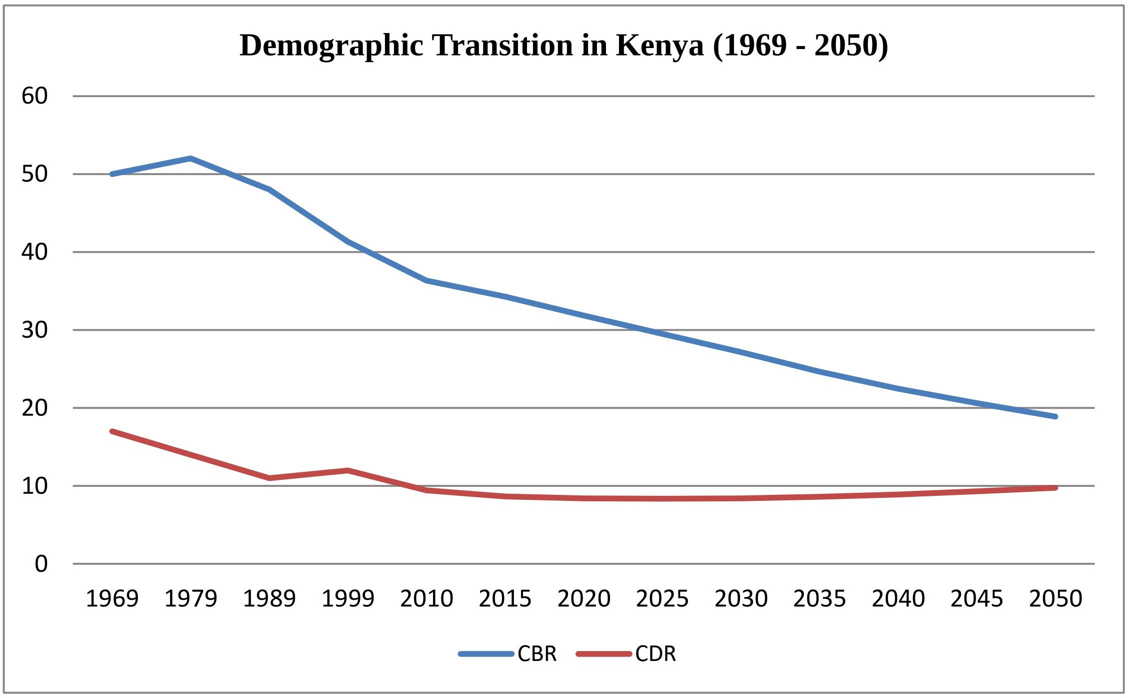


Figure 5.1: Illustration of Demographic Transition in Kenya (1969 – 2050)

Source: Table 5.5 *(The 2009 CBR and CDR are omitted in the illustration to obtain a smooth transition)*

Figure 5.1 shows a decline in the rate of natural population increase, the difference between the CBR and the CDR. Whereas the CBR continues to decline over the period, the CDR fluctuates between 1969 and 1999. Generally, the CDR declines from 1969 to 2015 except in 1999 when there is an increase. From 2015, the CDR increases. This demonstrates the demographic transition, an evolution of birth rates and death rates from high levels to low levels.

Most of the high-income countries have achieved the demographic transition (UN, 2015). For instance, Japan, the home to the world's most aged population, achieved its demographic transition in 1949 (Japan International Cooperation Agency [JICA], 2003). Three years after World War II, a baby boom occurred in Japan, which peaked in 1949 and thereafter the fertility rate declined suddenly, majorly due to establishment of Eugenic Protection Law in 1948 which sanctioned easy access to induced abortion (JICA, 2003).

5.3 Population Age Structure

Population pyramids, which illustrate changes in the size and age structure of a population over time, are used to show the contribution of the demographic transition to the increasing share of older persons in a population (UN, 2015). The age structures for the years 2010, 2030 and 2050 have been chosen for illustration.

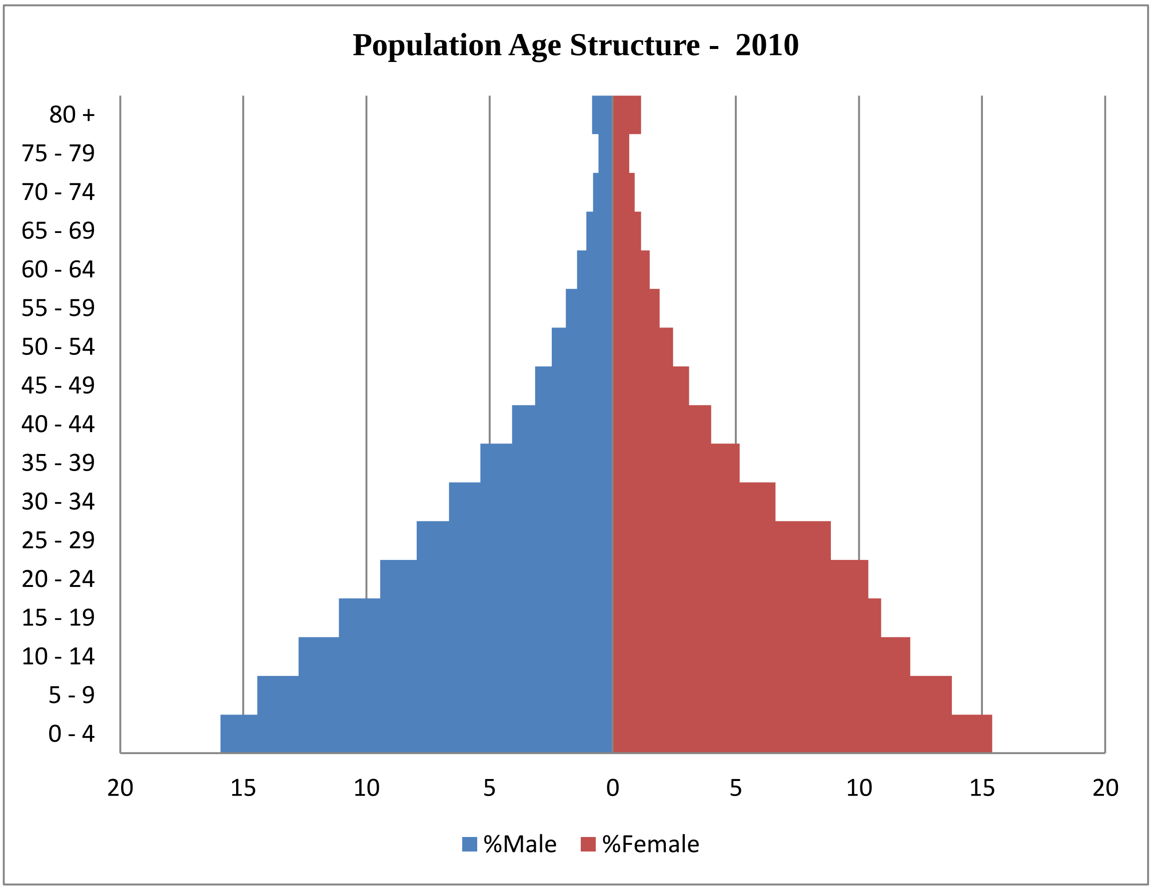


Figure 5.2: Population Age Structure, 2010 – Pyramid

Source : Table 4.11

The population structure for 2010 is youthful. The younger age groups are wider than the older age groups.

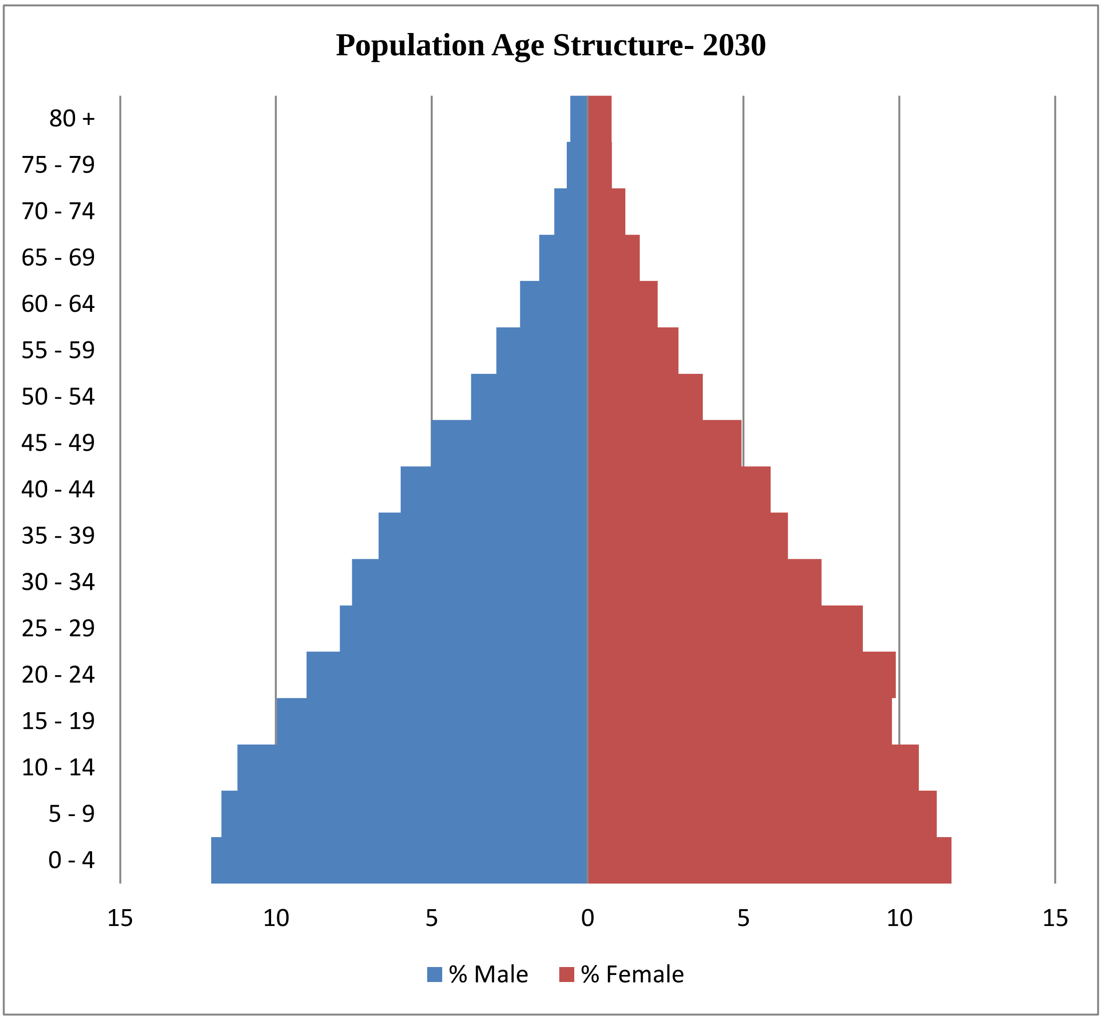


Figure 5.3: Population Age Structure, 2030 -Pyramid

Source : Table 4.11

The population structure for 2030 is still youthful though with some increase in the population of middle age groups.

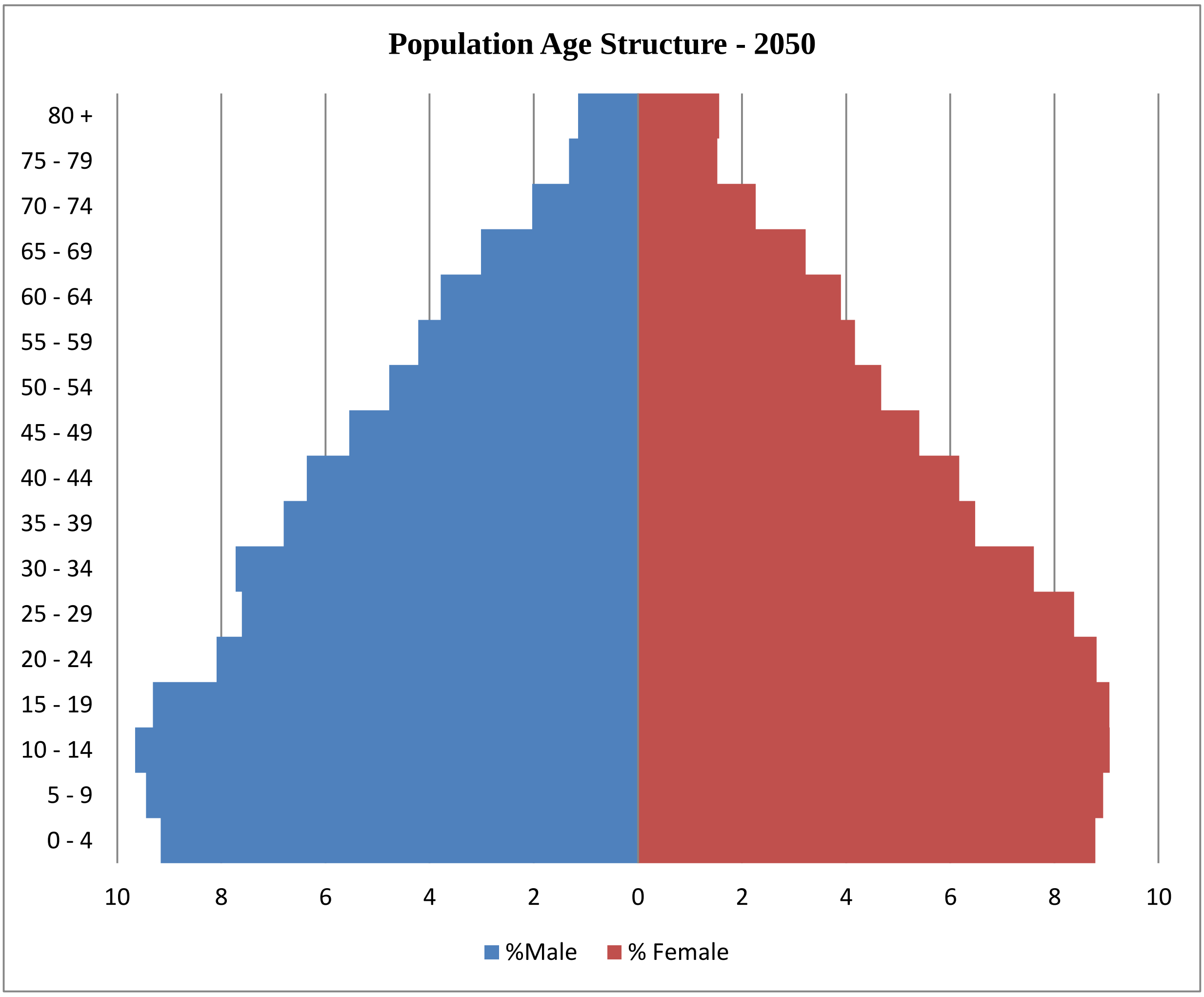


Figure 5.4: Population Age Structure, 2050 – Pyramid

Source : Table 4.11

The population structure for 2050 show that the population has started aging. The ages below 30 years are more less having a blocked structure and not pyramidal. There is also significant increase in the population of the older age groups.

The population age structures for 2010, 2030 and 2050 have been combined in Figure 5.5 to illustrate the shift of the population in age groups towards older ages.

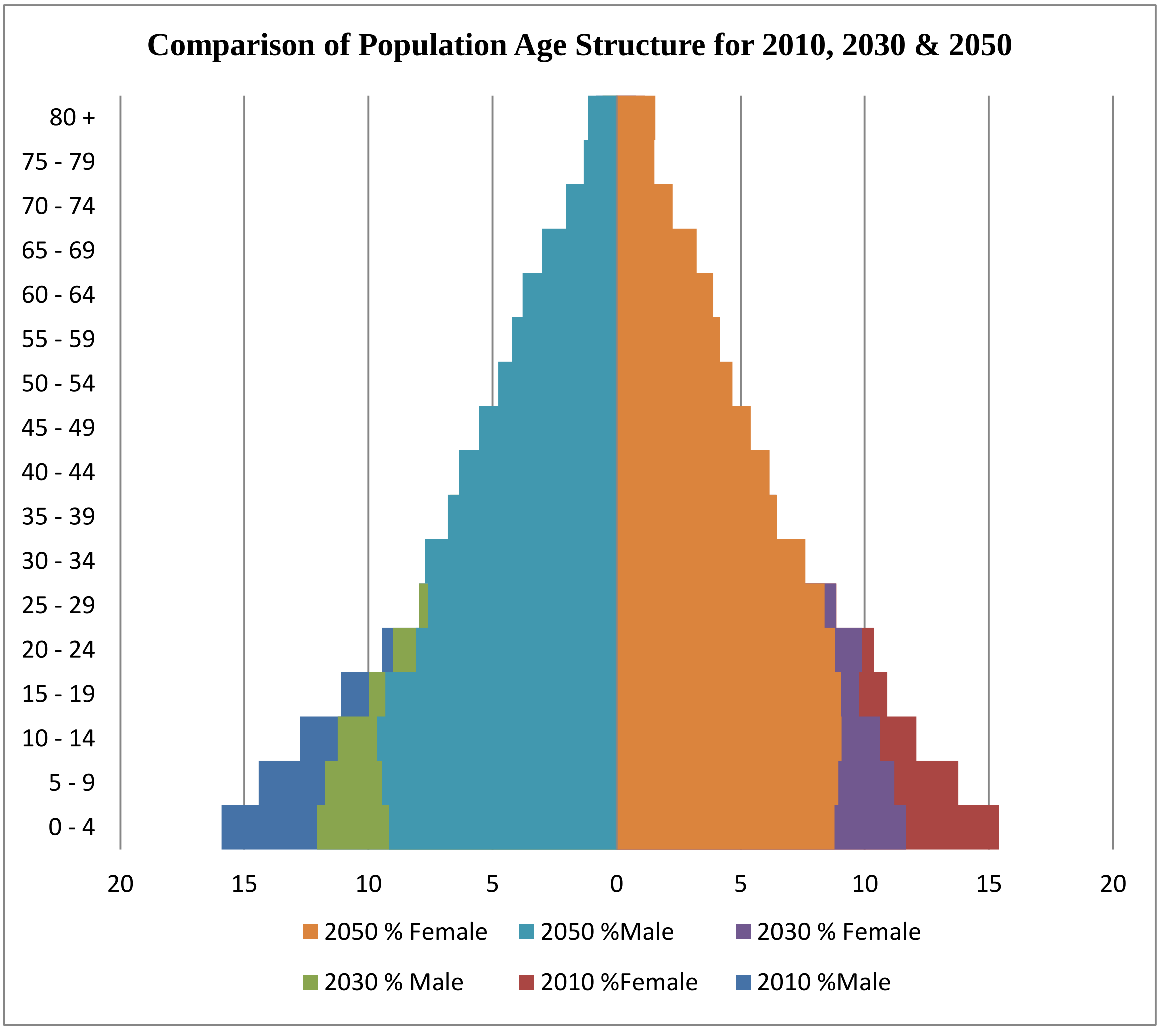


Figure 5.5: Comparison of Population Age Structures for 2010, 2030 and 2050

Source : Table 4.11

The age structures are broadening as the age groups increase towards the older ages. This demonstrates that the Kenyan population has started aging, though still far from being like that of Japan, the most aged country in the world (UN, 2015). The population age structure of Japan is shown by the population pyramid in Figures 5.6.

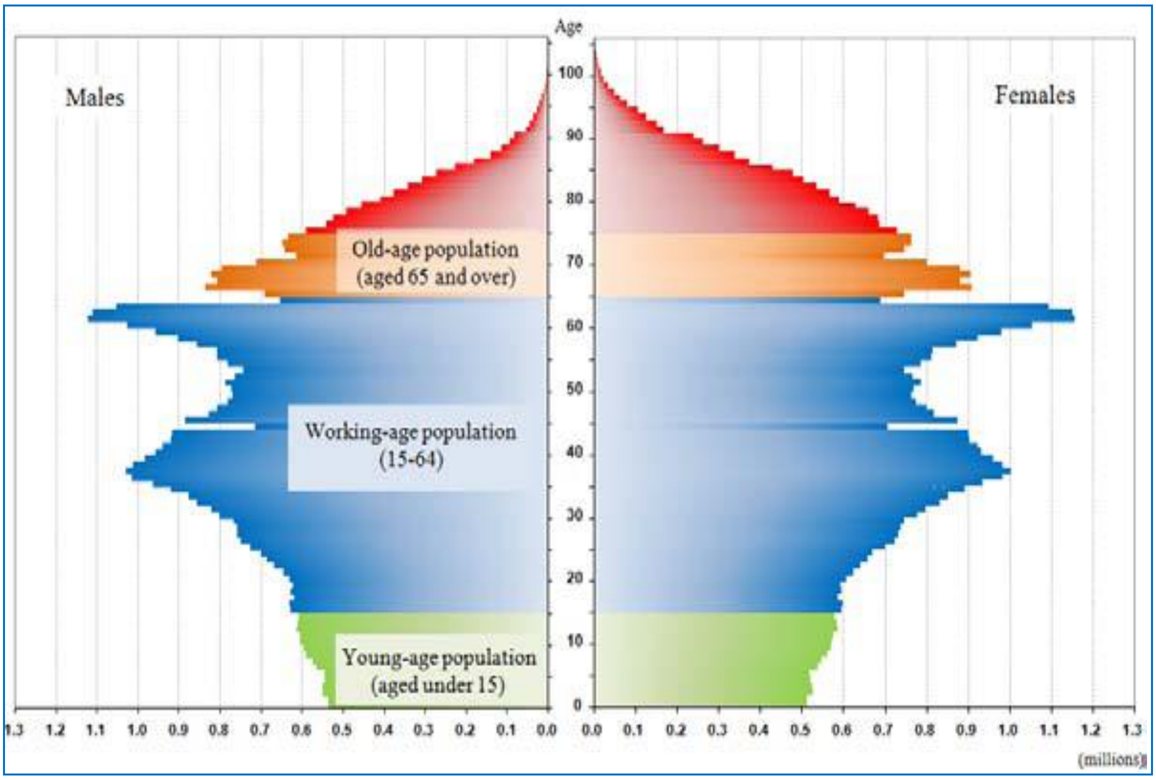


Figure 5.6: Population Pyramid for Japan - 2010

Source: National Institute of Population and Social Security Research (2012)

The population pyramid of Japan in 2010 has significant irregularities due to acute fluctuations in past numbers of live births. For example, there was a decrease in the number of live births from 1945 to 1946 in line with the termination of the World War II, an increase known as the first baby boom from 1947 to 1949, a subsequent decrease from 1950 to 1957, and a sharp single year drop in 1966, which corresponded to a period in the Chinese sexagenarian cycle that, owing to traditional beliefs, is accompanied by a sharp decline in birth rates. This was followed by a subsequent increase referred to as the second baby boom cohorts from 1971 to 1974, and a steady decrease thereafter (National Institute of Population and Social Security Research, 2012).

The members of first baby-boomer generation are in their early 60s and those of the second baby boomer generation are in their late 30s. Looking at the subsequent evolution of this pyramid shape according to the medium fertility projection, the first baby boomers will be in their early 80s and the second baby boomers will be in their late 50s in 2030. The projected population age structure for Japan in 2030 is shown in the Figure 5.7 below.

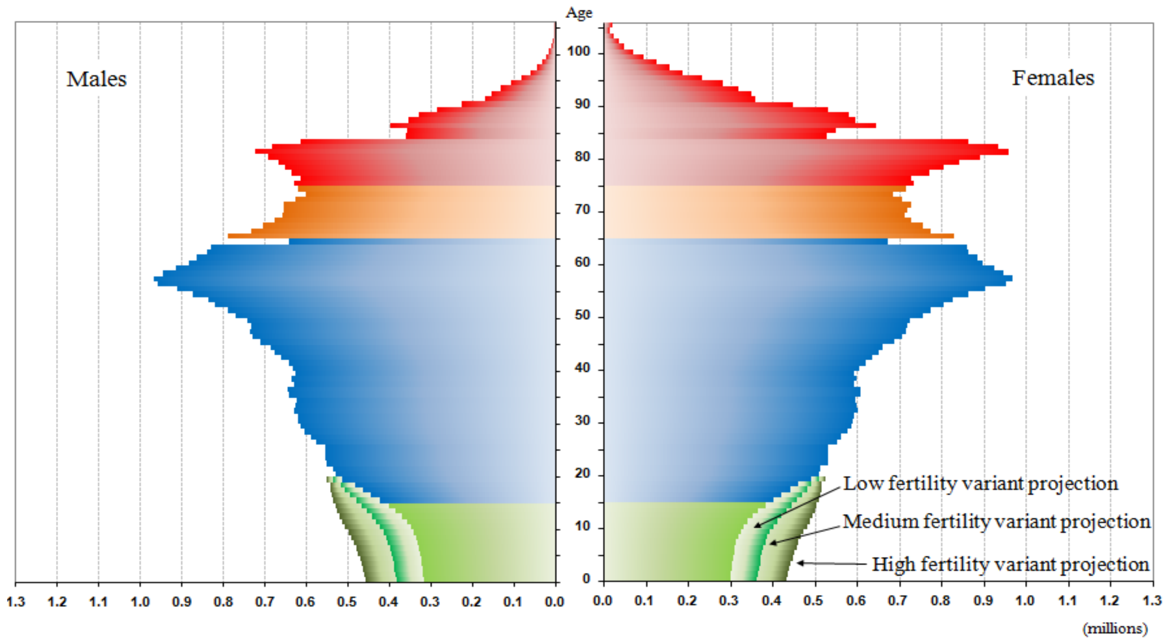


Figure 5.7: Population Pyramid for Japan - 2030

Source: National Institute of Population and Social Security Research (2012).

5.4 Population Aging Indicators

Population aging indicators are computed from data of the past census reports as compiled in Table 3.7 and projected population data as presented in Table 4.11. A summary of selected age groups is presented in Table 5.6, which are used in computation of aging indicators.

