# SUB-NATIONAL PROJECTION METHODS: APPLICATION TO THE COUNTIES IN THE FORMER NYANZA PROVINCE, KENYA.


**BY**

**HERBERT ODHIAMBO KODIKO**

**Q56/71913/2011**


**A PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN POPULATION STUDIES AT THE POPULATION STUDIES AND RESEARCH INSTITUTE, UNIVERSITY OF NAIROBI**

**Supervisors:**

**Prof. A Agwanda**

**Dr.GOdipo**


**POPULATION STUDIES AND RESEARCH INSTITUTE (PSRI)**

**UNIVERSITY OF NAIROBI**

**P O BOX 30197**

**NAIROBI**


**OCTOBER 2014**

# DECLARATION

This project is my original work and to the best of my knowledge has not been submitted to this or any other University for award of a degree.

Signature Date

………………….......................... ..................................................

Herbert Odhiambo Kodiko

Registration Number: Q56/71913/2011

This project has been submitted for examination with our approval as University supervisors:

1. Signature Date

   ……………………………............ ..............................................

   Prof. Alfred Agwanda
   Population Studies and Research Institute
   University of Nairobi

2. Signature Date

   ……………………………............ ..............................................

Dr. George Odipo
Population Studies and Research Institute
University of Nairobi

# DEDICATION

I dedicate this work to my late father, Emmanuel Kodiko and mum for making a decision to take me to school at an early age and hence provided me with the firm education foundation which has enabled me climb the academic ladder this far. I also dedicate this work to my lovely wife Mercy Awino, daughter Alexandria Hawi for the support and corporation they have given me. Many thanks for your understanding.

Glory be to God.

**ACKNOWLEDGEMENT**

I give Glory to our God for this far he has brought us. All through, I have seen His wholesome grace, favour, provision and protection in my entire period of study. I bless and glorify His Holy name. I do appreciate the critical evaluation, counsel and professional input by my supervisors: Prof. Alfred Agwanda and Dr. George Odipo, Many Thanks.

Many thanks to my colleagues at Cianda High School, for moral and physical support you offered to me during the entire period of study. Finally, I pass my sincere and heartfelt thanks to the entire PSRI family: The Director and Lecturers, for their tireless efforts and guidance provided to me throughout the entire course. Many thanks to the non-teaching staff as well. I am also indebted to my classmates; in particular my MSc classmates Lilian, Caudecia and Naomi.

God bless.

## ABSTRACT

The main objective of the study was to review the sub-national projection methods and to use the most appropriate method to project the primary school-age population among the sub-counties in the former Nyanza Province. In order to achieve this goal, the study projected the 1999 population of the counties to 2009 using the four models namely; the share of population model, share of growth model, the growth difference model and the shortcut cohort model. The study deduced that shortcut model gave better projection than the rest and thus was used to project the school-age population among the sub-counties.

The study then used the 2009 census data for the counties to project the sub-county school-age population. From the 2009 census data it was deduced that the school-age population would increase in all the sub-counties using a base population of 2010.This base population was then projected to 2030 making assumptions of constant fertility, mortality and migration throughout the study period. The counties population would increase with Kisii having the highest, followed by Kisumu, Homa-bay, Migori, Siaya then Nyamira was the last.

The study predicted an increasing demand for teachers, infrastructure and other amenities at the primary school level. Since the pupil teacher ratio in the year 2009 was 46.78:1 (UNESCO, 2000).This does not tally with the accepted ratio by the ministry of education’s ratio of 40:1.It means more teachers should be employed to conform to the recommended ratio. The class size which is easier to manage, give maximum attention per pupil and also control discipline is 40.This means therefore that as the number increases more classrooms should be constructed to cater for the increased number. Other amenities like separate toilets for boys and girls should also be considered. The recommended pupil to toilet ratio by the MOE is 30:1 for boys and 25:1 for girls, thus there is need for increased number of toilets to maintain good hygiene in primary schools.

## TABLE OF CONTENTS

## LIST OF ABBREVIATIONS

AIDS ..............................................................Acquired Immunodeficiency Syndrome

DHS................................................................Demographic and Health survey

ECDE .............................................................Early Childhood Development and Education

FTI..................................................................Fast Track Initiative

GER................................................................General Enrolment Rate

GOK ...............................................................Government of Kenya

HIV ................................................................Human Immunodeficiency Virus

KESSP............................................................Kenya Education Sector Support Programme

KNBS............................................................Kenya National Bureau of Statistics

MOE...............................................................Ministry of Education

TFR ................................................................Total Fertility Rate

# CHAPTER 1: INTRODUCTION

## 1.1 Background

Demographers are frequently called on to produce population information when census and related data are not available. An estimated population gives information about present or past populations not based on a census or population register. Some of the methods use the censal ratio, regression or component methods. Information about the future population is referred to as either a projection or a forecast and can be differentiated according to the expected likelihood of their outcomes.

Population projection is the estimation of future populations based on the present age-sex structure, together with assumed rates of fertility, mortality, and migration in the future, that is, extrapolation of past and present population trends into the future (Shryock, 1976). Projections must be evaluated in light of when they were made, prescribed assumptions and conditions at that time. Therefore, projections are based on current knowledge about population size, age structure, rates of birth, death, migration, and assumptions about how quickly these rates will change. Population projections are essentially concerned with future growth. They may be prepared for the total population of nations, their principal geographical subdivisions or specific localities within them. Although a given projection can be judged by the merits of its assumptions in relation to the use to which it may be put, it can never be proven right or wrong by future events.

A forecast may be defined as the projection that is selected as the one most likely to provide an accurate prediction of the population (Shryock, 1976). It represents a specific viewpoint regarding the validity of the underlying data and assumptions. A forecast reflects a judgement, and it can be proven right or wrong by future events.

Based on such projections, we can raise our understanding of the determinants of population change such as what impact would a 20% decline in birth rates have on a county's population size and  age structure in 50 years? They can also be used to provide information on possible future scenarios since we cannot "see" into the future (Tom, 2011). Population projections are essential for planning at the national, regional and district levels in both the private and public sectors. In order for planners and policy makers to efficiently allocate the scarce resources, they need to know the future size and structure of the country's population as well as their characteristics. Planning for any sector of the economy therefore requires information about the future size and structure of the population in the area

This is because the changes in population size and composition have many social, economic, environmental and political implications. Population projections often serve as a basis for producing other projections (e.g., households, school enrolment, income, labour force etc).The most common sub regional projection methods are non component; Trend Extrapolation, Auto-Regressive Integrated Moving Average (ARIMA), Comparative, Regression, Economic Base, Housing Unit, Land-use allocation, Averaged Projections and Shortcut Cohort methods. The Component projection methods are; Simple Component, Cohort-Component, Micro simulation and Integrated Projection models

The purpose of this study is to aid the decision-making process about what sort of model (or combination of models) is most suitable at the sub-regional level and use it to project the school age population at the Lake Region Counties. As a minimum these projections must be disaggregated by sex and five year age group and extend out 20 years, from 2010-2030.

### 1.2 Problem Statement

At the national level of projections, cohort component method is acceptable and easily applicable. This is due to the availability of migration data at the national level. At the sub-regional level, migration data is rarely available making it difficult to use this method. As a result, various methods have been proposed and tried to project the sub-regional population. Planning has also been devolved to the counties and subsequently to the sub-counties in Kenya. This calls for projected populations at the lower levels to make it easier for the planners to allocate resources, expand infrastructure, and avail the required amenities and human resources among others.

At the sub-regional scale a wide variety of methods has been proposed like the Share of growth, Share of population, Growth difference and shortcut cohort models and applied to produce population projections. In Kenya, there is need for various approaches to establish their applicability. None of these methods is dominant and generally accepted as the 'gold standard' in the same way the cohort-component model is for national, State and regional projections (Tom, 2011). This study therefore describes the key features, strengths and weaknesses of many existing sub-regional projection methods.

It makes recommendations on which are worthy of consideration to be taken and which model (or combination of models) is most suitable for use at the sub-county level. Few projections have been done in Kenya for sub-national regions as official statistics like the County population projections, etc. At the sub-regional level, there is also inadequate data on primary school-age population. At the sub-regional scale migration is by far the most significant, the most volatile, and the hardest to predict of the three demographic processes.

## 1.3 Research Question

Which population projection method/model (or combination of models) among the proposed at the sub regional level is the most suitable at the sub-county level in Kenya.

## 1.4 Objectives

### 1.4.1 General Objective

The study aims at reviewing the methods of population projections and to determine which is the most suitable at the sub-county level in Kenya.

### 1.4.2 Specific Objectives

1. To determine the most suitable method for use at the sub-county population projection.

2. To project the school age population at the primary level among counties in the former Nyanza Province

## 1.5 Justification of the Study

Most applications of the cohort-component method require a great deal of effort to collect, verify, and organize input data and to develop and implement a projection model. This is a costly and time-consuming process. Furthermore, the fertility, mortality, and migration data needed to apply a full-blown model are often unavailable for small areas. A simpler version of the cohort-component method was developed that requires data only from two consecutive censuses and a set of simple calculations (Hamilton and Perry 1962).

For sub-national areas, migration is often the major determinant of population growth (Smith and Ahmed 1990). It is also the most difficult component of growth to forecast accurately because state and local migration rates are subject to much greater volatility than are either fertility or mortality rates ( Kulkami 1994). Since migration rates vary markedly by age, forecast errors are likely to be larger for some age groups than for others. Typically, migration rates are high for young children, decline as those children reach adolescence, rise to a peak for young adults, and decline steadily thereafter. For sub-national areas, then, we expect forecast errors to be relatively large not only for young children but also for young adults.

