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Mathematical Model For Projecting Local Populations And Its Role In Regional Planning With Application

Dissertation

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To my parents,
to my wife and to my beloved children

ABSTRACT

Nations and states are concerned about the economic, social, political, and environmental consequences of population growth. At the local level, planning for schools, hospitals, and other projects is strongly affected by expected population growth. Population projections are very useful tools for planning if constructed and interpreted properly.

Population projections are used to predict future population change, to analyze the determinants of population change, to give the data users an indication of potential future scenarios and as a base for constructing other types of projections.

The importance of the population projections, which are considered in the present study can be stated in the following points:

1. Highlight the concept of projection and regional planning.
2. Identify the best and most effective methods which can be used to calculate the projection components [fertility, mortality, and migration].
3. Clarify the necessary data and rates required to make the local population projection.
4. Suggest a local population projection model to help planners and decision makers to take the right decision about regional planning policies on a scientific basis.
5. Apply the suggested mathematical model for the Qalyobia Governorate in the state of Egypt.
6. Discuss methods for projecting the main characteristics such as school enrollment and labor force.
7. Update the data at the local level.

Much of the researches on population projections have focused on projections at the national level. Although these researches have been very valuable, conclusions based on studies of national projections are not always applicable to states and local areas because the following two main reasons:

First, there are substantial differences in data availability and reliability between national and sub-national areas. Some data series are available only at the national level. Others are available with greater frequency at the national level than at state and local levels. Due to reporting, coverage, and sampling errors, data quality is likely to be better for nations than for sub-national areas.

Second, migration-both international and local plays a greater role in population growth at the state and local levels than at the national level. Fertility and mortality are the major determinants of population growth in most countries, with international migration having a relatively small impact. Migration is the primary determinant of population change in many states and local areas and it is much more volatile over time than either fertility or mortality. This volatility makes migration more difficult to forecast accurately.

Projections at the local level are very important for their unique characteristics, the relatively small amount of research that has been done at the local level, and for the decision making process. This requires to pay great attention to the problems of data availability and reliability and migration.

The present study is concerned with the development of a mathematical model for projecting local populations. The model considered in the present study has an advantage over the traditional methods because it is not concerned with the projection of population only, but the considered model is devoted to make a detailed local population projection to each of the demographic components (which are fertility, mortality, and net migration) to clarify the importance of each component in changing the characteristics and region size to help the regional planners in making good plans in light of the results of each component. The suggested model is referred to as the complete component projection model.

The present study considered many accuracy measures which can be used to show how well projections have performed over the projection horizon, also to show how well the suggested model fit the data observed during the base period.

An application to the suggested model is implemented to Qalyobia Governorate where a separate projection for each component [mortality, net migration and fertility] is carried out to clarify the importance of each component in changing the characteristics and size of the Qalyobia Governorate. Also, to know the real population numbers of this Governorate without excess or negligence to help in effective regional planning.

The local projection for Qalyobia Governorate is implemented through two stages, the 1st stage at year 2011 and the 2nd stage at year 2016.

Projections can be used not only to analyze the determinants of population change, but also to give the data user an indication of potential future scenarios.

The present study considered some extensions of the component model with respect to future changes, and other sectoral projections, which have great important uses of the model in the regional planning. Most data users, especially at the local level use projections as a guide for future events and regional planning. The effect of future changes in demographic components has an impact on governmental policies. The present study considered the future changes in fertility and mortality component by the synthetic projections. Also, this study contained related sectoral projections in school enrollment and labor force sectors in Qalyobia Governorate.

The application of the present study can be stated in the following points:

- 1-**The effect of the mortality component on Qalyobia distribution of male and female projected population by age at year 2016.
- 2-** The effect of the migration component on Qalyobia distribution of male and female projected migrants by age at year 2016.
- 3-** The effect of the fertility component on Qalyobia distribution of total male and female births by age of mother at year 2016.
- 4-** All the net migration values of the Qalyobia Governorate are positive values, i.e., the Qalyobia Governorate has an internal net migration. This result support the results in Mustafa and EL-Rouby in 1992, and in Central Agency for Public Mobilization and Statistics in 2006 that, the Qalyobia Governorate is an attractive area for people in the state of Egypt.
- 5-** Net migration is an important component in the population changes of the Qalyobia Governorate since the net migration rate of Qalyobia Governorate in 2006 is equal to 18.6%.
- 6-** The total population of the Qalyobia Governorate for the target year 2016 is equal to 5478267.
- 7-** As stated at the end of chapter three that, the measure of the model accuracy is equal to 0.33%, which is a good indicator that, the complete component projection model achieves a good accuracy.
- 8-** The projection of school enrollment for the Qalyobia Governorate at the target year 2016 indicates the following:

- The male population students of primary schools is equal to 336,900 students.
- The female population students of primary schools is equal to 318,979 students.
- The total population students of primary schools is equal to 655,879 students.
- Projected population number of students in primary schools is equal to 678,179.
- The male population students of preparatory schools is equal to 149,641 students.
- The female population students of preparatory schools is equal to 141,202 students.
- The total population students of preparatory schools is equal to 290,843 students.
- The projected population number of students in preparatory schools is equal to 280,372.
- The required projected classrooms in primary schools are equal to 22600 if it is assumed that, the classroom density is 30 students in each classroom.
- The required projected classrooms in preparatory school are equal to 9345 if it is assumed that, the classroom density is 30 students in each classroom.
- 9-** The projected male population at year 2016 in the labor force is equal to 13378 hundred.
- 10-** The projected female population at year 2016 in the labor force is equal to 4010 hundred.

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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

Nations and states are concerned about the economic, social, political, and environmental consequences of population growth. At the local level, planning for schools, hospitals, and other projects is strongly affected by expected population growth. Population projections are very useful tools for planning if constructed and interpreted properly.

Population projections are used to predict future population change, to analyze the determinants of population change, to give the data users an indication of potential future scenarios and as a base for constructing other types of projections.

Much of the researches on population projections have focused on projections at the national level. Although these researches have been very valuable, conclusions based on studies of national projections are not always applicable to states and local areas because the following two main reasons:

First, there are substantial differences in data availability and reliability between national and sub-national areas. Some data series are available only at the national level. Others are available with greater frequency at the national level than at state and local levels.

Due to reporting, coverage, and sampling errors, data quality is likely to be better for nations than for sub-national areas.

Second, migration-both international and local plays a greater role in population growth at the state and local levels than at the national level. Fertility and mortality are the major determinants of population growth in most countries, with international migration having a relatively small impact. Migration is the primary determinant of population change in many states and local areas and it is much more volatile over time than either fertility or mortality. This volatility makes migration more difficult to forecast accurately.

Projections at the local level are very important for their unique characteristics, the relatively small amount of research that has been done at the local level, and for the decision making process. This requires to pay great attention to the problems of data availability and reliability and migration [See Smith et al. (2013)].

The present study is concerned with the development of a mathematical model for projecting local populations. The model considered in the present study has an advantage over the traditional methods because it is not concerned with the projection of population only, but the considered model is devoted to make a detailed local population projection to each of the demographic components (which are fertility, mortality, and net migration) to clarify the importance of each component in changing the characteristics and region size to help the regional planners in making good plans in light of the results of each component. The suggested model is referred to as the complete component projection model.

The data required by the component method is generally not available for the migration component. Even if available, they are outdated and their quality is also not reliable. Use of the method requires expertise in demography and understanding of the demographic structure of the population, which may not be available at the migration level.

An application to the suggested model is implemented to Qalyobia Governorate where a separate projection for each component [mortality, net migration and fertility] is carried out to clarify the importance of each component in changing the characteristics and size of the Qalyobia Governorate. Also, to know the real population numbers of this Governorate without excess or negligence to help in effective regional planning.

The local projection for Qalyobia Governorate is implemented through two stages, the 1st stage at year 2011 and the 2nd stage at year 2016.

Furthermore, the present study is devoted to clarify some extensions of the component model with respect to future changes, and other sectoral projections, which have great important uses of the model in the regional planning. Alternative scenarios are introduced as an extension of the component model. The changes may be occurring in fertility and mortality component data in the foreseeable future. The future changes in the fertility and mortality components are considered by the synthetic projections.

The study importance can be stated in the following points:

1. Highlight the concept of projection and regional planning.
2. Identify the best and most effective methods which can be used to calculate the projection components [fertility, mortality, and migration].
3. Clarify the necessary data and rates required to make the local population projection.
4. Suggest a local population projection model to help planners and decision makers to take the right decision about regional planning policies on a scientific basis.
5. Apply the suggested mathematical model for a choosing area.
6. Discuss methods for projecting the main characteristics such as marital status, employment status, income, education and occupation.
7. Update the data at the local level.

This chapter consists of four sections. Section (1.1) is an introduction. Section (1.2) is devoted to the definitions and notations. Section (1.3) is discussed the review of literature. Section (1.4) is devoted to clarify the outline of the thesis.

1.2 Definitions and Notations

Definitions:

1.2.1 Estimate

An estimate is an indirect measure of a condition that exists or has existed, and which, in principle could be or could have been measured directly. Estimates are therefore made because direct measurement

data are not yet available or because it is (or was) impractical to collect such data. For example, suppose a census had been taken, but it would be several months before the data could be completely tabulated, in the absence of the census data; an estimate might have to suffice. In most demographic work, estimation techniques differ from projection techniques because symptomatic data are used. If the symptomatic data were not available, the estimate might have to be made using projection methods. In any event, the key distinction between estimates and projection is temporal [See Pittenger (1976)].

1.2.2 Projection

A projection is the exact measurement of a future conditioned that would exist if the rules and assumptions embodied in the projection method proved to be, empirically, valid in the future. Projections may assume continuations of past conditions, present conditions, or trended changes in historical conditions. They also may assume entirely new transition rates. The projection is always correct if the operations of the projection method are carried out without error given the appropriate method and the assumptions. The number of possible projections for any given population is therefore infinitely large [See Pittenger (1976)].

1.2.3 Forecast

A forecast is a projection that is also a judgmental statement concerning the expected measurement of future conditions. In other words, all forecasts are projections, but not all projections are forecasts. Most demographers refer to their forecasts as projections,

perhaps to protect themselves from being proved wrong [See Smith et al. (2013)].

1.2.4 Migration

Demographers defined migration as geographic movement of people across a specified boundary for the purpose of establishing a new permanent or semi-permanent residence. Migration may be local and international.

The following definitions are concerned with local migration [See Becker (2008)].

1.2.5 In-Migration

In migration is defined as movement into a new politically and geographically administratively defined area within the same country.

1.2.6 In-Migrant

A person who moves into a new area within the same country is described as in migrant.

1.2.7 Out-Migration

Out migration is defined as movement out of a politically and geographically administratively defined area within the same country.

1.2.8 Out-Migrant

A person who moves out of an area within the same country is described as out-migrant.

Notations:

The important notations which are used in the present study are as follows:

Base year: The year of the earliest date used to make a projection (t_0)

Launch year: The year of the latest date used to make a projection (t_1)

Target year: The year for which the population is projected (t_2)

Base period: The interval between the base year and the launch year
(t_0, t_1)

Projection horizon: The interval between the launch year and a target year (t_1, t_2)

Projection interval: The increments in which projections are made

1.3 Review of Literature

In this section the main techniques in population projections whether locally or at the state level are discussed in sub –section 1.3.1 and the previous studies in this area are mentioned in sub-section 1.3.2.

1.3.1 Population Projection Techniques

There are various methods or techniques for projecting population; some are very sophisticated and rigorous while others are simple and less sophisticated. The overall growth or decline of a population is determined by the interplay among the processes of mortality, fertility, and migration. The nature of this interplay is formalized in the demographic balancing equation.

The main equation for population projections is as follows: [See Mustafa (1992) and Arunc (2004)]

$$P(t_2) = P(t_1) + B(t_1, t_2) - D(t_1, t_2) + IM(t_1, t_2) - OM(t_1, t_2)$$

Where:

$P(t_2)$:Population at the target year

$P(t_1)$:Population at the launch year

$B(t_1,t_2)$:Births at the projection horizon

$D(t_1,t_2)$:Deaths at the projection horizon

$IM(t_1,t_2)$:In-migration at the projection horizon

$OM(t_1,t_2)$:Out-migration at the projection horizon

Keeping in view the net migration may be either positive or negative. Though population in the launch year $P(t_1)$ is available, number of births, deaths and migration in future needs to be projected which is not an easy task.

The component method is suitable for projecting sub-national level population. It requires detailed age-sex structure of population in the launch year $P(t_1)$ in different age groups along with estimation of a variety of demographic indicators about fertility, mortality, and migration. For fertility the needed indicators are age specific fertility rates (ASFR's). For mortality the needed indicators are survivorship ratio. Finally, for migration the net migration numbers and net migration rates are needed. Similarly, by using the appropriate life-tables, expectation of life at birth may be needed.

Population projection techniques may be classified as non-component and component methods. These techniques are reviewed in (1.3.1.1) and (1.3.1.2) respectively.

1.3.1.1 Non-component Population Projection Methods

The main non-component methods are; trend extrapolation, regression methods, time series methods, comparative methods, and density models.

1.3.1.1.1 Trend Extrapolation Methods

These methods can be classified into graph representation and mathematical formulation.

The quickest and simplest means of forecasting the total population of an area is to graph the historical population size data and then extend that line to represent the future [See Pittenger (1976)].

Also, the trend extrapolation methods consist of mathematical functions which extend the trend observed over a specified base period into the future. Functions commonly mentioned in the demographic literature 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. Equations for these functions are shown in Table (1.1).

Potentially many other mathematical functions could be applied to extrapolate total population trends. Openshaw and van der Knapp (1983) discuss many examples additional to those listed in Table (1.1) [See Wilson (2011)].

Table (1.1): Some Examples of Trend Extrapolation Population Projection Methods

Name	Equation	Limit to projections
Linear	$P(t) = a + bt$	Unlimited
Quadratic	$P(t) = a + bt + ct^2$	Unlimited
Cubic	$P(t) = a + bt + ct^2 + dt^3$	Unlimited

Exponential	$P(t) = ae^{rt}$	Unlimited
Power	$P(t) = at^b$	Unlimited
Hyperbolic	$P(t) = k + \frac{a}{t}$	Curve asymptotically approaches the limit k
Modified exponential	$P(t) = k + ae^{rt}$	Curve asymptotically approaches the limit k
Logistic	$P(t) = \frac{k}{1 + e^{a+bt}}$	Curve asymptotically approaches the limit k
Gompertz	$P(t) = ka^{b^t}$	Curve asymptotically approaches the limit k

Where; a, b, c, d ,k are parameters of curves and regression equations , r is the growth rate, and t is a point in time.

Advantages and disadvantages of extrapolation techniques

The limitations or disadvantages of the extrapolation techniques can be stated in the following points:

1. The very low data requirements that are so attractive also must be recognized as an inherent limitation to the projections.
2. Total population figures for past years are being used to project future conditions; there is no inclusion of housing trends, economic changes, growth management, or any other external pressures on population in this technique. Any factors other than past population totals are external to the method.
3. A further limitation to the model, which is also implied by the above, is that extrapolation techniques use past conditions to project future conditions and there is absolutely no guarantee that the past trends will continue into the future. Therefore, extrapolation techniques should be used carefully and with a full understanding of their limitations.
4. The neglect of standard demographic accounting relationships introduces inconsistencies [See Rogers (1995)].

The advantages of the extrapolation techniques can be stated in the following points:

1. Yet these methods have minimal input data requirements, can be easily and quickly calculated in spreadsheets, and therefore require modest staff person-hours and costs [See Smith (1997)].
2. 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.
3. In addition, in situations of very limited data availability where the analyst is required to produce projections, there may be few other options.
4. Finally, those methods with upper limits can prevent small area projections exceeding reasonable, legal dwelling or population densities [See Wilson (2011)].