Table 5.6: Population in Age Groups

Year	Population							
	< 15	15 - 59	15 - 64	60 +	65+	70+	80+	Total Population
1969	5292955	5061767	5258741	587983	391009	253091		10942705
1979	8305164	7262193	7483309	574002	352886	194775		16141359
1989	11316052	10966093	11314346	867456	519203	277940		23149601
1999	12755007	15283651	15710333	1414366	987684	651715		29453024
2010	16245793	20319958	20887197	1943715	1376476	948412	383677	38509466
2015	17209336	23554144	24229097	2118211	1443259	937063	327408	42881692
2020	18028874	27090800	27921927	2459325	1628198	1022302	311603	47578999
2025	18623167	30758261	31772633	2951779	1937407	1186908	328940	52333207
2030	19547305	33860276	35118839	3622239	2363677	1442730	380440	57029820
2035	20142127	36974937	38529587	4490684	2936034	1787826	463383	61607748
2040	20408043	39849202	41751834	5575664	3673032	2248288	588507	65832909
2045	20352463	42148536	44602599	7049147	4595084	2843216	757703	69550146
2050	20010295	44072552	46868808	8654167	5857911	3588910	988303	72737015

Source: Table 3.7 and Table 4.11

The population 60+, 65+ and 70+ drops between the years 1969 and 1979. This may be attributed to over-reporting of the population in these age groups in the year 1969 or under-reporting in the year 1979. The ideal scenario is that the population in these age groups should be higher in the year 1979 compared to that in the year 1969.

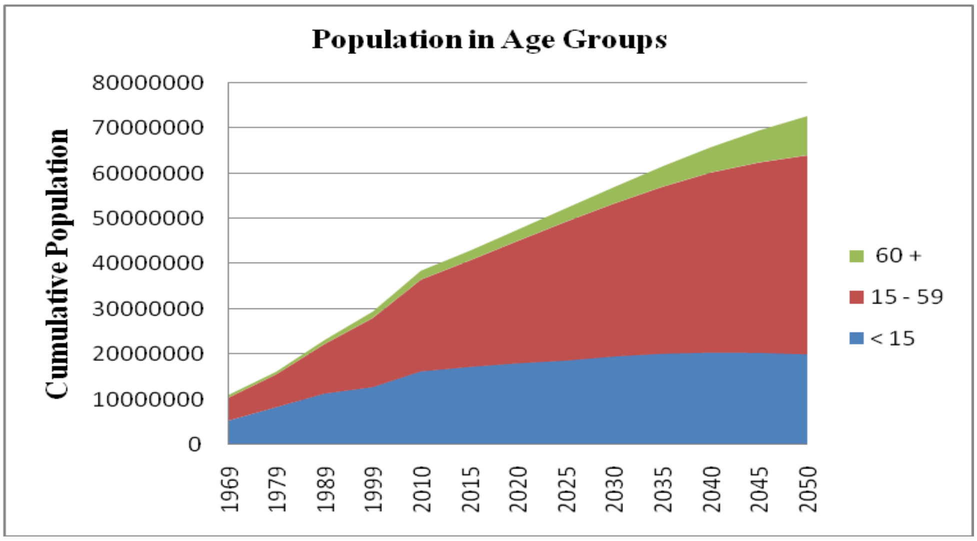


Figure 5.8: Population in Age Groups <15, 15- 59, 60+

Source: Table 5.6

The population 60+, the elderly population, increases over the years.

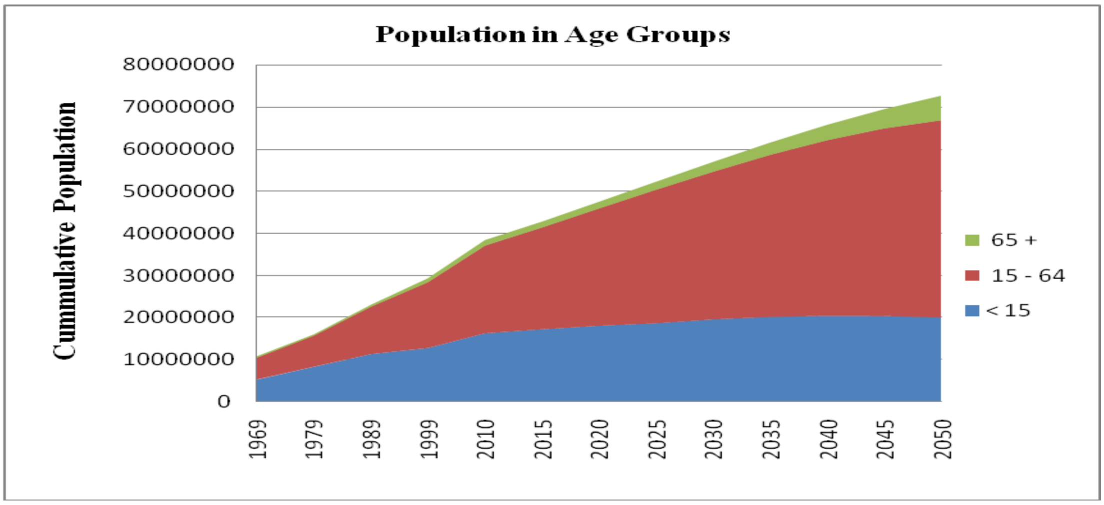


Figure 5.9: Population in Age Groups <15, 15- 64, 65+

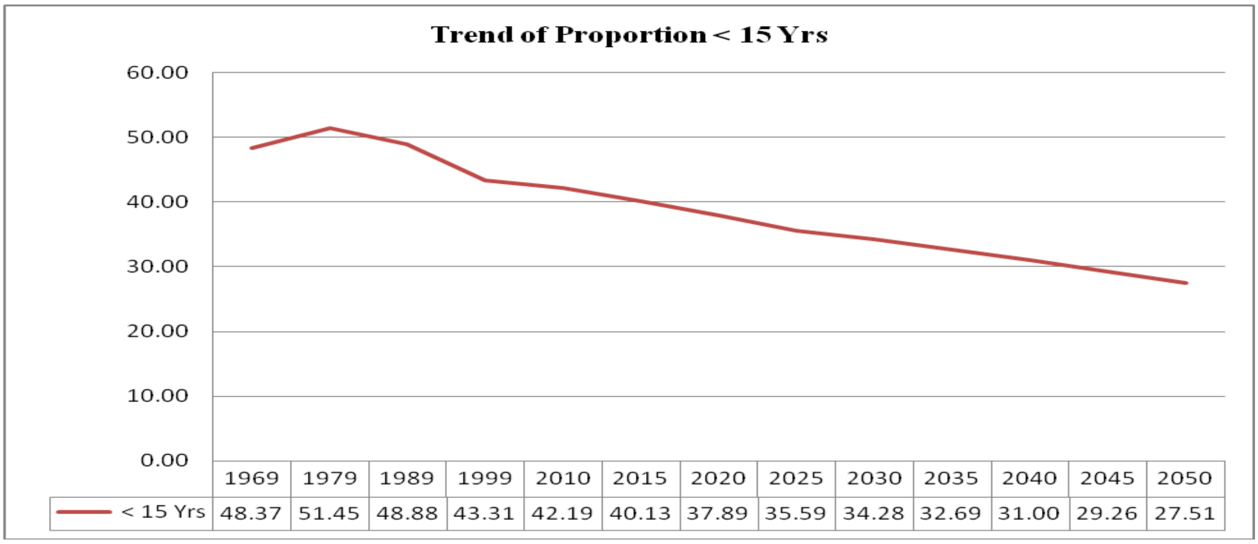
Source: Table 5.6

The population 65+, the aged population, increases over the years.

Table 5.7: Aging Indicators

Year	Proportion of the Population						Aging Index	Dependency Ratio	OADR	Potential Support Ratio	Median
	< 15	15 - 59	60+	65 +	70+	80 +					
1969	48.37	46.26	5.37	3.57	2.31		7.39	108.09	7.44	13.45	15.31
1979	51.45	44.99	3.56	2.19	1.21		4.25	115.70	4.72	21.21	13.96
1989	48.88	47.37	3.75	2.24	1.20		4.59	104.60	4.59	21.79	15.04
1999	43.31	51.89	4.80	3.35	2.21		7.74	87.48	6.29	15.91	17.27
2010	42.19	52.77	5.05	3.57	2.46	1.00	8.47	84.37	6.59	15.17	18.05
2015	40.13	54.93	4.94	3.37	2.19	0.76	8.39	76.98	5.96	16.79	19.04
2020	37.89	56.94	5.17	3.42	2.15	0.65	9.03	70.40	5.83	17.15	20.08
2025	35.59	58.77	5.64	3.70	2.27	0.63	10.40	64.71	6.10	16.40	21.31
2030	34.28	59.37	6.35	4.14	2.53	0.67	12.09	62.39	6.73	14.86	22.59
2035	32.69	60.02	7.29	4.77	2.90	0.75	14.58	59.90	7.62	13.12	23.84
2040	31.00	60.53	8.47	5.58	3.42	0.89	18.00	57.68	8.80	11.37	24.93
2045	29.26	60.60	10.14	6.61	4.09	1.09	22.58	55.93	10.30	9.71	26.21
2050	27.51	60.59	11.90	8.05	4.93	1.36	29.27	55.19	12.50	8.00	27.53

Source: Computed from Table 5.6 and Table 4.11

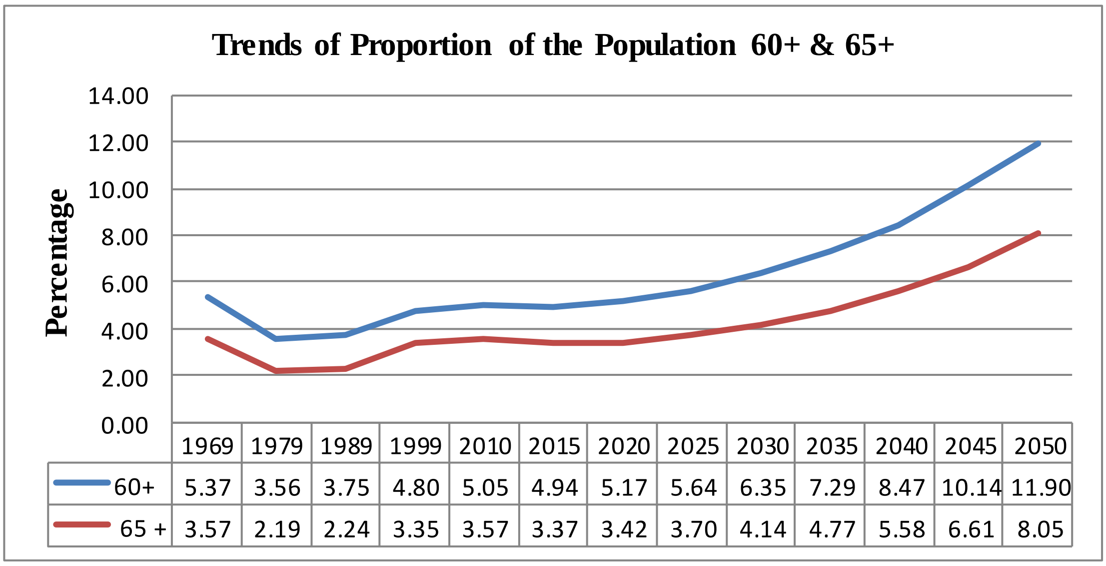


	1969	1979	1989	1999	2010	2015	2020	2025	2030	2035	2040	2045	2050
< 15 Yrs	48.37	51.45	48.88	43.31	42.19	40.13	37.89	35.59	34.28	32.69	31.00	29.26	27.51

Figure 5.10: Trend of Population Proportion Less than 15 Years

Source: Table 5.7

The proportion of the population less than 15 years decreases over the period from 1979.



	1969	1979	1989	1999	2010	2015	2020	2025	2030	2035	2040	2045	2050
60+	5.37	3.56	3.75	4.80	5.05	4.94	5.17	5.64	6.35	7.29	8.47	10.14	11.90
65 +	3.57	2.19	2.24	3.35	3.57	3.37	3.42	3.70	4.14	4.77	5.58	6.61	8.05

Figure 5.11: Trend of Proportion of Population 60 & 65 Years and Above

Source: Table 5.7

From the year 1979, the proportion of the population 60 years and above generally increases over the period just like that of the proportion of the population 65 years and above. Proportion of the total population 65 years with 10 percent or more is said to be old while those with fewer than 5 percent is considered to be young. The Kenyan population is young and will remain young until about 2035. It will then move to intermediate age. By 2050, the population will be almost old at 8.05 percent being aged (65 years and above).

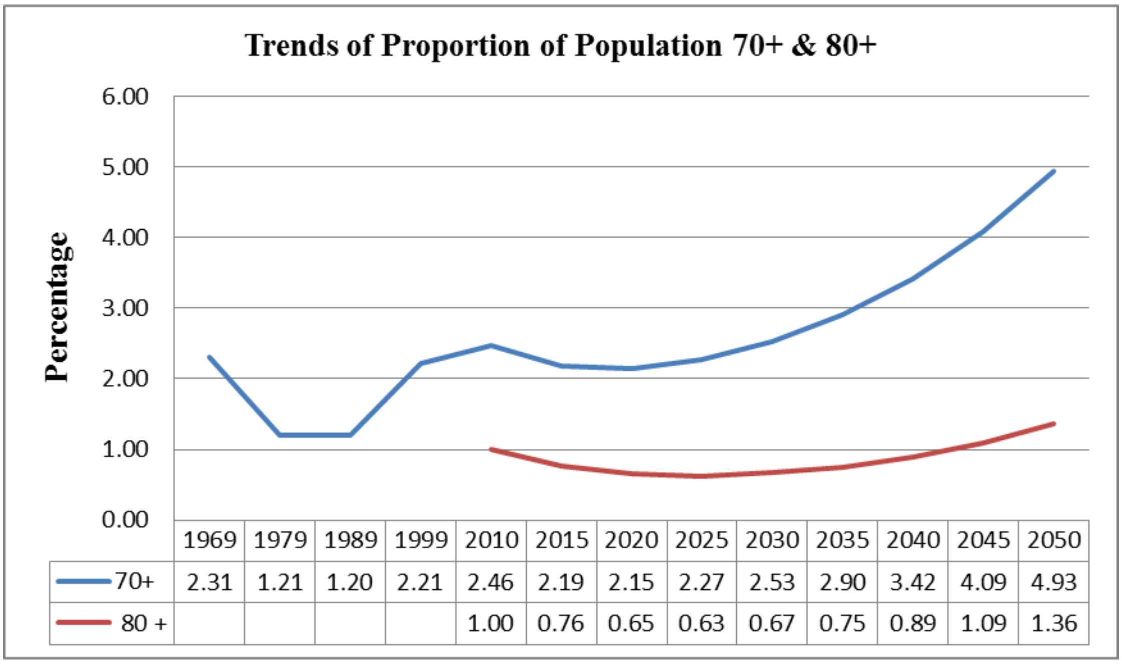


Figure 5.12: Trend of Proportion of Population 70 & 80 Years and Above

Source: Table 5.7

The proportion of the population 70 years and above fluctuates between 1969 and 2020 before increasing steadily. Similarly, the proportion of the population 80 years and above decreases from the year 2010 to 2025 before increasing gradually. The gap between the proportion of the population 70 years and above and 80 years and above widens from 2025 to 2050. This implies that majority of the Kenyans who reach 70 years do not live to their 80th birthday. The data for the proportion of the population 80 years and above from 1969 to 1999 are not indicated as their numbers are not provided in the census analytical reports which are used as the source of data. The exclusion of the proportions does not alter the depicted trends.

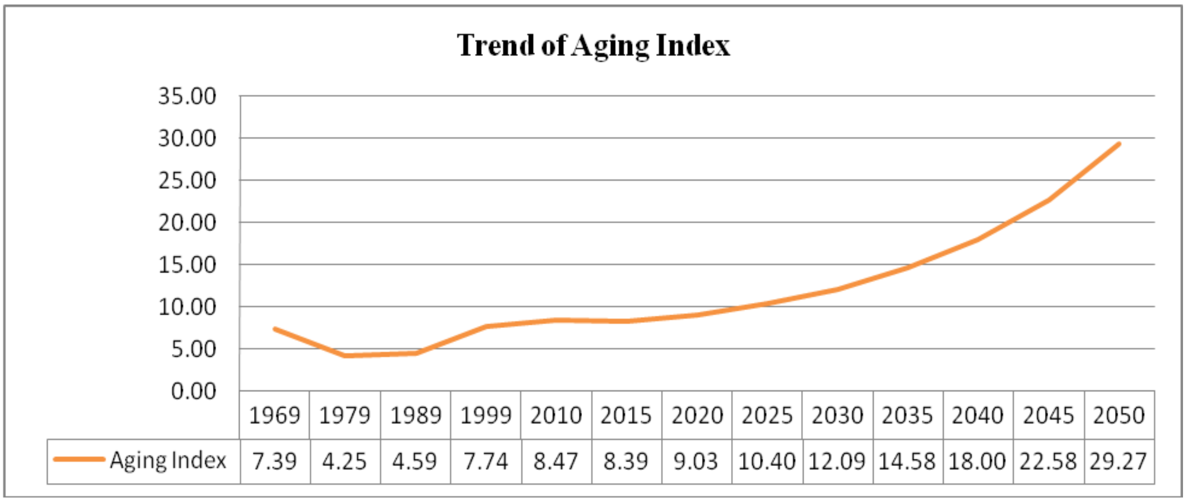


Figure 5.13: Trend of Aging Index

Source: Table 5.7

The aging index increases over time. Population with aging index under 15 percent is considered young while that with the index over 30 percent as old. The Kenyan population will remain young to the year 2035. By 2040, the population will have transited to intermediate age. By 2050, the population of Kenya will be almost old, with an aging index of 29.3 percent.

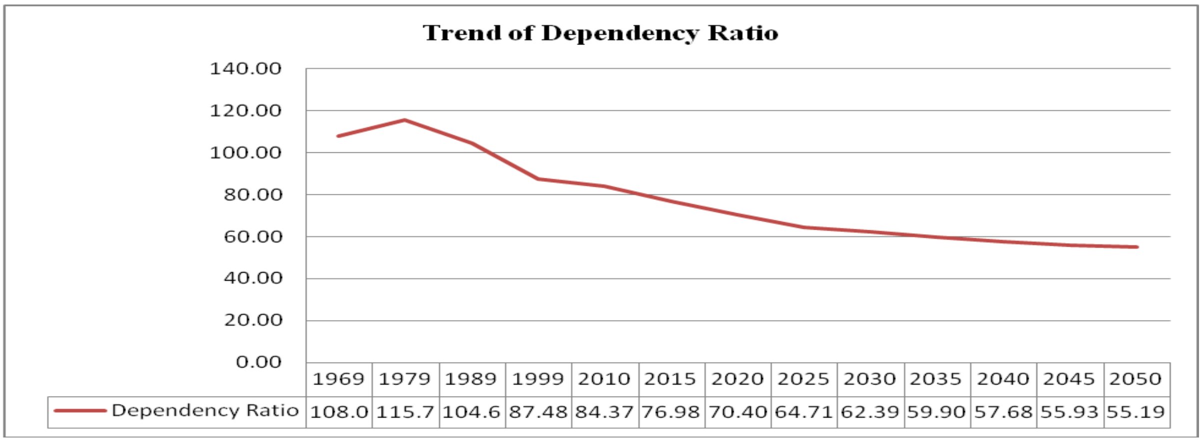
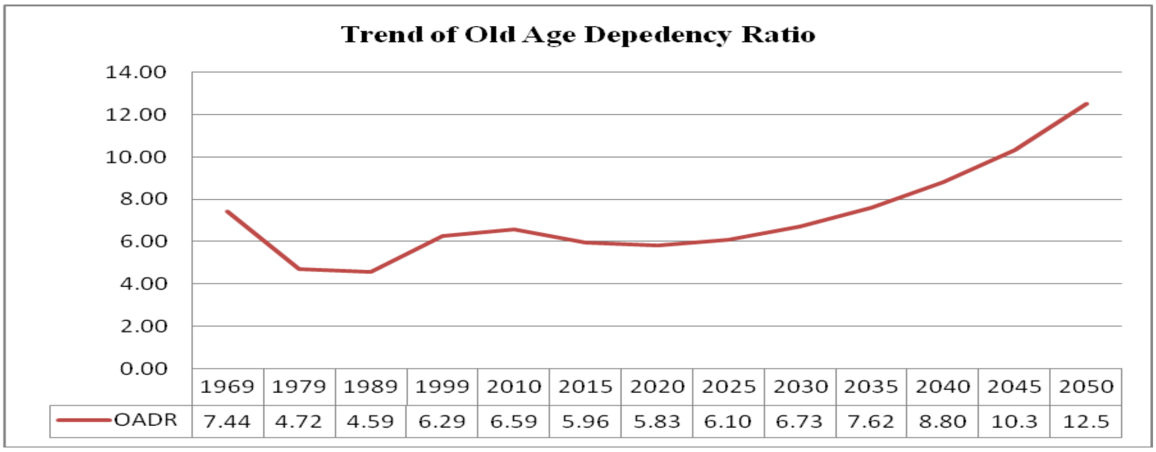


Figure 5.14: Trend of Dependency Ratio

Source: Table 5.7

The dependency ratio declines over time since 1979. This has been as a result of declining population under 15 years.

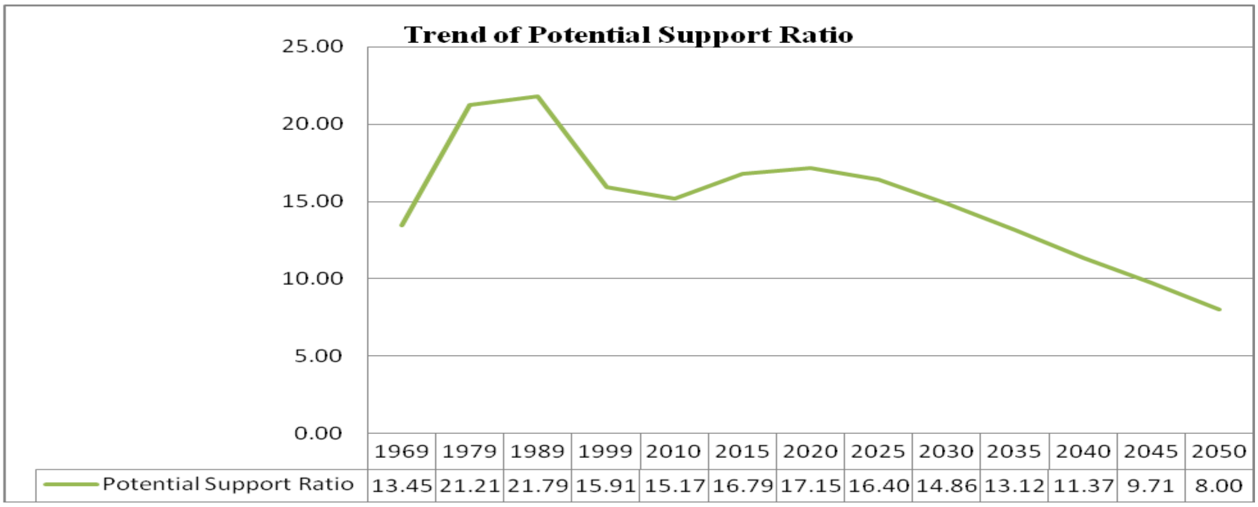


	1969	1979	1989	1999	2010	2015	2020	2025	2030	2035	2040	2045	2050
OADR	7.44	4.72	4.59	6.29	6.59	5.96	5.83	6.10	6.73	7.62	8.80	10.3	12.5

Figure 5.15: Trend of Old Age Dependency Ratio

Source: Table 5.7

The old age dependency ratio increases over time. This has been as a result of an increase in the population 65 years and above.



	1969	1979	1989	1999	2010	2015	2020	2025	2030	2035	2040	2045	2050
Potential Support Ratio	13.45	21.21	21.79	15.91	15.17	16.79	17.15	16.40	14.86	13.12	11.37	9.71	8.00

Figure 5.16: Trend of Potential Support Ratio

Source: Table 5.7

Potential support ratio declines generally over time. This is a consequence of aging population.

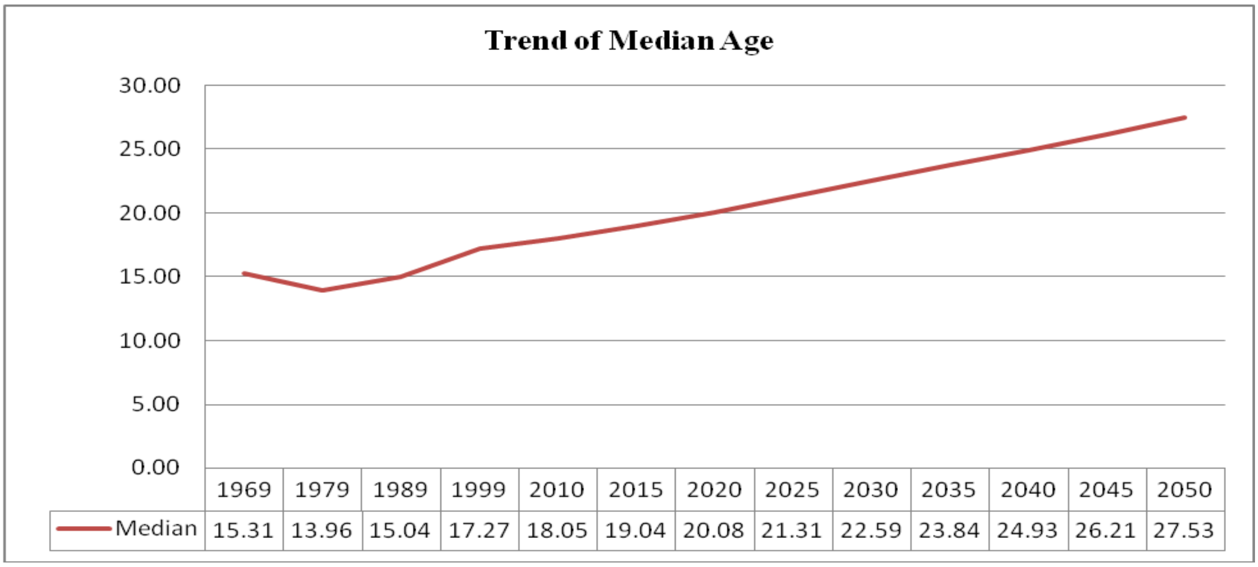


Figure 5.17: Trend of Median Age

Source: Table 5.7

The median increases over time. Populations with median age less than 20 years is described as young, those with median age of 20 years to 29 years as intermediate, while those with median age of 30 years or over as old.