Furthermore, the age- and sex-specific fertility, mortality, and migration data that are required for a full-blown cohort-component model are seldom available for sub-county areas, such as cities, districts, or market areas. Attempting to collect these data is expensive and time consuming; in some instances (e.g., out-migration data), it is virtually impossible. Constructing proxy measures for missing data is also expensive and time consuming and introduces additional sources of error.

With the promulgation of the new Constitution on 27th August 2010, 47 counties were created as centres of the devolved form of governance to be adopted in 2013. Planning has also been devolved to the county and sub-county level. Therefore these planners require these data for planning purposes. Population projections are essential for planning at the national, regional, county and sub-county levels in the private and public sectors. In order for planners and policy makers to allocate efficiently the scarce resources, they need to know the future size and structure of the country's population as well as their characteristics. The availed information by the projections is also used for research purposes. The former Nyanza Province consists of six counties and was chosen for this study.

This study will inform county planners to be better prepared to meet the challenges arising from the projected school age population at county level.It also aims at comparing the forecasting performance of other simpler methods with the performance of the shortcut cohort model.

## 1.6 Scope and Limitations

At the national, State and regional scales the cohort-component model is very widely accepted as the 'gold standard' of projection models (Tom, 2011). However, for sub-regional areas no single method dominates in the same way. A considerable variety of methods are used, depending on data availability, required outputs, staff resources, costs, knowledge of projection methods, individual preferences and other factors.

This report assesses both common and less common methods of producing sub-regional population projections. The study will look at the methods which just produce the total population; i.e. comparative methods. It will also look at methods which create projections by age group (age disaggregation); i.e. shortcut cohort model.The study will use secondary data from the 1999 and the 2009 Population and Housing Census for the review of methods and will focus on the school age population for counties in the former Nyanza Province for projections.
The limitations are that the study does not cover methods for the creation of predictive intervals and probabilistic projections, input data preparation methods, assumption-setting or household projections. Nor does the report include reviews of demographic projection software for sub-regional projections.

# CHAPTER 2: LITERATURE REVIEW

## 2.1 Introduction

An understanding of the concept of population projections is important in this study. To highlight on this concept, the literature review in this section is organized under the headings: Concepts of population Projections, Types of Population projections.

## 2.2 Concepts of Population Projections

Projections refer mostly to the exercises of extrapolation of the past trends into the future; and they do not take into account changes in the policy parameters. For example, a projection of the future population growth may not be taking into account changes in the government health policies, family health programmes, etc. Projections are based on the assumption that the past trends will continue to operate in the future and are usually extrapolations of past and present population trends into the future. Projections must be evaluated in the light of when they were made, and conditions at the time

Forecasts are the specific projections that are expected to provide the most accurate predictions of those values (Shryock, 1976).A longstanding controversy in demography is whether complex projection methods produce more accurate forecasts than do simpler methods (e.g., Keyfitz 1981; Long 1995; Rogers 1995; Smith and Sincich 1992). For projections of the total population, we believe the empirical evidence is clear: complex methods do not consistently produce more accurate forecasts than do simple extrapolation methods (Smith et al. 2001:307-16). For projections of demographic characteristics, however, few empirical tests have been performed.

The reliability and usefulness of projections depend on the assumptions and their closeness to reality. In the end, the policy parameters are to be incorporated in the projections. The likely effects of policy changes are to be judged and projections are to be made accordingly. Thus, when an element of judgment is added to the projections, it becomes a forecast.

Population forecasts predict the future size and composition of populations, based on predictions of fertility, mortality, and migration. Projections are used for many purposes, including for predicting the demand for food, water, education, medical services, labour markets, pension systems, and predicting future impact on the environment. It is important for decision makers to not only have a point forecast that states the most likely scenario of a future population, but also to know the uncertainty around it, that is, the possible future values of an outcome, and how likely each set of possible future values is. Forecasts enjoy the advantage of being based upon the assumption or a set of assumptions, which are likely to be realized in the near future and can yield a relatively more realistic picture of the future.

In general, population projections are treated as predictions and are never to be termed as final population. They should be reviewed frequently in order to determine the degree to which they agree with recent demographic changes. If the discrepancies between the projections and the ultimate events are significant, it should be found out whether it is due to the quality of input data or due to the methodology adopted (Mehta, 1994).

Population projections are used for a wide variety of planning and budgeting purposes. In many instances, projections of demographic characteristics are at least as important as projections of the total population. Age is a particularly important characteristic and is commonly used when projecting births (Lapkoff, 1993), school enrolment (Fishlow, 1994), residential care for children (Dunton, 1994), hospital services (Rives, 1994), social security revenues and expenditures (Lee and Tuljapurkar, 1997), and many other policy-relevant variables. By their very nature, population projections are uncertain. We cannot know precisely what the population will be one year from now, much less in 10, 20 or 30 years. The accuracy in a projection is improved by developing stochastic forecasting models that attach explicit statements of probability to population projections (Alho, 1990)

### 2.3 Types of Population Projection Methods

There are several methods, which can be used to project a given population depending on the objective of the research. While using the exponential equation $P_t=P_oe^{rt}$, Ondieki (1989) in his thesis, projected the population of Nairobi and its implications for Housing and observed that housing needs were increasing with time, as does the population.

Wekesa (1989) used the four parameter logit system to project the Kenya population and analyzed its implications for educational sector and more so the enrolment. The conclusion was that some provinces showed a consistently high retention rate while others performed very poorly. Bwila (2004) used the stable population model (an 18 by 18-matrix method) and in his finding projected that the population of Kenya will stabilize by the year 2090.

In the recent past, a study done by Kiema, et al (2011), reveal that Kenya's population had increased from 28.7 million in 1999 to 36.9 million in 2008. They project that the population will reach 42.1 million in 2012 and 46.1 million in 2015. The primary school-age population stood at 7.9 million in 2009 and it is projected to reach 9.3 million in the year 2012 and 10.7 million by the year 2015(GOK, 2011).They used the cohot-component method.

In 2006, Kenya evaluated and endorsed Education support from Fast Track Initiative (FTI) based on the credibility of the 'basic education for all' policy as formulated in the Kenya Education sector support programme (KESSP). While enrolment in ECDE increased from 1,672 thousand in 2006 to 1,691 thousand children in 2007, the gross enrolment rate (GER) of 59.3 percent is still below acceptable levels. Furthermore, the number of ECDE centres also increased marginally from 36 thousand in 2006 to 37 thousand in 2007. With low enrolment at this level, many children between ages 4-5 years end up directly joining primary schools without the relevant background thus negatively affecting quality of education.

Trend extrapolation methods consist of mathematical functions which extend the trend observed over a specified base period into the future. Functions commonly used in the demography include the linear model, polynomials such as quadratic and cubic curves, the power function, the hyperbolic curve, exponential and modified exponential curves, the logistic curve and the Gompertz curve. Taylor (2001) projected the population of Mutitjulu, a small Aboriginal community in central Australia. Projections over a 20 year horizon were created using both linear and geometric (exponential) extrapolation over differing base periods, along with a Projected Share of Population model.

Those trend extrapolation methods without limits simply assume a continuation of base period trends into the future, and can sometimes give highly implausible forecasts in the medium- and long-term, including run-away growth and negative numbers in some cases. Polynomials of order three and above are especially prone to project rapid increases and decreases in population. All trend extrapolation methods are very dependent on the historical period over which they are fitted. The advantages of trend extrapolation methods are that they have minimal input data requirements, can be easily and quickly calculated in spreadsheets, and therefore require modest staff person-hours and costs. In cases where the fit to recent data is good, very short-term projections of just one or two years will probably be quite accurate. In addition, in situations of very limited data availability where the analyst is required to produce projections, there may be few other options.(Tom 2011)

Few researchers have used ARIMA models to produce population projections. More commonly such models are employed to forecast variables such as the Total Fertility Rate and the index of mortality in the Lee-Carter model of mortality as part of probabilistic forecasts. After an examination of the forecast accuracy of his models he concluded: “ARIMA models produce population forecasts which are at least as reliable as more traditional demographic models” (Pflaumer 1992 p 337). More recently Abel et al. (2010) applied a series of Bayesian autoregressive models to forecast the population of England and Wales.

The strengths of this model is that, time series models for total population require only past data on population totals. And these models also generate prediction intervals, thus giving users an indication of forecast uncertainty. Pflaumer (1992) argues that the use of time series models is also justified on the grounds they can act as a benchmark against which more sophisticated models can be compared.
On the negative side, the process of fitting time series models is not trivial and requires the use of statistical software. Identifying the best-fitting model requires judgment and can be difficult, and must be done for each area at a time. Two alternative models may give fits which are very similar, but forecasts and/or prediction intervals which are quite different. Additionally, it is usually recommended that at least 50 observations are available when fitting the model, a length of time series which is rare for sub-regional areas. Furthermore, like trend extrapolation models, time series models do not take into account demographic process. (Tom 2011)

Regression approach was also used to project population, and the authors, Chi and Voss concluded that it’s advisable for horizons of less than ten years.One of the strengths of regression models is their incorporation of demographic, social, economic, environmental and other variables influencing population change. Their data inputs are modest if just a few predictor variables are used. Some authors have discovered regression methods to be more accurate than some alternatives, with Swanson and Beck (1994) finding their model’s performance superior to cohort-component and exponential extrapolation models over a two year projection horizon.