Assessments of extrapolative methods by academic demographers are mixed. Many are dismissive of trend extrapolation methods because of their poor representation of demographic processes and others assert that these methods are simpler in projecting population than others.

1.3.1.1.2 Regression Methods

Regression approaches project population, or some measure of population change, from a relationship with a set of independent variables from the recent past. For example, population change from time $t-5$ to t may be projected on the basis of independent variables covering the period $t-15$ to $t-5$. The parameters of the equation are established by regressing current populations against independent

variables for an earlier period. Where the dependent variable is a ratio, such as a local area's population at some point in the future divided by its current population, these methods are often described as "ratio-correlation" methods (or by Siegel (2002) as "ratio-regression"). Ratio-correlation methods are far more commonly used for population estimation, though a number of authors have adapted them for use in short-term population projections.

The use of regression approaches for local and small area projections is relatively rare. Chi and Voss (2011) suggest three reasons for this:

1. Parameters estimated for a past period may not be valid for the projection period,
2. Component models are so dominant, and
3. Regression models have not proved to be more accurate than other methods in the past [For more details see Wilson (2011)].

Advantages and disadvantages of regression technique

Advantages:

1. One of the strengths of regression models is their incorporation of demographic, social, economic, environmental and other variables influencing population change.
2. 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. Swanson and Beck (1994) found that, their model's performance is superior to cohort-component and exponential extrapolation models over a two year projection horizon.

Disadvantages

1. Amongst 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.
2. 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 [See Wilson (2011)].

1.3.1.1.3 Time Series Models

Autoregressive integrated moving average (ARIMA) models are a broad class of time series models which generates forecasts based on past trends. The current set of methods for creating (ARIMA) models was initially developed by Box and Jenkins (1970).

In algebraic notation an ARIMA model is written as ARIMA(p,d,q) where p denotes the number of autoregressive terms, d the order of differencing and q the number of moving average terms. Mostly p, d and q take values of 0, 1 or 2. An autoregressive model is one in which the current value includes part of the preceding value [See Makridakis et al. (1998)]:

$$Y(t) = \phi Y(t-1) + c + \varepsilon(t)$$

Where ϕ is the autoregressive parameter, c, a constant and ε random error. This may be described as an ARIMA(1,0,0) model, or simply AR (1). It only has one autoregressive term, no integration and no

moving average terms. A moving average model includes the current error term and part of the previous error term.

$$Y(t) = c + \varepsilon(t) - \phi\varepsilon(t-1)$$

Where ϕ is the moving average parameter. This may be described as an ARIMA(0,0,1) model or simply MA(1). A model with just differencing is known as a random walk model and may be expressed as:

$$Y(t) = Y(t-1) + c + \varepsilon(t)$$

The current value of the time series equals the previous value plus random error. Where the constant is non-zero it is termed a random walk with drift model. Various combinations of autoregressive, differencing and moving average parameters may be used. For example, the commonly-used ARIMA (1,1,0) model is:

$$Y(t) = Y(t-1) + \phi(Y(t-1) - Y(t-2)) + c + \varepsilon(t)$$

While ARIMA(0,1,1) is:

$$Y(t) = Y(t-1) + c + \varepsilon(t) - \phi\varepsilon(t-1)$$

According to the Box-Jenkins methodology, there are three stages to follow in generating ARIMA models [See Makridakis et al. (1998)]:

1. Identification: identifying the type of ARIMA model;
2. Estimation and testing: estimating model parameters and calculating diagnostic tests;
3. Application: use of the model to produce forecasts.

This approach to creating ARIMA models is quite complex and requires a reasonable knowledge of statistics and statistics software packages [See Wilson (2011)].

Advantages and disadvantages of auto regression integrated moving average:

Advantages:

1. On the positive side, time series models for total population require only past data on population totals.
2. They are widely used in a number of disciplines and so a large literature on their theory and practice is available for consultation.
3. 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.

Disadvantages

1. On the negative side, the process of fitting time series models is not trivial and requires the use of statistical software.
2. Identifying the best-fitting model requires judgment and can be difficult, and must be done for each area at a time.
3. Two alternative models may give fits which are very similar, but forecasts and/or prediction intervals which are quite different.
4. 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.
5. Furthermore, like trend extrapolation models, time series models do not take into account demographic processes.

1.3.1.1.4 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. Comparative models include:

1. The share of population model,
2. The share of growth model, and
3. The growth difference model.

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 [See Wilson (2011)].

1.3.1.1.4.1 Share of Population Model

Projections of a local area’s total population may be obtained simply by taking a share of an independent projection produced for its parent region. It may be written 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 shares can either be held constant or projected. The constant share of population model calculates the local area projection as a fixed share of the parent region’s population, where the share is usually computed from the jump-off year, or the average over a specified base period. No time series of local area population data is necessary for this model. Only the jump-off year populations are

needed. 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. When the share is projected at least two past population counts are required for both the local area and the parent region. Intervention may be necessary if shares for individual local areas become negative or exceed unity, and constraining may be required to ensure that shares for all local areas within a parent region sum to unity.

1.3.1.1.4.2 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. It may be expressed as:

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

Where; *SHAREGROWTH* refers to the local area's share of projected population growth in the parent region. It is defined as:

$$SHAREGROWTH^i(t-5,t) = \frac{P^i(t) - P^i(t-5)}{P^l(t) - P^l(t-5)}$$

The constant share of growth model uses shares which are held constant from a base period. One past period (with two population counts) is the minimum input data requirement. If the share of growth is projected into the future, then the projected share of growth model is created, where *SHAREGROWTH* is created with linear extrapolation or with any of the functions mentioned in the trend extrapolation section. This model therefore requires at least two past periods of growth (and three population counts).

Share of growth models can produce implausible results where the parent region grew in population over the base period whilst the local area declined. The local area's share of growth would be negative. An increase in growth in the parent region over the projection horizon would lead to greater decline in the small area, which in many cases would be unlikely [See Smith et al. (2001)].

1.3.1.1.4.3 The Growth Difference Model

The growth difference model assumes a certain difference in growth between a local area and its parent region. The projected population of the local area is [See Davis (1995) and Isserman (1977)]:

$$P^i(t) = P^i(t-5) \left(GROWTHDIFF^i(t-5,t) + \frac{P^l(t)}{P^l(t-5)} \right)$$

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:

$$GROWTHDIFF^i(t-5,t) = \frac{P^i(t)}{P^i(t-5)} - \frac{P^l(t)}{P^l(t-5)}$$

In the constant growth difference model the growth difference experienced over the base period is assumed to remain fixed into the future. In the projected growth difference model past trends in the growth difference are trended into the future. Unfortunately, empirical tests of growth difference models have revealed them to be quite inaccurate [See Isserman (1977)].

Advantages and disadvantages of comparative method

Most of the advantages and disadvantages of trend extrapolation models also apply to comparative models. Additional advantages of comparative models include:

1. If the parent region's population is projected by a component model then there is at least an indirect link to the modeling of demographic processes.
2. In the share of growth and share of population models local projections are automatically constrained to those of the parent region.

Disadvantages

1. A separate projection for the parent region may have to be produced.
2. If the projection for the parent region is inaccurate, projections for local areas are likely to be so too.
3. Share of growth models where the local area's growth was negative in the base period often give implausible projections (as mentioned above).

For more discussion of comparative methods [See Davis (1995), Isard (1960), Pittenger (1976), and Smith et al. (2001)].

1.3.1.1.5 Density Models

Population density models are a realistic approach to projecting population totals of regions and smaller areas. Previously discussed mathematical extrapolations were a theoretical and unbounded in some cases. Density models approximate the number of people or housing

per square mile or per acre, depending on the scope of investigation. The maximum density is considered a "ceiling" population total value and acts as an asymptotic limit, similar to the K value used in the Gompertz and Logistic Curve models [See Benedict (1990)].

This control allows the researcher to aggregate small subunit totals in what is called a "bottom-up" approach, to project the larger area. Without asymptotic control, local variations if trended, could lead to unreasonable projections in either a high or low range.

The niche of density models in projection methods lies in smaller areas such as metropolitan regions, counties, and municipalities. The lowest degree of a study area is usually the census tract.

There may be a data gathering difficulty if census tracts are continually subdivided as population increases. Re-aggregation usually resolves the problem unless investigation is sought at the lower subunit level. Small populations are difficult to project by component methods because of potentially high variability in the data (fertility, mortality and migration) and the lack of quantity and quality. Trend extrapolation techniques could be inaccurate in suburbanizing areas in metropolitan regions by continuing past behavior into the future.

An approximation of population density must be researched. In larger rural dominated areas, empirical data must be reviewed against similar areas for comparison and density approximation. In more urban minor civil divisions, population constraints are implicit in land use or zoning regulations which limit the number of housing units per unit area and in turn people per household. The complexity of the density modeling increases to a considerable measure when household size per

housing unit type is approximated. The age of the buyers and the neighborhood housing stock should be taken into account. The housing structure mix in the area whether it be single-family, duplex, condominium or apartments must also be considered. The investigation necessary in a density model could parallel the component projection strategy. The small area population projection totals would be added to arrive at a larger area total. In situations where population projection totals are available for the larger population using other methods, this independent constraint could re-filter the subunit density totals proportionally.

1.3.1.2 Component Population Projection Method

The component method is so widely used because it provides a flexible yet powerful approach to population projection. It can incorporate many application techniques, types of data, and assumptions regarding future population change. It can be used at any level of geography, from nations down to states, counties, and subcounty areas. Perhaps most important, it provides projections not only of total population, but also of demographic composition and individual components of growth such as fertility, mortality, and migration. The component method provides a good starting point for the study of state and local population projections [See Smith et al. (2013)].

1.3.1.2.1 Mortality Component

Mortality rates are the least variable of the demographic components. The rates for sub-national areas would normally parallel the national levels due to barring war, famine, natural diseases and

epidemic. Survival rates would be very gradually increasing. Death occurs due to a complicated interaction of socio, economic and physiological forces. The main causal variable is physiological aging, but that in turn is related to factors in the physical, social, economic and psychological environment. Mortality is a function of age. Death rates are known to be high at birth then decrease to a minimum at about 10 years of age.

Researchers do not adjust the mortality tables by trying to reflect the other causal factors that possibly affect changes in age and sex mortality rates.

The projection of mortality rates can be accomplished by two structurally different approaches. One method is in the form of analogue computations developed into model life tables. The other technique falls into the category of extrapolation or trending as discussed with the various non-component methods.

1.3.1.2.2 Fertility Component

Fertility is a more variable demographic process than mortality. Fertility rates can be greatly influenced by various socio, economic conditions and contraceptive methods. Researchers believe they have developed representative theories concerning human reproduction. Due to the complexity of their models, the required detailed base data is sometimes unavailable. Simpler models based on the available data often provide relatively accurate results.

As was indicative of mortality rates, fertility rates also have a higher statistical reliability at the national level. The migration of females among national subareas seriously deteriorates the derivation

of age specific fertility rates for small study areas.[For more details see Benedict (1990)]

The fertility component projection methodologies require many assumptions even at the national level. Local projections are best related to national levels or specific identifiable segments of national statistics because of many uncontrollable variables such as inadequate data, migration and development patterns. The effort and knowledge necessary in the usage of more complex models would most likely preclude their use at the local level.[See Benedict (1990)]

1.3.1.2.3 Migration Component

The migration component is the most difficult to estimate or measure for sub-national populations. The smaller the area, the more influence a migratory component can exert on a subarea population.

Drastic increases or decreases in population size can be directly attributable to migration prompted by economic conditions. Analysis of historical migration data may not foresee abrupt changes that may occur in a local economy. To complicate matters, crude rates of net migration may need to be divided into age and sex specific cohorts.

This division may be desirable so that local planning agencies can assess the intensity of the demand for particular public and private services in the future. The immediacy of this migration component knowledge is especially acute in regions of fast growth. Often ten year and even five year projections fall short of providing the annual population projection information essential in local level planning.

Projection techniques used for estimating the mortality and fertility components are also used in estimating the migration component.

However, the volatility of the later component creates an inherent weakness in the reliability of most extrapolation methods.

Different types of component models can be distinguished on the basis of (a) how they deal with migration and (b) what type of migration data they use. For sub-regional areas, standard multi-regional models which include migration flows between each origin and destination disaggregated by sex and age are inappropriate. The data demands are too high and the age schedules of fertility, mortality and migration rates are too unstable. Options for sub-regional areas include cohort-component models using:

1. net migration numbers,
2. net migration rates,
3. migration pool out-migration flows and in-migration shares,
4. bi-regional migration flows,
5. Multi-bi-regional migration flows.

[For more details see Rees (1996), Ledent (1982), and Rees & Wilson (1977)].

Component and non-component methods are distinct because they differ in purpose, complexity, and data requirements as follows:

1- The primary distinction is that component models deal directly with special effects of demographic elements, i.e., fertility, mortality and migration of population growth.

Non-component models employ data that represent net effects of population components without respect to detailed age-sex specific

information, i.e., population totals without disaggregation into components.

2- Component projection model rely heavily on demographic process data because these data form the mathematical platform on which future projections are launched.

Non-component models such as trend extrapolations are based on historical patterns of net population growth.

3-Component models require comprehensive and detailed demographic data. This age-sex specific data requirement for fertility, mortality, and migration is reliable at the national scale and to a lesser degree at the state level. The refinement of the data set is an integral part of the component projection. The component model uses and creates age-sex specific information which is an advantage. This detailed information increases the applicability of the model for uses concerning public service demands such as retirement housing, school planning and age specific community services.

Data requirements for non-component models are generally basic statistical summaries that are available at the local level for a given time period. The absence of age-sex specific population information at the local level usually restricts the smaller scale population analysis to non-component methods. Symptomatic data which are indicators of population (i.e., housing, voter registration, vehicle registration, etc.) are used more prevalently in non-component models and sub regional analysis [See Greenberg, et al. p. 15,(1978)].

Since non-component models are generated with net population values instead of refined age-sex specific data, the methods and the techniques are simpler and less time consuming.

However, the disaggregation of the three demographic components into age and sex groups increases the complexity of the model. The population component projection method is best employed by learned demographers and professionals who have extensive and detailed data and the aid of a computer. In-depth investigation into forces that affect the variability of each component can lead to more analytical explanations of population growth instead of the growth extrapolations and descriptions that are generated by non-component methods.

4- Another distinction between the two models relates to the reliability of the population projection into the future. Component models, by their disaggregated nature, are flexible enough to reflect potential changes in a specific sector of each component depending on future perceived conditions. Therefore, they are considerably more reliable for long term population projections of a national scale than would be realized in a fairly rigid non-component mathematical model.

The differences between the non-component and component models are indicative of the various needs of researchers and their clients [See Benedict (1990)].

1.3.2 Previous Studies in the Research Area

This sub-section is devoted to the previous studies in the research area of population projections which are conducted by non-component methods and component method either on the state level or regional level.

Harrier and Egan-Robinson (2008) prepared projections for minor civil divisions in Wisconsin using linear extrapolation based on a 15 year base period with change weighted towards the recent past. Two adjustments were made to these extrapolations to prevent high rates of growth or decline from continuing for the whole 25 year projection horizon.

First, the distribution of growth rates of all minor civil divisions in each county was calculated; all those lying beyond the mean \pm 1.5 standard deviations were pulled back to the mean \pm 1.5 standard deviations. Second, if the slope of the extrapolation implied a negative population 80 years beyond the jump-off year, then it was adjusted to give a population of zero after 80 years.

There are relatively few published examples of trend extrapolation projection methods used in Australia. Two are mentioned here by the office of economic and statistical research (Queensland Treasury) (OESR), and Taylor respectively, both of which concern projections of populations with mostly indigenous residents. The Office of Economic and Statistical Research has used linear extrapolation as one of three approaches to project the populations of indigenous local government area "LGAs in Queensland" [See OESR (2011)].

Linear extrapolation based on observed population change between 2001 and 2008 was used to create projections out to 2031. OESR regard all three projections of indigenous LGA populations as experimental. A second example can be found in the work of Taylor (2001), who 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.