The Kenya population will remain young with median age below 20 years up to 2020. From the year 2020 to the year 2050, the population will be in the intermediate median age of below 30 years though progressing towards the old age.

The expectations of life for the projected population at various ages are given in Table 5.8. These were obtained from Appendices 4 and 5.

Table 5.8: Expectation of Life at Various Ages

	Expectation of Life							
	At Birth		At 60 Yrs		At 65 Yrs		At 80 Yrs	
Year	Male	Female	Male	Female	Male	Female	Male	Female
2010	58.8	62.6	17.3	19.8	13.9	16.1	6.3	8.0
2015	59.6	63.4	17.6	20.3	14.2	16.6	6.5	8.4
2020	60.4	64.1	18.0	20.9	14.5	17.1	6.7	8.8
2025	61.1	64.7	18.3	21.5	14.8	17.7	6.8	9.2
2030	61.8	65.3	18.7	22.1	15.2	18.2	7.0	9.7
2035	62.4	65.8	19.1	22.7	15.5	18.8	7.2	10.2
2040	62.9	66.2	19.4	23.4	15.8	19.4	7.4	10.7
2045	63.3	66.5	19.8	24.0	16.1	20.0	7.6	11.2
2050	63.8	66.7	20.2	24.7	16.5	20.7	7.8	11.8

Source: Appendices 4 and 5

Expectation of life in Kenya increases over the years with females having a higher expectation of life than the males. These are illustrated in the Figures 5.17 to 5.20.

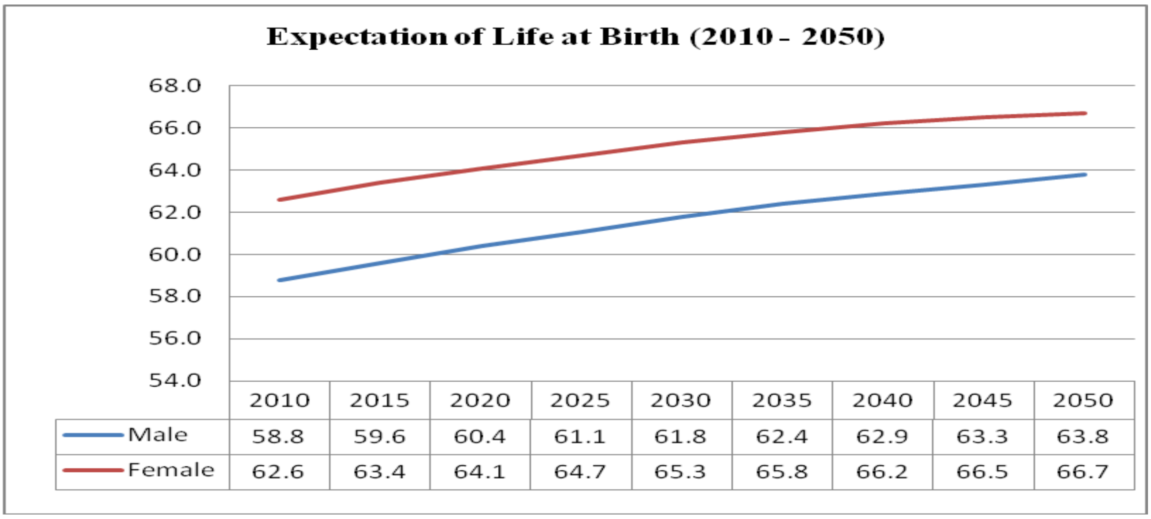


Figure 5.18: Expectation of Life at Birth

Source: Table 5.8

Expectation of life at birth for males is projected to increase from 58.8 years in 2010 to 63.8 years in 2050, an increase of 5 years. The females, on the other hand, are expected to live 4.1 years more, with life expectancy at birth increasing from 62.6 years to 66.7 years over the same period. On average, however, women are projected to live longer than men by 2.9 years at birth in 2050.

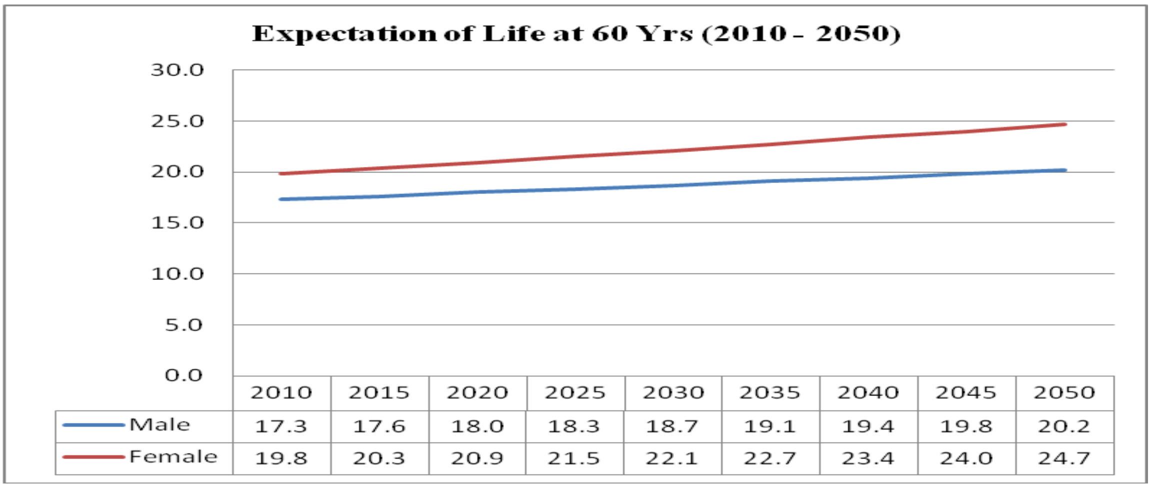


Figure 5.19: Expectation of Life at 60 Years

Source: Table 5.8

Expectation of life at 60 years for males is projected to increase from 17.3 years in 2010 to 20.2 years in 2050. This gives an increase of 2.9 years. The females, on the other hand, are projected to live for more 4.9 years from 19.8 years in 2010 to 24.9 years in 2050. The females aged 60 years, on average, are projected to outlive men by 4.5 years in the year 2050.

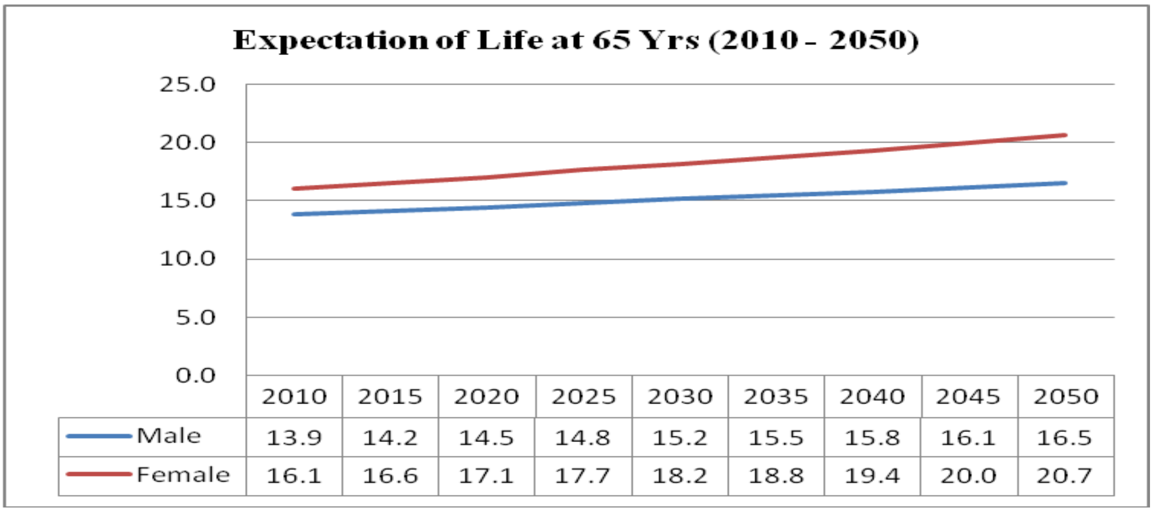


Figure 5.20: Expectation of Life at 65 Years

Source: Table 5.8

Expectation of life at 65 years for males is projected to increase from 13.9 years in 2010 to 16.5 years in 2050 being an increase of 2.6 years. The females will increase in life expectancy from 16.1 years to 20.7 years over the same period, being an increase of 4.6 years. On average, aged females are projected to outlive aged men by 4.2 years in 2050.

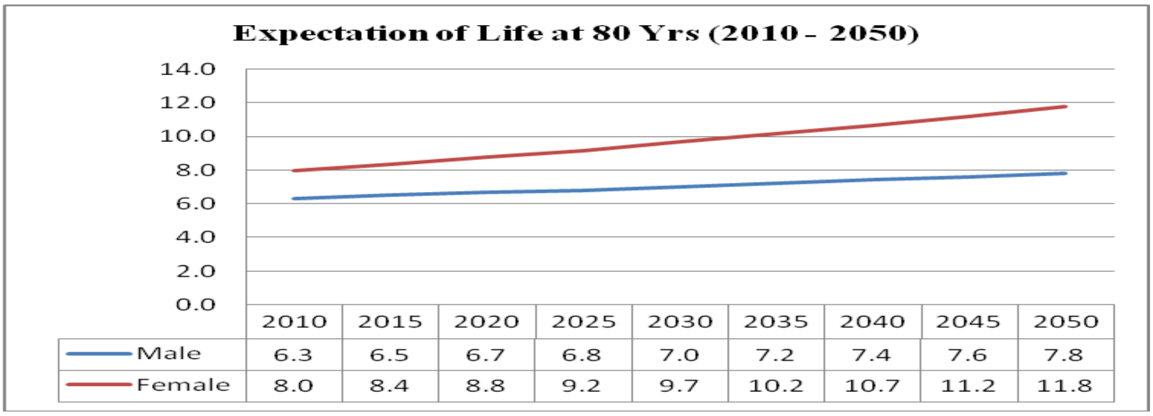


Figure 5.21: Expectation of Life at 80 Years

Source: Table 5.8

Expectation of life at 80 years for males is project to increase from 6.3 years to 7.8 years, an increase of 1.5 years between 2010 and 2050. For the females, they are projected to live for more 3.8 years, from 8.0 years to 11.8 years over the same period. On average, females 80 years are expected to outlive males at 80 years by 4 years in 2050.

5.5 Comparison of the Study Aging Indicators with those of UNPD for Kenya

The aging indicators from this study are compared with those of the UNPD (2015) for Kenya. The percentage population distribution in selected age groups for 2015 and 2050 are compared. Additionally, median age and life expectancy at birth in 2015, 2030 and 2050 are compared.

Table 5.9: Percentage Distribution of the Population in Selected Age Groups

Source	2015				2050			
Age Group	0 - 14	15 - 59	60 +	80+	0 - 14	15 - 59	60 +	80+
Study	40.1	55.0	4.9	0.8	27.5	60.6	11.9	1.4
UNPD (2015)	41.9	53.6	4.5	0.4	30.9	59.5	9.6	0.8

Source: The Study (Table 5.7) and UNPD (2015)

The age group 0 - 14 is projected to decline from 2015 to 2050 in both the study and UNPD (2015). The age group will reduce by 12.6 percent as per the study and 11 percent as per UNPD (2015). On the other hand, the age group 15 - 59 is projected to increase in both the study and UNPD (2015). In the study, it will increase by 5.6 percent while that of UNPD by 5.9 percent over the period 2015 to 2050.

The age group 60+ is projected to increase over the period 2015 to 2050. In the study, the age group increases by 7 percent while in the UNPD (2015) by 5.1 percent. The age group 80+ is also projected to increase over the period where it increases by 0.6 percent in the study and 0.4 percent in UNPD (2015)

The study aging indicators are consistent with those of UNDP (2015) despite the study indicators being slightly higher. The percentage distributions in selected population age groups are illustrated in Figure 5.21.

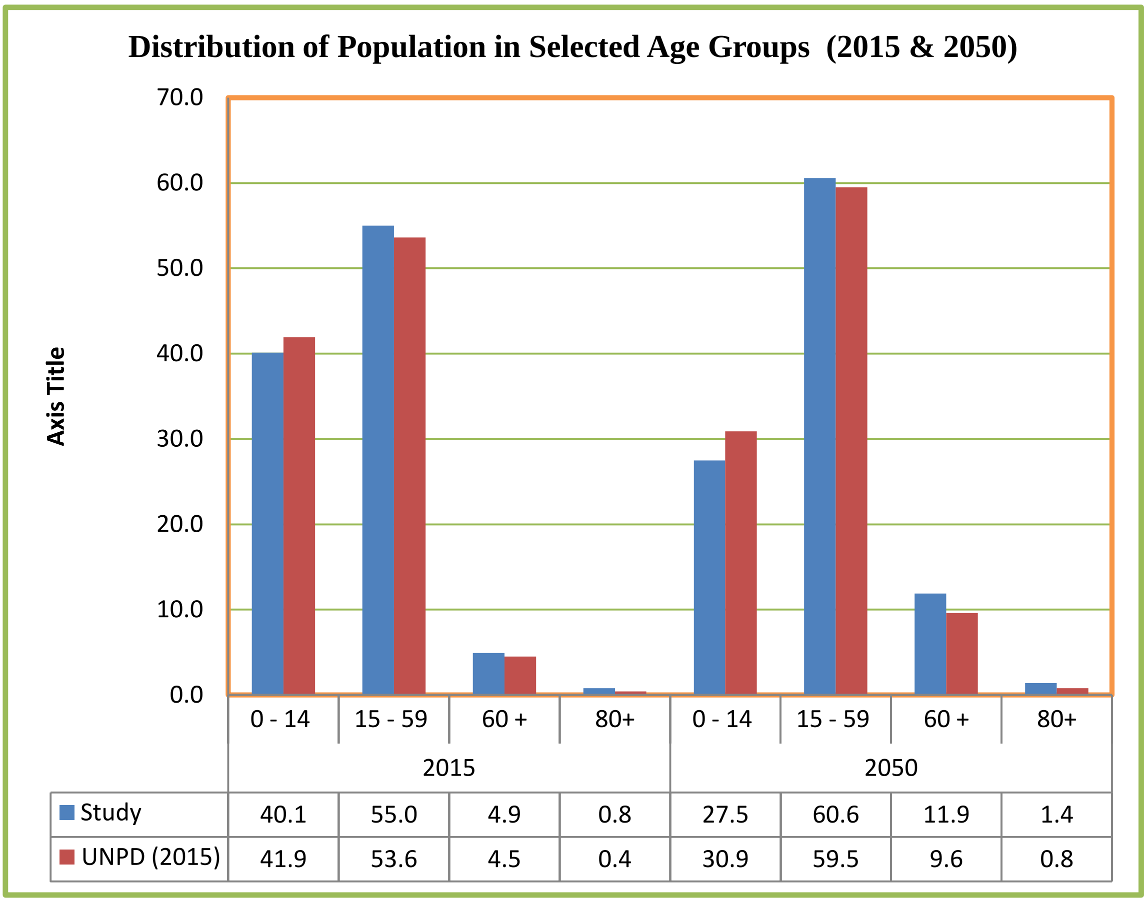


Figure 5.22: Percentage Distribution of the Population in Selected Age Groups

Source: Table 5.9

Table 5.10: Projected Median Age from the Study and UNPD (2015)

Year	Median Age	
	Study	UNPD (2015)
2015	19.0	18.9
2030	22.6	21.6
2050	27.5	25.7

Source: The Study (Table 5.7) and UNPD (2015)

The median age of Kenya from both the study and UNPD (2015) is projected to increase over the period. However, the study median age is higher than that of the UNPD (2015). Whereas both are increasing, the median age will still be in the intermediate median age, progressing towards the old age, by the year 2050. These are illustrated in Figure 5.22.

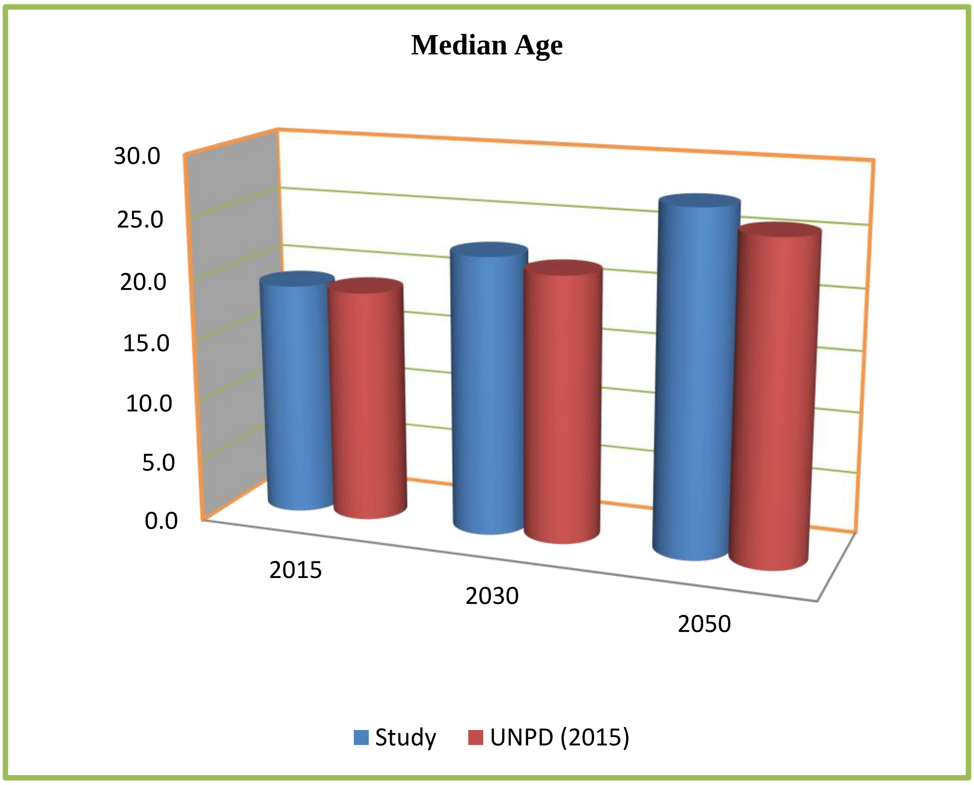


Figure 5.23: Projected Median Age from the Study and UNPD (2015)
Source: Table 5.10

Table 5.11: Projected Expectation of Life at Birth - Study and UNPD (2015)

Year	Life Expectancy at Birth (Combined)	
	Study	UNPD (2015)
2015	61.5	60.6
2030	63.6	66
2050	65.3	71.7

Source: The Study (Table 5.9) and UNPD (2015)

Life expectation at birth for the study is projected to increase by 3.8 years from 61.5 years to 65.3 years from 2015 to 2050. The UNPD (2015) projections for Kenya, however, show that life expectation at birth will increase by 11.1 years over the same period. This appears to be inconsistent with the rest of the indicators as UNPD (2015) has given a lower median age compared to that of the study over the period (Table 5.10; Figure 5.22). UNPD (2015) population distribution of 60+ and 80+ are also lower than those of the study (Table 5.9; Figure 5.21). Comparison of expectation of life at birth is shown in Figure 5.23.

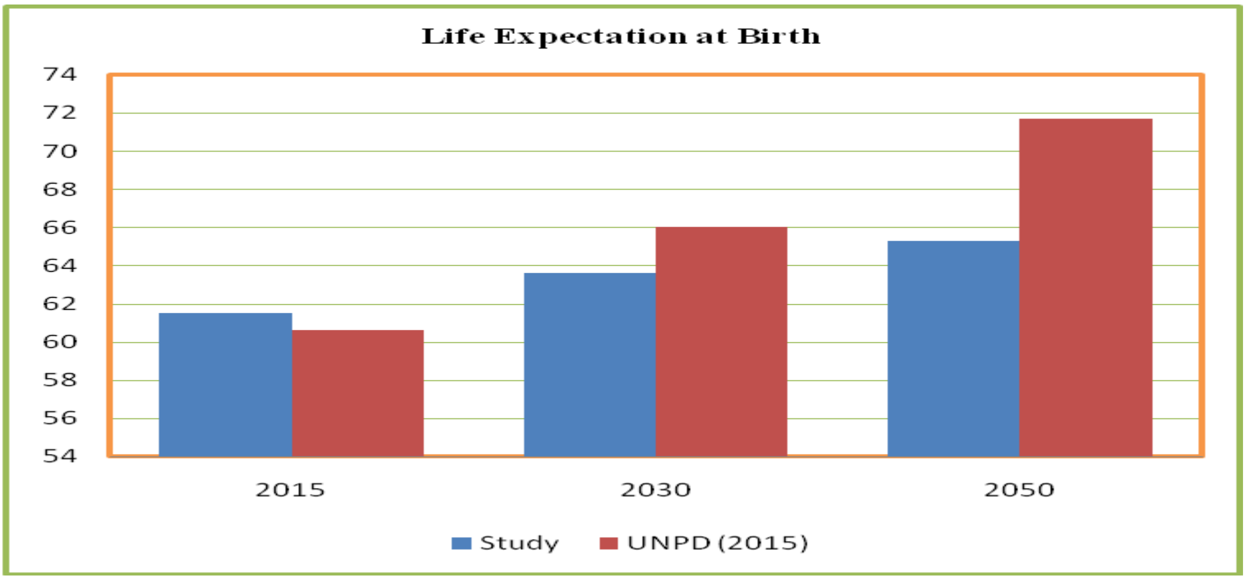


Figure 5.24: Projected Expectation of Life at Birth for Study and UNPD (2015)

Source: Table 5.11

5.6 Implications of Cash Payments to the Aged

The Kenyan Government initiated in January, 2018 the transfer of KShs.2000 per month as non-contributory social pension to registered persons of 70 years and above under the NSNP (Igadwah, 2018). The programme is an expansion of older persons cash transfer programme that was initiated in 2012 targeting population above 65 years and living in extreme poverty (Gender and Equality Commission, 2014). Colossal sums of money are required to implement this programme. A population of 523,129 aged 70 and above had registered to receive the monthly stipend as at March, 2018 and the Kenyan Government had allocated KShs. 6.7 billion to pay them for half year to June, 2018 (Igadwah, 2018). However, the registered numbers are low compared to the projected population as well as what the government is expected to pay. Table 5.12 below shows what the Government is expected to pay the population 70 years and above from the year 2015 to 2050 as per the projected population.

Table 5.12: Projected Cash Transfer to the Population 70 Years and Above (2015 – 2050)

Year	Population 70+	Monthly Stipend per person aged 70+ (KShs.)	Total Monthly Stipend (KShs. in Billions)	Total Yearly Stipend (KShs. in Billions)
2015	937063	2000	1.87	22.49
2020	1022302	2000	2.04	24.54
2025	1186908	2000	2.37	28.49
2030	1442730	2000	2.89	34.63
2035	1787826	2000	3.58	42.91
2040	2248288	2000	4.50	53.96
2045	2843216	2000	5.69	68.24
2050	3588910	2000	7.18	86.13

Source: Author

The projected cash transfer is KShs 22.49 billion in the year 2015. This means that the Kenyan Government is supposed to set aside more amount than what it has currently allocated to cater for the programme. By the year 2020, the Government should allocate KShs. 24.54 billion. This amount increases to KShs. 34.63 billion in the year 2030 and KShs. 86.13 billion in the year 2050 if the current stipend of KShs 2000 is paid per month per person. The trends of the payments are depicted in Figure 5.25 below.

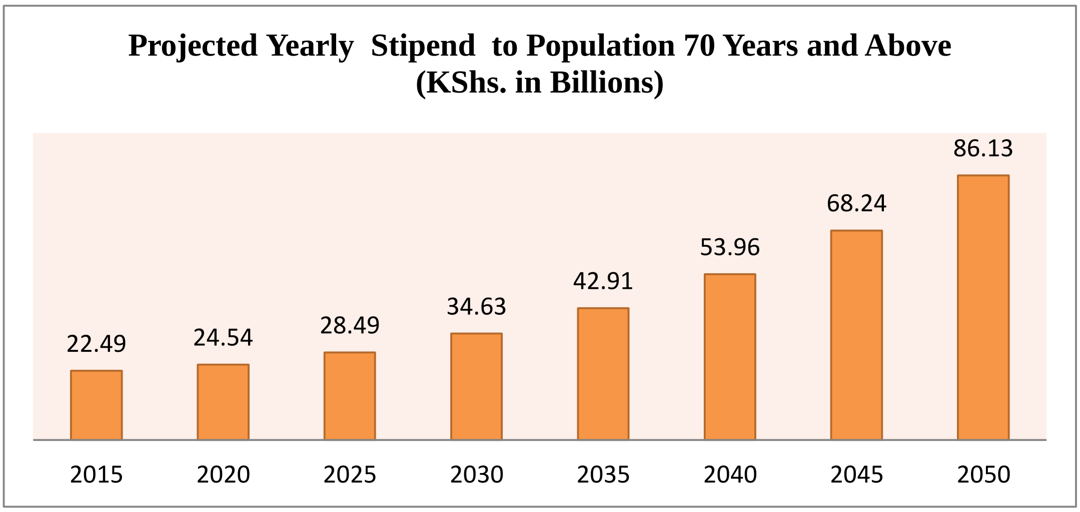


Figure 5.25: Trends in Projected Yearly Stipends to Population 70 Years and Above

Source: Table 5.12

The projected cash transfer amount is very high if the Government is to pay population 65 years and above in the country. This is shown in Table 5.13 below.