Some of the shortcomings of these types of models are that they assume relationships between variables observed in the recent past also apply for the projection horizon, input data requirements can be substantial, and the output detail is limited to total populations. They do not directly model fertility, mortality and migration processes. Most importantly, evaluations of forecast accuracy suggest they are only suitable for projections of up to about 5-10 years ahead.

Smith & tayman who are the proponents of the shortcut cohort method argue that it possesses the conceptual advantage of disaggregating the population by cohort, thus providing age-specific projections, whilst requiring little input data. The minimum data requirements are two populations disaggregated by age and sex five years apart. Its simplicity means that it can be easily calculated in a spreadsheet and is thus fairly cheap and quick to implement.

Amongst its disadvantages is its failure to model mortality, inward migration and outward migration separately. It is therefore difficult to formulate assumptions about how Cohort Change Ratios might trend in the future. From a practical standpoint, when there is positive net migration, the ‘net migration rates’ embedded in the Cohort Change Ratios have the potential to generate run-away growth. For this reason Smith et al. (2001) recommend constraining to independent projections.

# CHAPTER 3: METHODOLOGY

## 3.1 Introduction

This chapter gives a detailed account of the intended Methodology to be used in the study. The study will use the National and Regional base populations where Cohort Component Method was used to project these populations. The quality of data will be checked and smoothing done.Thereafter a series of other methods will be used to project county populations from regional projections to ascertain the most suitable method or combination of methods for sub-regional projections. The most effective model will then be used to project school age population among counties in the Lake Region.

Characteristics of projection methods taken into consideration in this review include:

(1) Conceptual adequacy – how good the model is at representing the demographic and other processes affecting population change.

(2) Output detail of the projections – primarily age, sex and temporal detail (the length of individual projection intervals),

(3) Input data preparation – the amount of input data required, the amount of data smoothing and adjustment needed, and the extent of assumption-setting,

(4) Forecast accuracy – as reported by studies which have examined past forecasts,

(5) Staff resources – especially the person-hours and expertise required to produce a set of projections

(6) Ease of validation – the extent to which it is possible to check projection outputs for plausibility in relation to past trends, expectations of future trends in demographic processes and other socio-economic constraints and influences on local populations (Murdock et al. 1991);

(7) Ease of scenario creation – how amenable the model is to alternative scenarios based on economic, social and policy influences; and

(8) Overall appropriateness as a method for sub-county level.(Tom 2011)

## 3.2 Quality of the 1999 and 2009 Census Data

Before using the data as provided for by the 1999 and the 2009 census for population projections, it was necessary to ascertain their quality. This is because demographic data collected in Kenya or elsewhere in the world, may have some problems due to administrative and logistics issues. Some of the errors may be due to content or coverage errors. The nature and magnitude of the errors differ from one country to another and one region to another.

The omission of certain pockets of the population will result to coverage errors while content of events pertain to misreporting or misclassification of events. The errors, if not rectified, will have a bias or a distortion of facts in the estimates from such data. The accuracy of the projection depends on the quality of the input data and the assumptions made about the course of future changes.

The census data may as well contain errors originating from the fact that some people do not know their true age and others do not report their age accurately. The distribution of a population by age and sex is one of the most basic types of information needed in planning for the future and with such importance of the age structure with respect to social and economic characteristics, it is imperative that the information on the population by age and sex be as accurate as possible. Therefore, for this reason it is of critical importance to evaluate the reported age and sex composition of the population before undertaking population projects. Therefore, it is necessary to evaluate both the content and coverage errors.

### 3.3.1 Coverage Errors

Coverage errors can occur in various forms. Some common coverage errors are; omitting a unit that should have been included, including a unit more than once or including a unit that should not have been included at all. One way of checking coverage error is by use of sex ratios.

Sex ratio is a simple analytical tool, which entails dividing the male population by the female population in the same age group and multiplying the result by 100. The larger the departure of this ratio from values close to 100 the larger the possibility of errors in the data.

### 3.3.2 Content Errors

Population data in most developing countries is often subjected to age misreporting. The irregularities in the age distribution may be because of the respondent's incorrect age declaration or the competency of the enumerator. Digit preference or age heaping is another common error that occurs in age reporting and Myers index can be used to detect it.

### 3.3.3 Age – Sex Accuracy Index

This is another tool used to test the accuracy of a census data. Based on the empirical analysis of the age and sex declaration in census from different developed and developing countries, the United Nations came up with an Age–sex Accuracy index as shown in the table below.

**United Nations Age-Sex Accuracy Index**

| | |
|---|---|
| Accurate | Less than 20 |
| Inaccurate | Between 20 and 40 |
| Highly inaccurate | Over 40 |

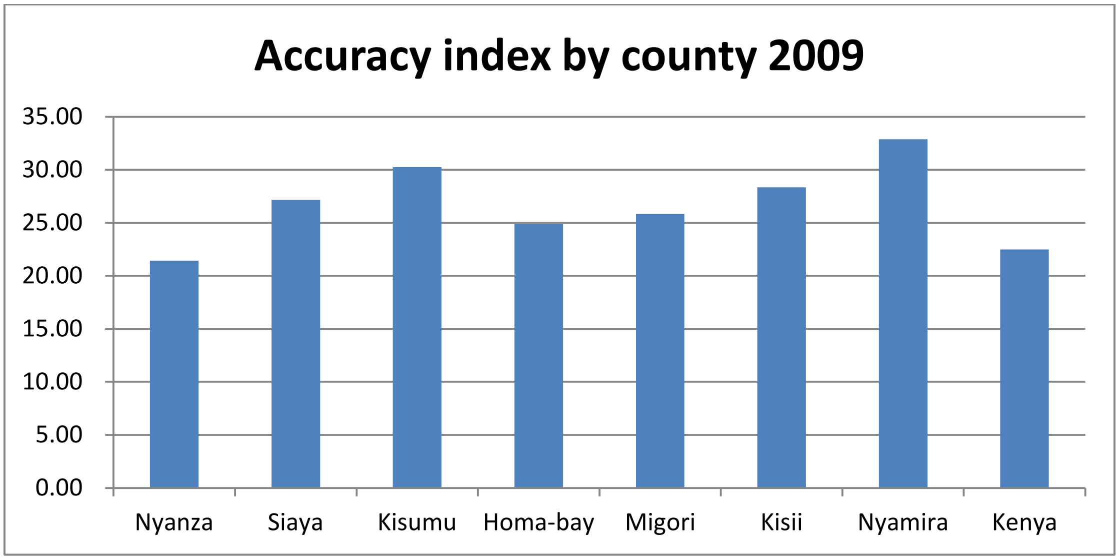
Further analysis of the 2009 census reveals regional differentials by counties as shown in the table below.

Table 3.1 Summary of Indices Measuring the Accuracy of Data

| Index | Nyanza | Siaya | Kisumu | Homa-bay | Migori | Kisii | Nyamira | Kenya |
|---|---|---|---|---|---|---|---|---|
| Sex ratio score | 4.75 | 5.73 | 6.75 | 5.18 | 5.53 | 5.80 | 6.98 | 4.51 |
| Male age ratio score | 3.69 | 4.94 | 4.14 | 4.87 | 4.19 | 5.19 | 5.65 | 4.10 |
| Female age ratio score | 3.51 | 5.04 | 5.84 | 4.46 | 5.06 | 5.75 | 6.28 | 6.08 |
| Accuracy index | 21.44 | 27.17 | 30.25 | 24.88 | 25.85 | 28.34 | 32.87 | 23.72 |

The Accuracy Index is computed by summing of the male and female age ratio scores plus thrice the sex ratio score. The above calculations are done using data for ages 10-14 through 65-69 age groups. The sex ratio score is the mean difference between sex ratio for the successive age groups, averaged irrespective of sign.

*Accuracy Index by County, 2009*




As captured in the coverage errors, Nyamira County had an index of 32.87, indicating that the Age-Sex Accuracy index for this County is the most inaccurate. The other five counties also had indices that placed them in the category of inaccurate with Homa-Bay (24.88) getting closer to the accurate reporting.

The next step is to correct the irregularities observed so far by generating smoothed age–sex distributions. The resultant smoothed populations are to be used in this study to generate base populations for projection purposes.

**3.4 Smoothed Population**

The main purpose of smoothing procedures is to correct any irregularities reported in coverage and content errors, in the population data. Smoothing techniques are frequently used for correcting data for age misreporting. Most of these techniques involve the application of a formula to the original data. Nevertheless, these formulas produce only a light smoothing. However, if the irregularities are so large, then a stronger smoothing procedure is required.

Finally, the smoothed population of all Counties is cumulated to yield the region’s population. The results are well captured by the comparison of the region’s enumerated and smoothed population as shown below. The graph observes a trend of consistency in both enumerated and smoothed population, with a slight difference in the age groups 5-9, 10-14 and 30-34 years.

This trend is consistently evident in other counties as illustrated in the subsequent graphs.