Further discussion and worked examples of trend extrapolation models can be found in Davis (1995), George et al. (2004), Isard (1960), Klosterman (1990), Munro (1975), Pittenger (1976), Openshaw and van der Knapp (1983), Smith et al. (2001), Tekse (1975), UN (1952) and Wang (2007).

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.

Of the few examples applied to population totals, one of the earliest is due to Saboia (1974) who projected the total population of Sweden using ARIMA(1,1,0) and ARIMA(0,2,1) models. The ARIMA(1,1,0) model was found to produce more accurate projections than those of the United Nations and a logistic curve. Ahlburg (1987) projected the populations of several south Pacific countries using autoregressive models. In another example, Pflaumer (1992) projected the total US population with ARIMA(2,2,0) and ARIMA(1,1,0) models, favoring the former. 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" More recently Abel et al. (2010) applied a series of Bayesian autoregressive models to forecast the population of England & Wales.

A small number of studies have explored the potential of ARIMA models for state and local area forecasts. Smith and Sincich (1992) used an ARIMA(1,1,0) model for US States, finding that forecast accuracy was of similar magnitude to trend extrapolation methods. More recently, Tayman et al. (2007) evaluated six time series models, specifically ARIMA(1,1,0), ARIMA(0,1,1), ARIMA(2,2,0), ARIMA(0,2,1), ARIMA(0,2,2) and ARIMA ln(0,1,1) to forecast the populations of selected US states. Of these six models the first two were found be the most accurate.

The US bureau of economic analysis (BEA) employed economic base model to prepare total population projections for US metropolitan regions and economic areas (BEA 1996). Projections were prepared in three steps. First, scaling factors of local population employment ratios divided by state population and employment ratios were calculated for past years,

$$SF^i = \frac{P^i}{E^i} / \frac{P^l}{E^l}$$

Where:

SF^i : The local area scaling factor

P^i : The local area population

P^l : The parent region population

E^i : The local area employment

E^l : The parent region employment

where SF denotes scaling factor. These were then projected on the basis of historical trends (BEA 1996). Second, the scaling factors were

multiplied by projected state population employment ratios to obtain local projected population and employment ratios,

$$R^i(t) = SF^i(t)R^l(t)$$

Where:

$R^i(t)$: The local projected population/employment ratios

$R^l(t)$: The state (parent region) projected population employment ratios

In the third step the local population/employment ratio was multiplied by the projected employment total to yield the projected population total:

$$P^i(t) = E^i(t)R^i(t).$$

Expert judgment was applied to modify population and employment projections in light of local factors where necessary.

Another example of this approach can be found in Waller (2010) who prepared employment and population projections for the Pilbara region for the period 2008-2020. Projections of the peak number of construction workers and operating workers for resource projects were obtained. Population projections were calculated by multiplying these employment projections by various multipliers to account for workers' families and indirect employment generated by population growth.

The Victorian department of planning & community development (DPCD) make use of the housing-unit method to prepare local government area population projections (Sykes 2011). The future numbers of dwelling commencements are obtained from three sources: the DPCD's annual urban development program, data obtained from local planning schemes and municipal strategic statements in

non-metropolitan Victoria, and analysis of infill potential in established urban areas. Assumptions are also made about dwelling stock loss, proportion occupied and persons in non-private dwellings.

The Queensland small area model (QSAM), was constructed by demographics Australia in the mid-1990s for use by the Queensland government (Demographics Australia 1996, 2000). The model produces annual projections of total population and dwellings for up to 500 small areas within an urban local government area (LGA) over a projection horizon of up to 20 years. Although QSAM is quite a complex model, its basic principles are simple: an existing projection of population and dwellings for an LGA is distributed to small areas within the LGA on the basis of past shares of growth and land availability. QSAM was designed to mimic the land development process in Queensland as closely as possible. The model operates as follows in each projection interval. First, projections of population and dwellings (divided into attached and detached types) for the LGA are required. These are external inputs and are not produced by QSAM. Projected dwelling growth by housing type in the LGA is compared with the total number of vacant residential lots to estimate the land required for construction plus a specified buffer amount. If more land is required it is obtained from broad hectare stocks and added to the number of vacant lots. The number of demolitions by small area is calculated. Projected dwelling growth is then distributed to vacant lots in small areas:

Attached dwellings are first allocated to demolition sites, and then to vacant lots.

Detached dwellings are allocated to small areas according to a weighted average of each small area's past dwelling commencements and its share of vacant land.

Projected dwelling increase by housing type is converted to population growth using the housing unit method. If necessary, adjustments are made to ensure consistency with the LGA population projection.

Projections for Urban Planning (PUP), is a model designed to forecast land use change and dwelling growth for $\frac{1}{4}$ km² small areas (cells) on the urban fringe of Adelaide (Bell et al. 2000). Essentially, PUP is a land-use model which allocates an exogenous regional forecast of housing construction to constituent zones based, primarily, on their shares of available residential land.

First, an exogenous population projection for the Adelaide region is converted into a household projection. From these are derived new dwelling construction projections in single year intervals over a 30 year projection horizon. The region's dwelling construction projections are then allocated to 30 metropolitan districts within the Adelaide region via the land-use model. Vacant allotments are created on broad hectare land with the highest expected probability of development. Probability of development is calculated from an equation which includes three broad sets of influences:

1. Likelihood of development on the basis of factors such as land-use zoning and ownership,
2. Accessibility to user-specified facilities and services (employment, schools, shops, public transport, etc.), and

3. Adjacency to existing development.

The new dwelling construction projection in each cell is added to the existing dwelling stock to obtain a projection of total dwelling numbers. Cell dwelling numbers are converted to population by multiplying by a projection of average household size (applying the housing unit method). The cell population projections are then constrained to sum to those for the Adelaide region as a whole.

Other examples of land use models, either as stand-alone models or embedded within large-scale multi-sectoral models, can be found in San Diego Association of Governments (2010), Stimson et al. (2007) and Westervelt et al. (2011).

Hyndman and Booth (2008) provide the component method for projection by a new idea about stochastic population forecasting. The age-sex-specific population forecasts are derived through stochastic population renewal using forecasts of mortality, fertility and net migration. Functional data models with time series coefficients are used to model age-specific mortality and fertility rates.

As detailed migration data are lacking, net migration by age and sex is estimated as the difference between historic annual population data and successive populations one year ahead derived from a projection using fertility and mortality data. This estimate, which includes error, is also modeled using a functional data model. The three models involve different strengths of the general Box- Cox transformation chosen to minimize out-of-sample forecast error.

Uncertainty is estimated from the model, with an adjustment to ensure the one-step-forecast variances are equal to those obtained with historical data. The three models are then used in the Monte Carlo simulation of future fertility, mortality and net migration, which are combined using the cohort-component method to obtain age-specific forecasts of the population by sex. The distribution of forecasts provides probabilistic prediction intervals. The method is demonstrated by making 20-year forecasts using Australian data for the period 1921–2003.

Egypt is one of the oldest countries in Arab region in conducting population censuses and also in the preparation of population projections [See CAPMAS (2008)].

The 1st population projections conducted in the state of Egypt using the component method was by Maqqar using 1947 population census data (Maqqar 1975) then, the Central Committee of the statistics prepared the 2nd population projections depending on the 1960 census data (The Central Committee of the statistics 1962), Makhoulf prepared the 3rd population projections depending on the 1966 sampling census data (Makhoulf 1977) , Feryal Abdulkader in 1983 prepared the 4th population projections depending on the 1976 census data (CAPMAS 1983). All these studies are depending on Meacham formula in forecasting mortality level additionally to special fertility levels expected in the future, without any notification about migration level which is the main factor in component method.

CAPMAS in 1988 prepared the 1st population projections on national and regional level depending on the 1986 larger sampling census data (20%) where the CAPMAS formed a committee including representatives from each of the University of Cairo, the ministries concerned with population studies and, also experts of CAPMAS in the same purpose (CAPMAS 1988).

In 1994 the Cairo Demographic Center (CDC) prepared population forecasting for planning purposes only on national level depending on the 1986 population census data in the light of the modern fertility trends (Cairo Demographic Center , 1994).

Also, the Cairo demographic center (CDC) prepared the 2nd population projections but on regional level under the title “Future population projections for the governorates of Egypt for the purposes of planning and development 2001-2021” depending on the 1996 population census data in addition to some of projections about sectors as “ household , labor force , students numbers in the age of pre-university education and university” using the method of the proportion of the population of each Governorate to the total population depending on three previous points in time, at least (Cairo Demographic Center 2000).

Using the latest population census in 2006, the National Planning Institute and Cairo Demographic Center prepared national population projections depending on the 2006 population census data using the component method (National Planning Institute 2008).

Mohamed Naguib in 2010 prepared national population projections depending on the 2006 population census data using the component method and he neglected the migration data and he said in the research “This component was neglected since migration data is of low quality”.

1.4 Outline of the Thesis

This thesis consists of five chapters:

Chapter 1 is an introductory chapter to realize the importance of the study , some basic definitions are introduced. The literature review is presented and the problem is described.

In Chapter 2, the complete component projection mathematical model is presented in details.

Chapter 3 deals with the application of the projection model and its role in regional planning.

Chapter 4 presents component model extensions and related projections.

Chapter 5 presents summary and conclusions.

CHAPTER 2

COMPLETE COMPONENT PROJECTION MODEL

2.1 Introduction

A variety of projection methods have been reviewed in the previous chapter. Advantages and disadvantages of each method have been noted. The model considered in the present chapter has an advantage over the traditional methods because it is not concerned with the projection of population only, but the considered model is devoted to make a detailed local population projection to each of the demographic components (which are fertility, mortality, and net migration) to clarify the importance of each component in changing the characteristics and region size to help the regional planners in making good plans in light of the results of each component. The suggested model is referred to as the complete component projection model.

In component projections an estimate of the population at a certain point in time classified according to a certain factor (for example, age, sex, educational status, marital status,..., etc) is derived from the population classified to the same factor at another point in time in conjunction with pertinent demographic changes in the intervening time interval (for example, births and deaths). The precision of estimates of the total population arrived at by summing over estimates of the components is usually higher than that of the total population.

The suggested complete component projection model will be clarified in this chapter.

The choice of the projection model depends on the available data, the researcher and his special needs. The choice of a population projection model must be decided before data is obtained and technical projection applications can be made [See Benedict (1990)].

In other words, the best model under one set of circumstances might not be the best model if the circumstances were changed. So that, when the population projections by age and sex are needed for longer periods of time the model which is called “Component Projection Model” may be appropriate. This projection tool allows planners to examine the future needs of different segments of the population including the needs of children, women in their reproductive years, persons in the labor force, and the elderly. It also allows planners to project the total size of the population. The results can be used in all aspects of local and regional development plans and are often used as a base for constructing other types of local projections (for example, school enrollment projections, labor force projections, projecting the number of births...,etc) [See Pittenger (1976) , Smith et al. (2013)].

This chapter consists of six sections. Section (2.1) is an introduction. In Section (2.2) the practical considerations for choosing the model are discussed. Model assumptions are introduced in section (2.3). Model variables are presented in section (2.4). Section (2.5) is devoted to the model design. Model extensions are introduced in section (2.6).

2.2 Practical Considerations

All of the practical considerations in choosing a model are interrelated, but it is good practice to disaggregate the factors as much as possible and develop a clear researchable outline [See Benedict (1990)].

2.2.1 The demographic component

The main consideration in choosing a complete projection model is its use of all the demographic components (which are fertility, mortality, and migration) which capture the population size and characteristics in any society [See Bracken (1981) , Field et al. (1987)].

2.2.2 Purpose

The purpose of the population projections should be known at the earliest possible time. This is the research task to satisfy the needs of the probable users of the projection information. For example, a population projection may be utilized as an indicator for future demands of water and sewage facilities, food supply, tax revenues, public services (i.e., fire, police, transportation...,etc) and government funding. Certain public services such as recreation and schools may require a more earlier information to identify associated needs of the population [See Benedict (1990)].

2.2.3 Accuracy

The accuracy of the model is perhaps a result of all the model considerations, model assumptions, and the required data. The length of the projection period plays an important role in the accuracy of a

population projection. Shorter projection time frames usually result in reliable or accurate projections. To achieve a model projection accuracy in long term projections, it is best to apply a model based on component projections [Smith et al. (2013)].

In the general projecting literature, accuracy measures are used not only to show how well projections have performed over the projection horizon, but also to show how well a particular model fit the data observed during the base period [See Ascher (1981) , Makridakis (1986) , Pant and Starbuck (1990)].

A number of researchers have discussed frequently several criteria that might be used to select measures of projection accuracy through projection error. Given the many different statistics that can be used to measure projection accuracy, how can one go about choosing the most appropriate measure(s).

The error measures should be related to loss functions that specify the cost of projection errors to data users. For example, if the cost of projection errors is linear in absolute terms, an error measure such as the mean absolute error is appropriate. If the cost of errors is linear in percent terms, a measure such as the mean absolute percent error is appropriate. If the cost of large errors is disproportionately high, a measure that assigns larger weights to larger errors is appropriate (e.g., mean square error, root mean square error, or root mean square percent error). If the direction of error is important, measures such as mean error, mean algebraic percent error, or proportion of positive errors or negative errors are useful. The best error measure for any given data

depends on the purposes for which the projections are to be used. [See Ahlburg (1995) , Fildes (1992)]

However, data users rarely know the exact costs associated with projection errors. Even if they did, loss functions would be difficult to estimate because error distributions are usually unknown conform to standard statistical assumptions. Perhaps more important, population projections are typically produced for general use rather than for a specific use by a particular data user. Consequently, it is impossible to specify a unique loss function that will be best for all data users and for all purposes. For these reasons, loss functions are seldom used to evaluate the projection accuracy of population projections [See Armstrong & Fildes (1995), Bryan (1999)].

The mean absolute percent error is used more frequently than any other error measure in evaluations of population projection accuracy. It is a good choice as a general accuracy measure because it incorporates the best characteristics among the various accuracy criteria [See Ahlburg (1995), Swanson et al. (2011), Makridakis (1993)].

Because of the impact of a few large errors, however, the mean absolute percent error may overstate the actual error in a set of projections; when this is a concern, the mean absolute percent error can be re-scaled mean absolute percent error reduction to reduce the impact of outliers [See Swanson et al. (2011), Tayman et al. (1999)].

Despite this shortcoming, the mean absolute percent error provides a reasonable measure for evaluating projection accuracy under a wide variety of circumstances.

Furthermore, as stated above the accuracy of the projection can be determined through the projection error, the statistic Δr can be used to obtain a homogeneous measure of error which takes the duration and size factors into account.

$$\Delta r = \frac{100}{T} \ln \left(\frac{\hat{P}(t_2)}{\hat{P}(t_1)} \cdot \frac{P(t_1)}{P(t_2)} \right) \quad (2.1)$$

Where:

Δr : Error in the projected population

$P(t_1)$: Initial population for projection at launch year

$\hat{P}(t_1)$: Estimated population for projection at launch year

$P(t_2)$: Initial population of projected region

$\hat{P}(t_2)$: Estimated population of projected region

T : Time of projection

The statistic, Δr , summarizes in one number the error in a population projection. It takes the initial population size for the projection horizon, the estimated population size for the projection horizon, and the projection duration into account. Since the use of Δr ignores errors caused by a bad estimate in the initial population, or a slight change in the coverage region. It does not reflect errors in the age or geographical distribution or the errors in the projection between the base and target years. The statistic, Δr , reflects only the error in total population size, and not the error in age composition. Sometimes future age composition, not size, is the main goal for regional planners. So that, the statistics Δr when it is used in any study do not regard as a measure of success, but simply as a measure of the difference between

actual and projected populations. It is a measure of the accuracy of projections [See Stoto (1983)].