Table 5.13: Projected Cash Transfer to the Population 65 Years and Above (2015 – 2050)

Year	Population 65+	Monthly Stipend per person aged 65+ (KShs.)	Total Monthly Stipend (KShs. in Billions)	Total Yearly Stipend (KShs. in Billions)
2015	1443259	2000	2.89	34.64
2020	1628198	2000	3.26	39.08
2025	1937407	2000	3.87	46.50
2030	2363677	2000	4.73	56.73
2035	2936034	2000	5.87	70.46
2040	3673032	2000	7.35	88.15
2045	4595084	2000	9.19	110.28
2050	5857911	2000	11.72	140.59

Source: Author

The amount to be paid to population 65 years and above increases from KShs. 34.64 billion in the year 2015 to KShs. 56.73 billion in the year 2030 to KShs.140.59 billion in the year 2050 if the stipends are to be paid at the rate of KShs. 2,000 per month over the period. Figure 5.26 below shows the trends in the payments.

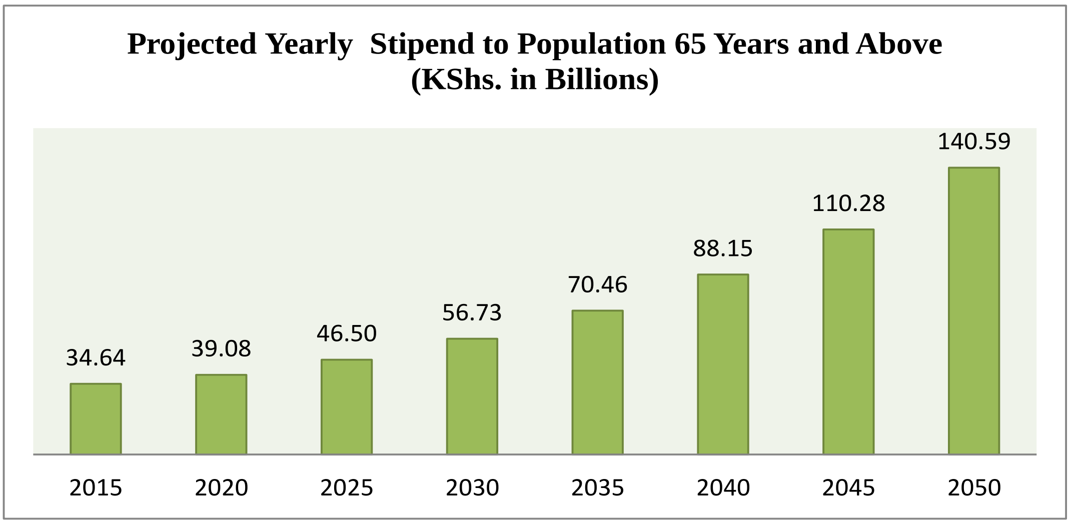


Figure 5.26: Trends in Projected Yearly Stipends to Population 65 Years and Above

Source: Table 5.13

The stipends payable per year increases drastically over the years. The monthly stipend of KShs. 2,000 is unlikely to remain constant to the year 2050 due to ever increasing cost of living. The stipend amount is likely to be increased in the coming years, which will make the cost of the cash transfer programme much higher.

5.7 Summary

Kenya is undergoing a demographic transition with CBR decreasing from 50.0 in 1969 to 34.28 in 2015 to 27.16 in 2030 to 18.90 in 2050. Similarly, the CDR declines from 17.0 in the year 1969 to 8.65 in the year 2015 to 8.36 in the year 2025 before increasing to 8.42 in 2030 and 9.78 in 2050.The natural rate of increase declines over the period. However, the increase in CDR from 2025 to 2050 slows down the demographic transition.

The demographic transition has resulted in the broadening of the age groups as the population increases towards older age groups depicting population aging. However, the Kenyan population will remain youthful to the year 2035 before transiting to intermediate age. By the year 2050, the Kenyan population will not have reached old age, though it will be approaching old age.

The elderly population, population 60 years and above, has been projected to increase over the years from 2.1 million in 2015 to 3.6 million in 2030 to 8.6 million in 2050. Equally, the aged population, population 65 and above, has been projected to increase over the years from 1.4 million (3.37 percent) in 2015 to 2.4 million (4.14 percent) in 2030 to 5.9 million (8.05 percent) in 2050. Additionally, the proportion of the population 70 years and above is projected to increase from 0.94 million (2.19 percent) in 2015 to 1.44 million (2.53 percent) in 2030 to 3.59 million (4.93 percent) in 2050. Moreover, the proportion of the population 80 years and above is projected to increase from 0.33 million (0.76 percent) in the year 2015 to 0.38 million (0.67 percent) in 2030 to 0.99 million (1.36 percent) in 2050. This shows that the Kenyan population will continue to have more people in the oldest old age category.

The aging index is projected to increase over time from 8.39 percent in 2015 to 12.09 percent in 2030, 14.58 percent in 2035 and 29.27 percent in 2050. This implies that the Kenyan population will remain young to the year 2035 after which it will transit to intermediate age. By the year 2050, the population of Kenya will be almost old, with an aging index of 29.27 percent.

The Kenyan population will remain young with median age below 20 years up to the year 2020. From 2020 to 2050, the population will remain in the intermediate age of below 30 years. However, the median age will be progressing towards the old age from 19.04 years in 2015 to 27.53 years in 2050.

Expectation of life at birth for males is projected to increase from 58.8 years in 2010 to 63.8 years in 2050, an increase of 5 years. Females on the other hand are expected to live 4.1 years more, with life expectancy at birth increasing from 62.6 years to 66.7 years over the same period. On average, however, women are projected to live longer than men by 2.9 years at birth in 2050. Expectation of life at 65 years for male is projected to increase from 13.9 years in 2010 to 16.5 years in 2050 being an increase of 2.6 years. Female life expectancy will increase from 16.1 years to 20.7 years over the same period, being an increase of 4.6 years. On average, aged women are projected to outlive aged men by 4.2 years in 2050.

The dependency ratio is projected to decline from 76.98 percent in 2015 to 62.39 percent in 2030 to 55.19 percent in 2050. On the other hand, old age dependency ratio is projected to increase over time from 5.96 percent in 2015 to 6.73 percent in 2030 to 12.50 percent in 2050 while the potential support ratio to decline from 16.79 in 2015 to 14.86 in 2030 and 8.0 in 2050.

The monthly cash transfer to population 70 years and above under the NSNP is projected to increase from KShs. 22.49 billion in 2015 to KShs. 34.63 billion in 2030 to KShs. 86.13 billion in 2050 if the current stipend of KShs. 2,000 per person remains constant. However, if the Government was to pay the population 65 years and above, the amount increases from KShs. 34.64 billion in 2015 to KShs. 56.73 billion in 2030 to KShs.140.59 billion in 2050. The increased costs of the welfare programme arising from population aging could adversely affect public finances.

CHAPTER SIX

SUMMARY OF THE FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter provides a summary of the study background, objectives, data and methods, findings, conclusions and contributions. It also gives recommendations for policy and further research.

6.2 Summary of the Study Background

Population age structure of most countries has been shifting towards older age groups over the years. This process, known as population aging, has seen tremendous increase in the proportion of the elderly (60 years and above) in populations. The shift has been occasioned by demographic transition, the decline in fertility and mortality rates as a result of social and economic changes.

The increase in the numbers of the elderly in a population often puts pressure on public finances and households. This is because the elderly requires more medical attention and pension payments which drain the public coffers as well as increase social welfare spending. Consequently, policy makers in many countries are struggling to deal with the challenges of population aging. Some countries have increased retirement age, others have increased taxes to pay for pension and health care costs, while others have increased participation of private sectors in providing pension and healthcare.

In Kenya, no study has been undertaken to document comprehensively population aging in the country, in spite of the efforts being made to address some of the challenges of population aging. The general objective of the study was to demonstrate population aging in Kenya as a consequence of demographic transition. The specific objectives are:

i. To project the population of Kenya to the year 2050 based on modelled fertility and mortality rates;
ii. To establish an implied demographic transition scenario for Kenya; and
iii. To establish trends in the population aging indicators computed from projected population of Kenya to the year 2050.

Data used is drawn from the Kenya population and housing census reports and select national surveys. Post-independence censuses of 1969, 1979, 1989, 1999, and 2009 are used. The surveys used are KFS of 1977/78, KCPS of 1984, and KDHS of 1988, 1993, 1998, 2003, 2008 and 2014.

The first objective is achieved through three steps. Firstly, the ASFRs and ASMRs are fitted to both linear and nonlinear models under regression analysis to determine the best model that fits them. This was done using excel spreadsheets to obtain the projected ASFRs and ASMRs. Secondly, the elements of the projection matrix are computed using the projected rates from the first step. Thirdly, the population projection is done. Instead of the elements in the matrix being held constant over the projection period, the elements are varied after every five years to incorporate the modelled ASFRs and ASMRs corresponding to the interval. Matlab software is used to multiply the projection matrix with the base population to obtain the projected population.

The second objective is achieved by computing the CBRs and CDRs based on the projected population obtained from the first objective. Together with the past CBRs and CDRs from the year 1969, the rates are used to illustrate demographic transition in the country.

The third objective is achieved by computing aging indicators and establishing the trends from 1969 to 2050. The indicators include; number of persons 60 years and above (elderly population), number of persons 65 years and above (aged population), proportion of the total population 60 years and above, proportion of the total population 65 years and above, aging index, median age, life expectancy at the age of 65, old age dependency ratio and potential support ratio.

6.3 Summary of the Findings

Exponential model is found to best fit both the ASFRs and ASMRs for Kenya. The model was used in the projection of fertility and mortality rates. Selected years are used to give the findings. Projected TFRs is 4.01 in 2015, 3.14 in 2030 and 2.28 in 2050. The projected population is 42.88 million in 2015, 57.03 million in 2030 and 72.74 million in 2050.

CBR decreases from 34.28 in 2015 to 27.16 in 2030 to 18.90 in 2050. Similarly, CDR declines from 8.65 in 2015 to 8.36 in 2025 before increasing to 8.42 in 2030 and 9.78 in 2050.

The population 60 years and above increases from 2.1 million (4.9 percent of the total population) in the year 2015 to 3.6 million (6.4 percent) in 2030 to 8.6 million (11.9 percent) in 2050. The population 65 years and above also increases from 1.4 million (3.4 percent of the total population) in the year 2015 to 2.4 million (4.1 percent) in the year 2030 to 5.9 million (8.1 percent) in the year 2050. Additionally, the population 70 years and above increases from 0.94 million (2.19 percent) in the year 2015 to 1.44 million (2.53 percent) in the year 2030 to 3.59 million (4.93 percent) in the year 2050. Equally, the population 80 years and above increases from 0.33 million (0.8 percent of the total population) in 2015 to 0.38 million (0.7 percent) in 2030 to 0.99 million (1.4 percent) in 2050.

The median age increases from 19.04 years in 2015 to 20.08 years in 2020 to 22.59 years in 2030 to 27.53 years in 2050. Similarly, life expectation at birth, both sexes combined, increases from 61.5 years in 2015 to 63.6 years in 2030 to 65.3 years in 2050.

The aging index increases from 8.4 percent in 2015 to 12.1 percent in 2030 to 14.6 percent in 2035 to 29.3 percent in 2050. The dependency ratio declines from 77.0 percent in 2015 to 62.4 percent in 2030 to 55.2 percent in 2050. On the other hand, old age dependency ratio increases from 6.0 percent in 2015 to 6.7 percent in 2030 to 12.5 percent in 2050, while the potential support ratio declines from 16.8 in 2015 to 14.9 in 2030 to 8.0 in 2050.

6.4 Conclusions

Exponential model best fits the age specific fertility and mortality rates for Kenya. It also produces comparable rates to those of other publications. For instance, the study's projected TFRs of 4.01 in 2015, 3.14 in 2030 and 2.28 in 2050 are lower than those of UNPD (2015) TFR of 4.44 in 2015, 3.36 in 2030 and 2.85 in 2050 and KNBS (2011c) TFR of 4.1 in 2015 and 3.2 in 2030. However, the study TFR of 3.14 is higher than that of the Kenyan Government policy objective of attaining a TFR of 2.6 by 2030.

The resultant projected population is comparable with those of other projections. The study's projected population of 42.88 million in 2015 is almost the same as that of KNBS (2011c) projected population of 43.42 million but less than the UNPD (2015) projected population of 46.05 million by about 3 million for the same year. The study projected population for 2030 of 57.03 million is lower by about 3 million of that of KNBS (2011c) of 59.85 million and lower by about 8 million of that of UNPD (2015) of 65.41 million. The projected population for 2050 of UNPD (2015) is very high at 95.51 million, differing with that of this study of

72.74 million by about 23 million. The huge difference may be attributed to the assumptions made on fertility rates. UNPD (2015) makes an assumption that by 2050 the TFR will be 2.85, while the projected TFR for this study is 2.28. This gives a significant difference of 0.57 births per woman.

Kenya is undergoing demographic transition which has resulted in population aging where more numbers have been shifting to older age groups. Equally, the trends in aging indicators show that the population of Kenya is aging. The population 65 years and above is projected to be 8.1 percent in 2050 and a population is considered old when it has at least 10 percent of its people aged 65 and above. Likewise, the median age of Kenya is projected to be 27.53 years in 2050, and a population is considered old when it has a median of at least 30 years. The aging index is projected to be 14.6 percent in 2035 and 29.3 percent in 2050 implying that the Kenyan population will remain young to the year 2035 and approach old age by the year 2050. A population is considered young when it has an aging index below 15 percent and old when it has an aging index of at least 30 percent. Equally, the decline in dependency and potential support ratios and subsequent increase in old age dependency ratio shows the aging of the Kenyan population.

6.5 Contributions of the Study

The study establishes that exponential model best fits Kenyan ASFRs and ASMRs. This offers an alternative to deterministic approach of obtaining TFRs based on expert opinion. It is also an improvement on probabilistic approach where the experience of other countries is used in obtaining TFRs. Equally, the use of exponential model in determining ASMRs offers an alternative to the use of Lee-Carter model for mortality projections.

The study further relaxes the stability assumption. Instead of holding the vital rates of the base population constant over the projection period, the vital rates are projected and varied after every five years.

The study illustrates demographic transition and gives trends of aging indicators in Kenya. These indicators can now inform policy decisions.

6.6 Recommendations for Policy and Programmes

The population aging indicators obtained in this study should be considered to improve the existing and planned programmes for the aged, especially the cash transfer programme under the National Safety Net Programme. For instance, the projected cash transfers increase from KShs. 22.49 billion in the year 2015 to KShs. 34.63 billion in 2030 to KShs. 86.13 billion in 2050 if the current stipend of KShs. 2,000 per person remains constant. The increased costs of the welfare programme arising from population aging could adversely affect public finances if not well planned for.

6.7 Recommendations for Further Research

The study recommends modelling of ASFRs and ASMRs in the projection of sub-national populations in Kenya. This could also be replicated in other countries to establish which model best fits them.

The role played by increase in life expectancy in global ageing process as proposed by Sanderson and Scherbov (2010) was not considered in this study. Further studies could be undertaken to use POADR, which takes into account the remaining lifetime unlike the old age dependency ratio, which compares the same chronological age across periods.

This study recommends for research on the implications of population aging especially on pension expenditure and medicare. The study did not consider these implications as they involve different methodological approaches. Further research may be undertaken to establish the institutional arrangements that the aged in Kenya prefer to receive care from, either home or facility based. Globally, the older population is growing faster in urban areas than in rural areas. It is equally important to establish whether such trends are reflected in Kenya and if so how prepared the Government is in addressing the implications of the trends.

References

Alkema, L., Raftery, A. E., Gerland, P., Clark, S.J., Pelletier, F., Buettner, T., & Heilig, G. K. (2011). Probabilistic projections of the total fertility rate for all countries. *Demography*. 48 (3): 815 – 839.

African Union (2016). Protocol to the African Charter on Human and Peoples' Rights on the Rights of Older Persons in Africa. Twenty Sixth Ordinary Session of the Assembly. Addis Ababa, Ethiopia . 31 January, 2016. Retrieved from https://www.africa-union.org

Bernardelli, H. (1941). Population waves. *Journal of Burma Research Society*, 31: 1- 18.

Bloom, D. E., Canning, D., & Fink, G. (2010). Implications of population aging for economic growth. *Oxford Review of Economic Policy*. Vol. 26, No. 4, 583-612.

Bloom, D. E., Canning, D., & Fink, G. (2011). Implications of population aging for economic growth. *Program on the global demography of aging*. NBER Working paper No. 16705.

Bwila, I.M. (2004). *Population projection in Kenya: An application of the stable population model*. MSc Unpublished Thesis. PSRI. University of Nairobi.

Caldwell, J. C. (2006). *Demographic transition theory*. Springer. Netherlands.

Caswell, H. (2001). *Matrix population models: Construction, analysis and interpretation*. Sunderland, Massachusetts: Sinauer Associates, Inc. Publishers (2nd ed.)

Central Bureau of Statistics. (1970a). *Kenya population census, 1969*. Volume I.

Central Bureau of Statistics. (1970b). *1969 population census: Analytical report*. Volume IV.

Central Bureau of Statistics. (1981a). *Kenya population census, 1979.* Volume I.

Central Bureau of Statistics.(1981b).*1979 population census: Analytical report.* Volume II.

Central Bureau of Statistics.(1984). *Kenya contraceptive prevalence survey 1984.* First report.

Central Bureau of Statistics. (1996a). *Kenya population census, 1989: Analytical report on fertility and nuptiality.* Volume IV.

Central Bureau of Statistics. (1996b). *Kenya population census, 1989: Analytical report on mortality.* Volume V.

Central Bureau of Statistics. (2002a). *Kenya 1999 population housing census: Analytical report on fertility and nuptiality*. Volume IV.

Central Bureau of Statistics. (2002b). *Kenya 1999 population housing census: Analytical report on mortality.* Volume V.

Central Bureau of Statistics. (2002c). *Kenya 1999 population and housing census: Analytical report on population projection.* Volume VII. Nairobi, Kenya.

Chirchir, S. (2010). *Conversion of defined benefits schemes to defined contributions schemes.* Retirement Benefits Authority.

Cipriani, G.P. (2013). Population ageing and PAYG pensions in the OLG Model. *IZA Discussion paper No. 7144.*University of Verona and IZA.

Cuaresma, J.C., La´baj, M., & Pruzˇinsky,ˇ P. (2014). Prospective ageing and economic growth in Europe. *Working paper No. 165*. Vienna University of Economics and Business.

Dorson, P. (2005). *Dynamics of population ageing: How can Asia and the Pacific respond?* Survey 05 Chapter III.

Euler, L. (1970). A general investigation into the mortality and multiplication of the human species. In D. Smith & N. Keyfitz (Eds.). *Mathematical demography*. New York.

European Commission. (2014). *The 2015 ageing report: Underlying assumptions and projection methodologies*. Retrieved from http://ec.europa.eu/economy_finance/publications

Gavrilov, L.A., & Heuveline, P. (2003). Ageing of population. In P. Demeny & G. McNicoll (Eds.). *The encyclopaedia of population*. New York. Macmillan publishers.

Girosi, F., & King, G. (2007). *Understanding the Lee- Carter mortality forecasting method*. http://www.gking.harvard.edu

Grigsby, J.S., & Olshansky, S. J. (1989). The demographic components of population aging in China**.** *Journal of Cross-Cultural Gerontology* 4:307-334. Kluwer Academic Publishers. Netherlands.

Goldstein, J.R., & Stecklov, G. (2002). Long range population projections made simple**.** *Population and Development Review*, Vol. 28, pp 121 – 141.

HelpAge International & African Union. (2003). African Union Policy Framework and Plan of Action on Ageing, 2002. HelpAge International Africa Regional Development Centre. Nairobi, Kenya.

Hermalin, A.I. (1966). The Effect of changes in mortality rates on population growth and age distribution in the United States. *Milbank Memorial Fund Quarterly,* 44: 451-469.

Hobbs, F. (2004). Age and Sex Composition. In Siegel J.S. and D.A. Swanson (Eds.). *The metho*ds and materials of demography; 125-173. Elsevier Science. USA.

Igadwah, L. (2018, February 11). *Pensioners to wait longer for KShs.4,000 stipend*. *http://www.nation.co.ke*

Japan International Cooperation Agency. (2003). *Second study on international cooperation for population and development new insights from the Japanese Experience*. http://www.jica-ri.jica.go.jp

Jones, G. W., Douglas, R.M., Caldwell, J. C., & D´Souza, R. M. (2004). *The continuing demographic transition*. Clarendon. Oxford.

Keilman, N. (2001). Data quality and accuracy of United Nations population projection, 1950-95. *Population Studies,* Vol. 55, pp 149-164. http://www.jstor.org/stable.

Kenya Demographic and Health Survey. (2015). *2014 Key indicators.* KNBS, Nairobi.

Kenya Law Reporting Council. (2010). *The Constitution of Kenya, 2010*. National Council for Law Reporting. http://www.kenyalaw.org.

Kenya National Bureau of Statistics and ICF Macro. (2010). *Kenya demographic and health survey 2008 – 09*. Calverton, Maryland: KNBS and ICF Macro

Kenya National Bureau of Statistics. (2011a). *Kenya 2009 population and housing census: Analytical report on fertility and nuptiality*. Volume *IV* .

Kenya National Bureau of Statistics. (2011b). *Kenya 2009 population and housing census: Analytical report on mortality*. Volume V.

Kenya National Bureau of Statistics. (2011c). *Kenya 2009 population and housing Census: Analytical report on population projections*. Volume IX .

Kenya National Bureau of Statistics. (2015). *Kenya demographic and health survey, 2014.* Nairobi. Kenya.

Keyfitz, N. (1968a). *Introduction to the mathematics of population*. Addison Wesley Publishing Company. Berkeley. California.

Keyfitz, N. (1968b). Changing vital rates and age distributions. *Population Studies* 22. 235-251.

Keyfitz, N.1985. *Applied mathematical demography* (2nd ed.). Wiley. New York:

Keyfitz, N., & Caswell, H. (2005). *Applied mathematical demography (*3rd ed.). Springer. USA.

Kipanga, B., Were, M. & Toroitich, C. (2013). *Impact of conversion of Kenyan state corporations' retirement benefit schemes from defined benefits to defined contributions.* Retirement Benefit Authority. Kenya.

Kinsella, K., & Velkott, V. A. (2001). *An aging world: 2001.* US Census Bureau. *http://www.census.gov*

Kithinji, C.T. (1988). *Ageing and retirement in Kenya: focus on ageing and retirement of teachers under Teachers' Service Commission (T.S.C.).* PhD Thesis. Kenyatta

University, Kenya. *http://www.researchkenya.org/search.html*

Lee, R. D. & Carter, L. (1992). Modelling and forecasting the time series of U.S. Mortality. *Journal of the American Statistical Association 87: 659 – 71.* http://www.jstor.org

Lee, R., Mason, A., & Cotlear, D. (2010). Some economic consequences of global aging: A discussion note for the World Bank. *Health, nutrition and population (HNP) Discussion paper*. Washington DC.

Leslie, P.H. 1945. On the use matrices in certain population mathematics. In D. Smith & N. Keyfitz (Eds.). *Mathematical demography.* New York.

Li, S.H., & Chan, W.S. (2007). The Lee- Carter model for forecasting mortality, revisited. *North American Actuarial Journal, Vol. II, Issue 1*. https://www.soa.org

Lisenkova, K. (2009). *The impact of population ageing on the economic development of Ukraine.* PhD. Thesis at the Department of Economics, Heriot -Watt University.

Miller, T. (2006). Demographic models for projections of social sector demand. *CEPAL-SERIE No, 66.* Santiago, Chile. *http:www,cepal.org/en*

Ministry of Gender, Children and Social Development. (2009). National Policy on Older Persons and Aging. Nairobi: Government of Kenya.

Ministry of Labour, Social Security and Services. (2014). National Policy on Older Persons and Ageing. Nairobi: Government of Kenya.

Miur, P.S. (2002). *Influence of age structure on population growth: The importance of population momentum.* Oregon State University. U.S.A.

Mwendo, L. (2009, March 06). *Retirement age increased to 60 years*. *http://www.kenyaweeklypost.com*

Nabalamba, A., & Chikoko, M. (2011). *Aging population challenges in Africa*. AfDB November 2011 Vol. 1. Issue 1. *http://www.afdb.org.*

National Council for Population and Development. (2011). *State of Kenya population 2011. Kenya's 41 million people: Challenges and possibilities*. *http://www.ncpd-ke.org.*

National Council for Population and Development. (2013). *Kenya population situation analysis report*. *http://www.ncpd-ke.org.*

National Gender and Equality Commission. (2014). *Participation of the vulnerable populations in their own programmes: The cash transfers in Kenya*. *http.www.ngeckenya.org.*

National Institute of Population and Social Security Research. (2012). *Population projections for Japan: 2011 to 2060*. http://www.ipss.go.jp/index-e.asp

National Intelligence Council. (2012). *Global trends 2030: Alternative worlds.* http://www.dni.gov/nic.

Notestein, F.W. (1945). Population: The long view. In T. W. Schultz (Ed.). *Food for the world.* Chicago, University of Chicago Press.

Oizumi, K., Kajiwara H., & Aratame N. (2006). *Facing up to the problem of population aging in developing countries: New perspective for assistance and cooperation.* IFIC/JICA. http://www.jica.go.jp

Omoke, K.J. (2008). *Population ageing in rural and urban Kenya: A case study of Lamu, Turkana and Nairobi districts*. PhD Unpublished Thesis, University of Nairobi. http://archive.uonbi.ac.ke.