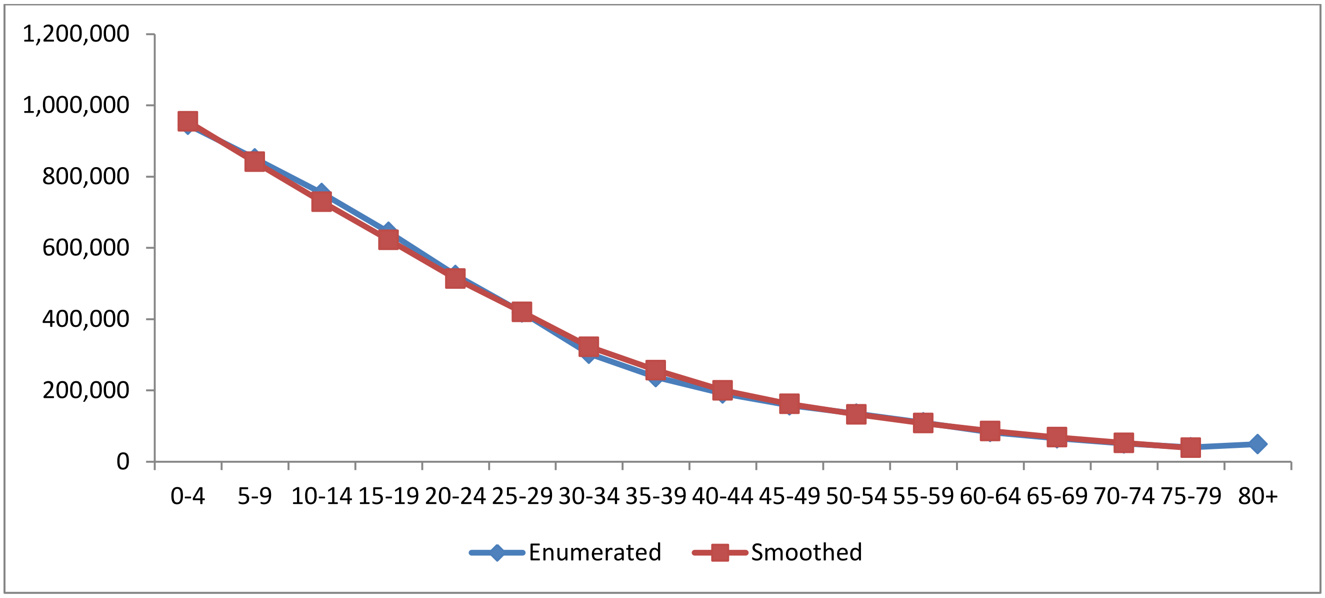



*Fig.3.1 Enumerated versus Smoothed population, Nyanza, 2009.*

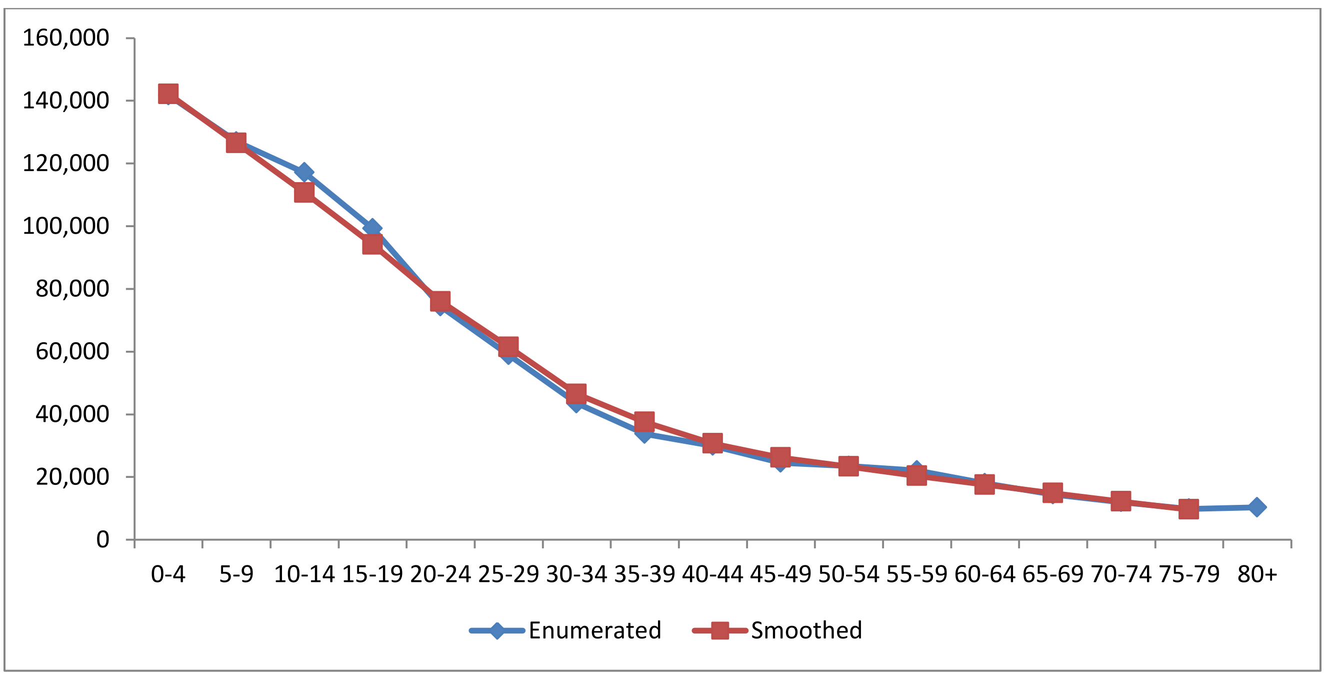



*Fig. 3.2 Enumerated versus Smoothed Population, Siaya County 2009.*

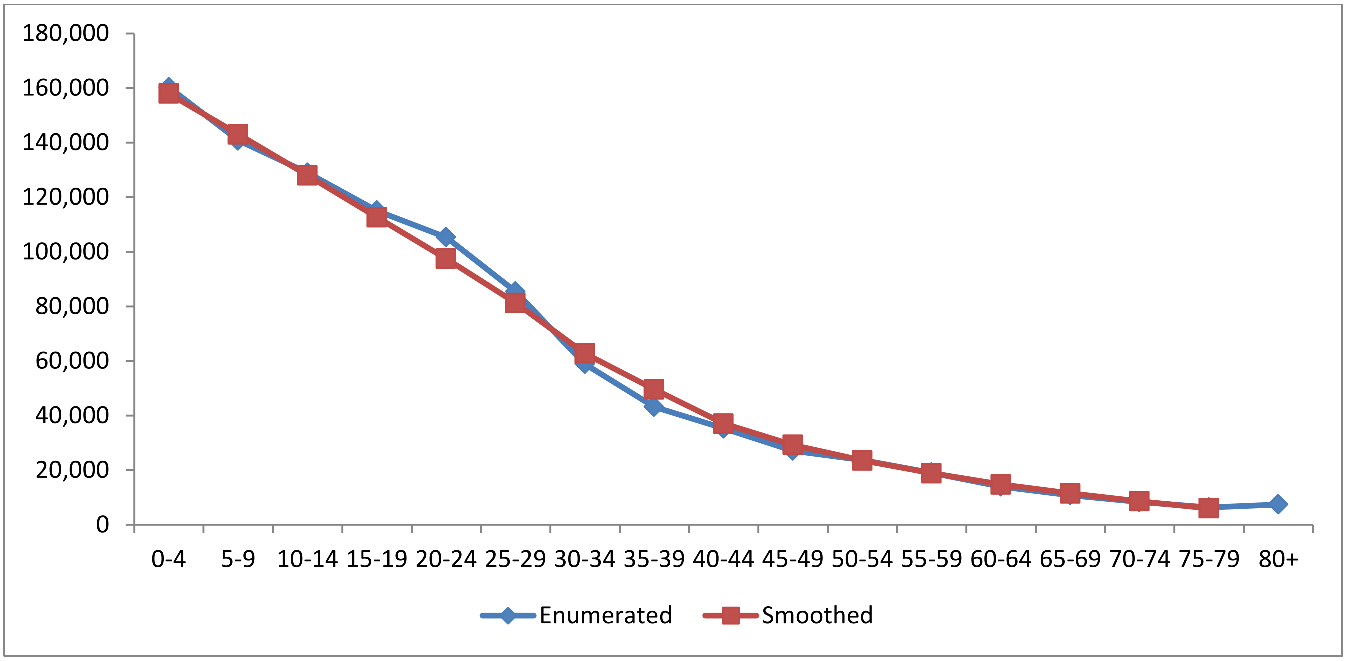



***Fig.3.3 Enumerated versus Smoothed Population, Kisumu County,2009***.

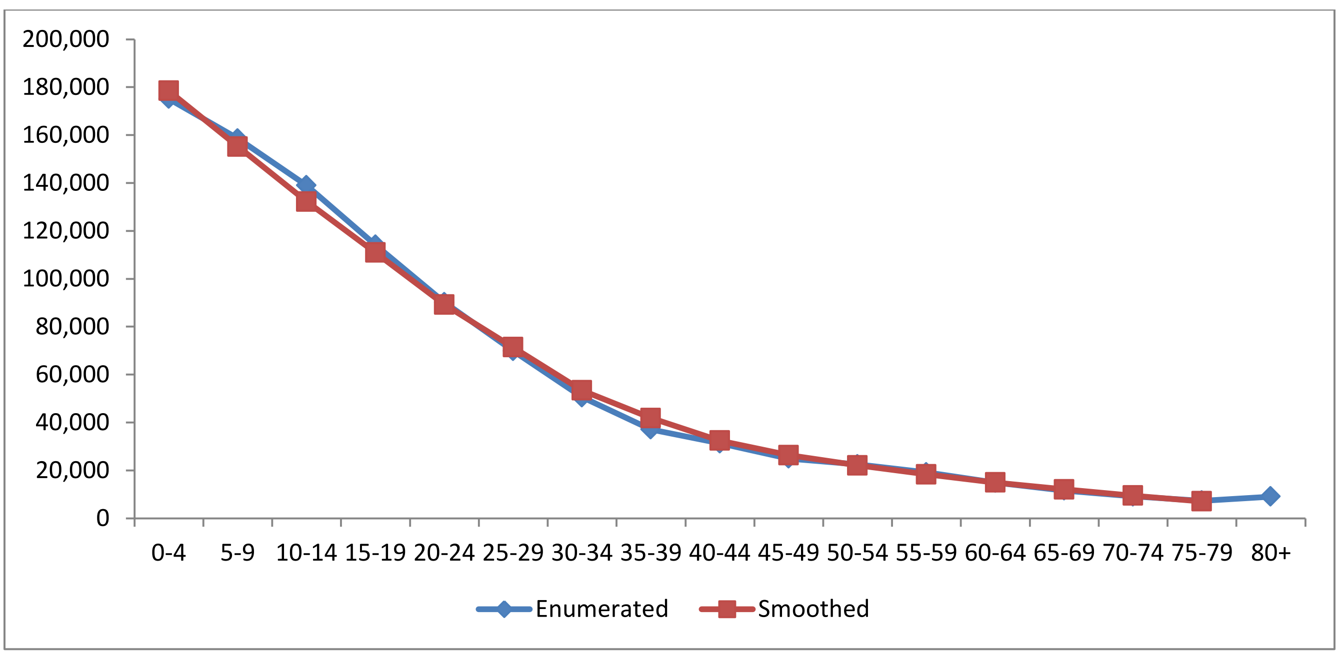



***Fig. 3.4 Enumerated versus Smoothed Population, Homa-bay County,2009***.

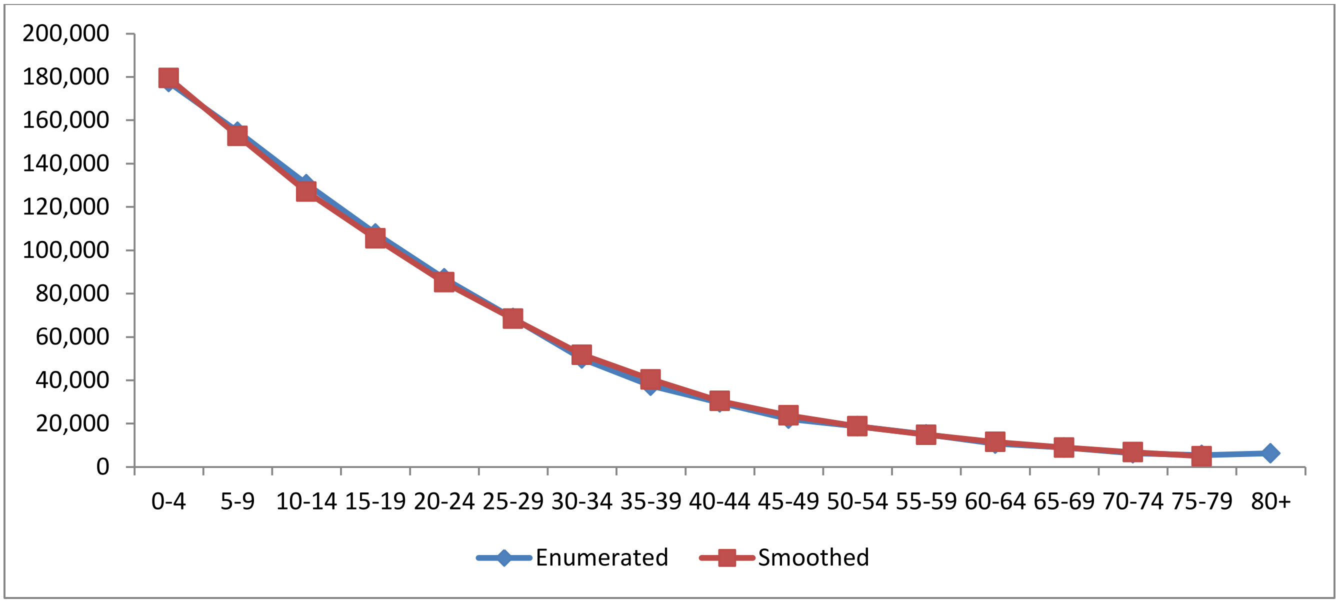



***Fig. 3.5 Enumerated versus Smoothed Population, Migori County, 2009.***

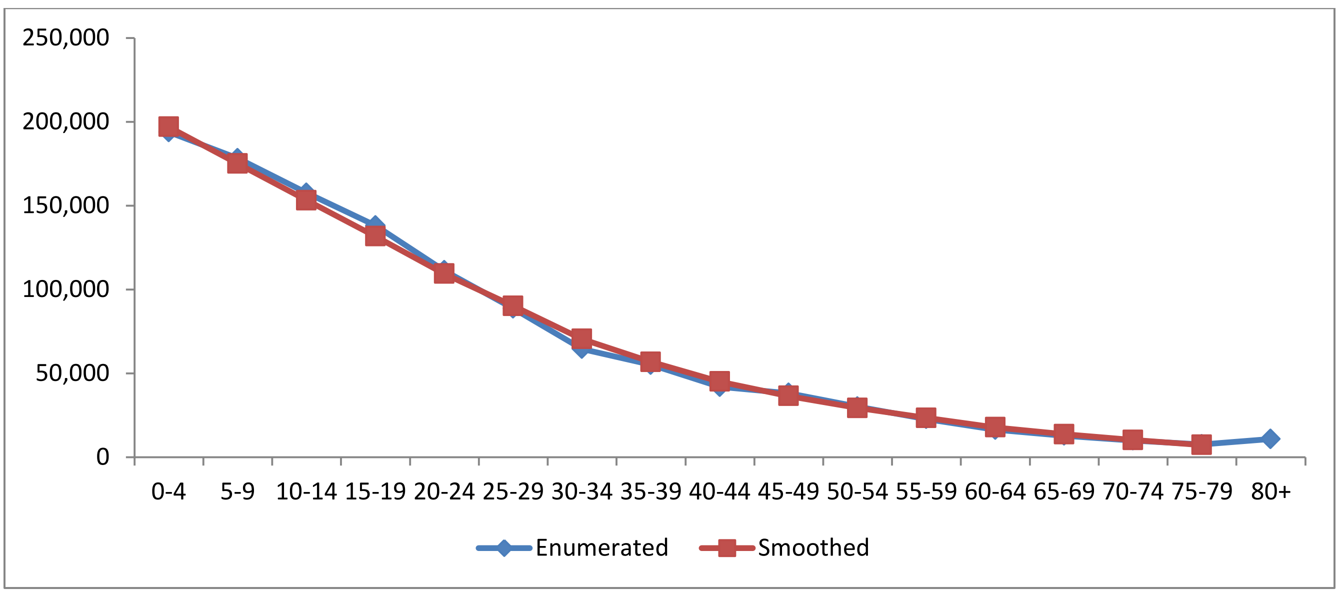