2.2.4 Required Data

The projection process must eventually face the problem of assembling data that form the basis of the projections. The best time to consider the availability, quantity, and quality of the data is very early in the project. Most of the data used in projections comes from population censuses and vital statistics.

Although the quantity, quality and type of data are very important in the choice of a model, it is necessary to verify the feasibility of obtaining the data in the proposed research task. Certain population projection methodologies and models cannot be employed without the historical data. The various and numerous types of population data available to the demographer have led to the redundancy in population projection techniques and methods.

In making projections, detailed information on fertility, mortality and migration are required. Forecasting fertility and mortality is often done by extrapolating them forward using mathematical methods.

Migration data can be easily recorded at the national level, but smaller study units must rely on residual estimations from fertility and mortality data. The census migration questionnaires are also assisting in the development of migration data. Small study areas can rely more heavily on data such as local birth and death records, voter registrations, utility connections, school enrollment, motor vehicle

licenses, housing permits, housing certificates of occupancy and income tax returns [See Benedict (1990)].

The required data for each of the three demographic variables which are fertility, mortality and net migration are discussed in detail as follows:

1-The distribution of the population by age and sex at the year of the earliest date to projection (base year t_0) for the specified region.

2-The distribution of the population by age and sex at the year of the latest date to projection (launch year t_1) to the same region.

3- Life table survivorship ratio of males and females at the base year.

4- Life table survivorship ratio of males and females at the launch year.

5- Net migration number at the base period.

6-The distribution of male and female births with respect to the age of mother at the projection horizon.

7-The distribution of females in the reproductive age groups at the launch year.

The available data among the required data are the distribution of the population by age and sex in the base year for the specified region, the distribution of the population by age and sex at the launch year to the same region, life tables for males and females at the base and launch year, the distribution of male and female births with respect to the age of mother from the vital statistics, and the distribution of females in the reproductive age groups at the launch year.

The only missing data are about the third main component in the projection model related to the net migration number during the base period between the base year and the launch year.

2.3 Model Assumptions

The design of the model is one of the most influential parts of the projection process. The model setting consists of a set of assumptions that are specified for the area and population. The model assumptions set the values of population growth rates or component growth rates for periods in the future. They may assume constant increases of a particular mathematical nature (arithmetic or geometric) or stable rates. The assumption can be based on the researcher's judgment or trended using historical data extrapolation. Once the assumption is locked into the model, the projection forthcoming is technically exact.

The assigned population component values calibrate the population projection formula which will operate as the methodology dictates to produce a projection outcome. The number of assumptions are responsible for the rigidity of the models. As discussed earlier, the data can seriously affect the results of the population projection. Demographers believe that the population growth components must be contained in the model, they cannot ignore any of the three main components of fertility, mortality, and migration in model design to produce a precise projection outcomes. Otherwise, the outcomes will be suspected.

In the proposed projection model it is assumed that:

1. The general assumptions usually assumed that the absence of natural disasters, economic depressions and war.
2. The component growth rates of demographic change (fertility, mortality and migration) will remain constant throughout the projection period.
3. Methods used in estimating net migration assume that population change not accounted only by fertility and mortality is due to migration.

2.4 Model Variables

One of the most important steps in the projection process is to use demographic variables or demographic components to project population at the local level. The components are fertility, mortality, and migration. The complete component model computes the population at a future point in time by using demographic components data throughout adding the survived population number at a future point in time interval, net migrants of the region during the time interval, and by adding births of local resident and births of net migrants due to the age of mother living into the area. [See Smith et al. (1990)].

The variables of the complete component projection model are discussed in detail in the following points.

2.4.1 Fertility

Fertility is the main factor shaping the population projections since mortality and migration have minimal effect on the size of population

in the future. The projection model which contains fertility must take into consideration the age specific fertility rates (ASFR's) in calculating the number of births for local resident and for migrant persons , and finally add the total births for both local and migrant persons.

In calculating the number of births taking place during the projection horizon , the age specific fertility rates (ASFR's) are used to estimate this number. The rates are multiplied by the number of women in the reproductive years (15 – 49). The results give an annual number of expected births. Then multiplying the annual number of expected births at the projection horizon by the survival rates to obtain the total number of births that take place in the future.

The age specific fertility rate at age(x) is the number of live births per 1000 women in a specific age(x) for a specified geographic area and for a specific period, usually a census year. The ASFR at age(x) denoted by [ASFR(x)] is calculated as:

$$ASFR(x) = \frac{B(x)}{{}_fP(x)} \cdot 1000 \quad (2.2)$$

Where:

$B(x)$: Number of live births to women aged x in the reproductive age groups at the launch year (t_1).

${}_fP(x)$: Number of women aged x in the reproductive age groups at the launch year (t_1).

The sex – ratio at birth (R) is used to find the number of male and female babies born.

The sex ratio denoted by R is the ratio of males to females and it is calculated as follows:

$$R = \left(\frac{M}{F} \right) \cdot 100 \quad (2.3)$$

Where:

M :Number of live male births by age of mother in the reproductive age groups at the launch year (t_1).

F :Number of live female births by age of mother in the reproductive age groups at the launch year (t_1).

Once, the number of male and female births for local resident and for migrant persons has been determined , the results are multiplied by a survival rate to determine the number of babies survive into the future.

2.4.2 Mortality

Mortality like fertility and migration affects the shape of the population and it is considered as an health indicator. So that the projection process must contain the mortality variable, in the absence of this variable the projection process results must be suspicious. The mortality variable is considered in the projection process by using the survivorship ratios for each age class to compute the survived persons taking place during the projection horizon.

The projection model which contains mortality must take into consideration the survival rates.

Survival rates show the probability of surviving from one age (or age group) to another. There are two main approaches to constructing survival rates. One is based on life tables, which are statistical tables summarizing a population's mortality characteristics. The other is based on a comparison of age groups in two consecutive censuses. The first is used much more frequently than the second for places with good vital statistics data, but the second is useful for places lacking such data. Also, the second approach can be very useful when the focus is on population change over time rather than on survival rates [See Smith et al. (2013)].

2.4.2.1 Life Table Survival Rates

The idea behind a period life table lies in summarizing the mortality and survival probabilities observed in a particular population during a particular period of time. In countries with good vital statistics data, life tables provide the most frequently used source of data for calculating survival rates. For population projections, survival rates are often based on 5-year time horizons and 5-year age groups.

Due to the peculiar nature of mortality patterns in the first year of life, the 0 – 4 age group is often split into two groups: less than 1 and 1– 4. Survival rates are calculated separately for each group.

2.4.2.2 Census Survival Rates

The second approach to constructing survival rates does not require age-specific mortality data, making it particularly useful for countries (or regions) lacking vital statistics data. This approach is based on the

formation of ratios between age groups in two consecutive censuses. These ratios are called census survival rates and are calculated as:

$$S(t_0, t_1) = \left(\frac{P_{x+n}(t_1)}{P_x(t_0)} \right) \quad (2.4)$$

Where:

$S(t_0, t_1)$: Survival ratio at the base period

$P_{x+n}(t_1)$: Number of persons at age $(x+n)$ at the launch year

$P_x(t_0)$: Number of persons at age (x) at the base year

Once, the survival rates are available from life tables or from two successive censuses they are multiplied by the population at the launch year to determine the number of persons survive into the future.

2.4.3 Migration

Migration are movements across political or local boundaries that are semi-permanent or permanent in nature [See Becker (2008)].

The migrant is defined as a person who changes his permanent place of residence to another place inside or outside his county. The migration component plays also an important role in shaping the population size and characteristics, especially in attracting societies which considered migration as an important item in the changes in its population size and characteristics. These societies are called open populations for migration. So that, the migration variable must be contained also in the projection process, but its data are not easily to attain by any direct method especially on the local level in developing countries. For this reason this study takes into consideration the indirect methods to compute the net migration number and then the net

migration rates to compute the net migration number to the projection year which called target year to complete the population projection process [See Smith et al. (2013)].

The measurement of net migration data is a difficult task. The effects of migration are paramount in the reliable projection of populations.

There are inherent difficulties in the attempt to develop the net migration number and net migration rates. Initially, a problem arises from poor data, and inadequate records of the migration event, especially at small geographic scales [See Mustafa (1992)].

So that, there are various techniques which are employed to estimate net migration numbers. These techniques are called direct and indirect methods to help in finding the net migration number and the net migration rates. These methods are discussed as follows:

2.4.3.1 Direct Migration Method

The direct measurement of migration can be obtained in basically by a population register which recorded immediate movements of people from area to area and it would create the best migration database. In this case the net migration number can be obtained easily as the number of in-migrants minus the number of out-migrants. Unfortunately, this is only occurs in a developed state where the documents would probably be restricted. In this case the net number of migrants is computed by the following equation[See Mustafa (1992)].

$$NM(t_0, t_1) = IM(t_0, t_1) - OM(t_0, t_1) \quad (2.5)$$

Where:

$NM(t_0, t_1)$: Net migration at the base period

$IM(t_0, t_1)$: In-migration at the base period

$OM(t_0, t_1)$: Out-migration at the base period

Once , the net migration number is available at the base year, the net migration rates are calculated and multiplied by the survived population at the target year to obtain the net migration number at the target year, this is in the case of absence of the net migration rates at the launch year.

2.4.3.2 Indirect Migration Methods

Indirect measurement of migration is also widely used. Basically, depends on such data provided by population censuses and sample surveys. The methods of estimating net migration depends on the accuracy of the available data and the available level of details to them. In general, these methods are the vital statistics and survival ratio methods.

2.4.3.2.1 The Vital Statistics Method

Vital statistics is an indirect way of net migration enumeration. It depends on vital statistics registrations of births and deaths by age and sex between two censuses.

The net migration can be calculated in any region between two successive censuses by using special population equation devoted to this region as follows:

$$NM(t_0, t_1) = P(t_1) - [P(t_0) + NI(t_0, t_1)] \quad (2.6)$$

Where:

$NM(t_0, t_1)$: Net migration at the base period

$P(t_1)$: Population at the launch year

$P(t_0)$: Population at the base year

$NI(t_0, t_1)$: Natural increase at the base period

Also, the net migration can be calculated by using birth and death numbers instead of the natural increase, the accuracy of this method depends on the accuracy of birth and death numbers as follows:

$$NM(t_0, t_1) = P(t_1) - P(t_0) + B(t_0, t_1) - D(t_0, t_1) \quad (2.7)$$

Where:

$B(t_0, t_1)$: Birth numbers at the base period

$D(t_0, t_1)$: Death numbers at the base period

2.4.3.2.2 The Survival Ratio Method

It is often best suited to use the survival ratios to estimate the net number of migrants that occurred between the two successive censuses, instead of using vital statistics to reach the ratio used in estimating the net migration. There are two main types of survival ratio as follows:

2.4.3.2.2.1 Life Table Survival Ratio Method

If a life table describing the average mortality conditions of the intercensal period is available for the particular area, survival ratios may be calculated from it and it is used to estimate net migration number for the area.

2.4.3.2.2.2 Census Survival Ratio Method

Where appropriate life tables are lacking, or where use of life table survival ratios is contra-indicated for other reasons, survival ratios can be computed from census age and sex distributions and are used instead of life table ratios to estimate the net migration number at the base year, then multiplying the expected population at the launch year by net migration rates at the base year to determine the net migrants for the area at the launch year.

A census survival ratio is simply the ratio of the population aged $(x+n)$ in the launch year to the population aged (x) in the base year.

The census survival ratio formula is discussed previously in equation (2.4) as follows:

$$S(t_0, t_1) = \left(\frac{P_{x+n}(t_1)}{P_x(t_0)} \right)$$

The survival ratio may be extracted directly from the life tables or as stated above from the last two successive censuses to the projection horizon. There are three formulas which use the survival ratio technique to calculate the net migration number which are forward formula, backward formula, and average formula which are also discussed as follows [See Mustafa (1992)]:

- 1- Forward Formula
- 2- Backward Formula
- 3- Average Formula

The explanation of each formula is as follows:

2.4.3.2.2.2.1 Forward Formula

The forward formula of indirectly estimating net migration used census survival ratios to calculate the net migration number for the area. The population aged x at the base year is multiplied by the census survival ratios and the result is the expected survivors which are subtracted from the corresponding population enumerated at the launch year to yield estimates of net migration.

The forward formula estimates the number of net migrants at the end of the period and assumes that:

- All migrants takes place at the end of the period.
- All deaths occurs in the community for which the estimates are being prepared, or all deaths are to non-migrants.

One problem is that residents and migrants are moving and dying throughout the period. The forward formula is as follows:

$$NM_x^F(t_0, t_1) = [P_{x+n}(t_1)] - [S(t_0) \cdot P_x(t_0)] \quad (2.8)$$

Where:

$NM_x^F(t_0, t_1)$: The estimated net migration at age (x) at the base period obtained by the forward formula

$P_{x+n}(t_1)$: Number of persons at age ($x+n$) at the launch year

$P_x(t_0)$: Number of persons at age (x) at the base year

$S(t_0)$: Census survival ratio from the base year

2.4.3.2.2.2.2 Backward Formula

The backward formula use the same concepts of census survival ratios to estimate the net migration. This method assumes that deaths occurs to people after they migrate, and it produces more net migrants. The differences are greatest at the older ages, where mortality is highest. The backward formula is as follows:

$$NM_x^B(t_0, t_1) = \frac{P_{x+n}(t_1)}{S(t_0)} - P_x(t_0) \quad (2.9)$$

Where:

$NM_x^B(t_0, t_1)$: The estimated net migration at age (x) at the base period obtained by the backward formula

2.4.3.2.2.2.3 Average Formula

The average formula is the mean of forward and backward formula to estimate the net migration, this formula depends on taking the average of both forward and backward formula to avoid any deficiencies in the two previous formulas as follows:

$$\therefore NM_x^A(t_0, t_1) = \left(\frac{1 + S(t_0)}{2S(t_0)} \right) [P_{x+n}(t_1) - S(t_0) \cdot P_x(t_0)] \quad (2.10)$$

Where:

$NM_x^A(t_0, t_1)$: The estimated net migration at age (x) at the base period obtained by the average formula

Once, the net migration number is available at the base year by any of the discussed direct or indirect methods, the net migration rates are calculated and multiplied by the survived population at the target year to obtain the net migration number at the target year, this is in the case of the absence of the net migration rates at the launch year.

The internal migration rates , out migration rates, and net migration rates are calculated as follows:

$$\bullet \text{IMR}(t_0, t_1) = \frac{I(t_0, t_1)}{\left(\frac{P(t_0) + P(t_1)}{2}\right)} \cdot 100 \quad (2.11)$$

where:

$\text{IMR}(t_0, t_1)$: Internal migration rate at the base period

$I(t_0, t_1)$: Internal migration number to the region at the base period

$\left(\frac{P(t_0) + P(t_1)}{2}\right)$: Estimated total population number in the mid of the base period

$$\bullet \text{OMR}(t_0, t_1) = \frac{O(t_0, t_1)}{\left(\frac{P(t_0) + P(t_1)}{2}\right)} \cdot 100 \quad (2.12)$$

where:

$\text{OMR}(t_0, t_1)$: Out- migration rate at the base period

$O(t_0, t_1)$: Out- migration number from the region at the base period

$$\bullet \text{NMR}(t_0, t_1) = \frac{NM(t_0, t_1)}{\left(\frac{P(t_0) + P(t_1)}{2}\right)} \cdot 100 \quad (2.13)$$

where:

$\text{NMR}(t_0, t_1)$: Net migration rate at the base period

$NM(t_0, t_1)$: Net migration number at the base period

Finally, it is important to notice that the best calculation of net migration number in a population projections is considered by the average formula to avoid the shortage in forward and backward formula as stated earlier. Also, the average formula is chosen for calculating the internal net migration data as an indirect method because as stated previously the results of this method are reasonably and accepted in estimating the number of internal net migration numbers and rates in subareas.