Pandey, A., & Singh, O.P. (2015). Projection of some fertility indicators of UP, India using MCMC technique in Bayesian procedure. *Research Journal of Mathematical and Statistical Sciences.* Vol. 3 (7), 9-14. http://www.isca.in

Pettinger, T. (2013). *The impact of an ageing population on the economy.* http://www.infoplease.com/ipa.html.

Picard, N. & Liang, J. (2014). *Matrix models for size-structured populations: Unrealistic fast growth or simply diffusion?* PLoS ONE 9(6): e98254.

Pool, I. (2006). Mapping age-structural transitions: A comparative perspective. In I. Pool, L. Wong, & E. Vilquin (Eds). *Age structural transitions: Challenges for development.* Committee for International Cooperation in National Research and Demography (CICRED). Paris. Pp.21-57.

Pool, I. (2007). Demographic dividends: Determinants of development or merely windows of opportunity? Ageing horizons, 7:28-35

Pool, I., Wong, I.R. & Vilquin, E. (Eds.) (2006). *Age structural transition: Challenges for development*. Committee for International Cooperation in National Research and Demography (CICRED). Paris.

Pool, I.,& Wong, L.R. (2006). Age-structural transitions and policy: An emerging issue. In I. Pool, L. Wong, & E. Vilquin (Eds). *Age structural transitions: Challenges for development.* Committee for International Cooperation in National Research and Demography (CICRED). Paris. Pp.3-19.

Preston, S.H., Heuveline, P., & Guillot, M. (2001). *Demography: Measuring and modeling population processes*. Blackwell Publishing.

Preston, S. H., Himes, C., & Eggers, M. (1989). Demographic conditions responsible for population aging. *Demography* 26:691-704.

Rowland, D.T. (2003). *Demographic methods and concepts*. Oxford University Press. New York.

Sanderson, W. C., & Scherbov, S. (2005). Average remaining lifetimes can increase as human populations age. *Nature*, 435 (7043), 811-13.

Sanderson, W. C., & Scherbov, S. 2008. Rethinking age and aging. *Population Bulletin*, 63(4), 3-16.

Sanderson, W. C., & Scherbov, S. (2010). Re-measuring aging. *Science*, 329(5997), 1287-88.

Shryock, H.S., & Siegel, J.S. (1980). *The methods and materials of demography*. Volume 1. US Government Printing Office. Washington D.C.

Smith, D., & Keyfitz, N. (1977). Mathematical demography. Selected Papers. *Biomathematics*. V.6. New York.

Thomas, S. P. (1992). *Old age in Meru, Kenya: Adaptive reciprocity in a changing rural community*. PhD Thesis, University of Florida, USA. *http://www.researchkenya.org/search.html.*

United Nations. (1983a). Vienna International Plan of Action on Ageing of 1982. New York. Retrieved from *https://www.un.org/development/desa/ageing/resources/vienna-international-plan-of-action.html*

United Nations. (1983b). *Indirect techniques for demographic estimation*. Manual X. pp181. New York (ST/ESA/SER.A/81)

United Nations. (2002a). *The world population ageing 1950 – 2050 report.* Department of Economic and Social Affairs. Population Division. New York.

United Nations. (2002b). Political Declaration and Madrid International Plan of Action on Ageing. Second World Assembly on Ageing, Madrid Spain. 8-12 April, 2002

United Nations. (2015). *World population ageing 2015.* Department of Economic and Social Affairs, Population Division (ST/ESA/SER.A/390).

United Nations Population Division. (2011). *World population prospects: The 2010 revision. http://esa.un.org/unpd/wpp.*

United Nations Population Division. (2015). *World population prospects: The 2015 revision, key findings and advance tables*. Working Paper No. ESA/P/WP.241.

Walker, A. (1990). The economic 'burden' of ageing and the prospect of intergenerational conflict. *Ageing and Society*,10, pp 377-396.

Waweru, L. M. (2002). *A Study on the health status and social support systems of the elderly persons in Dagoretti Division, Nairobi, Kenya.* MPHE Thesis. Kenyatta University, http://www.researchkenya.org/search.html.

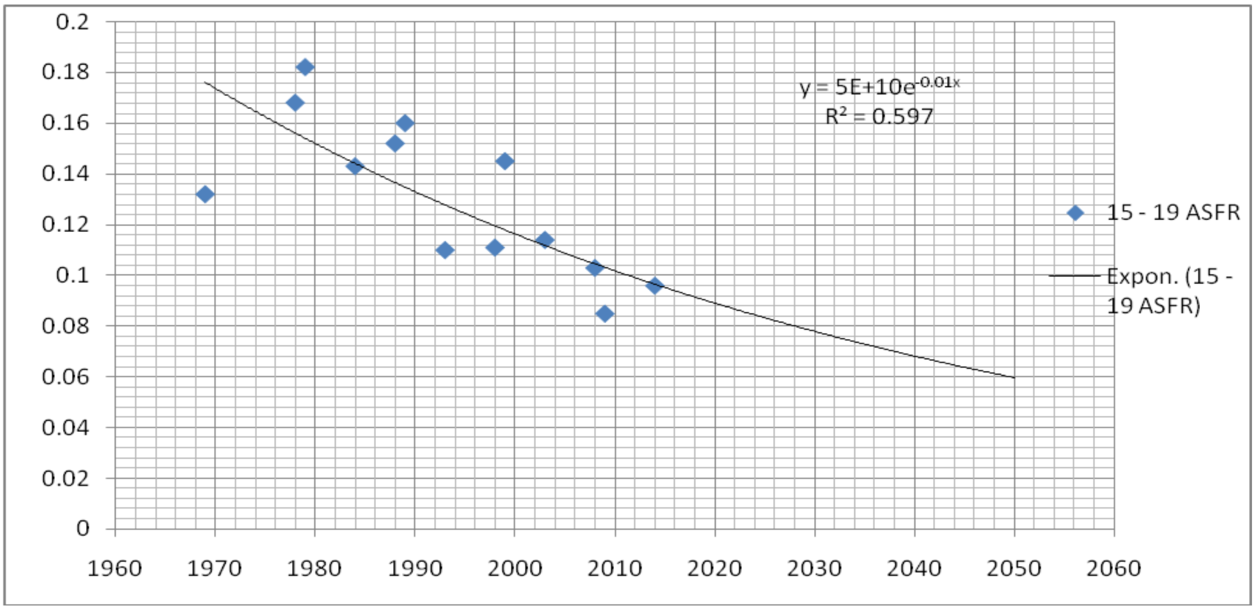
Weil, D. N. (2006). *Population aging. Working Paper No.2006-09.* Brown University, Department of Economics.

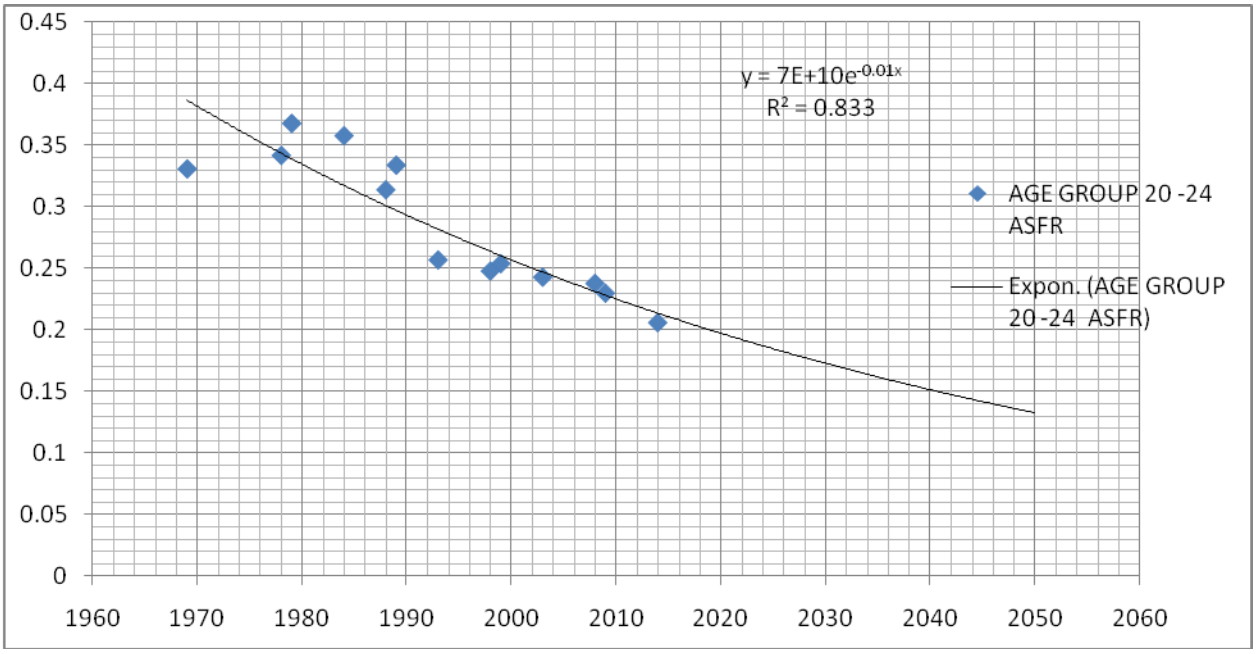
Wekesa, J.M. (1989). *Kenya's population projections and some of their implications to education planning*. MSc Unpublished Thesis. PSRI. University of Nairobi.

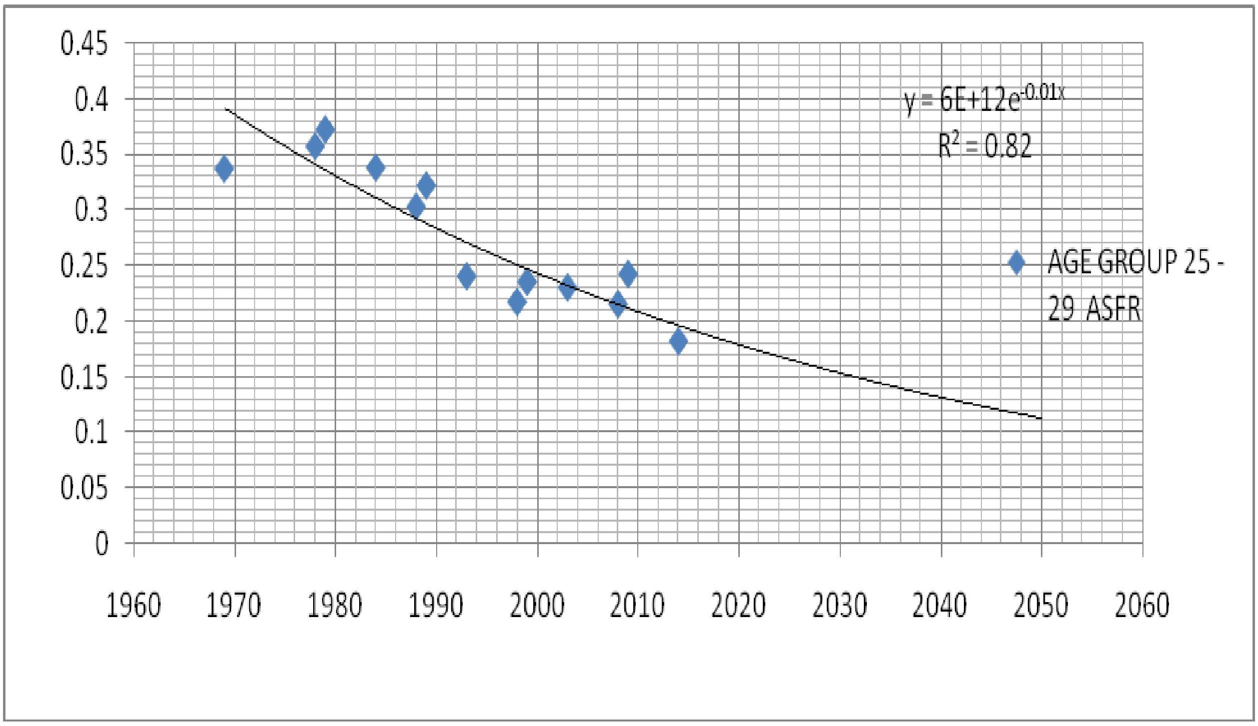
APPENDICES

Appendix 1: Figures of Exponential Models for ASFRs from Censuses and Fertility Surveys

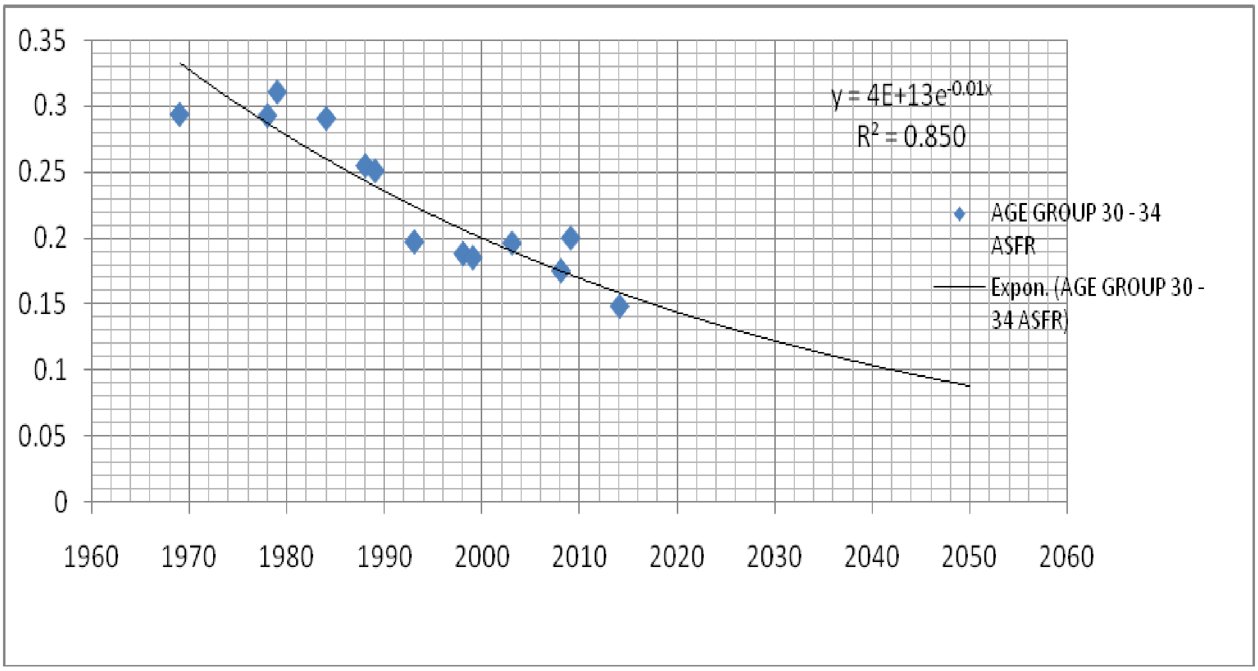
(Source: Computed from Table 4.3)



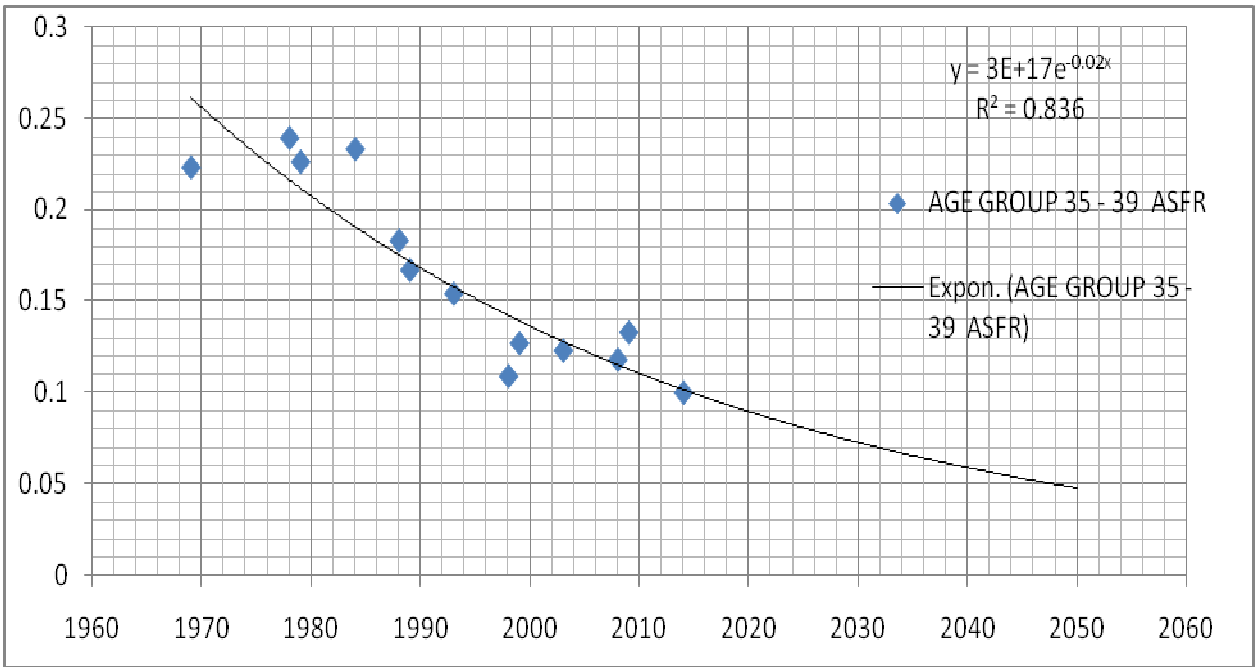


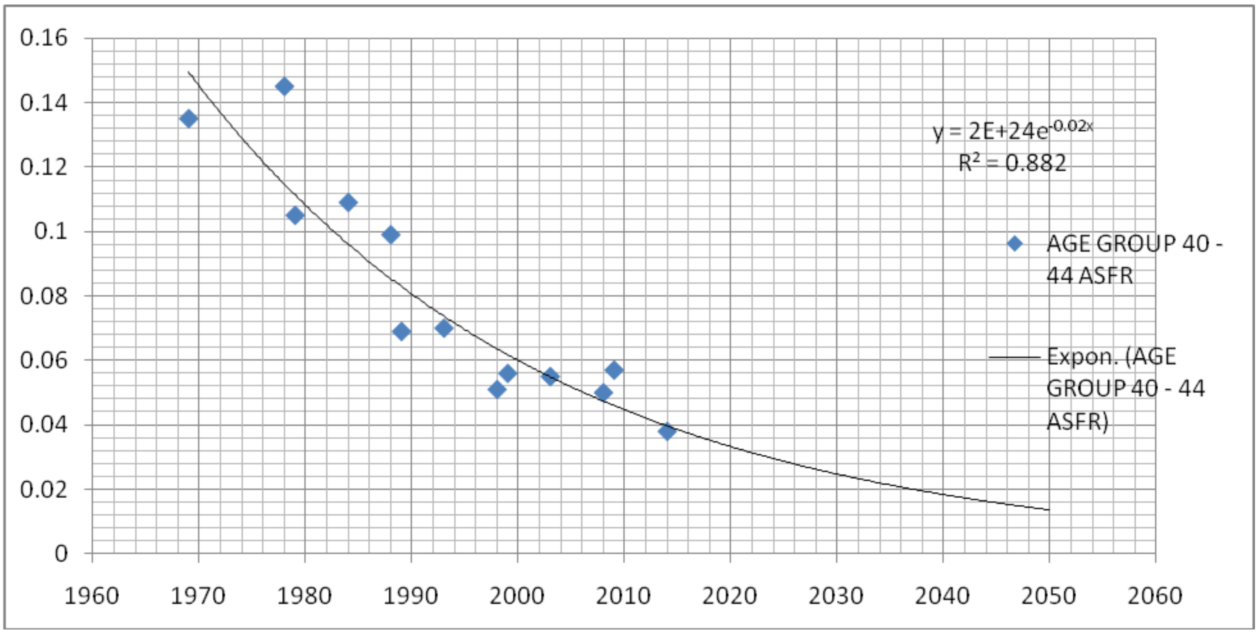


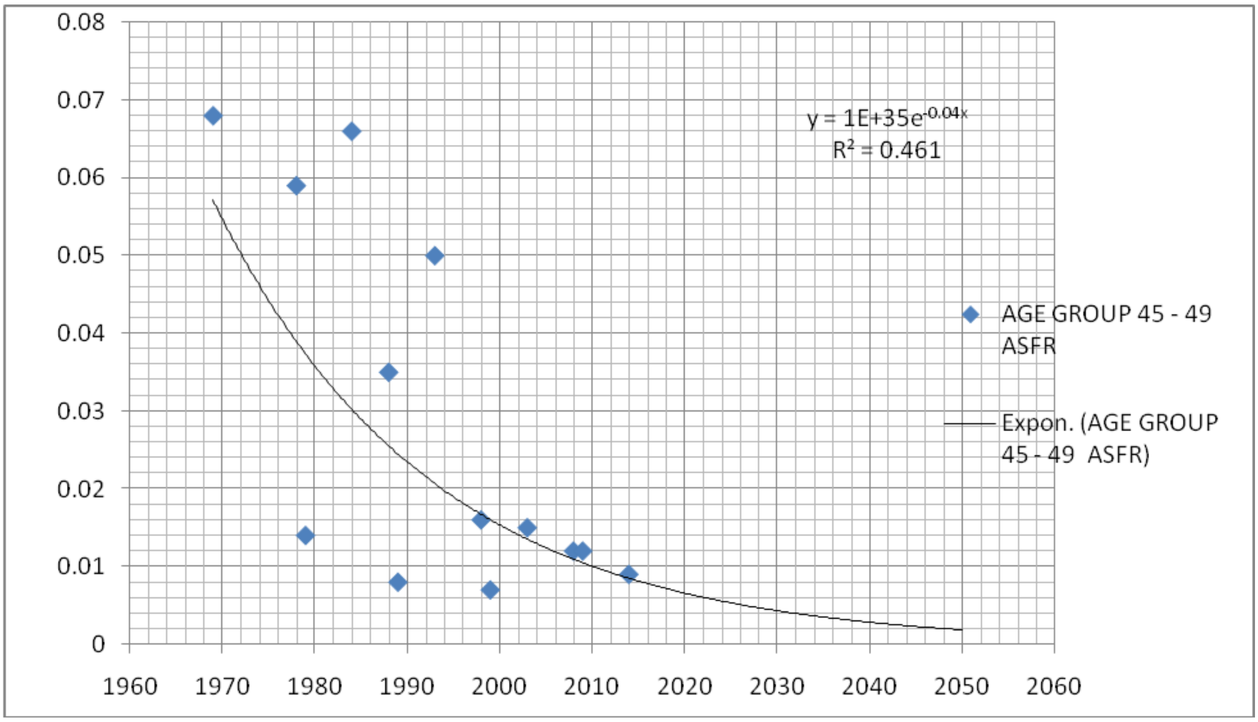
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
y = 6E+12e-0.01x
R² = 0.82
AGE GROUP 25 - 29 ASFR



0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
y = 4E+13e-0.01x
R² = 0.850
AGE GROUP 30 - 34 ASFR
Expon. (AGE GROUP 30 - 34 ASFR)


0.3
0.25
0.2
0.15
0.1
0.05
0
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
y = 3E+17e-0.02x
R² = 0.836
AGE GROUP 35 - 39 ASFR
Expon. (AGE GROUP 35 - 39 ASFR)


0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
y = 2E+24e-0.02x
R² = 0.882
AGE GROUP 40 - 44 ASFR
Expon. (AGE GROUP 40 - 44 ASFR)


0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
y = 1E+35e-0.04x
R² = 0.461
AGE GROUP 45 - 49 ASFR
Expon. (AGE GROUP 45 - 49 ASFR)

Appendix 2: Female Life Tables (2010 – 2050)

Female Life Table for Kenya - 2010 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x*}$	$_nSR_x$	ASFR	Fx = FF *ASFR	$L_o/2l_o(F_{x-5} + (L_x/L_{x-5})F_x)$
0	0.0517	0.0499	0.9501	10,000	499	9651	625789	62.6				0.4926	2.3549
1	0.0062	0.0244	0.9756	9,501	232	37447	616138	64.8	47098				
5	0.0024	0.0119	0.9881	9,269	111	46068	578691	62.4	46068	0.9781			
10	0.0018	0.0087	0.9913	9,158	80	45592	532623	58.2	45592	0.9897			
15	0.0018	0.0090	0.9910	9,079	81	45189	487031	53.6	45189	0.9912	0.1020	0.0502	0.1173
20	0.0033	0.0164	0.9836	8,997	147	44618	441841	49.1	44618	0.9874	0.2255	0.1111	0.3766
25	0.0055	0.0271	0.9729	8,850	240	43650	397224	44.9	43650	0.9783	0.2084	0.1027	0.4981
30	0.0087	0.0426	0.9574	8,610	367	42133	353574	41.1	42133	0.9653	0.1695	0.0835	0.4315
35	0.0105	0.0512	0.9488	8,243	422	40162	311441	37.8	40162	0.9532	0.1103	0.0543	0.3186
40	0.0092	0.0450	0.9550	7,822	352	38229	271279	34.7	38229	0.9519	0.0448	0.0221	0.1774
45	0.0089	0.0435	0.9565	7,470	325	36537	233050	31.2	36537	0.9557	0.0100	0.0049	0.0631
50	0.0088	0.0431	0.9569	7,145	308	34955	196513	27.5	34955	0.9567			
55	0.0105	0.0512	0.9488	6,837	350	33311	161558	23.6	33311	0.9530			
60	0.0150	0.0723	0.9277	6,487	469	31264	128247	19.8	31264	0.9386			
65	0.0236	0.1114	0.8886	6,018	671	28416	96983	16.1	28416	0.9089			
70	0.0378	0.1727	0.8273	5,348	923	24430	68567	12.8	24430	0.8598			
75	0.0667	0.2858	0.7142	4,424	1265	18960	44137	10.0	18960	0.7761			
80+	0.1255	1	0.0000	3,160	3160	25177	25177	8.0	25177	0.5704			

X - Start of the age interval

$_nM_x$ - Age specific mortality rate

$_nq_x$ - Probability of dying in the age interval

$_nP_x$ - Probability of surviving in the age interval (1 - $_nq_x$)

l_x - Number of persons from a radix (in this case 10,000 births) who reach the beginning of the age interval

$_nd_x$ - Number of deaths within the age interval

$_nL_x$ - Number of persons in the populations who at any moment are living within the indicated age interval

$_nL_x$* - For the calculation of survival ratio by recalculating $_5L_0$ as $_1L_0 + L_1$

$_nSR_x$ - Diagonal values of the projection matrix are the survival ratio ($_nSR_x$) values which are calculated as ${}_nSR_x = {}_nL_x/{}_nL_{x-5}$. Some exceptions are, however, made in the calculation of the survival ratios of the first and last age groups. The life tables have ASMRs for the age groups 0 and 1 - 4 and not the age group 0 - 4. The ${}_5L_0$ value for the age group 0 - 4 is obtained by summing ${}_1L_0$ and ${}_4L_1$ values (UN, 1983b). The survival ratio for the last age group, SR_{80+} is calculated as $SR_{80+} = T_{80+}/T_{75+}$ (Preston et al. 2001)

ASFR - Age specific fertility rate

F_x - ASFR that correspond only to girl children being born

FF - Female fraction (female births over the total births). Sex ratio for 2009 census was 103, which gives a female fraction of 0.4926 (100/203).