***Fig. 3.6 Enumerated versus Smoothed Population, Kisii County, 2009.***

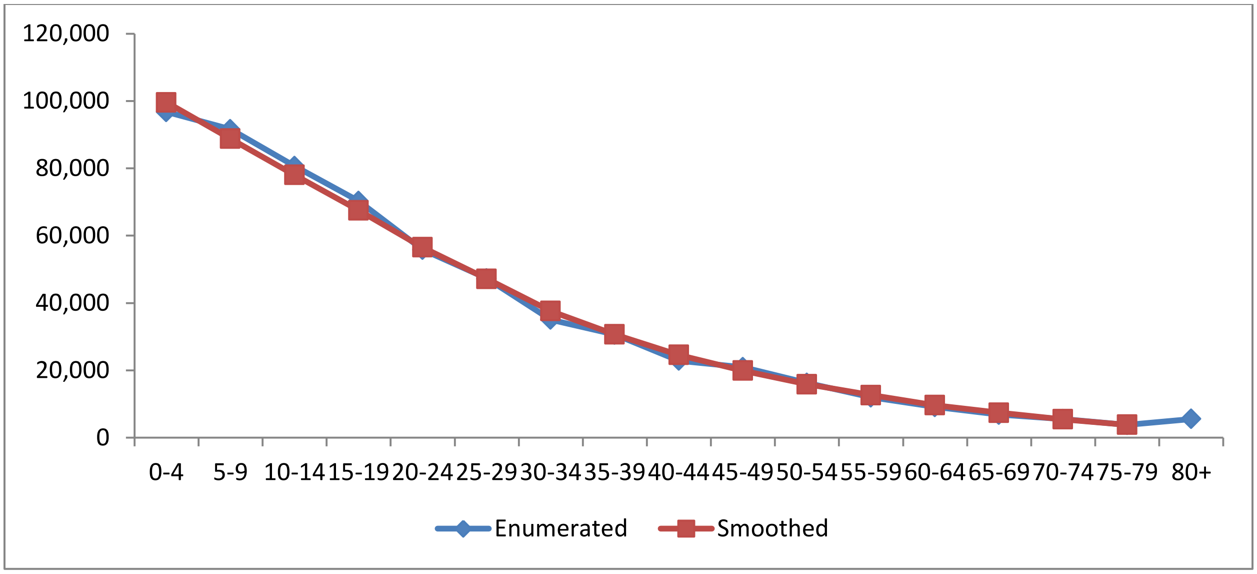



***Fig. 3.7 Enumerated versus Smoothed Population, Nyamira County,2009.***

To come up with the base populations for projection purposes, it is necessary to adjust the smoothed populations pertaining to 24/25 August 2009 to those referring to mid-year 2010.Having obtained the smoothed population using the Arriaga model, since it preserves the original total population, the next step is to have projections for the components of population, including HIV prevalence.