2.5 Model Design

This section is devoted to clarify the framework of the suggested model of the three demographic components which are mortality, net migration, and fertility. Most applications of this method divide the population into age –sex groups and project the components of growth separately for each group. The population can be further subdivided by other demographic characteristics such as race.

For several reasons, it is useful to distinguish among the components of population change when producing population projections. First, such distinctions enable us to account separately for the demographic causes of population change. Is an area changing primarily because of natural increase or net migration, is an area attracting for people or not attracting for people, is the birth rate unusually high or the death rate unusually low, if a population is aging rapidly, is it because older people are moving in or younger people are moving out. Making these distinctions is the first step in gaining insight into why some areas are growing more rapidly than others and how the three demographic composition change the characteristics and size of an area.

Second, each component of change responds differently to changes in economic, social, political, cultural, medical, environmental, and other factors. For example, medical advances lead to greater life expectancies but have little impact on migration, whereas changing employment conditions have a substantial impact on migration but little impact on life expectancies. Developing an understanding of non-

demographic causes of population change requires that population change be broken down into its individual components.

Furthermore, the behavior of each component of change varies among places and follows different trends over time. In one area, for example, the number of births may be increasing and the number of deaths declining, while in another area the opposite is occurring. In-migrants may exceed out-migrants in one place while out-migrants exceed in-migrants in another. Separating the components projections of change enables the analyst to account for these differences when developing assumptions about future population trends.

The complete component projection model is based on the idea of the traditional demographic balancing equation as follows:

$$P(t_2) = P(t_1) + B(t_1, t_2) - D(t_1, t_2) + IM(t_1, t_2) - OM(t_1, t_2) \quad (2.14)$$

where:

$P(t_2)$: Projected population at the target year at the end of the projection horizon

$P(t_1)$: Population at the launch year in the beginning of the projection horizon

$B(t_1, t_2)$: Births during the projection horizon

$D(t_1, t_2)$: Deaths during the projection horizon

$IM(t_1, t_2)$: In-migration during the projection horizon

$OM(t_1, t_2)$: Out-migration during the projection horizon

Equation (2.14) can be used to estimate the population at the target year t_2 if we have an accurate population count in a census year, $P(t_1)$, and reliable data on births, deaths, and in and out migration.

If equation (2.14) is computed from actual data, the two sides may not be equal due to errors in the component data, especially in the absence of direct migration data in undeveloped countries which not possess a continuous migration records whether on the state or local level.

So that, the population projection is accomplished through separate projections for each of the three demographic components which form the components of the suggested complete component projection model as follows:

2.5.1 Mortality Projection

The first step in the projection process is to calculate the number of persons surviving to the end of the projection horizon.

Mortality is the process by which deaths occur in a population. The mortality can be considered by the survived population at the target year which means that all the deaths are subtracted directly from the population at the launch year. This is accomplished by the multiplication of the population at the launch year by the survival rates. So that, the projection of mortality in the complete component projection model can be obtained as follows:

$$\hat{P}(t_2) = P(t_1) \cdot S(t_1) \tag{2.15}$$

Where:

$\hat{P}(t_2)$: Expected or survived population at the target year

$P(t_1)$: Population at the launch year

$S(t_1)$: Survival rates at the launch year

2.5.2 Migration Projection

The second step in the projection process is to project migration during the projection horizon.

Migration is the process of changing one's place of residence from one geographic area to another. The projection of net migration in the complete component projection model in the future is considered by multiplying the survived population at the target year by the calculated net migration rates at the base period as follows:

$$NM(t_2) = \hat{P}(t_2) \cdot NMR(t_0, t_1) \quad (2.16)$$

Where:

$NM(t_2)$: Net migrants at the target year

$\hat{P}(t_2)$: Expected or survived population at the target year

$NMR(t_0, t_1)$: Net migration rate at the base period

The net migration rate is calculated by equation (2.13).

2.5.3 Fertility Projection

The third step in the projection process is to project the number of births occurring at the target year and during the projection horizon.

Fertility is the occurrence of live births. The calculation of the fertility variable in the complete component projection model is considered by computing births for net migrants and local residents at the target year and during the projection horizon. The first age class from (0 – 4) in the projection process is considered by the summation of births at the target year plus survived births at the end of the projection horizon which is the survived births between the launch year and the target year as follows:

Births for net migrants at the target year are calculated through multiplying the ASFR's in the reproductive age groups at the launch year by the estimated number of female migrants by age in the reproductive age groups at the target year.

$${}_{NM}B(x, t_2) = \left[\hat{NM}(x, t_2) \times (\text{ASFR's}) \right] \quad (2.17)$$

Where:

${}_{NM}B(x, t_2)$: Births of net migrants at the end of the projection horizon

$\hat{NM}(x, t_2)$: Net migrants of females in the reproductive age groups at the target year

Births for local residents at the target year are calculated through multiplying the ASFR's in the reproductive age groups at the launch year by the estimated number of female residents by age in the reproductive age groups at the target year.

$${}_LB(x, t_2) = \left[{}_F\hat{P}(x, t_2) \times (\text{ASFR's}) \right] \quad (2.18)$$

Where:

${}_LB(x, t_2)$: Births of local residents at the end of the projection horizon

${}_F\hat{P}(x, t_2)$: Expected Local female residents in the reproductive age groups at the target year

Aggregation of migrant and local births to obtain the total births at the target year as follows:

Births for all subgroups are summed by age of mother from (15 – 49)

$$B(x, t_2) = [{}_LB(x, t_2) + {}_{NM}B(x, t_2)] \quad (2.19)$$

Male births are calculated by the age of mother from (15 – 49) as follows:

$${}_mB(x, t_2) = [B(x, t_2) \cdot (R)] \quad (2.20)$$

Where R is a sex ratio and it is calculated by equation (2.3).

Male births are summed by age of mother in the reproductive age groups to obtain the total number of male births

$${}_m B(t_2) = \sum_{x=15}^{49} {}_m B(x, t_2) \quad (2.21)$$

Female births are derived from the total births and male births as follows:

$${}_f B(x, t_2) = [B(x, t_2) - {}_m B(x, t_2)] \quad (2.22)$$

Female births are summed by age of mother in the reproductive age groups to obtain the total number of female births

$${}_f B(t_2) = \sum_{x=15}^{49} {}_f B(x, t_2) \quad (2.23)$$

After obtaining the male and female births at the target year for all subgroups as stated above equation (2.19) can be rewritten as follows:

$$B(t_2) = [{}_m B(t_2) + {}_f B(t_2)] \quad (2.24)$$

Survived births for both males and females by the age of mother in the reproductive age groups at the end of the projection horizon which they are added to the target year male and female births are calculated respectively as follows:

$${}_m B'(x, t_1, t_2) = \left[\sum_{x=15}^{49} {}_m B(x, t_1, t_2) \cdot S(t_1) \right] \quad (2.25)$$

Where:

$B'(x, t_1, t_2)$: Survived male births between the launch year and the target year.

${}_m B(x, t_1, t_2)$: Male births between the launch year and the target year by age of mother (15-49).

$S(t_1)$: Survival male rate at age zero at the launch year.

$${}_f B'(x, t_1, t_2) = \left[\sum_{x=15}^{49} {}_f B(x, t_1, t_2) \cdot S(t_1) \right] \quad (2.26)$$

Where:

$B'(x, t_1, t_2)$: Survived female births between the launch year and the target year.

${}_f B(x, t_1, t_2)$: Female births between the launch year and the target year by age of mother (15-49).

$S(t_1)$: Survival female rate at age zero at the launch year.

All survived male and female births through the projection horizon which they are added to the target year 1st age class from (0-4) are calculated as follows:

$$B'(t_1, t_2) = [{}_m B'(t_1, t_2) + {}_f B'(t_1, t_2)] \quad (2.27)$$

Total survived population births at the first age class (0-4) at the end of the projection horizon are the summation of the target year male and female births plus all survived male and female births through the projection horizon as follows:

$$B''(t_2) = [B(t_2) + B'(t_1, t_2)] \quad (2.28)$$

The projected population at the target year $\hat{P}(t_2)$ is the final result of the three components of the suggested model and it is calculated as follows:

$$\hat{P}(t_2) = \left[\hat{P}(t_2) + NM(t_2) + B''(x, t_2) \right] \quad (2.29)$$

Where:

$\hat{P}(t_2)$: Projected population at the target year

$\hat{P}(t_2)$: Expected or survived population at the target year

$NM(t_2)$: Net migrants at the end of the target year

$B''(x, t_2)$: Total population births in the first age class (0 – 4) at the end of the target year

2.6 Model Extensions

This section is devoted to clarify some of the different approaches which can be used as an extension of the fertility and mortality variables in the complete component projection model.

2.6.1 Mortality Extension

In the present study, it is assumed that, the present mortality rates will continue unchanged. This assumption of constant rates is reasonable for short projection horizons of 5 or 10 years. For longer horizons, this assumption may not be reasonable. Many approaches can be used for projecting mortality and survival rates, such as: targeting, trend extrapolation, cause-delay, and synthetic projection [See Smith et al. (2013)].

2.6.1.1 Targeting

The targeting approach is based on the assumption that mortality rates in the population to be projected will gradually converge toward those observed in another population (i.e., the target). A target population is chosen which provides a set of mortality rates believed to be realistic for the population to be projected. This choice is based on similarities in socioeconomic, cultural, and behavioral characteristics; levels of medical technology; primary causes of death; and similar factors [See Olshansky (1988)].

2.6.1.2 Trend Extrapolation

Trend extrapolation techniques assume that, the future will be similar to the past in several important ways. Mortality and survival rates can also be projected by extrapolating historical trends. This is

not always a valid assumption. More recent sets of national projections have also extrapolated recent trends, but have projected that, mortality rates will converge toward a set of survival rates based on expert judgment. Extrapolation trend techniques which use time series models are used much more frequently for national projections than for state and local projections [See Hollmann et al. (2000), U. S. Census Bureau (2008, 2012)].

2.6.1.3 Cause-Delay

Cause-delay models focus on the implications of delaying (or completely eliminating) the occurrence of one or more causes of death [See Manton et al. (1980) and Olshansky (1987)].

The basic premise behind this approach is that changes in lifestyle and medical technology have delayed the occurrence of various types of deaths until progressively older ages. Cause-delay models are often operationalized by assuming that cause-specific mortality rates for one age group in a population will gradually move toward those currently found in a younger age group in the same population.

Cause-delay models are similar to targeting models in that, one set of mortality rates gradually converges toward another. They differ in that, the target population in cause-delay models is a younger cohort in the same population rather than the same cohort in a different population. An advantage of cause-delay models compared to targeting models is that by staying within the same population, cause-delay models control for many factors that cause mortality rates to differ from one population to another. The primary issue in applying cause-delay models is deciding what causes of death to focus on and how rapidly

mortality rates for one cohort will move toward those currently found in another cohort.

2.6.1.4 Synthetic Projection

The synthetic approach can be applied using either survival rates or mortality rates. Some demographers use a synthetic approach tying projected changes in county (small area) survival rates to projected changes in state (large area) survival rates [For more details see Chapter 4].

2.6.2 Fertility Extension

Births in the complete component model can be projected by applying projected ASFR's to the projected female population by age. Many approaches can be used for projecting births, such as: targeting, trend extrapolation, and synthetic projection [See Smith et al. (2013)].

2.6.2.1 Targeting

The targeting approach is based on the assumption that birth rates in the population to be projected will converge over time toward those found in another population (i.e., the target). The target rates can be those currently observed in the target population, rates projected for some future point in time, or rates based on the application of expert judgment. This approach is similar to the targeting approach for mortality rates. The targeting approach can be implemented by forming ratios of current birth rates in the areas to be projected to current birth rates in the target population. For any given set of projections, the analyst must make a judgment call regarding whether the convergence of age-specific birth rates among geographic areas is a reasonable assumption.

2.6.2.2 Trend Extrapolation

Another approach is based on the extrapolation of historical trends. This approach will be useful when birth rates have been changing in a systematic manner and are expected to continue to change systematically in the future. Extrapolation techniques will be risky, of course, when no long-run trends are discernible or when there is no firm basis for forecasting turning points.

2.6.2.3 Synthetic Projection

Synthetic birth rates can be created by forming ratios of birth rates in one area to those in another and applying those ratios to the birth rates projected for the second area (called the model population). [For more details see Chapter 4].

In the present study, it is assumed that, the ASFR's in Qalyobia Governorate will converge over time toward these found in the complete component projection model.

CHAPTER 3

MODEL APPLICATION AND RESULTS

3.1 Introduction

This chapter is an application to the suggested complete component projection model in chapter two on Qalyobia Governorate in the state of Egypt as an example of detailed local population projection.

The projection in this study is implemented by the complete component projection model where a separate projection for each component [mortality, net migration and fertility] is carried out to clarify the importance of each component in changing the characteristics and size of the Qalyobia Governorate. Also, to know the real population numbers of this Governorate without excess or negligence to help in effective regional planning.

The local projection for Qalyobia Governorate is implemented through two stages, the 1st stage at year 2011 and the 2nd stage at year 2016.

To achieve the ultimate goal of this study which is the detailed local population projections for Qalyobia Governorate, a brief introduction about the general characteristics of this Governorate, and the required data and rates are discussed.

This chapter consists of four sections. Section (3.1) is an introduction. In Section (3.2) the general characteristics of Qalyobia Governorate are discussed. Section (3.3) is devoted to model application. In section (3.4) the model accuracy is studied.

3.2 General Characteristics of Qalyobia Governorate

Qalyobia is a northern Governorate, located east of the Rosetta branch of the Nile at the head of the delta, a fact that made it instrumental in regulating irrigation to all northern Governorates by virtue of its containing the three major inland waterways (rayyah) at the El- Kanater El-Khairia Barrages to the east and to the west of the delta. Also, the location of the Governorate puts it at the transportation crossroads to all northern and southern Governorates.

Qalyobia is bounded from the north by the Dakahlia governorate, from the northeast by the Sharqia governorate, from the south by the Cairo and Giza governorates across by the Ismailia waterway, from the east and southeast by the Sharqia and Cairo governorates, from the west by Monufia governorate, and from the southwest by Giza governorate. The governorate contains seven districts "markaz", nine cities, two boroughs "hai" and 46 local village units, with 195 satellite villages and 901 hamlets "ezbah" and "kafr" [See Egypt Description, IDSC, Cabinet of Ministers (2002)].

The total area of the Qalyobia Governorate is 1,124 square kilometers. The land uses of this area includes 110.13 square kilometers for housing and open space, 65.45 square kilometers for public utilization and cemeteries, 807.23 square kilometers within the demarcated registry "Zimam" and 88.89 square kilometers outside of the demarcated registry "Zimam" for agricultural use, 51.28 square kilometers for factories and parks, and 1.02 square kilometers are fallow [See Qalyobia Human Development Report (2003)].

The Qalyobia Governorate is considered an important industrial center, by virtue of its four main industrial establishments in Shubra El-Khaima, El-Khanka, Banha, and Qalyob as follows:

- Shubra El-Khaima has industries of spinning and weaving, pottery , ceramics, glass ,crystal, rubber, modern chemicals, paper, and electric appliances (for example, electric generation, petrochemical generation, and petrochemical refineries).
- El-Khanka has industries of medicine, fertilizers, metallurgy, and chemical industries.
- Banha has industries of electronics, leather, shoes, food processing, and perfumes.
- Qalyob has industries of automotives, iron and steel, spinning and weaving, minerals and chemicals, and food processing.

The Qalyobia Governorate is distinguished for its superior production of vegetables, fruits, particularly citrus, sugar cane, bananas, and peaches. Thus, the Governorate has a concentration of fruit processing industries. There is also an elaborate animal and poultry production in the Governorate, contributing to the establishment of many related industries, such as slaughter houses and meat processing, as well as egg production farms (e.g., in Kafr Shukr). In addition, the prevalence of mulberry trees in the Governorate led to the establishment of a silkworm industry and silk weaving (e.g., in Qaha) [See Qalyobia Human Development Report (2003)].