$L_0/2l_0(F_{x-5} + (L_x/L_{x-5})\, F_x)$ -First raw values of the projection matrix

Female Life Table for Kenya - 2015 from Projected ASMR

x	${}_nM_x$	${}_nq_x$	${}_nP_x$	l_x	${}_nd_x$	${}_nL_x$	T_x	e_x	${}_nL_{x*}$	${}_nSR_x$	ASFR	Fx = FF *ASFR	$L_0/2l_0(F_{x-5} + (L_x/L_{x-5})F_x)$
0	0.0470	0.0455	0.9545	10,000	455	9681	633960	63.4				0.4926	2.3691
1	0.0053	0.0209	0.9791	9,545	200	37700	624279	65.4	47382				
5	0.0021	0.0104	0.9896	9,345	98	46482	586579	62.8	46482	0.9810			
10	0.0017	0.0085	0.9915	9,248	78	46042	540097	58.4	46042	0.9905			
15	0.0017	0.0085	0.9915	9,169	78	45652	494055	53.9	45652	0.9915	0.0954	0.0470	0.1104
20	0.0031	0.0154	0.9846	9,092	140	45109	448403	49.3	45109	0.9881	0.2112	0.1040	0.3549
25	0.0056	0.0276	0.9724	8,952	247	44141	403294	45.1	44141	0.9786	0.1932	0.0952	0.4671
30	0.0094	0.0459	0.9541	8,705	400	42524	359153	41.3	42524	0.9634	0.1562	0.0769	0.4011
35	0.0114	0.0554	0.9446	8,305	460	40374	316629	38.1	40374	0.9494	0.0992	0.0489	0.2922
40	0.0094	0.0459	0.9541	7,845	360	38323	276255	35.2	38323	0.9492	0.0388	0.0191	0.1588
45	0.0090	0.0440	0.9560	7,484	329	36599	237932	31.8	36599	0.9550	0.0082	0.0040	0.0544
50	0.0084	0.0411	0.9589	7,155	294	35039	201333	28.1	35039	0.9574			
55	0.0098	0.0478	0.9522	6,861	328	33483	166294	24.2	33483	0.9556			
60	0.0140	0.0676	0.9324	6,533	442	31558	132811	20.3	31558	0.9425			
65	0.0222	0.1052	0.8948	6,091	641	28852	101253	16.6	28852	0.9143			
70	0.0352	0.1618	0.8382	5,450	882	25047	72400	13.3	25047	0.8681			
75	0.0640	0.2759	0.7241	4,569	1260	19692	47353	10.4	19692	0.7862			
80+	0.1196	1	0.0000	3,308	3308	27661	27661	8.4	27661	0.5841			

Female Life Table for Kenya - 2020 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x*}$	$_nSR_x$	ASFR	Fx = FF *ASFR	$L_o/2l_o(F_{x-5} + (L_x/L_{x-5})F_x)$
0	0.0426	0.0414	0.9586	10,000	414	9710	641490	64.1				0.4926	2.3819
1	0.0046	0.0182	0.9818	9,586	174	37927	631780	65.9	47637				
5	0.0018	0.0090	0.9910	9,412	84	46849	593853	63.1	46849	0.9834			
10	0.0017	0.0082	0.9918	9,328	77	46446	547004	58.6	46446	0.9914			
15	0.0015	0.0075	0.9925	9,251	69	46082	500558	54.1	46082	0.9922	0.0892	0.0439	0.1038
20	0.0029	0.0144	0.9856	9,182	132	45578	454477	49.5	45578	0.9891	0.1976	0.0973	0.3340
25	0.0056	0.0276	0.9724	9,050	250	44623	408898	45.2	44623	0.9790	0.1788	0.0881	0.4372
30	0.0101	0.0493	0.9507	8,800	433	42915	364275	41.4	42915	0.9617	0.1437	0.0708	0.3719
35	0.0125	0.0606	0.9394	8,366	507	40564	321360	38.4	40564	0.9452	0.0893	0.0440	0.2676
40	0.0099	0.0483	0.9517	7,859	380	38347	280796	35.7	38347	0.9454	0.0335	0.0165	0.1419
45	0.0090	0.0440	0.9560	7,480	329	36575	242449	32.4	36575	0.9538	0.0066	0.0033	0.0467
50	0.0080	0.0392	0.9608	7,150	280	35051	205874	28.8	35051	0.9583			
55	0.0091	0.0445	0.9555	6,870	306	33586	170823	24.9	33586	0.9582			
60	0.0130	0.0630	0.9370	6,564	413	31789	137237	20.9	31789	0.9465			
65	0.0208	0.0989	0.9011	6,151	608	29235	105448	17.1	29235	0.9197			
70	0.0331	0.1529	0.8471	5,543	847	25597	76213	13.7	25597	0.8755			
75	0.0615	0.2665	0.7335	4,696	1252	20350	50616	10.8	20350	0.7950			
80+	0.1138	1	0.0000	3,444	3444	30266	30266	8.8	30266	0.5980			

Female Life Table for Kenya - 2025 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x*}$	$_nSR_x$	ASFR	Fx = FF *ASFR	$L_o/2l_o(F_{x-5} + (L_x/L_{x-5})F_x)$
0	0.0388	0.0378	0.9622	10,000	378	9736	647469	64.7				0.4926	2.3934
1	0.0039	0.0155	0.9845	9,622	149	38132	637733	66.3	47868				
5	0.0016	0.0080	0.9920	9,474	75	47179	599601	63.3	47179	0.9856			
10	0.0016	0.0080	0.9920	9,398	75	46802	552422	58.8	46802	0.9920			
15	0.0014	0.0070	0.9930	9,323	65	46451	505620	54.2	46451	0.9925	0.0834	0.0411	0.0976
20	0.0028	0.0139	0.9861	9,258	129	45967	459169	49.6	45967	0.9896	0.1852	0.0912	0.3144
25	0.0057	0.0281	0.9719	9,129	257	45004	413203	45.3	45004	0.9790	0.1653	0.0814	0.4092
30	0.0109	0.0531	0.9469	8,872	471	43185	368199	41.5	43185	0.9596	0.1327	0.0654	0.3450
35	0.0137	0.0662	0.9338	8,402	556	40617	325014	38.7	40617	0.9405	0.0805	0.0397	0.2457
40	0.0104	0.0507	0.9493	7,845	398	38232	284396	36.3	38232	0.9413	0.0249	0.0123	0.1225
45	0.0090	0.0440	0.9560	7,448	328	36419	246164	33.1	36419	0.9526	0.0053	0.0026	0.0353
50	0.0076	0.0373	0.9627	7,120	266	34936	209745	29.5	34936	0.9593			
55	0.0085	0.0416	0.9584	6,854	285	33559	174809	25.5	33559	0.9606			
60	0.0121	0.0587	0.9413	6,569	386	31881	141251	21.5	31881	0.9500			
65	0.0195	0.0930	0.9070	6,183	575	29480	109369	17.7	29480	0.9247			
70	0.0309	0.1434	0.8566	5,609	804	26032	79890	14.2	26032	0.8830			
75	0.0590	0.2571	0.7429	4,804	1235	20933	53858	11.2	20933	0.8041			
80+	0.1084	1	0.0000	3,569	3569	32925	32925	9.2	32925	0.6113			

Female Life Table for Kenya – 2030 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x*}$	$_nSR_x$	ASFR	Fx = FF *ASFR	$L_o/2l_o(F_{x-5} +(L_x/L_{x-5})F_x)$
0	0.0352	0.0344	0.9656	10,000	344	9760	652729	65.3				0.4926	2.4036
1	0.0034	0.0135	0.9865	9,656	130	38313	642970	66.6	48073				
5	0.0014	0.0070	0.9930	9,526	66	47465	604656	63.5	47465	0.9874			
10	0.0016	0.0079	0.9921	9,460	75	47111	557191	58.9	47111	0.9926			
15	0.0013	0.0065	0.9935	9,385	61	46772	510080	54.4	46772	0.9928	0.0779	0.0384	0.0916
20	0.0026	0.0129	0.9871	9,324	120	46319	463308	49.7	46319	0.9903	0.1734	0.0854	0.2956
25	0.0057	0.0281	0.9719	9,204	259	45371	416989	45.3	45371	0.9795	0.1530	0.0754	0.3828
30	0.0119	0.0578	0.9422	8,945	517	43433	371617	41.5	43433	0.9573	0.1220	0.0601	0.3194
35	0.0149	0.0718	0.9282	8,428	605	40627	328184	38.9	40627	0.9354	0.0723	0.0356	0.2245
40	0.0108	0.0526	0.9474	7,823	411	38086	287557	36.8	38086	0.9374	0.0249	0.0123	0.1132
45	0.0090	0.0440	0.9560	7,411	326	36242	249471	33.7	36242	0.9516	0.0043	0.0021	0.0343
50	0.0074	0.0363	0.9637	7,085	257	34783	213229	30.1	34783	0.9597			
55	0.0080	0.0392	0.9608	6,828	268	33470	178447	26.1	33470	0.9623			
60	0.0113	0.0549	0.9451	6,560	360	31900	144976	22.1	31900	0.9531			
65	0.0183	0.0875	0.9125	6,200	542	29642	113077	18.2	29642	0.9292			
70	0.0289	0.1348	0.8652	5,657	762	26380	83435	14.7	26380	0.8900			
75	0.0567	0.2483	0.7517	4,895	1215	21436	57055	11.7	21436	0.8126			
80+	0.1033	1	0.0000	3,679	3679	35619	35619	9.7	35619	0.6243			

Female Life Table for Kenya – 2035 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_x$*	$_nSR_x$	ASFR	F_X = FF *ASFR	$L_o/2l_o(F_{x-5} + (L_x/L_{x-5})F_x)$
0	0.0322	0.0315	0.9685	10,000	315	9780	657773	65.8				0.4926	2.4126
1	0.0029	0.0115	0.9885	9,685	112	38473	647994	66.9	48252				
5	0.0013	0.0065	0.9935	9,574	62	47713	609521	63.7	47713	0.9888			
10	0.0015	0.0077	0.9923	9,512	73	47375	561808	59.1	47375	0.9929			
15	0.0011	0.0055	0.9945	9,439	52	47063	514433	54.5	47063	0.9934	0.0729	0.0359	0.0861
20	0.0025	0.0124	0.9876	9,387	117	46642	467370	49.8	46642	0.9911	0.1624	0.0800	0.2779
25	0.0058	0.0286	0.9714	9,270	265	45688	420728	45.4	45688	0.9795	0.1415	0.0697	0.3577
30	0.0127	0.0615	0.9385	9,005	554	43640	375039	41.6	43640	0.9552	0.1125	0.0554	0.2959
35	0.0163	0.0783	0.9217	8,451	662	40600	331399	39.2	40600	0.9303	0.0652	0.0321	0.2058
40	0.0112	0.0545	0.9455	7,789	424	37885	290799	37.3	37885	0.9331	0.0215	0.0106	0.1013
45	0.0090	0.0440	0.9560	7,365	324	36014	252914	34.3	36014	0.9506	0.0035	0.0017	0.0295
50	0.0069	0.0339	0.9661	7,041	239	34607	216900	30.8	34607	0.9609			
55	0.0074	0.0363	0.9637	6,802	247	33392	182293	26.8	33392	0.9649			
60	0.0105	0.0512	0.9488	6,555	335	31936	148901	22.7	31936	0.9564			
65	0.0173	0.0829	0.9171	6,220	516	29808	116965	18.8	29808	0.9334			
70	0.0270	0.1265	0.8735	5,704	721	26716	87157	15.3	26716	0.8963			
75	0.0544	0.2394	0.7606	4,982	1193	21930	60441	12.1	21930	0.8209			
80+	0.0984	1	0.0000	3,790	3790	38511	38511	10.2	38511	0.6372			

Female Life Table for Kenya – 2040 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_x$*	$_nSR_x$	ASFR	Fx = FF *ASFR	$L_0/2l_0(F_{x-5}+(L_x/L_{x-5})F_x)$
0	0.0293	0.0287	0.9713	10,000	287	9799	661769	66.2				0.4926	2.4209
1	0.0025	0.0099	0.9901	9,713	97	38620	651970	67.1	48419				
5	0.0011	0.0055	0.9945	9,616	53	47950	613350	63.8	47950	0.9903			
10	0.0015	0.0075	0.9925	9,564	71	47639	565400	59.1	47639	0.9935			
15	0.0010	0.0050	0.9950	9,492	47	47342	517761	54.5	47342	0.9938	0.0681	0.0335	0.0807
20	0.0024	0.0119	0.9881	9,445	113	46942	470419	49.8	46942	0.9916	0.1518	0.0748	0.2607
25	0.0058	0.0286	0.9714	9,332	267	45994	423476	45.4	45994	0.9798	0.1312	0.0646	0.3343
30	0.0137	0.0662	0.9338	9,065	600	43826	377483	41.6	43826	0.9529	0.1034	0.0509	0.2740
35	0.0178	0.0852	0.9148	8,465	721	40522	333657	39.4	40522	0.9246	0.0586	0.0289	0.1879
40	0.0117	0.0568	0.9432	7,744	440	37618	293135	37.9	37618	0.9283	0.0186	0.0092	0.0905
45	0.0091	0.0445	0.9555	7,304	325	35705	255517	35.0	35705	0.9492	0.0028	0.0014	0.0254
50	0.0066	0.0325	0.9675	6,979	227	34327	219812	31.5	34327	0.9614			
55	0.0070	0.0344	0.9656	6,752	232	33180	185485	27.5	33180	0.9666			
60	0.0098	0.0478	0.9522	6,520	312	31819	152305	23.4	31819	0.9590			
65	0.0161	0.0774	0.9226	6,208	480	29839	120486	19.4	29839	0.9378			
70	0.0253	0.1190	0.8810	5,728	681	26934	90647	15.8	26934	0.9027			
75	0.0523	0.2313	0.7687	5,046	1167	22313	63713	12.6	22313	0.8284			
80+	0.0937	1	0.0000	3,879	3879	41400	41400	10.7	41400	0.6498			

Female Life Table for Kenya – 2045 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x^*}$	$_nSR_x$	ASFR	$F_x = FF * ASFR$	$L_0/2l_0(F_{x-5} + (L_x/L_{x-5})F_x)$
0	0.0266	0.0261	0.9739	10,000	261	9817	664742	66.5				0.4926	2.4284
1	0.0022	0.0088	0.9912	9,739	85	38751	654925	67.2	48568				
5	0.0010	0.0050	0.9950	9,654	48	48148	616174	63.8	48148	0.9913			
10	0.0015	0.0073	0.9927	9,605	70	47853	568026	59.1	47853	0.9939			
15	0.0009	0.0045	0.9955	9,536	43	47571	520174	54.6	47571	0.9941	0.0638	0.0314	0.0759
20	0.0023	0.0114	0.9886	9,493	109	47193	472603	49.8	47193	0.9920	0.1422	0.0700	0.2451
25	0.0059	0.0291	0.9709	9,384	273	46239	425410	45.3	46239	0.9798	0.1217	0.0600	0.3128
30	0.0148	0.0714	0.9286	9,111	650	43932	379171	41.6	43932	0.9501	0.0955	0.0470	0.2541
35	0.0195	0.0930	0.9070	8,461	787	40340	335239	39.6	40340	0.9182	0.0528	0.0260	0.1722
40	0.0122	0.0592	0.9408	7,675	454	37237	294900	38.4	37237	0.9231	0.0162	0.0080	0.0811
45	0.0091	0.0445	0.9555	7,220	321	35299	257662	35.7	35299	0.9479	0.0023	0.0011	0.0220
50	0.0063	0.0310	0.9690	6,899	214	33961	222364	32.2	33961	0.9621			
55	0.0065	0.0320	0.9680	6,685	214	32891	188403	28.2	32891	0.9685			
60	0.0091	0.0445	0.9555	6,471	288	31637	155512	24.0	31637	0.9619			
65	0.0151	0.0728	0.9272	6,183	450	29793	123875	20.0	29793	0.9417			
70	0.0236	0.1114	0.8886	5,734	639	27071	94082	16.4	27071	0.9086			
75	0.0502	0.2230	0.7770	5,095	1136	22633	67011	13.2	22633	0.8361			
80+	0.0892	1	0.0000	3,959	3959	44378	44378	11.2	44378	0.6622			

Female Life Table for Kenya - 2050 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x*}$	$_nSR_x$	ASFR	Fx = FF *ASFR	$L_o/2l_o(F_{x-5} + (L_x/L_{x-5})F_x)$
0	0.0241	0.0237	0.9763	10,000	237	9834	667379	66.7				0.4926	2.4354
1	0.0019	0.0076	0.9924	9,763	74	38875	657545	67.4	48709				
5	0.0009	0.0045	0.9955	9,689	44	48337	618670	63.9	48337	0.9924			
10	0.0014	0.0071	0.9929	9,646	69	48056	570333	59.1	48056	0.9942			
15	0.0008	0.0040	0.9960	9,577	38	47789	522277	54.5	47789	0.9944	0.0596	0.0294	0.0711
20	0.0021	0.0104	0.9896	9,539	100	47444	474488	49.7	47444	0.9928	0.1332	0.0656	0.2302
25	0.0061	0.0300	0.9700	9,439	284	46486	427044	45.2	46486	0.9798	0.1125	0.0554	0.2920
30	0.0159	0.0765	0.9235	9,155	700	44027	380557	41.6	44027	0.9471	0.0878	0.0433	0.2347
35	0.0213	0.1011	0.8989	8,455	855	40140	336530	39.8	40140	0.9117	0.0475	0.0234	0.1573
40	0.0127	0.0615	0.9385	7,600	468	36833	296390	39.0	36833	0.9176	0.0138	0.0068	0.0722
45	0.0091	0.0445	0.9555	7,133	317	34870	259557	36.4	34870	0.9467	0.0018	0.0009	0.0186
50	0.0060	0.0296	0.9704	6,815	201	33573	224687	33.0	33573	0.9628			
55	0.0060	0.0296	0.9704	6,614	195	32581	191114	28.9	32581	0.9704			
60	0.0085	0.0416	0.9584	6,418	267	31424	158533	24.7	31424	0.9645			
65	0.0142	0.0686	0.9314	6,151	422	29702	127108	20.7	29702	0.9452			
70	0.0221	0.1047	0.8953	5,730	600	27148	97406	17.0	27148	0.9140			
75	0.0482	0.2151	0.7849	5,130	1103	22890	70258	13.7	22890	0.8432			
80+	0.0850	1	0.0000	4,026	4026	47368	47368	11.8	47368	0.6742			

Appendix 3: Computation of Crude Birth Rates

Age Group	2010- Base Population					2015				
	Male	Female	Total	ASFR	Births	Male	Female	Total	ASFR	Births
0 - 4	3036260	2996900	6033160			2954820	2916515	5871335		
5 -9	2751137	2678618	5429755			3010627	2931268	5941895		
10 - 14	2433120	2349758	4782878			2745078	2651028	5396107		
15 - 19	2119052	2120355	4239407	0.1020	216276	2327649	2329080	4656729	0.0954	222194
20 - 24	1800433	2017920	3818353	0.2255	455041	1867991	2093639	3961629	0.2112	442176
25 - 29	1518683	1722576	3241259	0.2084	358985	1740463	1974131	3714594	0.1932	381402
30 - 34	1268075	1284748	2552823	0.1695	217765	1641223	1662803	3304026	0.1562	259730
35 - 39	1023636	1002818	2026454	0.1103	110611	1250044	1224622	2474666	0.0992	121482
40 - 44	777974	777404	1555378	0.0448	34828	955282	954582	1909865	0.0388	37038
45 - 49	600723	603103	1203826	0.0100	6031	740033	742965	1482998	0.0082	6092
50 - 54	472669	476058	948727			572881	576989	1149870		
55 - 59	363767	369964	733731			446084	453683	899767		
60 - 64	275407	291832	567239			327704	347248	674952		
65 - 69	203759	224305	428064			240950	265246	506196		
70 - 74	151629	173700	325329			168352	192857	361210		
75 - 79	109502	129904	239406			113636	134809	248445		
80 +	159780	223897	383677			136347	191061	327408		
Total	19065606	19443860	38509466		1399536	21239165	21642526	42881692		1470115
CBR					36.3427					34.28305

Age Group	2020					2025				
	Male	Female	Total	ASFR	Births	Male	Female	Total	ASFR	Births
0 - 4	3180296	3139069	6319365			3317528	3274522	6592050		
5 -9	2938561	2861101	5799662			3170535	3086960	6257495		
10 - 14	3006425	2903421	5909846			2937126	2836496	5773622		
15 - 19	2626879	2628494	5255374	0.0892	234462	2879004	2880774	5759778	0.0834	240257
20 - 24	2053328	2301364	4354692	0.1976	454750	2319638	2599844	4919482	0.1852	481491
25 - 29	1806324	2048835	3855159	0.1788	366332	1986355	2253035	4239390	0.1653	372427
30 - 34	1877196	1901878	3779074	0.1437	273300	1944794	1970364	3915158	0.1327	261467
35 - 39	1611437	1578665	3190102	0.0893	140975	1834973	1797655	3632628	0.0805	144711
40 - 44	1163263	1162411	2325674	0.0335	38941	1493564	1492470	2986034	0.0249	37162
45 - 49	908029	911626	1819655	0.0066	6017	1104332	1108708	2213040	0.0053	5876
50 - 54	706251	711315	1417566			867392	873611	1741004		
55 - 59	542135	551370	1093505			670165	681582	1351747		
60 - 64	403530	427596	831127			492500	521872	1014372		
65 - 69	288408	317489	605897			357238	393260	750499		
70 - 74	201002	230260	431263			242643	277962	520604		
75 - 79	127811	151625	279436			154307	183057	337364		
80 +	129765	181838	311603			136985	191955	328940		
Total	23570641	24008358	47578999		1514775	25909079	26424128	52333207		1543392
CBR					31.83705					29.49163

Age Group	2030					2035				
	Male	Female	Total	ASFR	Births	Male	Female	Total	ASFR	Births
0 - 4	3408101	3363921	6772022			3466725	3421784	6888509		
5 -9	3314744	3227369	6542113			3411461	3321536	6732996		
10 - 14	3170904	3062265	6233169			3317136	3203486	6520622		
15 - 19	2813492	2815222	5628715	0.0779	219306	3038348	3040216	6078565	0.0729	221632
20 - 24	2543560	2850814	5394374	0.1734	494331	2487439	2787915	5275354	0.1624	452757
25 - 29	2243979	2545247	4789226	0.1530	389423	2461853	2792372	5254225	0.1415	395121
30 - 34	2133955	2162013	4295968	0.1220	263766	2404944	2436565	4841509	0.1125	274114
35 - 39	1891598	1853128	3744725	0.0723	133981	2064330	2022347	4086676	0.0652	131857
40 - 44	1693373	1692133	3385506	0.0249	42134	1738396	1737122	3475517	0.0215	37348
45 - 49	1416116	1421727	2837843	0.0043	6113	1603879	1610233	3214113	0.0035	5636
50 - 54	1056012	1063583	2119595			1354718	1364431	2719149		
55 - 59	825134	839191	1664326			1006342	1023486	2029829		
60 - 64	611060	647503	1258562			754817	799833	1554650		
65 - 69	438372	482575	920947			546548	601659	1148208		
70 - 74	303126	347249	650375			374919	429492	804411		
75 - 79	188406	223509	411915			237858	282175	520032		
80 +	158432	222008	380440			192973	270410	463383		
Total	28210364	28819456	57029820		1549054	30462685	31145063	61607748		1518464
CBR					27.16218					24.64729