### 3.5 Projections

The key population components are fertility, mortality and net migration. However, the HIV prevalence cannot be ignored, more so if it is greater than one percent. Each component is to be separately projected.

#### 3.5.1 Fertility Projections

In this study, fertility refers to the number of children a woman gives birth to, in her lifetime. The contribution of births to a country's population growth is always more than any other demographic event unless a catastrophe occurs. Total fertility rate (TFR) is the number of children a woman expects to have after going through her reproductive life.

Fertility projections are made by projecting the trend of TFR over time, and translating this TFR into age-specific fertility rates. It is important to note that, the projection of TFR is divided into assumptions regarding an assumed eventual fertility level, and the course taken from the current to the eventual level. The two assumptions are important in determining trends in population size and age structure.

### 3.5.2 Mortality Projections

This is based on projecting future expectation of life at birth for males and females. Mortality projection is defined as the average lifespan of a child born today if current age-specific mortality levels were held fixed in the future.

Based on the 2008/2009 KDHS report, which registered an improvement in infant and child mortality, life expectation at birth was assumed to increase from 64.9 (males) and 69.2 (females) in 2010 to 70.5 and 75.6 in 2030 respectively.

### 3.5.3 Migration Projections

In contrast with mortality and fertility where the impact of policy is much less evident, migration is strongly influenced by policies. Migration is the most difficult demographic component to predict due to migration regulations and practices of different countries. Equally difficult to predict is the international migration due to data inadequacy.

The 2009 census recorded a low rate (less than 1%) of international migration, which was no difference with the past records; hence, it was not incorporated into the national population projections. However, internal migration (migration between provinces) was to be accounted for in 2009 census, ensuring that the sum of all county internal flows by age and sex must be zero.

The study assumes that the rate of net migration would remain constant at the 2009 level for the entire projection period, 2010-2030.

### 3.6 Projection Methods

There are various methods of projecting population (e.g. mathematical, economic, and component methods). Some are very sophisticated and rigorous while others are simple and less sophisticated. In population projections, it is important to consider the size of the geographical area (projection at national level) where uncertainty is lower or smaller area (projection at county level). At county level, migration makes future population developments more volatile and projections more difficult.

In choosing which projection method to use, it is important to note that there is no superior method than the other for all purposes. However, each projection method has its strengths and weakness that must be evaluated according to, among others, its face validity, cost, data requirements, ease of application, and other parameters. Methods of population projections may be classified as mathematical and cohort component methods.

The choice of method usually depends on the available data. Mathematical methods require relatively less data than the cohort component method. Mathematical methods entail fitting one of several mathematical curves to the total population observed in one census to derive a projected total population at some future date. This class of methods yields reasonably good results for short-range projections (not more than ten years) and is very useful for projecting populations at sub-national levels. However, the results obtained from this approach may have very large errors for medium to long-range projections (10-25 years, and more than 25 years respectively) because the assumptions underlying mathematical methods may not hold in the medium to long term.

The cohort-component method is widely used at the national level projection because it accounts separately for the components of growth, can accommodate a number of different theoretical models and projection techniques, and provides projections of demographic characteristics and the size of the total population. However, it is a data-intensive method (i.e. have heavy data requirements, hence time consuming) that requires the collection or calculation of many age- and sex-specific fertility, mortality, and migration rates which are rarely available at the sub-regional levels.

In this method, the components of population change i.e. fertility; mortality and net migration are projected separately for each birth cohort. In populations where HIV prevalence is greater than one percent, it is recommended by the United Nations to project mortality including the impact of HIV/AIDS. *(Shryock, Siegel, and Associates, 1976)*

### 3.6.1 Comparative methods

Comparative models, also known as ratio-share models, are those which create a sub-regional population projection through some relationship to a projection already produced for the encompassing ‘parent’ region (Tom, 2011). Comparative models include:

-  **The Share of Population model**,

The Projected Share of Population model (termed Shift-Share by Smith et al. 2001) also projects a local area’s population as a share of its parent region’s population but the share is projected into the future, often using linear extrapolation. It is given as:

$$P^i(t)=P^I(t)SHAREPOP^i(t)$$

Where i refers to the local area, I the parent region and SHAREPOP the population share.

The data required are the population of parent region and the jump-off year population.

-  **The Share of Growth model**,

The Share of Growth model works by adding a share of the parent region’s projected population growth to the jump-off year population of the local area. (Pittenger (1976) refers to this approach the “apportionment method”). It may be expressed as:

$$P^i(t)=P^i(t-5)+SHAREGROWTH^i(t-5,t)[P^I(t)-P^I(t-5)]$$

Where SHAREGROWTH refers to the local area’s share of projected population growth in the parent region. The data required are the jump-off year population at the local area. It may also require two past periods of growth and three population counts.

-  **The Growth Difference model**.

The Growth Difference model assumes a certain difference in growth between a local area and its parent region (Davis 1995). The projected population of the local area is:

$$P^i(t)=P^i(t-5)\{GROWTHDIFF^i(t-5,t)+P^I(t)/P^I(t-5)$$

Where GROWTHDIFF is defined as the ratio of the local population at two points in time minus the ratio of the parent region population at two points in time. Because of the relationship between the sub-regional area and the larger parent region, comparative methods differ from extrapolative methods in that they do not necessarily assume a continuation of past trends. This method requires local population at two points in time and respective parent region population.

### 3.6.2 Shortcut cohort methods

Shortcut cohort methods of projection are similar to cohort-component methods except that they aggregate the demographic components of change. The standard model of this type was first described by Hamilton and Perry (1962) who proposed a 'short method for projecting population by age from one decennial census to another'. For all cohorts except infants born during the projection interval the population of the cohort aged x-5 to x at time t-5 is the population of that cohort aged x to x+5 at time multiplied by a Cohort Change Ratio. It can be expressed as:

$$\mathbf{{}_5P_x(t)={}_5P_{x-5}(t-5)\,{}_5CCR_{x-5,x}(t-5,t)}$$

Where CCR is expressed as:

$$\mathbf{{}_5CCR_{x-5,x}(t-10,t-5)={}_5P_x(t-5)/{}_5P_{x-5}(t-10)}$$

The data requirements are detailed because it requires two populations disaggregated by age and sex five years apart. Survival of people already in the population at the beginning of the projection period is also considered. Survivorship of the newborn and number of deaths derived from the previous population should also be taken into consideration. Fertility together with the migrants and their survivorship are also taken into account for the projection to be carried out.

# CHAPTER FOUR: PROJECTIONS OF SCHOOL- AGE POPULATION.

## 4.1 Introduction

This chapter presents the findings of the study on methods of sub-national population projections and primary school-age population projections among the counties in the former Nyanza Province and their interpretation. The analysis of the data commences with projecting the 1999 census data to 2009 among the counties using the various methods of sub-national projections. The method that is more accurate is then used to project primary school-age population among the six counties, namely Homa-bay, Siaya, Kisumu, Migori, Nyamira and Kisii.

## 4.2 Testing the Accuracy of various Projection methods.

The study projected county population of 1999 to 2009 and compared with the actual population. Then projected county population was used in getting the best method for projecting the primary school-age population for each of the counties. The table below shows the results obtained when the ***Share of growth model, Share of population model, Growth difference model and shortcut cohort models*** were used to project the 1999 population to 2009 and the deviations deduced.

**Table 4.1: Deviations of Projected from actual county population, using share of growth model, share of population model, Growth difference model and shortcut cohort model 1999-2009.**

| County | Actual population (1999) | Actual population (2009) | Deviations | | | |
|---|---|---|---|---|---|---|
| | | | Share of growth model | Share of population model | Growth difference model | Shortcut cohort model |
| Homa-bay | 746,247 | 963,794 | 23,262 | 2,954 | 8,993 | 379 |
| Migori | 657,387 | 917,170 | 6,853 | -3,933 | -14,943 | 626 |
| Siaya | 714,059 | 842,304 | 8,391 | 3,003 | 29,217 | -287 |
| Kisumu | 789,167 | 968,909 | 7,995 | -248 | 1,348 | 908 |

From the above results, the county populations increased but had a big margin of deviation from the actual population obtained from the 2009 census for the share of growth model, share of population model, except for Kisumu County and growth difference model. Although there was significant population increase due to either natural growth or migration, the three models gave wide margins of deviation from the actual population of 2009.

The ***shortcut cohort model*** when used to project the 1999 population to 2009 showed an increase in population although it also had smaller deviations. The study reveals that shortcut cohort model is more accurate as compared to the three comparative methods in the selected sample counties.

### 4.3 School-Age Population Projections

The primary school-age in Kenya is from age 6 to 13 years. Usually regional population projections, when summed up to obtain the counties total population, may produce inconsistent trends of mortality and fertility. To overcome this problem, the population projection for all the counties was used to act as control total for the sum of the sub-counties. The sum of all the sub-county projections was done to get the county projections and adjusted appropriately by considering the AIDS-only age-specific mortality rates from KDHS estimates to obtain non-Aids life table for the reference year. This was to be consistent with the projected county population. Any difference between the projected sub-county and aggregated county population were noted and finally, adjusted to keep the consistent with the county population.

An aggregate of the adjusted sub-county projection was done to confirm that the aggregated county totals matched the county projection. Table 4.2 below shows the projected school age population for all counties along the lake region.