Qalyobia future vision of human development is built on the current human development realities and the prevailing gaps and disparities at all levels of the Governorate.

According to Egypt 2001 human development index, Qalyobia Governorate comes in the 9th position in the ranking of Egyptian Governorates. The governorate's human development index increased from 0.660 in 1998 to 0.690 in 2001, which is seen as an improvement on the human development index scale.

Furthermore, the human development index is an indicator of development level, which is calculated at different administrative levels, namely, markaz, cities, and villages. It also provides important information on the gaps and disparities among and within the different administrative units in the Governorate. It is necessary, therefore, to measure and monitor and analyze these disparities to help develop plans and policies that ensure equality of distribution and balanced development interventions throughout the Governorate.

Before ending the basic features of the Qalyobia Governorate it must be noted that the Governorate faces problems in healthcare and education as follows:

There is no doubt that any improvement in healthcare services will be reflected in better health conditions, which in turn improves the human development index. It is noticed, however, that there is a low human development index in life expectancy at birth which is equal to 0.694 according to the Central Agency for Public Mobilization and Statistics in year 2013 in the governorate compared to other

Governorates. The 2000 National Human Development Report (NHDR) also shows that the rate of mothers receiving prenatal health care is 38.5% in rural areas, as compared to 61.0% in urban areas. The differences in these rates have implications on the effect of the lack of healthcare for pregnant women and their fetuses in many rural areas. Also, according to the 2000 NHDR, the rate of mothers delivering under medical supervision was 34.6% in rural areas as opposed to 69.8% in urban areas, attesting to the gap between rural and urban areas in healthcare.

Human development index values also show a low level of health services provided in the Governorate in general and rural areas in particular. There is a lower human development index of doctor and hospital bed rates and other medical services, which requires intensive efforts to establish new hospitals and medical units, and to reinforce a fair geographical distribution of the doctors between cities, markaz, and villages of the Governorate. This will help establish a realistic balance in providing medical and preventive treatment services all over the Governorate.

The second problem, in this Governorate is related to the education human development index value of 0.696 at the Governorate level which is considered higher than the national value of 0.682. This clearly reflects a clear and plausible improvement in the educational status in the Governorate. However, there are wide disparities in the value of this index within the governorate itself that must be considered in order improve the educational level in all areas of the

Governorate, be it rural or urban [See Qalyobia Human Development Report (2003)].

As stated in Human Development Report, (2003) the Qalyobia Governorate occupies the 9th position in the general ranking between the twenty seven Governorates in Egypt in development. This is not commensurate with the Governorate that occupies the fourth place and third place in attracting population as stated in Mustafa and El-Rouby in 1992 and in the central agency for public mobilization and statistics in 2008.

From all the stated above, we hope that this study is a real and effective contribution to the solution of the Qalyobia problems, through a trial to make local population projection to this Governorate. This can be done by implementing future projections for each of mortality, migration and, fertility component to determine the required massive future services in all aspects of life in this important Governorate in the state of Egypt.

3.3 Model Application

This section is devoted to clarify the application of the complete component projection model on Qalyobia Governorate in the state of Egypt as an example of the local population projection through the three demographic components which are mortality, migration, and fertility.

In order to make the local population projection in the present study, consider the following:

- The base year is 1996
- The launch year is 2006
- The target year is 2016
- The base period from 1996 up to 2006
- The projection horizon from 2006 up to 2016

The projection is made for each five years separately i.e., from year 2006 up to year 2011, then from year 2011 up to year 2016.

First of all, the population projections for each of the three demographic components for each five-year interval are created by applying the survival rates to the launch year population, adding net migration for each age and sex groups and finally adding births by sex and mother's age, as tabulated below:

Component	Projection
Mortality	Survived population by age and sex
Migration	Net migration by age and sex
Fertility	Births by sex and mother's age

This section consists of four sub-sections. Sub-Section (3.3.1) is devoted to clarify the mortality component. Sub-Section (3.3.2) is devoted to clarify the migration component. Sub-Section (3.3.3) is devoted to clarify the fertility component. Sub-Section (3.3.4) is devoted to the final results of the considered projection stages.

In each sub-section the main equation which is used in the projection of each component [mortality, migration , and fertility], the required data for the equation, the differentiation between the available and calculated data, the accuracy of the available data, and the treatment of the available data if it is necessary are discussed.

3.3.1 Mortality

- Equation:

The survived population at t_2 is calculated using equation (2.15) as follows:

$$\hat{P}(t_2) = P(t_1) \cdot S(t_1)$$

- Required Data:

- 1- The observed distribution of the population by age and sex of Qalyobia at the launch year 2006, $P(t_1)$.
- 2- Male and female survivorship ratio, $S(t_1)$, at the launch year 2006.

- Available Data:

- 1- The observed distribution of the population by age and sex of Qalyobia at year 2006, $P(t_{2006})$ which can be shown in table (1) in Appendix A.
- 2- Male life table survivorship ratio, $S(t_{2006})$, at the year 2006 which is extracted from Cairo Demographic Center life tables for Egypt governorate projections which can be used approximately in the present study and is shown in column (3) in table (2) in Appendix A.
- 3- Female life table survivorship ratio, $S(t_{2006})$, at the year 2006 which is extracted from Cairo Demographic Center life tables for Egypt governorate projections which can be used approximately in the present study and is shown in column (3) in table (3) in Appendix A.

- Accuracy of the Available Data:

This part is devoted to some procedures which must be implemented on the available observed age and sex distribution data of Qalyobia

Governorate at the launch year 2006. These procedures are related to verify the accuracy of the observed data which is used in the complete component projection model. This verification process includes evaluating the data with respect to coverage errors and content errors to show whether the available data are free from these errors or the available data requires adjustment and then smoothing to be valid.

1-Evaluating Qalyobia Launch Year Data for Coverage Errors

Qalyobia launch year data is evaluated with respect to coverage errors using two measures :Internal and external comparisons as follows:

Internal comparison of evaluating the census data coverage errors to Qalyobia Governorate at the launch year 2006 can be attained by using the sex ratio formula for the total population as follows [See Shryock et al. (1976), US Bureau of the Census (1985), Fosu (2001)]:

*Sex ratio for the total population of Qalyobia 2006 census is calculated

as:
$$R = \left(\frac{\text{total number of males at 2006}}{\text{total number of females at 2006}} \right) \cdot 100 = \left(\frac{2187288}{2064384} \right) \cdot 100 = 106 \%$$

This ratio 106% means that there are small coverage error as over counting in males or undercounting in females for Qalyobia governorate 2006 census data because the limit of this ratio is between 95% and 105%, but the difference in the calculated ratio (1%) may be accepted for the coverage of 2006 data ,and this data can be used in the complete component projection model without suspicion in the absence of another evaluating criteria.

But, it must be noted that there are another criterion to evaluate the coverage error in the population census data which is called "External Comparisons" using two approaches. The first approach by using

population balancing equation which is conditioned by the availability of the total number of births, deaths, and net migration data, and the second approach by using another equation about the current and previous Governorate of residence which is conditioned by the availability of the current and previous Governorate of residence.

- Qalyobia Governorate balancing equation gives the total population at 2006 as follows:

$$P_{2006} = P_{1996} + B(t_{1996}, t_{2006}) - D(t_{1996}, t_{2006}) + IM(t_{1996}, t_{2006}) - OM(t_{1996}, t_{2006})$$

Using tables (4),(5),(6),(7a), and (7b) in Appendix A, the total population at 2006 is given by:

$$P_{2006} = 3301240 + 1005125 - 223110 + 611287 - 110750 = 4583792$$

This total number of Qalyobia is over counted since the observed total number is equal to 4251672. So that, it must be at least another source to make a comparison.

- Qalyobia data due to the current and previous Governorate of residence also gives the total population number as follows:

$$P_{2006} = \text{People not leaved the Qalyobia until 2006} + IM(t_{1996}, t_{2006}) - OM(t_{1996}, t_{2006})$$

Using tables (7c),(7a), and (7b) in the Appendix A, the total population number at 2006 is given by:

$$P_{2006} = 3629842 + 611287 - 110750 = 4130379$$

This total number of Qalyobia is under counted since the observed total number equals 4251672. So that, comparisons must be done using the three numbers to reach to the adjusted number about the launch year at 2006.

To achieve this aim the net coverage error rate formula can be used which is an important indicator of the quality of census coverage, and it is considered as a measure of the shortage in counting as follows [See Dauphin and Canamucio (1993)]:

$$\text{Net Coverage Error Rate} = \left(\frac{* \text{Corrected Number at 2006} - \text{Observed Number at 2006}}{* \text{Corrected Number at 2006}} \right) \cdot 100$$

* Where the corrected number at 2006 is calculated as a mean of 4583792 and 4130379 as over and under counting for Qalyobia at 2006 as follows:

$$\text{Net Coverage Error Rate} = \left(\frac{\frac{4583792 + 4130379}{2} - 4251672}{\frac{4583792 + 4130379}{2}} \right) \cdot 100 = 2.42\% \approx 2\%$$

The shortage in counting is approximately equal to 2% is used to adjust the observed data at the launch year to achieve a good accuracy to the data used in the complete component projection model, and the adjusted data are stated later in the calculated data section.

2-Evaluating Qalyobia Launch Year Data for Content Errors

Evaluating data content errors can be achieved by different methods such as: sex ratio analysis , age ratio analysis , and United Nations secretaries index. In the present study sex ratio analysis is used as a direct indicator about the content errors.

The sex ratio of any society takes a consistent pattern ranging between two values 104 and 107 at birth in the case of normal situations of any country, and then it takes to decrease gradually until the value of 100 in the middle ages, then it continues in decreasing gradually till older ages, which is the results of higher death rates for

males than for females in older ages. Sex ratio and the deviation values from 100 in the launch year data are shown in table (1) in Appendix B.

The analysis of sex ratio for the launch year shows that, there are errors in the data content based on the registered deviations from 100%, and these errors must be smoothed by the suitable method as follows:

- Calculated Data

This part is devoted to clarify the calculated data of the Qalyobia governorate as adjusted, and smoothed data for the launch year 2006 which can be used in the complete component projection model as follows:

1- Adjustment of Qalyobia Launch Year Data with Respect to Coverage Errors

The previous analysis shows that Qalyobia Governorate suffers from under estimation by 2%. This under estimation is corrected using the percentage $(\frac{102}{100})$.

The adjusted age and sex distribution at the launch year 2006 for Qalyobia Governorate is shown in table (2) in Appendix B.

2- Smoothing Qalyobia Launch Year Data with Respect to Contents Errors

This part is devoted to clarify the methods that can be used in smoothing the Qalyobia observed data at the launch year 2006 from content errors.

There are five different methods that are used in smoothing age and sex data from content errors which are the main data used in the present study.

These smoothing methods are: Carrier-Farrag, Karup-King Newton, United Nations, Arriaga, and Strong formula. For each method, the smoothing is done separately for each sex, but the extent of the use of any of these methods depends on the available data. The strong formula is used for smoothing the ages in the interval 10-69 and Arriaga formula is used to divide the ten age groups to five age groups. Since the strong formula is valid only for the age groups 10-69, Arriaga formula is used for smoothing the other groups. For all age groups 0-75+ including the first age group 0-9 and the last age group 70+ , the Arriaga formula is used to divide the ten age groups to five age groups. A detailed illustration is given in columns (3) and (4) in table (1) and column (5) in table (2) in Appendix C [See Arriaga et al.(1994)].

The adjusted age and sex distribution which is used in the local population projection for Qalyobia is smoothed using Strong formula through PAS computer package program.

Strong formula and Arriaga process in smoothing data is illustrated as follows:

The Strong formula for the age interval 10-69 is:

$${}_{10}P_x = \left({}_{10}P_{x-10} + 2{}_{10}P_x + {}_{10}P_{x+10} \right) / 4 \Big) \text{Classes}(10 - 69)$$

Arriaga formula for all age groups is as follows:

For the first age group at ($x = 0$)

$${}_5P_{X+5} = \left(8 {}_{10}P_X + 5 {}_{10}P_{X+10} - {}_{10}P_{X+20}\right) / 24 \text{ Classes}(0-4), (5-9)$$

$${}_5P_X = \left({}_{10}P_X - {}_5P_{X+5}\right)$$

For the last age group at ($x = 70$)

$${}_5P_X = \left(8 {}_{10}P_X + 5 {}_{10}P_{X-10} - {}_{10}P_{X-20}\right) / 24 \text{ Classes}(70-74), (75+)$$

$${}_5P_{X+5} = \left({}_{10}P_X - {}_5P_X\right)$$

For the other age groups at ($x = 10, 20, 30, 40, 50, 60$)

$${}_5P_{X+5} = \left(11 {}_{10}P_X + 2 {}_{10}P_{X+10} - {}_{10}P_{X-10}\right) / 24 \text{ Classes}(10-14), (60-69)$$

$${}_5P_X = \left({}_{10}P_X - {}_5P_{X+5}\right)$$

Where:

${}_5P_{X+5}$: Population number in the age class from ($X + 5$) till ($X + 9$)

${}_{10}P_X$: Population number in the age class from X till ($X + 9$)

${}_5P_X$: Population number in the age class from X till ($X + 4$)

${}_{10}P_{X-10}$: Population number in the age class from ($X - 10$) till ($X - 1$)

${}_{10}P_{X+10}$: Population number in the age class from ($X + 10$) till ($X + 19$)

${}_{10}P_{X-20}$: The prior of ${}_{10}P_{X-10}$

${}_{10}P_{X+20}$: The posterior of ${}_{10}P_{X+10}$

Smoothed age and sex distribution at the launch year 2006 for local and migrant residents in Qalyobia Governorate using Strong formula is illustrated in table (3.1) using PAS computer package program.

Table (3.1):Smoothed Age and Sex Distribution for Qalyobia at the Launch Year 2006

Ages	Male	Female	Total
0-4	245910	231411	477321
5-9	242882	231093	473975
10-14	238727	229518	468245
15-19	228930	221662	450592
20-24	219167	214772	433939
25-29	200280	194937	395217
30-34	176400	167726	344126
35-39	153835	143713	297548
40-44	130124	118382	248506
45-49	109331	98110	207441
50-54	89281	79682	168963
55-59	70811	62659	133470
60-64	51819	44900	96719
65-69	37133	32384	69517
70-74	23995	21742	45737
75+	12405	12973	25378
Σ	2231029	2105664	4336693

Source: Researcher calculations for Qalyobia smoothed data at year 2006.

The accuracy of Carrier-Farrag, Karup-King Newton, United Nations, Arriaga, and Strong formula is studied and it is found that the best method according to the United Nations Secretariat index is the Strong formula [See Table (3.2)].

The accuracy of the smoothed 2006 Qalyobia census data using Strong formula can be determined using the United Nations Secretariat index.

In 1952 the United Nations supposed a measure to determine the accuracy of the age and sex data which is called the Secretariat index of the United Nations. This measure is calculated for both sexes in five year age groups using sex and age ratio. The United Nations Secretariat

index is calculated as follows [See United Nations (1955) Manual II, NO.23 , Hussein (1997)]:

1- Calculate the age and sex ratio as follows:

$$*_5AR_X = \frac{{}_5P_X}{\left(\frac{{}_5P_{X-5} + {}_5P_{X+5}}{2}\right)} \cdot 100$$

Where:

${}_5AR_X$:The age ratio in the age class (X) till (X + 4)

${}_5P_X$:Population number in the age class from X till (X + 4)

${}_5P_{X-5}$:The population number in the age class prior of ${}_5P_X$

${}_5P_{X+5}$:The population number in the age class posterior of ${}_5P_X$

$$*_5SR_X = \frac{{}_5MP_X}{{}_5FP_X} \cdot 100$$

Where:

${}_5SR_X$: The sex ratio in the age class (X) till (X + 4)

${}_5MP_X$:Male population in the age class from X till (X + 4)

${}_5FP_X$:Female population in the age class from X till (X + 4)

2- Calculate the successive differences in the sex ratio (i.e. the differences between the selected age group and the previous one), then the sum of the absolute differences is used to calculate the average of these differences to get the sex ratio score (SRS).