Age Group	2040					2045				
	Male	Female	Total	ASFR	Births	Male	Female	Total	ASFR	Births
0 - 4	3440608	3396007	6836615			3368379	3324714	6693093		
5 -9	3475062	3383460	6858522			3454115	3363065	6817180		
10 - 14	3414954	3297953	6712906			3480722	3361468	6842190		
15 - 19	3180388	3182343	6362731	0.0681	216718	3275491	3277505	6552997	0.0638	209105
20 - 24	2688407	3013159	5701565	0.1518	457397	2815507	3155612	5971118	0.1422	448728
25 - 29	2407535	2730762	5138298	0.1312	358276	2602844	2952293	5555137	0.1217	359294
30 - 34	2632659	2667274	5299933	0.1034	275796	2568374	2602143	5170517	0.0955	248505
35 - 39	2313793	2266737	4580529	0.0586	132831	2517358	2466162	4983520	0.0528	130213
40 - 44	1888435	1887052	3775487	0.0186	35099	2105754	2104212	4209966	0.0162	34088
45 - 49	1644792	1651308	3296100	0.0028	4624	1784121	1791190	3575311	0.0023	4120
50 - 54	1536258	1547273	3083532			1576266	1587568	3163833		
55 - 59	1294487	1316540	2611027			1470543	1495594	2966137		
60 - 64	923769	978862	1902632			1191501	1262561	2454063		
65 - 69	678180	746564	1424744			833892	917977	1751869		
70 - 74	470746	539267	1010013			588292	673923	1262216		
75 - 79	297197	352570	649767			376568	446729	823297		
80 +	245080	343427	588507			315541	442162	757703		
Total	32532351	33300558	65832909		1480741	34325268	35224878	69550146		1434053
CBR					22.49241					20.61898

Age Group	2050				
	Male	Female	Total	ASFR	Births
0 - 4	3284190	3241616	6525805		
5 -9	3385017	3295789	6680805		
10 - 14	3461134	3342551	6803685		
15 - 19	3339582	3341635	6681217	0.0596	199161
20 - 24	2900869	3251285	6152154	0.1332	433071
25 - 29	2725899	3091868	5817767	0.1125	347835
30 - 34	2768571	2804973	5573545	0.0878	246277
35 - 39	2438889	2389288	4828177	0.0475	113491
40 - 44	2278183	2276514	4554697	0.0138	31416
45 - 49	1986711	1994582	3981293	0.0018	3590
50 - 54	1711035	1723303	3434339		
55 - 59	1511805	1537559	3049364		
60 - 64	1357644	1438612	2796256		
65 - 69	1080048	1188954	2269002		
70 - 74	728093	834074	1562167		
75 - 79	474972	563467	1038440		
80 +	411573	576730	988303		
Total	35844213	36892802	72737015		1374842
CBR					18.90154

Appendix 4: Male Life Table Values

Male Life Table for Kenya - 2010 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x*}$	$_nM_{x*}$ for CDR
0	0.0624	0.0598	0.9402	10,000	598	9581	588060	58.8		
1	0.0071	0.0279	0.9721	9,402	263	36978	578479	61.5	46560	0.0185
5	0.0031	0.0154	0.9846	9,140	141	45346	541500	59.2	45346	0.0031
10	0.0021	0.0104	0.9896	8,999	94	44760	496154	55.1	44760	0.0021
15	0.0024	0.0119	0.9881	8,905	106	44259	451394	50.7	44259	0.0024
20	0.0034	0.0169	0.9831	8,799	148	43623	407134	46.3	43623	0.0034
25	0.0047	0.0232	0.9768	8,650	201	42750	363511	42.0	42750	0.0047
30	0.0073	0.0358	0.9642	8,450	303	41490	320761	38.0	41490	0.0073
35	0.0105	0.0512	0.9488	8,147	417	39691	279271	34.3	39691	0.0105
40	0.0116	0.0564	0.9436	7,730	436	37560	239579	31.0	37560	0.0116
45	0.0126	0.0611	0.9389	7,294	446	35357	202019	27.7	35357	0.0126
50	0.0131	0.0634	0.9366	6,849	434	33158	166662	24.3	33158	0.0131
55	0.0152	0.0732	0.9268	6,414	470	30898	133504	20.8	30898	0.0152
60	0.0212	0.1007	0.8993	5,945	598	28227	102607	17.3	28227	0.0212
65	0.0320	0.1481	0.8519	5,346	792	24751	74380	13.9	24751	0.0320
70	0.0503	0.2234	0.7766	4,554	1017	20228	49628	10.9	20228	0.0503
75	0.0824	0.3416	0.6584	3,537	1208	14663	29401	8.3	14663	0.0824
80+	0.1580	1	0.0000	2,329	2329	14738	14738	6.3	14738	0.1580

$_5M_0 = (d_0 + {}_4d_1)/ {}_5L_0$

Male Life Table for Kenya - 2015 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x*}$	$_nM_{x*}$ for CDR
0	0.0572	0.0550	0.9450	10,000	550	9615	596241	59.6		
1	0.0061	0.0240	0.9760	9,450	227	37255	586626	62.1	46870	0.0166
5	0.0027	0.0134	0.9866	9,223	124	45805	549371	59.6	45805	0.0027
10	0.0021	0.0104	0.9896	9,099	95	45258	503566	55.3	45258	0.0021
15	0.0022	0.0109	0.9891	9,004	99	44774	458309	50.9	44774	0.0022
20	0.0031	0.0154	0.9846	8,906	137	44185	413535	46.4	44185	0.0031
25	0.0045	0.0222	0.9778	8,769	195	43355	369349	42.1	43355	0.0045
30	0.0075	0.0368	0.9632	8,573	316	42078	325994	38.0	42078	0.0075
35	0.0112	0.0545	0.9455	8,258	450	40165	283916	34.4	40165	0.0112
40	0.0122	0.0592	0.9408	7,808	462	37885	243751	31.2	37885	0.0122
45	0.0129	0.0625	0.9375	7,346	459	35582	205866	28.0	35582	0.0129
50	0.0128	0.0620	0.9380	6,887	427	33367	170284	24.7	33367	0.0128
55	0.0146	0.0704	0.9296	6,460	455	31161	136918	21.2	31161	0.0146
60	0.0202	0.0961	0.9039	6,005	577	28581	105756	17.6	28581	0.0202
65	0.0306	0.1421	0.8579	5,427	771	25209	77176	14.2	25209	0.0306
70	0.0480	0.2143	0.7857	4,656	998	20786	51967	11.2	20786	0.0480
75	0.0793	0.3309	0.6691	3,658	1211	15265	31181	8.5	15265	0.0793
80+	0.1538	1	0.0000	2,448	2448	15915	15915	6.5	15915	0.1538

Male Life Table for Kenya - 2020 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x*}$	$_nM_{x*}$ for CDR
0	0.0526	0.0507	0.9493	10,000	507	9645	604401	60.4		
1	0.0052	0.0205	0.9795	9,493	195	37503	594756	62.7	47148	0.0149
5	0.0024	0.0119	0.9881	9,298	111	46211	557254	59.9	46211	0.0024
10	0.0020	0.0100	0.9900	9,187	91	45705	511043	55.6	45705	0.0020
15	0.0020	0.0100	0.9900	9,095	91	45250	465337	51.2	45250	0.0020
20	0.0029	0.0144	0.9856	9,005	130	44700	420087	46.7	44700	0.0029
25	0.0043	0.0213	0.9787	8,875	189	43904	375387	42.3	43904	0.0043
30	0.0076	0.0373	0.9627	8,686	324	42622	331482	38.2	42622	0.0076
35	0.0118	0.0573	0.9427	8,362	479	40614	288860	34.5	40614	0.0118
40	0.0126	0.0611	0.9389	7,883	481	38213	248246	31.5	38213	0.0126
45	0.0131	0.0634	0.9366	7,402	469	35835	210033	28.4	35835	0.0131
50	0.0126	0.0611	0.9389	6,932	423	33603	174198	25.1	33603	0.0126
55	0.0139	0.0672	0.9328	6,509	437	31452	140595	21.6	31452	0.0139
60	0.0192	0.0916	0.9084	6,072	556	28968	109143	18.0	28968	0.0192
65	0.0291	0.1356	0.8644	5,516	748	25708	80175	14.5	25708	0.0291
70	0.0458	0.2055	0.7945	4,767	980	21388	54467	11.4	21388	0.0458
75	0.0763	0.3204	0.6796	3,788	1214	15905	33079	8.7	15905	0.0763
80+	0.1499	1	0.0000	2,574	2574	17173	17173	6.7	17173	0.1499

Male Life Table for Kenya - 2025 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x^*}$	$_nM_{x^*}$ for CDR
0	0.0480	0.0464	0.9536	10,000	464	9675	611462	61.1		
1	0.0045	0.0178	0.9822	9,536	170	37735	601787	63.1	47410	0.0134
5	0.0021	0.0104	0.9896	9,366	98	46584	564053	60.2	46584	0.0021
10	0.0020	0.0100	0.9900	9,268	92	46109	517468	55.8	46109	0.0020
15	0.0018	0.0090	0.9910	9,176	82	45673	471359	51.4	45673	0.0018
20	0.0026	0.0129	0.9871	9,094	117	45174	425686	46.8	45174	0.0026
25	0.0042	0.0208	0.9792	8,976	187	44414	380512	42.4	44414	0.0042
30	0.0077	0.0378	0.9622	8,790	332	43118	336097	38.2	43118	0.0077
35	0.0125	0.0606	0.9394	8,458	513	41006	292980	34.6	41006	0.0125
40	0.0132	0.0639	0.9361	7,945	508	38456	251973	31.7	38456	0.0132
45	0.0134	0.0648	0.9352	7,437	482	35981	213518	28.7	35981	0.0134
50	0.0123	0.0597	0.9403	6,955	415	33739	177536	25.5	33739	0.0123
55	0.0134	0.0648	0.9352	6,540	424	31641	143798	22.0	31641	0.0134
60	0.0182	0.0870	0.9130	6,116	532	29250	112157	18.3	29250	0.0182
65	0.0278	0.1300	0.8700	5,584	726	26105	82906	14.8	26105	0.0278
70	0.0437	0.1970	0.8030	4,858	957	21898	56801	11.7	21898	0.0437
75	0.0735	0.3105	0.6895	3,901	1211	16478	34903	8.9	16478	0.0735
80+	0.1460	1	0.0000	2,690	2690	18425	18425	6.8	18425	0.1460

Male Life Table for Kenya - 2030 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x*}$	$_nM_{x*}$ for CDR
0	0.0441	0.0428	0.9572	10,000	428	9701	618183	61.8		
1	0.0038	0.0151	0.9849	9,572	144	37943	608483	63.6	47643	0.0120
5	0.0019	0.0095	0.9905	9,428	89	46917	570540	60.5	46917	0.0019
10	0.0019	0.0095	0.9905	9,339	88	46474	523623	56.1	46474	0.0019
15	0.0016	0.0080	0.9920	9,251	74	46069	477149	51.6	46069	0.0016
20	0.0024	0.0119	0.9881	9,177	109	45611	431080	47.0	45611	0.0024
25	0.0040	0.0198	0.9802	9,067	180	44888	385470	42.5	44888	0.0040
30	0.0079	0.0387	0.9613	8,888	344	43579	340582	38.3	43579	0.0079
35	0.0132	0.0639	0.9361	8,544	546	41353	297003	34.8	41353	0.0132
40	0.0137	0.0662	0.9338	7,998	530	38664	255650	32.0	38664	0.0137
45	0.0136	0.0658	0.9342	7,468	491	36112	216985	29.1	36112	0.0136
50	0.0121	0.0587	0.9413	6,977	410	33860	180873	25.9	33860	0.0121
55	0.0128	0.0620	0.9380	6,567	407	31818	147013	22.4	31818	0.0128
60	0.0173	0.0829	0.9171	6,160	511	29523	115195	18.7	29523	0.0173
65	0.0265	0.1243	0.8757	5,649	702	26491	85673	15.2	26491	0.0265
70	0.0417	0.1888	0.8112	4,947	934	22401	59182	12.0	22401	0.0417
75	0.0708	0.3008	0.6992	4,013	1207	17048	36781	9.2	17048	0.0708
80+	0.1422	1	0.0000	2,806	2806	19733	19733	7.0	19733	0.1422

Male Life Table for Kenya - 2035 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x*}$	$_nM_{x*}$ for CDR
0	0.0405	0.0394	0.9606	10,000	394	9724	623652	62.4		
1	0.0033	0.0131	0.9869	9,606	126	38123	613928	63.9	47847	0.0109
5	0.0017	0.0085	0.9915	9,480	80	47201	575805	60.7	47201	0.0017
10	0.0019	0.0095	0.9905	9,400	89	46778	528604	56.2	46778	0.0019
15	0.0015	0.0075	0.9925	9,311	70	46382	481825	51.7	46382	0.0015
20	0.0022	0.0109	0.9891	9,242	101	45956	435443	47.1	45956	0.0022
25	0.0038	0.0188	0.9812	9,141	172	45273	389488	42.6	45273	0.0038
30	0.0080	0.0392	0.9608	8,969	352	43963	344215	38.4	43963	0.0080
35	0.0140	0.0676	0.9324	8,617	583	41627	300252	34.8	41627	0.0140
40	0.0143	0.0690	0.9310	8,034	555	38784	258624	32.2	38784	0.0143
45	0.0139	0.0672	0.9328	7,479	502	36141	219841	29.4	36141	0.0139
50	0.0119	0.0578	0.9422	6,977	403	33877	183699	26.3	33877	0.0119
55	0.0122	0.0592	0.9408	6,574	389	31897	149822	22.8	31897	0.0122
60	0.0164	0.0788	0.9212	6,185	487	29706	117925	19.1	29706	0.0164
65	0.0253	0.1190	0.8810	5,698	678	26793	88219	15.5	26793	0.0253
70	0.0398	0.1810	0.8190	5,020	909	22827	61426	12.2	22827	0.0398
75	0.0683	0.2917	0.7083	4,111	1199	17558	38598	9.4	17558	0.0683
80+	0.1384	1	0.0000	2,912	2912	21040	21040	7.2	21040	0.1384

Male Life Table for Kenya - 2040 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x*}$	$_nM_{x*}$ for CDR
0	0.0372	0.0363	0.9637	10,000	363	9746	628919	62.9		
1	0.0028	0.0111	0.9889	9,637	107	38292	619173	64.2	48039	0.0098
5	0.0015	0.0075	0.9925	9,530	71	47473	580880	61.0	47473	0.0015
10	0.0018	0.0090	0.9910	9,459	85	47083	533407	56.4	47083	0.0018
15	0.0014	0.0070	0.9930	9,374	65	46708	486324	51.9	46708	0.0014
20	0.0020	0.0100	0.9900	9,309	93	46313	439616	47.2	46313	0.0020
25	0.0037	0.0183	0.9817	9,216	169	45659	393303	42.7	45659	0.0037
30	0.0082	0.0402	0.9598	9,047	363	44328	347644	38.4	44328	0.0082
35	0.0148	0.0714	0.9286	8,684	620	41870	303316	34.9	41870	0.0148
40	0.0149	0.0718	0.9282	8,064	579	38873	261447	32.4	38873	0.0149
45	0.0141	0.0681	0.9319	7,485	510	36150	222574	29.7	36150	0.0141
50	0.0117	0.0568	0.9432	6,975	396	33885	186423	26.7	33885	0.0117
55	0.0117	0.0568	0.9432	6,579	374	31959	152538	23.2	31959	0.0117
60	0.0156	0.0751	0.9249	6,205	466	29860	120579	19.4	29860	0.0156
65	0.0241	0.1137	0.8863	5,739	652	27065	90720	15.8	27065	0.0241
70	0.0380	0.1735	0.8265	5,087	883	23227	63655	12.5	23227	0.0380
75	0.0658	0.2825	0.7175	4,204	1188	18051	40428	9.6	18051	0.0658
80+	0.1348	1	0.0000	3,016	3016	22377	22377	7.4	22377	0.1348

Male Life Table for Kenya - 2045 from Projected ASMR

x	${}_nM_x$	${}_nq_x$	${}_nP_x$	l_x	${}_nd_x$	${}_nL_x$	T_x	e_x	${}_nL_{x^*}$	${}_nM_{x^*}$ for CDR
0	0.0340	0.0332	0.9668	10,000	332	9768	633331	63.3		
1	0.0025	0.0099	0.9901	9,668	96	38441	623564	64.5	48209	0.0089
5	0.0013	0.0065	0.9935	9,572	62	47704	585123	61.1	47704	0.0013
10	0.0018	0.0090	0.9910	9,510	85	47336	537419	56.5	47336	0.0018
15	0.0013	0.0065	0.9935	9,425	61	46970	490083	52.0	46970	0.0013
20	0.0019	0.0095	0.9905	9,364	89	46596	443113	47.3	46596	0.0019
25	0.0035	0.0173	0.9827	9,275	161	45973	396517	42.8	45973	0.0035
30	0.0083	0.0407	0.9593	9,114	371	44644	350544	38.5	44644	0.0083
35	0.0156	0.0751	0.9249	8,744	656	42077	305900	35.0	42077	0.0156
40	0.0156	0.0751	0.9249	8,087	607	38918	263823	32.6	38918	0.0156
45	0.0144	0.0695	0.9305	7,480	520	36100	224905	30.1	36100	0.0144
50	0.0115	0.0559	0.9441	6,960	389	33828	188805	27.1	33828	0.0115
55	0.0112	0.0545	0.9455	6,571	358	31961	154976	23.6	31961	0.0112
60	0.0148	0.0714	0.9286	6,213	443	29958	123016	19.8	29958	0.0148
65	0.0230	0.1087	0.8913	5,770	627	27280	93058	16.1	27280	0.0230
70	0.0364	0.1668	0.8332	5,142	858	23567	65778	12.8	23567	0.0364
75	0.0633	0.2733	0.7267	4,285	1171	18496	42210	9.9	18496	0.0633
80+	0.1313	1	0.0000	3,114	3114	23715	23715	7.6	23715	0.1313

Male Life Table for Kenya - 2050 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x*}$	$_nM_{x*}$ for CDR
0	0.0313	0.0306	0.9694	10,000	306	9786	637942	63.8		
1	0.0020	0.0080	0.9920	9,694	77	38590	628157	64.8	48375	0.0079
5	0.0012	0.0060	0.9940	9,617	58	47939	589567	61.3	47939	0.0012
10	0.0017	0.0085	0.9915	9,559	81	47593	541628	56.7	47593	0.0017
15	0.0012	0.0060	0.9940	9,478	57	47249	494035	52.1	47249	0.0012
20	0.0017	0.0085	0.9915	9,421	80	46908	446787	47.4	46908	0.0017
25	0.0034	0.0169	0.9831	9,342	157	46315	399879	42.8	46315	0.0034
30	0.0085	0.0416	0.9584	9,184	382	44965	353564	38.5	44965	0.0085
35	0.0165	0.0792	0.9208	8,802	697	42266	308599	35.1	42266	0.0165
40	0.0162	0.0778	0.9222	8,105	631	38946	266333	32.9	38946	0.0162
45	0.0147	0.0709	0.9291	7,474	530	36044	227387	30.4	36044	0.0147
50	0.0112	0.0545	0.9455	6,944	378	33773	191343	27.6	33773	0.0112
55	0.0107	0.0521	0.9479	6,566	342	31973	157570	24.0	31973	0.0107
60	0.0140	0.0676	0.9324	6,223	421	30065	125597	20.2	30065	0.0140
65	0.0219	0.1038	0.8962	5,803	602	27507	95532	16.5	27507	0.0219
70	0.0347	0.1597	0.8403	5,200	830	23925	68026	13.1	23925	0.0347
75	0.0609	0.2643	0.7357	4,370	1155	18963	44100	10.1	18963	0.0609
80+	0.1279	1	0.0000	3,215	3215	25138	25138	7.8	25138	0.1279

Appendix 5: Adjusted Female Life Tables

Female Life Table for Kenya - 2010 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_x$*	$_nM_x$* for CDR
0	0.0517	0.0499	0.9501	10,000	499	9651	625789	62.6		
1	0.0062	0.0244	0.9756	9,501	232	37447	616138	64.8	47098	0.0155
5	0.0024	0.0119	0.9881	9,269	111	46068	578691	62.4	46068	0.0024
10	0.0018	0.0087	0.9913	9,158	80	45592	532623	58.2	45592	0.0018
15	0.0018	0.0090	0.9910	9,079	81	45189	487031	53.6	45189	0.0018
20	0.0033	0.0164	0.9836	8,997	147	44618	441841	49.1	44618	0.0033
25	0.0055	0.0271	0.9729	8,850	240	43650	397224	44.9	43650	0.0055
30	0.0087	0.0426	0.9574	8,610	367	42133	353574	41.1	42133	0.0087
35	0.0105	0.0512	0.9488	8,243	422	40162	311441	37.8	40162	0.0105
40	0.0092	0.0450	0.9550	7,822	352	38229	271279	34.7	38229	0.0092
45	0.0089	0.0435	0.9565	7,470	325	36537	233050	31.2	36537	0.0089
50	0.0088	0.0431	0.9569	7,145	308	34955	196513	27.5	34955	0.0088
55	0.0105	0.0512	0.9488	6,837	350	33311	161558	23.6	33311	0.0105
60	0.0150	0.0723	0.9277	6,487	469	31264	128247	19.8	31264	0.0150
65	0.0236	0.1114	0.8886	6,018	671	28416	96983	16.1	28416	0.0236
70	0.0378	0.1727	0.8273	5,348	923	24430	68567	12.8	24430	0.0378
75	0.0667	0.2858	0.7142	4,424	1265	18960	44137	10.0	18960	0.0667
80+	0.1255	1	0.0000	3,160	3160	25177	25177	8.0	25177	0.1255

Female Life Table - 2015

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x*}$	$_nM_{x*}$ for CDR
0	0.0470	0.0455	0.9545	10,000	455	9681	633960	63.4		
1	0.0053	0.0209	0.9791	9,545	200	37700	624279	65.4	47382	0.0138
5	0.0021	0.0104	0.9896	9,345	98	46482	586579	62.8	46482	0.0021
10	0.0017	0.0085	0.9915	9,248	78	46042	540097	58.4	46042	0.0017
15	0.0017	0.0085	0.9915	9,169	78	45652	494055	53.9	45652	0.0017
20	0.0031	0.0154	0.9846	9,092	140	45109	448403	49.3	45109	0.0031
25	0.0056	0.0276	0.9724	8,952	247	44141	403294	45.1	44141	0.0056
30	0.0094	0.0459	0.9541	8,705	400	42524	359153	41.3	42524	0.0094
35	0.0114	0.0554	0.9446	8,305	460	40374	316629	38.1	40374	0.0114
40	0.0094	0.0459	0.9541	7,845	360	38323	276255	35.2	38323	0.0094
45	0.0090	0.0440	0.9560	7,484	329	36599	237932	31.8	36599	0.0090
50	0.0084	0.0411	0.9589	7,155	294	35039	201333	28.1	35039	0.0084
55	0.0098	0.0478	0.9522	6,861	328	33483	166294	24.2	33483	0.0098
60	0.0140	0.0676	0.9324	6,533	442	31558	132811	20.3	31558	0.0140
65	0.0222	0.1052	0.8948	6,091	641	28852	101253	16.6	28852	0.0222
70	0.0352	0.1618	0.8382	5,450	882	25047	72400	13.3	25047	0.0352
75	0.0640	0.2759	0.7241	4,569	1260	19692	47353	10.4	19692	0.0640
80+	0.1196	1	0.0000	3,308	3308	27661	27661	8.4	27661	0.1196

Female Life Table for Kenya - 2020 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x*}$	$_nM_{x*}$ for CDR
0	0.0426	0.0414	0.9586	10,000	414	9710	641490	64.1		
1	0.0046	0.0182	0.9818	9,586	174	37927	631780	65.9	47637	0.0123
5	0.0018	0.0090	0.9910	9,412	84	46849	593853	63.1	46849	0.0018
10	0.0017	0.0082	0.9918	9,328	77	46446	547004	58.6	46446	0.0017
15	0.0015	0.0075	0.9925	9,251	69	46082	500558	54.1	46082	0.0015
20	0.0029	0.0144	0.9856	9,182	132	45578	454477	49.5	45578	0.0029
25	0.0056	0.0276	0.9724	9,050	250	44623	408898	45.2	44623	0.0056
30	0.0101	0.0493	0.9507	8,800	433	42915	364275	41.4	42915	0.0101
35	0.0125	0.0606	0.9394	8,366	507	40564	321360	38.4	40564	0.0125
40	0.0099	0.0483	0.9517	7,859	380	38347	280796	35.7	38347	0.0099
45	0.0090	0.0440	0.9560	7,480	329	36575	242449	32.4	36575	0.0090
50	0.0080	0.0392	0.9608	7,150	280	35051	205874	28.8	35051	0.0080
55	0.0091	0.0445	0.9555	6,870	306	33586	170823	24.9	33586	0.0091
60	0.0130	0.0630	0.9370	6,564	413	31789	137237	20.9	31789	0.0130
65	0.0208	0.0989	0.9011	6,151	608	29235	105448	17.1	29235	0.0208
70	0.0331	0.1529	0.8471	5,543	847	25597	76213	13.7	25597	0.0331
75	0.0615	0.2665	0.7335	4,696	1252	20350	50616	10.8	20350	0.0615
80+	0.1138	1	0.0000	3,444	3444	30266	30266	8.8	30266	0.1138

Female Life Table for Kenya - 2025 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x^*}$	$_nM_{x^*}$ for CDR
0	0.0388	0.0378	0.9622	10,000	378	9736	647469	64.7		
1	0.0039	0.0155	0.9845	9,622	149	38132	637733	66.3	47868	0.0110
5	0.0016	0.0080	0.9920	9,474	75	47179	599601	63.3	47179	0.0016
10	0.0016	0.0080	0.9920	9,398	75	46802	552422	58.8	46802	0.0016
15	0.0014	0.0070	0.9930	9,323	65	46451	505620	54.2	46451	0.0014
20	0.0028	0.0139	0.9861	9,258	129	45967	459169	49.6	45967	0.0028
25	0.0057	0.0281	0.9719	9,129	257	45004	413203	45.3	45004	0.0057
30	0.0109	0.0531	0.9469	8,872	471	43185	368199	41.5	43185	0.0109
35	0.0137	0.0662	0.9338	8,402	556	40617	325014	38.7	40617	0.0137
40	0.0104	0.0507	0.9493	7,845	398	38232	284396	36.3	38232	0.0104
45	0.0090	0.0440	0.9560	7,448	328	36419	246164	33.1	36419	0.0090
50	0.0076	0.0373	0.9627	7,120	266	34936	209745	29.5	34936	0.0076
55	0.0085	0.0416	0.9584	6,854	285	33559	174809	25.5	33559	0.0085
60	0.0121	0.0587	0.9413	6,569	386	31881	141251	21.5	31881	0.0121
65	0.0195	0.0930	0.9070	6,183	575	29480	109369	17.7	29480	0.0195
70	0.0309	0.1434	0.8566	5,609	804	26032	79890	14.2	26032	0.0309
75	0.0590	0.2571	0.7429	4,804	1235	20933	53858	11.2	20933	0.0590
80+	0.1084	1	0.0000	3,569	3569	32925	32925	9.2	32925	0.1084