**Table 4.2: School-age population projection, Former Nyanza counties 2010-2030**

| County | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|
| **Migori** | 385,888 | 396,288 | 406,803 | 417,419 | 428,096 | 438,754 | 502,629 | 576,823 | 634,995 |
| **Siaya** | 354,513 | 364,068 | 373,727 | 383,481 | 393,290 | 403,081 | 461,763 | 529,924 | 583,367 |
| **Homa-bay** | 405,583 | 416,514 | 427,565 | 438,724 | 449,946 | 461,148 | 528,283 | 606,263 | 667,405 |
| **Kisumu** | 407,644 | 418,631 | 429,738 | 440,953 | 452,232 | 463,491 | 530,967 | 609,344 | 670,796 |
| **Nyamira** | 251,686 | 258,469 | 265,327 | 272,252 | 279,215 | 286,167 | 327,828 | 376,219 | 414,160 |
| **Kisii** | 484,822 | 497,889 | 511,099 | 524,437 | 537,852 | 551,242 | 631,493 | 724,709 | 797,795 |
| **Total** | **2,290,136** | **2,351,859** | **2,414,259** | **2,477,266** | **2,540,631** | **2,603,883** | **2,982,963** | **3,423,282** | **3,768,519** |

The table shows that school age population would increase from 2.3million in 2010 to 3.8 million in 2030.Kisii county has the highest school-age population of 0.5 million and would remain highest throughout the projection period. It is followed by Kisumu county and the least in population is Nyamira county with 0.3 million increasing to 0.4 million in 2030.

### 4.4 Projected School-Age Population by Sub-County, 2010-2030

Having obtained the above results on county projections the study focused on the sub-county school-age projections. Each sub-county's population was projected and the sum total adjusted to conform to the county population. The study used the shortcut cohort model to project the sub-county population. The table below shows the projections for Migori County from the year 2010-2030.

**Table 4.3:School-age population projection, Migori county 2010-2030**

| Sub-county | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|
| **Rongo** | 84,471 | 86,747 | 89,049 | 91,373 | 93,710 | 96,043 | 110,025 | 126,267 | 139,000 |
| **Awendo** | 92,189 | 94,673 | 97,185 | 99,721 | 102,272 | 104,818 | 120,078 | 137,803 | 151,700 |
| **Migori** | 150,728 | 154,790 | 158,897 | 163,044 | 167,214 | 171,377 | 196,327 | 225,307 | 248,029 |
| **Kuria** | 58,501 | 60,077 | 61,671 | 63,281 | 64,899 | 66,515 | 76,199 | 87,446 | 96,265 |
| **Total** | **385,888** | **396,288** | **406,803** | **417,419** | **428,096** | **438,754** | **502,629** | **576,823** | **634,995** |

It was noted that Migori sub-county, having the highest school age population would experience the highest increase as well compared to the rest of the sub-counties. It's population would increase from 150,728 in 2010 to 248,090 in 2030.This may be attributed to the fact that it is the county headquarter .It is followed by Awendo due to its vast area and sugarcane farming which increases from 92,189 in 2010 to 151,700 in 2030.Rongo sub-county comes third and the least is Kuria which would contribute a population increase from 58,501 in 2010 to 96,265 in 2030.

Siaya county school-age population was also projected by sub-county from 2010-2030 and the results obtained tabulated as shown in table 4.4 below.

**Table 4.4: School-age population projection, Siaya county 2010-2030**

| Sub-county | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|
| **Bondo** | 66,294 | 68,081 | 69,887 | 71,711 | 73,545 | 75,376 | 86,350 | 99,096 | 109,090 |
| **Rarieda** | 56,616 | 58,142 | 59,684 | 61,242 | 62,808 | 64,372 | 73,744 | 84,629 | 93,164 |
| **Alego** | 78,808 | 80,932 | 83,080 | 85,248 | 87,428 | 89,605 | 102,650 | 117,802 | 129,683 |
| **Gem** | 67,641 | 69,464 | 71,307 | 73,168 | 75,039 | 76,908 | 88,104 | 101,110 | 111,306 |
| **Ugenya** | 85,154 | 87,449 | 89,769 | 92,112 | 94,468 | 96,820 | 110,915 | 127,288 | 140,125 |
| **Total** | **354,513** | **364,068** | **373,727** | **383,481** | **393,290** | **403,081** | **461,763** | **529,924** | **583,367** |

The study revealed that due to its vast area Ugenya's school-age population would remain highest throughout the study period, 2010-2030.It would increase from 85,154 in 2010 to 140,125 in 2030 contributing to 24% of the county's population increase. It would be followed by Alego, Gem, Bondo and Rarieda whose population would increase from 56,616 to 93,164 throughout the study period.

Homa-bay County having six sub-county administrative units was also projected from 2010-2030 and the findings of the school-age population tabulated as shown in the table below.

**Table 4.5: School-age population projection, Homa-bay County 2010-2030**

| Sub-county | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|
| **kasipul-kabondo** | 93,140 | 95,646 | 98,183 | 100,746 | 103,324 | 105,907 | 121,311 | 139,218 | 153,258 |
| **karachuonyo** | 68,404 | 70,238 | 72,097 | 73,984 | 75,876 | 77,766 | 89,085 | 102,236 | 112,546 |
| **rangwe** | 82,057 | 84,275 | 86,516 | 88,769 | 91,039 | 93,305 | 106,888 | 122,667 | 135,038 |
| **gwasi** | 43,486 | 44,664 | 45,849 | 47,046 | 48,249 | 49,450 | 56,647 | 65,011 | 71,568 |
| **ndhiwa** | 72,693 | 74,653 | 76,634 | 78,634 | 80,645 | 82,653 | 94,684 | 108,662 | 119,621 |
| **mbita** | 45,803 | 47,038 | 48,286 | 49,545 | 50,813 | 52,068 | 59,669 | 68,468 | 75,373 |
| **Total** | 405,583 | 416,514 | 427,565 | 438,724 | 449,946 | 461,148 | 528,283 | 606,263 | 667,405 |

The findings shows that there was an increase in school-age population in all the sub-counties with Kasipul-Kabondo having the highest number from 93,140 in 2010 to 153,258 in 2030.This may be attributed to its vast area as compared to the other regions in the county. Rangwe county hosting the County headquarter was second in population and would increase from 82,057 in 2010 to 135,038 by 2030.The least would be Mbita sub-county with an increase of 29,570 children in the entire study period.

Kisumu county, the second largest in Nyanza province was also projected from 2010-2030 and the findings were as in table 4.6 below.

**Table 4.6: School-age population projection, Kisumu County 2010-2030**

| Sub-county | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|
| **Kisumu town east** | 111,165 | 114,161 | 117,190 | 120,248 | 123,324 | 126,394 | 144,795 | 166,168 | 182,926 |
| **Kisumu town west** | 58,864 | 60,450 | 62,054 | 63,674 | 65,302 | 66,928 | 76,672 | 87,989 | 96,863 |
| **Kisumu rural** | 60,984 | 62,627 | 64,289 | 65,967 | 67,654 | 69,338 | 79,433 | 91,158 | 100,351 |
| **Nyando** | 59,353 | 60,953 | 62,570 | 64,203 | 65,845 | 67,484 | 77,309 | 88,720 | 97,668 |
| **Muhoroni** | 61,310 | 62,962 | 64,633 | 66,319 | 68,016 | 69,709 | 79,857 | 91,645 | 100,888 |
| **Nyakach** | 55,970 | 57,478 | 59,003 | 60,543 | 62,091 | 63,637 | 72,902 | 83,663 | 92,100 |
| **Total** | **407,644** | **418,631** | **429,738** | **440,953** | **452,232** | **463,491** | **530,967** | **609,344** | **670,796** |

Due to its area of coverage Kisumu Town East had the highest population during the entire study period. Its population increased from 111,165 in 2010 to 182,926 in 2030.This contributed a 27% increase of school-age population in the entire projection period. It was followed by Muhoroni due to agricultural activities with an increase from 61,310 to 100,888 in the entire study period. The least populated with school-age was Nyakach which contributed 13.7% increase in the entire county during the study period.

Kisii County which has the highest population was projected from 2010 to 2030 and the results obtained tabulated as shown below.

**Table 4.7: School-age population projection, Kisii County, 2010-2030**

| Sub-county | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|
| **Bonchari** | 69,184 | 71,049 | 72,934 | 74,837 | 76,751 | 78,662 | 90,114 | 103,416 | 113,845 |
| **Kitutuchache** | 134,829 | 138,463 | 142,137 | 145,846 | 149,577 | 153,300 | 175,618 | 201,542 | 221,867 |
| **Nyaribarichache** | 85,959 | 88,276 | 90,618 | 92,983 | 95,361 | 97,735 | 111,964 | 128,491 | 141,449 |
| **Nyaribarimasaba** | 73,693 | 75,679 | 77,687 | 79,714 | 81,754 | 83,789 | 95,987 | 110,156 | 121,265 |
| **Bomachoge** | 121,157 | 124,422 | 127,724 | 131,057 | 134,409 | 137,755 | 157,810 | 181,105 | 199,369 |
| **Total** | **484,822** | **497,889** | **511,099** | **524,437** | **537,852** | **551,242** | **631,493** | **724,709** | **797,795** |

The results indicate that Kitutu-chache has the highest school-age population of 134,829 in 2010 and would increase to 221,867 by 2030.This is due to its agricultural activities as well as being the county headquarters. The least populated would be Bonchari which had an increase of 44,661 school age population during the entire study period, 2010-2030.