3- Calculate the deviations from 100 in the age ratio, then the sum of the absolute differences is used to calculate the average of these differences to get the male and female age ratio scores denoted by (MARS) ,and (FARS) respectively.

4- Calculate the United Nations Secretariat Age–Sex Accuracy index as follows:

$$\text{Age-Sex Accuracy index} = [3(\text{SRS}) + \text{MARS} + \text{FARS}]$$

The values of the Age-Sex Accuracy index can be determined by the following criteria:

- 1- A high accurate of the age and sex distribution when the index value is less than 20.
- 2- Inaccurate of the age and sex distribution when the index value is between 20 and 40
- 3- Highly inaccurate age and sex distribution when the index value is greater than 40.

The calculated United Nations Accuracy index for the different methods is shown in table (3.2). It is found from table (3.2) that there is an improvement in the smoothed distribution of age and sex at launch year 2006, where the value of United Nations Secretariat index is equal to 21.39 before smoothing, and dropped to 7.13 after smoothing, this is an indicator to a great improvement in data. So that, the smoothed distribution of the 2006 age and sex data can be used in the complete component projection model as a launch year with a high precision.

Table (3.2): Summary of the Indices Measuring the Accuracy of Data

Index	Smoothed					
	Adjusted	Carrier Farrag	K-King Newton	Arriaga	United Nations	Strong
^a Sex Ratio Score (SRS)	4.03	3.52	3.46	3.31	3.69	1.46
^b Male Age Ratio Score (MARS)	3.12	3.24	3.17	3.38	2.12	1.08
^c Female Age Ratio Score (FARS)	6.17	5.57	5.43	5.63	4.15	1.67
^d Accuracy Index	21.39	19.83	18.99	18.93	17.34	7.13

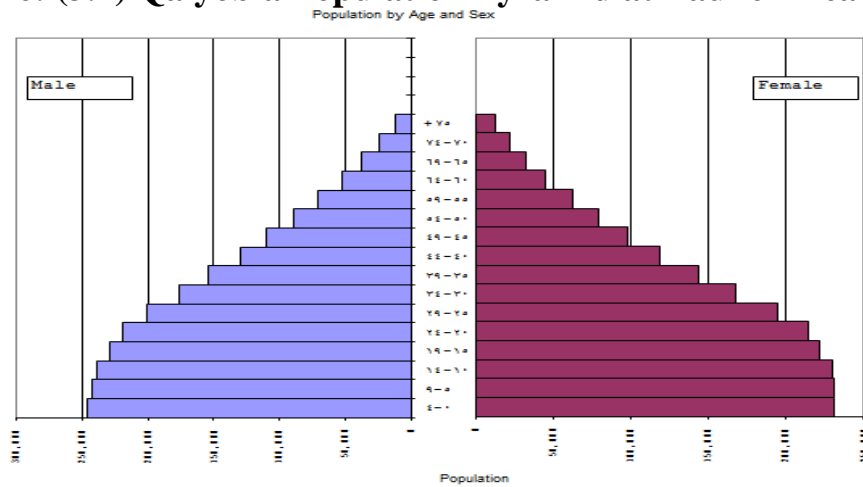
Source :Researcher calculations.

^aData in table (3b) in Appendix B, ^{b,c}Data in table (3d) in Appendix B

^dAge - Sex Accuracy index = [3(SRS) + MARS + FARS]

The population pyramid for the smoothed Qalyobia in 2006 is drawn in figure (3.1). The following relatively symmetrical population pyramid is an evidence about the accuracy of the Qalyobia Governorate smoothed distribution of the population by age and sex at year 2006 and this distribution is ready for using in the complete component model.

Figure: (3.1) Qalyobia Population Pyramid at Launch Year 2006



3.3.2 Migration

- Equation:

The survived migrant population at t_2 is calculated using equation (2.16) as follows:

$$NM(t_2) = \hat{P}(t_2) \cdot NMR(t_0, t_1)$$

- Required Data:

- 1- The observed distribution of population by age and sex groups at the base year 1996 $P(t_0)$.
- 2- The observed distribution of population by age and sex groups at the launch year 2006 $P(t_1)$.

- 3- Male and female survivorship ratio $S(t_0)$ at the base year 1996.
- 4- Net migration distribution of population by age and sex groups at the base period between the base and the launch year.
- 5- The survived males and females population $P(t_2)$ at the target year.

-Available Data:

- 1- The observed distribution of population by age and sex groups at the base year $P(t_{1996})$ which can be shown in table (4) in Appendix A.
- 2- The observed distribution of population by age and sex groups at the launch year $P(t_{2006})$ which can be shown in table (1) in Appendix A.
- 3- Life table survivorship ratio of males $S(t_{1996})$ at the base year which can be shown in column (1) in table (2) in Appendix A.
- 4- Life table survivorship ratio of females $S(t_{1996})$ at the base year which can be shown in column (1) in table (3) in Appendix A.

-Unavailable Data:

- 1- The survived males and females population $\hat{P}(t_2)$ at the target year.
- 2- The main unavailable data in the migration component calculation is the net migration distribution of population by age and sex groups at the base period denoted by $NM(t_{1996}, t_{2006})$ between the base year 1996 and the launch year 2006 which can be calculated using equation (2.10) depending on 1996 and 2006 smoothed data. Then the net migration rates denoted by $NMR(t_{1996}, t_{2006})$ are calculated by equation (2.13), and these rates are used in equation (2.16) to calculate the net migration

distribution of population by age and sex groups at the target year denoted by $NM(t_2)$.

But before these calculations of the net migration data and net migration rates are carried out, the accuracy of the base year data at 1996 must be checked with respect to content and coverage errors as illustrated in Subsection (3.3.1) in the mortality component as follows:

- Accuracy of the Available Data:

The accuracy for the Qalyobia governorate census data at 1996 as a base year may be accomplished by the same criteria applied for the Qalyobia governorate census data at 2006 as a launch year.

1- Evaluating Qalyobia Base Year Data for Coverage Errors

Qalyobia base year data is evaluated with respect to coverage errors using internal comparison as follows:

As stated in subsection (3.3.1) that the evaluation of the census data coverage errors can be attained using sex ratio formula for the total population as follows:

$$R = \left(\frac{\text{total number of males at 1996}}{\text{total number of females at 1996}} \right) \cdot 100 = \left(\frac{1704860}{1596380} \right) \cdot 100 = 106.8 \%$$

This ratio 106.8% means that there are small coverage error as over counting in males or undercounting in females for Qalyobia governorate 1996 census data because the limit of this ratio is between 95% and 105%, but the difference in the calculated ratio (1.8 %) may be accepted for the coverage of 1996 data ,and this data can be used in the complete component projection model without suspicion in the absence of another evaluating criteria.

2-Evaluating Qalyobia Base Year Data for Content Errors

Qalyobia Governorate census data at 2006 as a launch year is evaluated with respect to content errors by sex ratio analysis , also the same criterion may be applied to the Qalyobia Governorate census data at 1996 as a base year.

The analysis of sex ratios which can be shown in table (3) in Appendix B for the base year shows that, there are errors in the data content based on the registered deviations from 100%, and these errors must be smoothed by the suitable method as follows:

- Calculated Data

This part is devoted to clarify the calculated data of the Qalyobia Governorate, as smoothed data and net migration data for the base year 1996 which can be used in the complete component projection model as follows:

- 1- The survived males and females population $\hat{P}(t_2)$ at the target year are calculated from the mortality component projection process.
- 2- Qalyobia distribution of population by age and sex groups at the census of the base year 1996 is smoothed by the same criterion applied for the Qalyobia Governorate at 2006 and the results are shown in table (3.2).

Table (3.3): Smoothed Age and Sex Distribution for Qalyobia at the Base Year 1996

Ages	Male	Female	Total
0-4	199614	189769	389383
5-9	203613	193250	396863
10-14	204521	193909	398430
15-19	189977	180458	370435
20-24	165743	158783	324526
25-29	145860	139200	285060
30-34	125343	118164	243507
35-39	108403	100520	208923
40-44	93602	83995	177597
45-49	77434	68473	145907
50-54	59283	52016	111299
55-59	46103	40423	86526
60-64	34233	30458	64691
65-69	24896	22436	47332
70-74	16672	15343	32015
75+	9563	9183	18746
Σ	1704860	1596380	3301240

Source: Researcher calculations for Qalyobia smoothed data at year 1996.

The accuracy of Carrier-Farrag, Karup-King Newton, United Nations, Arriaga, and Strong formula is studied and it is found that the best method according to the United Nations Secretariat index is the Strong formula [See Table (3.4)].

The accuracy of the smoothed 1996 Qalyobia census data may be accomplished by the same criterion applied for the Qalyobia Governorate census data at 2006.

The calculated United Nations Accuracy index for the different methods is shown in table (3.4). It is found from table (3.4) that there is an improvement in the smoothed distribution of age and sex at base year 1996, where the value of United Nations Secretariat index is equal

to 38.74 before smoothing, and dropped to 7.16 after smoothing, this is an indicator to a great improvement in data. So that, the smoothed distribution of the 1996 age and sex data can be used in the complete component projection model as a base year with a high precision.

Table (3.4): Summary of the Indices Measuring the Accuracy of Data

Index	Smoothed					
	Observed	Carrier Farrag	K-King Newton	Arriaga	United Nations	Strong
^a Sex Ratio Score (SRS)	8.26	2.54	2.76	2.52	2.85	1.26
^b Male Age Ratio Score (MARS)	6.31	5.83	6.27	5.49	4.42	1.75
^c Female Age Ratio Score (FARS)	7.63	4.58	5.11	4.47	3.63	1.63
^d Accuracy Index	38.74	18.02	19.66	17.52	16.59	7.16

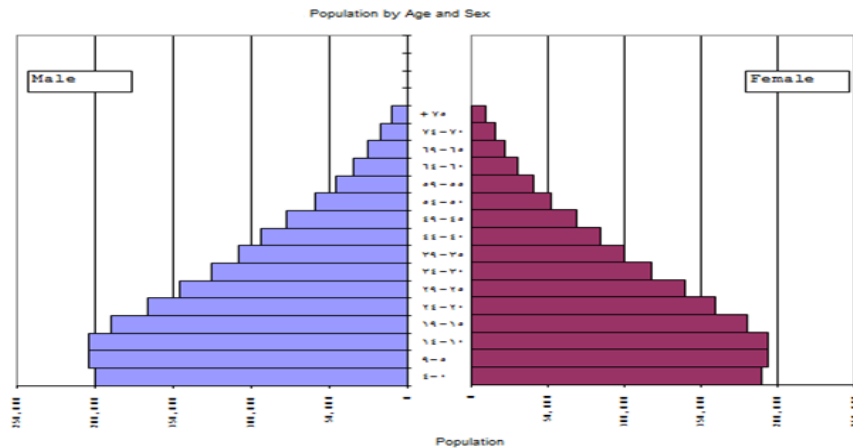
Source :Researcher calculations.

^aData in table (6b) in Appendix B, ^{b,c}Data in table (6d) in Appendix B

^dAge - Sex Accuracy index = [3(SRS) + MARS+ FARS]

The population pyramid for the smoothed Qalyobia in 1996 is drawn in figure (3.2).The following relatively symmetrical population pyramid is an evidence about the accuracy of the Qalyobia Governorate smoothed distribution of the population by age and sex at year 1996 and this distribution can be used in the complete component model with great accuracy.

Figure: (3.2) Qalyobia Population Pyramid at Base Year 1996



3- Net migration distribution of age and sex at the base period between 1996 and 2006 for Qalyobia is calculated using the average formula in equation (2.10) because this formula avoid the shortage in forward and backward formula as stated earlier. The average formula is chosen for calculating the net migration data as an indirect method because as stated the results of this method are reasonably and accepted in estimating the data of net migration in subareas. Also, the net migration rates are calculated using formula in equation (2.13), and the details of the calculations of the net migration data and net migration rates at the base period can be shown in tables (4a) and (4b) in Appendix B.

The following tables (3.5) and (3.6) shown the net migration data and net migration rate distribution of the Qalyobia population by age and sex groups at the base period.

Table(3.5):Net Migration Data for Qalyobia at Base Period

Ages	Male	Female	Total
5-9	45983	44286	90269
10-14	36065	36998	73063
15-19	25675	28471	54146
20-24	30431	35159	65590
25-29	35863	37030	72893
30-34	32026	29433	61459
35-39	30117	26522	56639
40-44	23753	18963	42716
45-49	18508	15579	34087
50-54	15543	13292	28835
55-59	16369	13490	29859
60-64	11242	7972	19214
65-69	9038	6552	15590
70-74	5959	5104	11063
75+	2541	5037	7578
Σ	338844	323618	662462

Source :Researcher calculations using average formula depending on Qalyobia 1996 and 2006 smoothed and adjusted data

Table(3.6):Net Migration Rates for Qalyobia at Base Period

Ages	Male	Female
5-9	0.025	0.026
10-14	0.020	0.021
15-19	0.014	0.016
20-24	0.017	0.020
25-29	0.019	0.021
30-34	0.017	0.017
35-39	0.016	0.015
40-44	0.013	0.011
45-49	0.010	0.009
50-54	0.008	0.007
55-59	0.009	0.008
60-64	0.006	0.005
65-69	0.005	0.004
70-74	0.003	0.003
75+	0.001	0.003
Σ	18.4%	18.7%

Source :Researcher calculations using net migration rate formula as tabulated in table (4b) and (4a) in Appendix B

From tables (3.5) and (3.6) it is found that, the distribution of net migration and net migration rates of Qalyobia population by age and sex groups at the base period between 1996 and 2006 census are positive values which means that this Governorate is an attracting for population.

The net migration rate at the whole Governorate level can be calculated by equation (2.13) as follows:

$$NMR(t_0, t_1) = \frac{NM(t_0, t_1)}{\left(\frac{P(t_0) + P(t_1)}{2}\right)} \cdot 100$$

$$NMR(t_{1996}, t_{2006}) = \frac{NM(t_{1996}, t_{2006})}{\left(\frac{P(t_{1996}) + P(t_{2006})}{2}\right)} \cdot 100$$

$$NMR(t_{1996}, t_{2006}) = \frac{338844 + 323618}{\left(\frac{(3301240 - 18746) + (4336693 - 477321)}{2}\right)} \cdot 100 = 18.6\%$$

The net migration rate which is equal to 18.6% is an indicator that the Qalyobia Governorate is an attracting place for population in the state of Egypt as noted in the introduction.

3.3.3 Fertility

- Equations:

The fertility component which represents the first age class from (0 – 4) in the complete component projection model is carried out through two stages as follows:

The first stage is concerned with the projection of births at the target years 2011 and 2016 [steps 1- 8]. The second stage is concerned with the projection of births for the periods 2006 - 2011 and 2011 - 2016 [steps 9 – 12].