Female Life Table for Kenya - 2030 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x*}$	$_nM_{x*}$ for CDR
0	0.0352	0.0344	0.9656	10,000	344	9760	652729	65.3		
1	0.0034	0.0135	0.9865	9,656	130	38313	642970	66.6	48073	0.0099
5	0.0014	0.0070	0.9930	9,526	66	47465	604656	63.5	47465	0.0014
10	0.0016	0.0079	0.9921	9,460	75	47111	557191	58.9	47111	0.0016
15	0.0013	0.0065	0.9935	9,385	61	46772	510080	54.4	46772	0.0013
20	0.0026	0.0129	0.9871	9,324	120	46319	463308	49.7	46319	0.0026
25	0.0057	0.0281	0.9719	9,204	259	45371	416989	45.3	45371	0.0057
30	0.0119	0.0578	0.9422	8,945	517	43433	371617	41.5	43433	0.0119
35	0.0149	0.0718	0.9282	8,428	605	40627	328184	38.9	40627	0.0149
40	0.0108	0.0526	0.9474	7,823	411	38086	287557	36.8	38086	0.0108
45	0.0090	0.0440	0.9560	7,411	326	36242	249471	33.7	36242	0.0090
50	0.0074	0.0363	0.9637	7,085	257	34783	213229	30.1	34783	0.0074
55	0.0080	0.0392	0.9608	6,828	268	33470	178447	26.1	33470	0.0080
60	0.0113	0.0549	0.9451	6,560	360	31900	144976	22.1	31900	0.0113
65	0.0183	0.0875	0.9125	6,200	542	29642	113077	18.2	29642	0.0183
70	0.0289	0.1348	0.8652	5,657	762	26380	83435	14.7	26380	0.0289
75	0.0567	0.2483	0.7517	4,895	1215	21436	57055	11.7	21436	0.0567
80+	0.1033	1	0.0000	3,679	3679	35619	35619	9.7	35619	0.1033

Female Life Table for Kenya - 2035 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x*}$	$_nM_{x*}$ for CDR
0	0.0322	0.0315	0.9685	10,000	315	9780	657773	65.8		
1	0.0029	0.0115	0.9885	9,685	112	38473	647994	66.9	48252	0.0088
5	0.0013	0.0065	0.9935	9,574	62	47713	609521	63.7	47713	0.0013
10	0.0015	0.0077	0.9923	9,512	73	47375	561808	59.1	47375	0.0015
15	0.0011	0.0055	0.9945	9,439	52	47063	514433	54.5	47063	0.0011
20	0.0025	0.0124	0.9876	9,387	117	46642	467370	49.8	46642	0.0025
25	0.0058	0.0286	0.9714	9,270	265	45688	420728	45.4	45688	0.0058
30	0.0127	0.0615	0.9385	9,005	554	43640	375039	41.6	43640	0.0127
35	0.0163	0.0783	0.9217	8,451	662	40600	331399	39.2	40600	0.0163
40	0.0112	0.0545	0.9455	7,789	424	37885	290799	37.3	37885	0.0112
45	0.0090	0.0440	0.9560	7,365	324	36014	252914	34.3	36014	0.0090
50	0.0069	0.0339	0.9661	7,041	239	34607	216900	30.8	34607	0.0069
55	0.0074	0.0363	0.9637	6,802	247	33392	182293	26.8	33392	0.0074
60	0.0105	0.0512	0.9488	6,555	335	31936	148901	22.7	31936	0.0105
65	0.0173	0.0829	0.9171	6,220	516	29808	116965	18.8	29808	0.0173
70	0.0270	0.1265	0.8735	5,704	721	26716	87157	15.3	26716	0.0270
75	0.0544	0.2394	0.7606	4,982	1193	21930	60441	12.1	21930	0.0544
80+	0.0984	1	0.0000	3,790	3790	38511	38511	10.2	38511	0.0984

Female Life Table for Kenya - 2040 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x*}$	$_nM_{x*}$ for CDR
0	0.0293	0.0287	0.9713	10,000	287	9799	661769	66.2		
1	0.0025	0.0099	0.9901	9,713	97	38620	651970	67.1	48419	0.0079
5	0.0011	0.0055	0.9945	9,616	53	47950	613350	63.8	47950	0.0011
10	0.0015	0.0075	0.9925	9,564	71	47639	565400	59.1	47639	0.0015
15	0.0010	0.0050	0.9950	9,492	47	47342	517761	54.5	47342	0.0010
20	0.0024	0.0119	0.9881	9,445	113	46942	470419	49.8	46942	0.0024
25	0.0058	0.0286	0.9714	9,332	267	45994	423476	45.4	45994	0.0058
30	0.0137	0.0662	0.9338	9,065	600	43826	377483	41.6	43826	0.0137
35	0.0178	0.0852	0.9148	8,465	721	40522	333657	39.4	40522	0.0178
40	0.0117	0.0568	0.9432	7,744	440	37618	293135	37.9	37618	0.0117
45	0.0091	0.0445	0.9555	7,304	325	35705	255517	35.0	35705	0.0091
50	0.0066	0.0325	0.9675	6,979	227	34327	219812	31.5	34327	0.0066
55	0.0070	0.0344	0.9656	6,752	232	33180	185485	27.5	33180	0.0070
60	0.0098	0.0478	0.9522	6,520	312	31819	152305	23.4	31819	0.0098
65	0.0161	0.0774	0.9226	6,208	480	29839	120486	19.4	29839	0.0161
70	0.0253	0.1190	0.8810	5,728	681	26934	90647	15.8	26934	0.0253
75	0.0523	0.2313	0.7687	5,046	1167	22313	63713	12.6	22313	0.0523
80+	0.0937	1	0.0000	3,879	3879	41400	41400	10.7	41400	0.0937

Female Life Table for Kenya - 2045 from Projected ASMR

x	$_nM_x$	$_nq_x$	$_nP_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x	$_nL_{x*}$	$_nM_{x*}$ for CDR
0	0.0266	0.0261	0.9739	10,000	261	9817	664742	66.5		
1	0.0022	0.0088	0.9912	9,739	85	38751	654925	67.2	48568	0.0071
5	0.0010	0.0050	0.9950	9,654	48	48148	616174	63.8	48148	0.0010
10	0.0015	0.0073	0.9927	9,605	70	47853	568026	59.1	47853	0.0015
15	0.0009	0.0045	0.9955	9,536	43	47571	520174	54.6	47571	0.0009
20	0.0023	0.0114	0.9886	9,493	109	47193	472603	49.8	47193	0.0023
25	0.0059	0.0291	0.9709	9,384	273	46239	425410	45.3	46239	0.0059
30	0.0148	0.0714	0.9286	9,111	650	43932	379171	41.6	43932	0.0148
35	0.0195	0.0930	0.9070	8,461	787	40340	335239	39.6	40340	0.0195
40	0.0122	0.0592	0.9408	7,675	454	37237	294900	38.4	37237	0.0122
45	0.0091	0.0445	0.9555	7,220	321	35299	257662	35.7	35299	0.0091
50	0.0063	0.0310	0.9690	6,899	214	33961	222364	32.2	33961	0.0063
55	0.0065	0.0320	0.9680	6,685	214	32891	188403	28.2	32891	0.0065
60	0.0091	0.0445	0.9555	6,471	288	31637	155512	24.0	31637	0.0091
65	0.0151	0.0728	0.9272	6,183	450	29793	123875	20.0	29793	0.0151
70	0.0236	0.1114	0.8886	5,734	639	27071	94082	16.4	27071	0.0236
75	0.0502	0.2230	0.7770	5,095	1136	22633	67011	13.2	22633	0.0502
80+	0.0892	1	0.0000	3,959	3959	44378	44378	11.2	44378	0.0892

Female Life Table for Kenya - 2050 from Projected ASMR

x	${}_nM_x$	${}_nq_x$	${}_nP_x$	l_x	${}_nd_x$	${}_nL_x$	T_x	e_x	${}_nL_{x^*}$	${}_nM_{x^*}$ for CDR
0	0.0241	0.0237	0.9763	10,000	237	9834	667379	66.7		
1	0.0019	0.0076	0.9924	9,763	74	38875	657545	67.4	48709	0.0064
5	0.0009	0.0045	0.9955	9,689	44	48337	618670	63.9	48337	0.0009
10	0.0014	0.0071	0.9929	9,646	69	48056	570333	59.1	48056	0.0014
15	0.0008	0.0040	0.9960	9,577	38	47789	522277	54.5	47789	0.0008
20	0.0021	0.0104	0.9896	9,539	100	47444	474488	49.7	47444	0.0021
25	0.0061	0.0300	0.9700	9,439	284	46486	427044	45.2	46486	0.0061
30	0.0159	0.0765	0.9235	9,155	700	44027	380557	41.6	44027	0.0159
35	0.0213	0.1011	0.8989	8,455	855	40140	336530	39.8	40140	0.0213
40	0.0127	0.0615	0.9385	7,600	468	36833	296390	39.0	36833	0.0127
45	0.0091	0.0445	0.9555	7,133	317	34870	259557	36.4	34870	0.0091
50	0.0060	0.0296	0.9704	6,815	201	33573	224687	33.0	33573	0.0060
55	0.0060	0.0296	0.9704	6,614	195	32581	191114	28.9	32581	0.0060
60	0.0085	0.0416	0.9584	6,418	267	31424	158533	24.7	31424	0.0085
65	0.0142	0.0686	0.9314	6,151	422	29702	127108	20.7	29702	0.0142
70	0.0221	0.1047	0.8953	5,730	600	27148	97406	17.0	27148	0.0221
75	0.0482	0.2151	0.7849	5,130	1103	22890	70258	13.7	22890	0.0482
80+	0.0850	1	0.0000	4,026	4026	47368	47368	11.8	47368	0.0850

Appendix 6: Computation of CDRs

Age Group	2010- Base Population							
	Male	Female	Total	ASMR-Male	ASMR-Female	Death-Male	Death-Female	Total Deaths
0 - 4	3036260	2996900	6033160	0.0185	0.0155	56171	46452	102623
5 -9	2751137	2678618	5429755	0.0031	0.0024	8529	6429	14957
10 - 14	2433120	2349758	4782878	0.0021	0.0018	5110	4112	9222
15 - 19	2119052	2120355	4239407	0.0024	0.0018	5086	3817	8902
20 - 24	1800433	2017920	3818353	0.0034	0.0033	6121	6659	12781
25 - 29	1518683	1722576	3241259	0.0047	0.0055	7138	9474	16612
30 - 34	1268075	1284748	2552823	0.0073	0.0087	9257	11177	20434
35 - 39	1023636	1002818	2026454	0.0105	0.0105	10748	10530	21278
40 - 44	777974	777404	1555378	0.0116	0.0092	9024	7152	16177
45 - 49	600723	603103	1203826	0.0126	0.0089	7569	5368	12937
50 - 54	472669	476058	948727	0.0131	0.0088	6192	4189	10381
55 - 59	363767	369964	733731	0.0152	0.0105	5529	3885	9414
60 - 64	275407	291832	567239	0.0212	0.0150	5839	4377	10216
65 - 69	203759	224305	428064	0.0320	0.0236	6520	5294	11814
70 - 74	151629	173700	325329	0.0503	0.0378	7627	6566	14193
75 - 79	109502	129904	239406	0.0824	0.0667	9023	8665	17688
80 +	159780	223897	383677	0.1580	0.1255	25245	28099	53344
Total	**19065606**	**19443860**	**38509466**			**190728**	**172244**	**362972**
CDR								**9.43**

Age Group	2015							
	Male	Female	Total	ASMR-Male	ASMR-Female	Death-Male	Death-Female	Total Deaths
0 - 4	2954820	2916515	5871335	0.0166	0.0138	49050	40248	89298
5 -9	3010627	2931268	5941895	0.0027	0.0021	8129	6156	14284
10 - 14	2745078	2651028	5396107	0.0021	0.0017	5765	4507	10271
15 - 19	2327649	2329080	4656729	0.0022	0.0017	5121	3959	9080
20 - 24	1867991	2093639	3961629	0.0031	0.0031	5791	6490	12281
25 - 29	1740463	1974131	3714594	0.0045	0.0056	7832	11055	18887
30 - 34	1641223	1662803	3304026	0.0075	0.0094	12309	15630	27940
35 - 39	1250044	1224622	2474666	0.0112	0.0114	14000	13961	27961
40 - 44	955282	954582	1909865	0.0122	0.0094	11654	8973	20628
45 - 49	740033	742965	1482998	0.0129	0.0090	9546	6687	16233
50 - 54	572881	576989	1149870	0.0128	0.0084	7333	4847	12180
55 - 59	446084	453683	899767	0.0146	0.0098	6513	4446	10959
60 - 64	327704	347248	674952	0.0202	0.0140	6620	4861	11481
65 - 69	240950	265246	506196	0.0306	0.0222	7373	5888	13262
70 - 74	168352	192857	361210	0.0480	0.0352	8081	6789	14869
75 - 79	113636	134809	248445	0.0793	0.0640	9011	8628	17639
80 +	136347	191061	327408	0.1538	0.1196	20970	22851	43821
Total	**21239165**	**21642526**	**42881692**			**195098**	**175976**	**371074**
CDR								**8.65**

Age Group	2020							
	Male	Female	Total	ASMR-Male	ASMR-Female	Death-Male	Death-Female	Total Deaths
0 - 4	3180296	3139069	6319365	0.0149	0.0123	47386	38611	85997
5 -9	2938561	2861101	5799662	0.0024	0.0018	7053	5150	12203
10 - 14	3006425	2903421	5909846	0.0020	0.0017	6013	4791	10803
15 - 19	2626879	2628494	5255374	0.0020	0.0015	5254	3943	9197
20 - 24	2053328	2301364	4354692	0.0029	0.0029	5955	6674	12629
25 - 29	1806324	2048835	3855159	0.0043	0.0056	7767	11473	19241
30 - 34	1877196	1901878	3779074	0.0076	0.0101	14267	19209	33476
35 - 39	1611437	1578665	3190102	0.0118	0.0125	19015	19733	38748
40 - 44	1163263	1162411	2325674	0.0126	0.0099	14657	11508	26165
45 - 49	908029	911626	1819655	0.0131	0.0090	11895	8205	20100
50 - 54	706251	711315	1417566	0.0126	0.0080	8899	5691	14589
55 - 59	542135	551370	1093505	0.0139	0.0091	7536	5017	12553
60 - 64	403530	427596	831127	0.0192	0.0130	7748	5559	13307
65 - 69	288408	317489	605897	0.0291	0.0208	8393	6604	14996
70 - 74	201002	230260	431263	0.0458	0.0331	9206	7622	16828
75 - 79	127811	151625	279436	0.0763	0.0615	9752	9325	19077
80 +	129765	181838	311603	0.1499	0.1138	19452	20693	40145
Total	**23570641**	**24008358**	**47578999**			**210246**	**189806**	**400052**
CDR								**8.41**

Age Group	2025							
	Male	Female	Total	ASMR-Male	ASMR-Female	Death-Male	Death-Female	Total Deaths
0 - 4	3317528	3274522	6592050	0.0134	0.0110	44455	36020	80475
5 -9	3170535	3086960	6257495	0.0021	0.0016	6658	4939	11597
10 - 14	2937126	2836496	5773622	0.0020	0.0016	5874	4567	10441
15 - 19	2879004	2880774	5759778	0.0018	0.0014	5182	4033	9215
20 - 24	2319638	2599844	4919482	0.0026	0.0028	6031	7280	13311
25 - 29	1986355	2253035	4239390	0.0042	0.0057	8343	12842	21185
30 - 34	1944794	1970364	3915158	0.0077	0.0109	14975	21477	36452
35 - 39	1834973	1797655	3632628	0.0125	0.0137	22937	24628	47565
40 - 44	1493564	1492470	2986034	0.0132	0.0104	19715	15522	35237
45 - 49	1104332	1108708	2213040	0.0134	0.0090	14798	9978	24776
50 - 54	867392	873611	1741004	0.0123	0.0076	10669	6639	17308
55 - 59	670165	681582	1351747	0.0134	0.0085	8980	5793	14774
60 - 64	492500	521872	1014372	0.0182	0.0121	8963	6315	15278
65 - 69	357238	393260	750499	0.0278	0.0195	9931	7669	17600
70 - 74	242643	277962	520604	0.0437	0.0309	10603	8589	19193
75 - 79	154307	183057	337364	0.0735	0.0590	11342	10800	22142
80 +	136985	191955	328940	0.1460	0.1084	20000	20808	40808
Total	**25909079**	**26424128**	**52333207**			**229457**	**207899**	**437356**
CDR								**8.36**

Age Group	2030							
	Male	Female	Total	ASMR-Male	ASMR-Female	Death-Male	Death-Female	Total Deaths
0 - 4	3408101	3363921	6772022	0.0120	0.0099	40897	33303	74200
5 -9	3314744	3227369	6542113	0.0019	0.0014	6298	4518	10816
10 - 14	3170904	3062265	6233169	0.0019	0.0016	6025	4869	10894
15 - 19	2813492	2815222	5628715	0.0016	0.0013	4502	3660	8161
20 - 24	2543560	2850814	5394374	0.0024	0.0026	6105	7412	13517
25 - 29	2243979	2545247	4789226	0.0040	0.0057	8976	14508	23484
30 - 34	2133955	2162013	4295968	0.0079	0.0119	16858	25728	42586
35 - 39	1891598	1853128	3744725	0.0132	0.0149	24969	27612	52581
40 - 44	1693373	1692133	3385506	0.0137	0.0108	23199	18275	41474
45 - 49	1416116	1421727	2837843	0.0136	0.0090	19259	12796	32055
50 - 54	1056012	1063583	2119595	0.0121	0.0074	12778	7871	20648
55 - 59	825134	839191	1664326	0.0128	0.0080	10562	6714	17275
60 - 64	611060	647503	1258562	0.0173	0.0113	10571	7317	17888
65 - 69	438372	482575	920947	0.0265	0.0183	11617	8831	20448
70 - 74	303126	347249	650375	0.0417	0.0289	12640	10035	22676
75 - 79	188406	223509	411915	0.0708	0.0567	13339	12673	26012
80 +	158432	222008	380440	0.1422	0.1033	22529	22933	45462
Total	**28210364**	**28819456**	**57029820**			**251124**	**229054**	**480178**
CDR								**8.42**

Age Group	2035							
	Male	Female	Total	ASMR-Male	ASMR-Female	Death-Male	Death-Female	Total Deaths
0 - 4	3466725	3421784	6888509	0.0109	0.0088	37787	30112	67899
5 -9	3411461	3321536	6732996	0.0017	0.0013	5799	4318	10117
10 - 14	3317136	3203486	6520622	0.0019	0.0015	6303	4933	11236
15 - 19	3038348	3040216	6078565	0.0015	0.0011	4558	3344	7902
20 - 24	2487439	2787915	5275354	0.0022	0.0025	5472	6970	12442
25 - 29	2461853	2792372	5254225	0.0038	0.0058	9355	16196	25551
30 - 34	2404944	2436565	4841509	0.0080	0.0127	19240	30944	50184
35 - 39	2064330	2022347	4086676	0.0140	0.0163	28901	32964	61865
40 - 44	1738396	1737122	3475517	0.0143	0.0112	24859	19456	44315
45 - 49	1603879	1610233	3214113	0.0139	0.0090	22294	14492	36786
50 - 54	1354718	1364431	2719149	0.0119	0.0069	16121	9415	25536
55 - 59	1006342	1023486	2029829	0.0122	0.0074	12277	7574	19851
60 - 64	754817	799833	1554650	0.0164	0.0105	12379	8398	20777
65 - 69	546548	601659	1148208	0.0253	0.0173	13828	10409	24236
70 - 74	374919	429492	804411	0.0398	0.0270	14922	11596	26518
75 - 79	237858	282175	520032	0.0683	0.0544	16246	15350	31596
80 +	192973	270410	463383	0.1384	0.0984	26707	26608	53316
Total	**30462685**	**31145063**	**61607748**			**277048**	**253080**	**530127**
CDR								**8.60**

Age Group	2040							
	Male	Female	Total	ASMR-Male	ASMR-Female	Death-Male	Death-Female	Total Deaths
0 - 4	3440608	3396007	6836615	0.0098	0.0079	33718	26828	60546
5 -9	3475062	3383460	6858522	0.0015	0.0011	5213	3722	8934
10 - 14	3414954	3297953	6712906	0.0018	0.0015	6147	4947	11094
15 - 19	3180388	3182343	6362731	0.0014	0.0010	4453	3182	7635
20 - 24	2688407	3013159	5701565	0.0020	0.0024	5377	7232	12608
25 - 29	2407535	2730762	5138298	0.0037	0.0058	8908	15838	24746
30 - 34	2632659	2667274	5299933	0.0082	0.0137	21588	36542	58129
35 - 39	2313793	2266737	4580529	0.0148	0.0178	34244	40348	74592
40 - 44	1888435	1887052	3775487	0.0149	0.0117	28138	22079	50216
45 - 49	1644792	1651308	3296100	0.0141	0.0091	23192	15027	38218
50 - 54	1536258	1547273	3083532	0.0117	0.0066	17974	10212	28186
55 - 59	1294487	1316540	2611027	0.0117	0.0070	15145	9216	24361
60 - 64	923769	978862	1902632	0.0156	0.0098	14411	9593	24004
65 - 69	678180	746564	1424744	0.0241	0.0161	16344	12020	28364
70 - 74	470746	539267	1010013	0.0380	0.0253	17888	13643	31532
75 - 79	297197	352570	649767	0.0658	0.0523	19556	18439	37995
80 +	245080	343427	588507	0.1348	0.0937	33037	32179	65216
Total	**32532351**	**33300558**	**65832909**			**305331**	**281047**	**586378**
CDR								**8.91**

Age Group	2045							
	Male	Female	Total	ASMR-Male	ASMR-Female	Death-Male	Death-Female	Total Deaths
0 - 4	3368379	3324714	6693093	0.0089	0.0071	29979	23605	53584
5 -9	3454115	3363065	6817180	0.0013	0.0010	4490	3363	7853
10 - 14	3480722	3361468	6842190	0.0018	0.0015	6265	4908	11173
15 - 19	3275491	3277505	6552997	0.0013	0.0009	4258	2950	7208
20 - 24	2815507	3155612	5971118	0.0019	0.0023	5349	7258	12607
25 - 29	2602844	2952293	5555137	0.0035	0.0059	9110	17419	26528
30 - 34	2568374	2602143	5170517	0.0083	0.0148	21318	38512	59829
35 - 39	2517358	2466162	4983520	0.0156	0.0195	39271	48090	87361
40 - 44	2105754	2104212	4209966	0.0156	0.0122	32850	25671	58521
45 - 49	1784121	1791190	3575311	0.0144	0.0091	25691	16300	41991
50 - 54	1576266	1587568	3163833	0.0115	0.0063	18127	10002	28129
55 - 59	1470543	1495594	2966137	0.0112	0.0065	16470	9721	26191
60 - 64	1191501	1262561	2454063	0.0148	0.0091	17634	11489	29124
65 - 69	833892	917977	1751869	0.0230	0.0151	19180	13861	33041
70 - 74	588292	673923	1262216	0.0364	0.0236	21414	15905	37318
75 - 79	376568	446729	823297	0.0633	0.0502	23837	22426	46263
80 +	315541	442162	757703	0.1313	0.0892	41431	39441	80871
Total	**34325268**	**35224878**	**69550146**			**336673**	**310921**	**647594**
CDR								**9.31**

Age Group	2050								
	Male	Female	Total	ASMR-Male	ASMR-Female	Death-Male	Death-Female	Total Deaths
0 - 4	3284190	3241616	6525805	0.0079	0.0064	25945	20746	46691
5 -9	3385017	3295789	6680805	0.0012	0.0009	4062	2966	7028
10 - 14	3461134	3342551	6803685	0.0017	0.0014	5884	4780	10664
15 - 19	3339582	3341635	6681217	0.0012	0.0008	4007	2673	6681
20 - 24	2900869	3251285	6152154	0.0017	0.0021	4931	6828	11759
25 - 29	2725899	3091868	5817767	0.0034	0.0061	9268	18860	28128
30 - 34	2768571	2804973	5573545	0.0085	0.0159	23533	44599	68132
35 - 39	2438889	2389288	4828177	0.0165	0.0213	40242	50892	91133
40 - 44	2278183	2276514	4554697	0.0162	0.0127	36907	28912	65818
45 - 49	1986711	1994582	3981293	0.0147	0.0091	29205	18151	47355
50 - 54	1711035	1723303	3434339	0.0112	0.0060	19164	10340	29503
55 - 59	1511805	1537559	3049364	0.0107	0.0060	16176	9225	25402
60 - 64	1357644	1438612	2796256	0.0140	0.0085	19007	12228	31235
65 - 69	1080048	1188954	2269002	0.0219	0.0142	23653	16883	40536
70 - 74	728093	834074	1562167	0.0347	0.0221	25265	18433	43698
75 - 79	474972	563467	1038440	0.0609	0.0482	28926	27159	56085
80 +	411573	576730	988303	0.1279	0.0850	52640	49022	101662
Total	**35844213**	**36892802**	**72737015**			**368815**	**342698**	**711512**
CDR								**9.78**