Nyamira County having a school-age population of 251,661 by 2010 was projected to 2030 and attained a population of 414,119.The results of the projected sub-counties population was as shown in the table below.

**Table 4.8: School-age population projection, Nyamira County 2010-2030**

| Sub-county | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|
| **Borabu** | 60,691 | 62,325 | 63,978 | 65,649 | 67,328 | 69,004 | 79,049 | 90,716 | 99,866 |
| **Kitutumasaba** | 63,586 | 65,297 | 67,030 | 68,779 | 70,538 | 72,295 | 82,819 | 95,043 | 104,627 |
| **North mugirango** | 76,442 | 78,502 | 80,585 | 82,688 | 84,803 | 86,914 | 99,571 | 114,268 | 125,790 |
| **West mugirango** | 50,967 | 52,345 | 53,734 | 55,136 | 56,546 | 57,954 | 66,389 | 76,192 | 83,877 |
| **Total** | **251,686** | **258,469** | **265,327** | **272,252** | **279,215** | **286,167** | **327,828** | **376,219** | **414,160** |

North mugirango hosting the county headquarter has the highest school-age population of 76,442 in 2010 and would increase to 125,790 by 2030.It is followed by Kitutumasaba, Borabu, then least was West Mugirango which had a population increase of  32,910 for the entire study period,2010-2030.

## CHAPTER 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

### 5.1 Introduction

This chapter summarizes the research findings, makes conclusions and recommendations that are based on the research findings. The main objective of the research was to review the various methods used for sub-regional projections, then use the appropriate method to project the school age population of the sub-counties in the lake region counties from the year 2010-2030.

### 5.2 Summary of the Findings

The general objective of the study was to review the sub-regional population projection methods. The study specifically looked at four methods of population projections namely shortcut cohort model, share of population model, share of growth model and the growth difference model.

According to the study the various methods used showed an increasing trend in population in the sample counties chosen. Among the counties chosen in the lake region, Share of population model had the highest deviation when projected from 1999 to 2009 of 46,501.It was followed by Growth difference model with 24,615, Share of growth model with 1,776 and shortcut cohort model had the least deviation of 1,626.This informed the choice of using shortcut cohort model for the sub-county population projections among the counties of Nyanza province.

The study also found out that the projected school-age population would increase in all the sub-counties in the lake region. Kisii county has the highest school-age population and would increase from 484,822 in 2010 to 797,795 by 2030.Kisumu was second with an increase from 407,644 in 2010 to 670,796 in the year 2030,followed by Homa-bay county which had a population increase from 405,500 to 667,272 during the research period,2010-2030.Migori was fourth with an increase from 385,888 to 634,995,it was followed by Siaya and Nyamira which had increases from 354,513 to 583,367 and 251,661 to 414,119 respectively during the study period 2010-2030.This increase would trickle down to the sub-counties with each experiencing a population increase of approximately 2,000 school-age children every year. This population increase would be attributed to the fact that devolution was driving people back to the county as well as the natural growth rate of the counties.

The study predicted an increasing demand for teachers, infrastructure and other amenities at the primary school level. Since the pupil teacher ratio in the year 2009 was 46.78:1 (UNESCO, 2000).This does not tally with the accepted ratio by the ministry of education’s ratio of 40:1.It means more teachers should be employed to conform to the recommended ratio. The class size which is easier to manage, give maximum attention per pupil and also control discipline is 40.This means therefore that as the number increases more classrooms should be constructed to cater for the increased number. Other amenities like separate toilets for boys and girls should also be considered. The recommended pupil to toilet ratio by the MOE is 30:1 for boys and 25:1 for girls, thus there is need for increased number of toilets to maintain good hygiene in primary schools.

**5.3 Conclusions**

The study found out that the shortcut cohort method is the most appropriate method in projecting population at the sub-county level. This finding is unique to the counties chosen and may be different in other regions. The study also found out that the different methods had different results in urban and rural areas. Shortcut cohort method though slightly accurate did not exactly project the population from 1999-2009 as given by the KNBS data.

The study shows that the population of primary school–age population for the lake region counties will continuously increase, particularly in Kisii, Kisumu and Homabay Counties. The study observed that the three counties contribute to about 74% of the total primary school-age population projected in the province.

The Regional and county education planners  together with the county governance should take stock of the educational requirements and plan to mobilise the available resources to meet the demands of the increasing population. This would ensure quality education to the children, improve gender equity among the boy and girl child and also improve pupil retention in schools.

**5.4 Policy Recommendations**

The study found out that the population of primary school–age population would continue to increase rapidly over time under the current fertility and mortality rates. There is a direct link between the school–age population and the educational needs like, number of teachers, number of classrooms e.t.c. The county administration should therefore set policies that address the expansion of the existing facilities and proper utilization of the available resources based on the needs of each sub-county as the study has clearly shown.

### 5.5 Recommendations for Further Research

The study observed that shortcut cohort method gave better results than the other models, however there was no single method which can give accurate population projection at the sub-county level as cohort component does at the national level. This calls for other research to be done on the other methods to come up with an appropriate method including statistical packages. Other counties should also be projected using the four methods and a comparison done with the above findings to conclusively come up with the best method or group of methods to be used at the sub-county level. We recommend the extension of this study to investigate further why there is a large increase in the projected primary school-age population in Kisii County, yet all the other five counties have similar demographic perspective with a slight change on environmental conditions. There is need to investigate if this trend has any bearing on the fertility differential among the six counties.

## REFERENCES

Alho J.M. 1990. Stochastic Methods in Population Forecasting. International Journal of Forecasting 6:521-30.

Bongaarts J. and Bulatao R.A. 2000.Beyond Six Billion. National Academy Press. Washington, DC.

Bwila M.I. 2004. Population projection in Kenya: An application of the stable population model. Unpublished MSc. Population Studies and Research Institute. University of Nairobi.

Chesswas J. D. 1969. Methodologies of Education Planning for Developing Countries, 2 Volumes, IIEP (UNESCO), Paris.

Hamilton, C.H. and J. Perry. 1962. "A Short Method for Projecting Population by Age From One Decennial Census to Another." Social Forces 41:163-70.

Kenya National Bureau of Statistics (KNBS) and ICF Macro 2010. Kenya Demographic and Health Survey 2008-09. Calverton, Maryland: KNBS and ICR Macro.

Kenya National Bureau of Statistics 2010.2009 Kenya Population and Housing Census. Nairobi.

Kenya National Bureau of Statistics 2010.Economical Survey 2009. Government Printer, Nairobi

Kenya Vision 2030.A globally competitive and prosperous Kenya. Nairobi. Government Press 2008.

Kulkami, M. and L.G. Pol. 1994. "Migration Expectancy Revisited: Results for the 1970s, 1980s and 1990s." Population Research and Policy Review 13:195-202.

Lapkoff S. 1993. Projecting Births in a California School District. Paper presented at the annual meeting of the Population Association of America, Cincinnati, April 1-3.

Lee R.D. and S. Tuljapurkar. 1997. Stochastic Population Forecasts for the United States: Beyond High, Medium, and Low. Journal of the American Statistical Association 89:1175-89.

Masaviru R. A. 1981. Population Trends and Provision of Primary Education in Nairobi, Kenya. Unpublished MA. Population Studies and Research Institute. University of Nairobi.

Ministry of Education, 2009: Education Facts and Figures. GOK, Nairobi.

Ondieki D.N.1989.Population Projections of Nairobi and its Implications on Housing. 1989. Unpublished Msc. Population Studies and Research Institute. University of Nairobi.

Preston S.H, Heuveline P &Guillot M. 2001. Demography: Measuring and Modelling Population Processes. Blackwell Publishers, Oxford.

Shryock H.S. 1976. The Methods and Materials of Demography. Academic Press. New York.

Smith, S.K. and B. Ahmed. 1986. "Population Estimates and Projections by Age and Sex: Florida and Its Counties, 1985-2000." Florida Population Studies, Bulletin 77. Gainesville: Bureau of Economic and Business Research, University of Florida.

Smith, S.K., J. Tayman, and D.A. Swanson. 2001. State and Local Population Projections: Meth-odology and Analysis. New York: Kluwer Academic..

Smith, S.K. and T. Sincich. 1988. "Stability Over Time in the Distribution of Population Forecast Errors." Demography 25:461-74. 756. .1992. "Evaluating the Forecast Accuracy and Bias of Alternative Population Projections for States." International Journal of Forecasting 8:495-508.

Tom W. 2011.A Review of Sub-Regional Population Projection Methods, Queensland Centre. The University of Queensland.

U.S Bureau of Census 1996.Current Population Reports, Series P-25, No. 1092. Washington, DC. U.S. Government Printing Office.

United Nations. 2004. Methodology of the United Nations Population Estimates and Projections. New York.

United Nations. 2010. World Population Prospects: The 2010 Revision, Vol I, Comprehensive Tables. New York.

United Nations. 2011. World Population Prospects: The 2010 Revision. New York

United Nations Educational, Scientific and Cultural Organization (2000). *Education for All. 2000 Assessment: Statistical Document*. Paris: UNESCO/International Consultative Forum on Education for All.

Wekesa J.M.1989.Kenya's Population Projections and Some of their Implications to Education Planning. Unpublished Msc. Thesis. Population Studies and Research Institute. University of Nairobi.

Win T. 1990. Population Projections for Myanmar (1983-2013). Asia-Pacific Population Journal, Vol. 6, No.2.