1- Calculate the births for net migrants at the target year using equation

$$(2.17): {}_{NM}B(x, t_2) = \left[\hat{NM}(x, t_2) \times (\text{ASFR's}) \right]$$

2- Calculate the births for local residents at the target year using

$$\text{equation (2.18): } {}_L B(x, t_2) = \left[{}_F \hat{P}(x, t_2) \times (\text{ASFR's}) \right]$$

3- Aggregation of migrant and local births by age of mother from (15 - 49) to obtain the total births at the target year using equation

$$(2.19): B(x, t_2) = [{}_L B(x, t_2) + {}_{NM} B(x, t_2)]$$

4- Calculate male births by the age of mother from (15 - 49) using

$$\text{equation (2.20): } {}_m B(x, t_2) = [B(x, t_2) \cdot (R)]$$

5- Male births are summed by age of mother in the reproductive age groups to obtain the total number of male births using equation

$$(2.21): {}_m B(t_2) = \sum_{x=15}^{49} {}_m B(x, t_2)$$

6- Female births are derived from the total births and male births using equation (2.22): ${}_f B(t_2) = [B(t_2) - {}_m B(t_2)]$

7- Female births are summed by age of mother in the reproductive age groups to obtain the total number of male births using equation

$$(2.23): {}_f B(t_2) = \sum_{x=15}^{49} {}_f B(x, t_2)$$

8- After obtaining the male and female births at the target year for all subgroups as stated above using equation (2.19). This equation is used to aggregate the male and female births for local residents and migrants using equation (2.24): $B(t_2) = [{}_m B(t_2) + {}_f B(t_2)]$

9- Calculate survived male births by the age of mother in the reproductive age groups through the projection horizon using

$$\text{equation (2.25): } {}_m B'(x, t_1, t_2) = \left[\sum_{x=15}^{49} {}_m B(x, t_1, t_2) \cdot S(t_1) \right]$$

10- Calculate survived female births by the age of mother in the reproductive age groups through the projection horizon using

$$\text{equation (2.26): } {}_f B'(x, t_1, t_2) = \left[\sum_{x=15}^{49} {}_f B(x, t_1, t_2) \cdot S(t_1) \right]$$

11- Calculate all the survived male and female births through the projection horizon using equation (2.27): $B'(t_1, t_2) = [{}_m B'(t_1, t_2) + {}_f B'(t_1, t_2)]$

12- Calculate the total population births at the target year using equation

$$(2.28): B''(t_2) = [B(t_2) + B'(t_1, t_2)]$$

-Required Data:

1- Net migrant female distribution $NM(x, t_2)$ by age in the reproductive age groups at the target year.

2- Female resident distribution ${}_F P(x, t_2)$ by age in the reproductive age groups at the target year.

3- Male and female births by mother's age in the reproductive age groups for the periods 2006 up to 2011 and 2011 up to 2016.

It is noted that, for Qalyobia Governorate, the required data for calculating the fertility component is not available except the male and female births for the periods 2006 up to 2011 and 2011 up to 2016 which are shown in table (5) in Appendix A. Age specific fertility rates by mother's age in the reproductive age groups which extracted from the UN fertility models of the Asian countries with respect to medium assumption are used as an approximation to the Age specific fertility rates for Qalyobia as a good model in recording the vital statistics which is very closely to the Egyptian governorates fertility pattern [See CAPMAS (2009) pages 38- 40].

The ASFR's shown in table (8) in Appendix A can be used to project the fertility component for both migrants and local residents in the present study through the projection stages at years 2011 and 2016.

-Unavailable Data:

1-Net migrant female distribution $NM(x, t_2)$ by age in the reproductive age groups at the target year.

2- Female resident distribution ${}_F P(x, t_2)$ by age in the reproductive age groups at the target year.

3- Sex ratio for births by mother's age in the reproductive age groups at the launch year.

- Calculated Data:

1- Net migrant female distribution $\hat{N}M(x, t_2)$ by age in the reproductive age groups at the target year which is calculated as dicussed in the migration component process [See table (3.8)].

- 2- Female resident distribution ${}_F\hat{P}(x, t_2)$ by age in the reproductive age groups at the target year which is calculated as discussed in the mortality component process [See table (3.7)].
- 3- The sex ratio at birth in Qalyobia Governorate is calculated for the years 1996 – 2014 as shown in table (5) in Appendix A. It is noticed that this ratio ranges from 0.5176 to 0.5086. The sex ratio at birth for the year 2013 is used as an approximation.

3.3.4 Population Projection Stages And Results

This subsection is devoted to the application of the complete component projection model as a local projection to Qalyobia Governorate using the available, and calculated data of the three components of the model and the equations of each component. The mathematical steps of the projection model are carried out separately in to two stages.

The first stage from year 2006 up to year 2011 and the second stage from year 2011 up to year 2016.

3.3.4.1 First Projection Stage

The first stage of the local projection is implemented from year 2006 up to year 2011 as follows:

3.3.4.1.1 Mortality Projection

The projection of the effect of mortality is conducted using equation (2.15), data in table (3.1), data in column (3) in tables (2) and (3) in Appendix A, the calculations are listed in tables (5a) and (5b) in Appendix B, and the results are as follows:

Table (3.7): The Distribution of Male and Female Projected Population By Age at Year 2011

Final Age	Male	Female	Total
0-4			
5-9	244034	229550	473584
10-14	242199	230638	472837
15-19	237987	229068	467055
20-24	227982	221132	449114
25-29	218076	214171	432247
30-34	199006	194263	393269
35-39	174969	166965	341934
40-44	151954	142775	294729
45-49	127484	117069	244553
50-54	105619	96130	201749
55-59	84078	76774	160852
60-64	64450	58829	123279
65-69	44766	39935	84701
70-74	29139	26133	55272
75+	22281	19750	42031

Source: Researcher calculations for survived male and female population at year 2011 using 2006 smoothed data

Table (3.7) is the distribution of the survived male and female population by age at year 2011 for the local population projection process for Qalyobia governorate.

3.3.4.1.2 Migration Projection

The migration projection is conducted using equation (2.16), data in table (3.7), data in table (3.6), the calculations are listed in tables (6a) and (6b) in Appendix B , and the results are as follows:

Table (3.8): The Distribution of Male and Female Projected Migrants By Age at Year 2011

Final Age	Male	Female	Total
0-4			
5-9	6100	5968	12068
10-14	4844	4843	9687
15-19	3332	3665	6997
20-24	3876	4423	8299
25-29	4143	4498	8641
30-34	3383	3302	6685
35-39	2800	2504	5304
40-44	1975	1571	3546
45-49	1275	1054	2329
50-54	845	673	1518
55-59	757	614	1371
60-64	387	294	681
65-69	224	160	384
70-74	87	78	165
75+	22	59	81

Source: Researcher calculations for male and female migrant at year 2011

Table (3.8) is the distribution of migrant male and female populations by age at year 2011 for the local population projection process for Qalyobia Governorate.

3.3.4.1.3 Fertility Projection

The fertility projection is carried out through three main steps, the 1st step to project the births of migrants, 2nd step to project the local births, and the final step is related to the calculation of the total births.

3.3.4.1.3.1 Projection of Migrant Births

Migrant births are projected using equation (2.17), data in table (3.8), data in table (8) in column (2) in Appendix A, and the results are as follows:

Table (3.9):The Distribution of Migrant Births By Age of Mother at Year 2011

Age of Mother	$NM(t_{2011})$	(ASFR's)	${}_{NM}B(x, t_{2011}) = [NM(t_{2011}) \times (ASFR's)]$
15-19	3665	0.032	117
20-24	4423	0.113	500
25-29	4498	0.138	621
30-34	3302	0.120	396
35-39	2504	0.079	198
40-44	1571	0.034	53
45-49	1054	0.005	5

Source: Researcher calculations for migrant births at year 2011 using 2006 smoothed data

3.3.4.1.3.2 Projection of Local Births

Local births are projected using equation (2.18), data in table (3.7), data in table (8) in column (2) in Appendix A, and the results are as follows:

Table (3.10): The Distribution of Local Births By Age of Mother at Year 2011

Age of Mother	${}^{\wedge}{}_F P(t_{2011})$	ASFR's	${}_{L}B(x, t_{2011}) = [{}^{\wedge}{}_F P(t_{2011}) \times (ASFR's)]$
15-19	229068	0.032	7330
20-24	221132	0.113	24988
25-29	214171	0.138	29555
30-34	194263	0.120	23312
35-39	166965	0.079	13190
40-44	142775	0.034	4854
45-49	117069	0.005	585

Source: Researcher calculations for local births at year 2011 using 2006 smoothed data

3.3.4.1.3.3 Total Births Calculations

Firstly, the total male and female births for both migrant and local resident at 1st class (0 – 4) at the end of the target year are carried out using equations (2.19) , (2.20) , (2.21), (2.22) (2.23), data in table (3.9) ,(3.10) , using the sex ratio at birth for year the 2013 as an approximate value which is equal 0.5086, and the results are as follows:

Table (3.11): The Distribution of Total Male and Female Births By Age of Mother at Year 2011

Age of Mother	$B(x, t_{2011}) = \begin{bmatrix} L B(x, t_{2011}) \\ + \\ NM B(x, t_{2011}) \end{bmatrix}$	R	${}_m B(x, t_{2011}) = [B(t_{2011}) \cdot (R)]$	${}_f B(x, t_{2011}) = \begin{bmatrix} B(x, t_{2011}) - \\ {}_m B(x, t_{2011}) \end{bmatrix}$
15-19	7330+117=7447	0.5086	3788	3659
20-24	24988+500=25488	0.5086	12963	12525
25-29	29555+621=30176	0.5086	15348	14828
30-34	23312+396=23708	0.5086	12058	11650
35-39	13190+198=13388	0.5086	6809	6579
40-44	4854+53=4907	0.5086	2496	2411
45-49	585+5=590	0.5086	300	290
Σ	105704	X	53762	51942

Source: Researcher calculations for total births at year 2011

Secondly, survived or lived male and female births for both migrant and local resident included in 1st class (0 – 4) through the interval 2006 to 2011 are carried out using equations (2.25), (2.26), (2.27), and the results are as follows:

Table (3.12): Survived Male and Female Births Through 2006 - 2011

Ages	${}_m B'(x, t_{2006}, t_{2011}) = \sum_{x=15}^{49} {}_m B(x, t_{2006}, t_{2011}) \cdot S(t_{2006})$	${}_f B'(x, t_{2006}, t_{2011}) = \sum_{x=15}^{49} {}_f B(x, t_{2006}, t_{2011}) \cdot S(t_{2006})$	$B'(x, t_{2006}, t_{2011}) = \begin{bmatrix} {}_m B'(x, t_{2006}, t_{2011}) + \\ {}_f B'(x, t_{2006}, t_{2011}) \end{bmatrix}$
0 – 4	$*0.95561 \times \begin{pmatrix} 56175 + 61997 \\ + 63829 + 64237 \end{pmatrix}$	$*0.95502 \times \begin{pmatrix} 54569 + 57853 \\ + 58641 + 61779 \end{pmatrix}$	235307+222388 =457695
Σ	235307	222388	

Source: Researcher calculations for survived births at year 2011

* The 1st column is calculated by multiplying the survival rate at age zero in the launch year, which = 0.95561 by the summation of male births at year (2007,2008,2009,2010) due to the annual bulletin for vital statistics births and deaths.

The 2nd column is calculated by multiplying the survival rate at age zero in the launch year, which = 0.95502 by the summation of female births at year (2007,2008,2009,2010) due to the annual bulletin for vital statistics births and deaths.

The total Projected Population at year 2011 is carried out using equations (2.24),(2.28), (2.29), data in tables (3.7),(3.8),(3.11),(3.12), and the calculations are listed in table (7) in Appendix B.

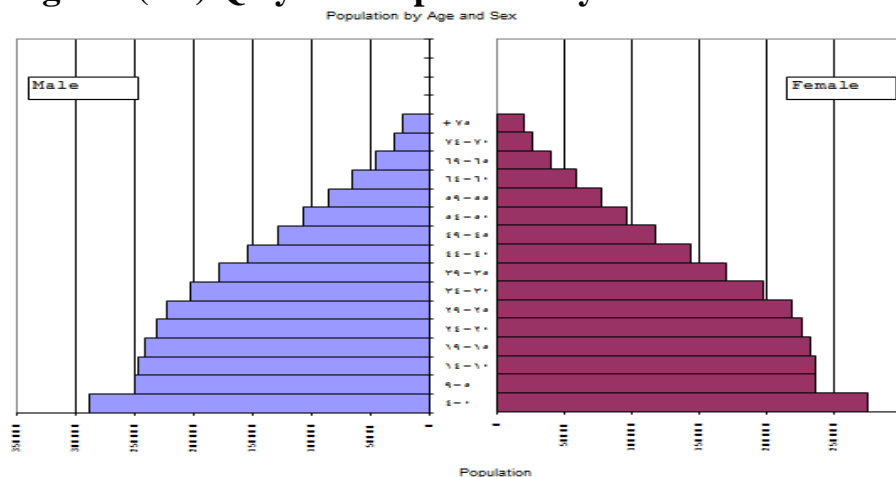
The distribution of Qalyobia population by age and sex at year 2011 is carried out using data in tables (3.7),(3.8),(3.11),(3.12), and the results are as follows:

Table (3.13):The Distribution of Qalyobia Population at Year 2011

Age	Male	Female	Total
0-4	289069	274330	563399
5-9	250134	235518	485652
10-14	247043	235481	482524
15-19	241319	232733	474052
20-24	231858	225555	457413
25-29	222219	218669	440888
30-34	202389	197565	399954
35-39	177769	169469	347238
40-44	153929	144346	298275
45-49	128759	118123	246882
50-54	106464	96803	203267
55-59	84835	77388	162223
60-64	64837	59123	123960
65-69	44990	40095	85085
70-74	29226	26211	55437
75+	22303	19809	42112
Σ	2497143	2371218	4868361

Source: Researcher calculations for the distribution of age and sex population at year 2011

Figure: (3.3) Qalyobia Population Pyramid at Year 2011



It is noticed from fig.(3.3) that, the base of Qalyobia projected population pyramid at year 2011 is more wider than the previous pyramids at year 1996 and 2006 which indicates the main feature of the higher birth rates in young populations .This improvement is due to separately calculations for the migration data beside the fertility and mortality data using the complete component projection model.

3.3.4.2 Second Projection Stage

The second stage of the local projection is implemented from year 2011 up to year 2016 as follows:

3.3.4.2.1 Mortality Projection

The projection of the effect of mortality is conducted using equation (2.15), data in table (3.13), data listed in column (4) in tables (2), (3) in Appendix A, the calculations are listed in tables (8a) and (8b) in Appendix A, and the results are as follows:

Table (3.14): The Distribution of Male and Female Projected Population By Age at Year 2016

Final Age	Male	Female	Total
0-4			
5-9	287294	272629	559923
10-14	249556	235160	484716
15-19	246403	235125	481528
20-24	240479	232311	472790
25-29	230886	225070	455956
30-34	221027	218080	439107
35-39	200996	196853	397849
40-44	175897	168564	344461
45-49	151193	142996	294189
50-54	124855	116070	240925
55-59	100777	93712	194489
60-64	77788	73187	150975
65-69	56582	53207	109789
70-74	35836	32971	68807
75+	31636	26624	58260

Source: Researcher calculations for survived male and female population at year 2016 using data of 2011

Table (3.14) is the distribution of the survived male and female population by age at year 2016 for the local population projection process for Qalyobia Governorate.

3.3.4.2.2 Migration Projection

The migration projection is conducted using equation (2.16) ,data in table (3.14) assuming that, the net migration rates in tables (3.6) may be continued to the 2nd stage in the projection process, the calculations are listed in tables (9a) and (9b) in Appendix B ,and the results are as follows:

Table (3.15): The Distribution of Male and Female Projected Migrants By Age at Year 2016

Final Age	Male	Female	Total
0-4			
5-9	7182	7088	14270
10-14	4991	4938	9929
15-19	3450	3762	7212
20-24	4088	4646	8734
25-29	4387	4726	9113
30-34	3757	3707	7464
35-39	3216	2953	6169
40-44	2287	1854	4141
45-49	1512	1287	2799
50-54	999	812	1811
55-59	907	750	1657
60-64	467	366	833
65-69	283	213	496
70-74	227	99	326
75+	32	80	112

Source: Researcher calculations for male and female migrant projection at year 2016

Table (3.15) is the distribution of migrant male and female populations by age at year 2016 for the local population projection process for Qalyobia Governorate.

3.3.4.2.3 Fertility Projection

The fertility projection is carried out through three main steps , the 1st step to project the births of migrants , 2nd step to project the local births, and the final step is related to the calculation of the total births.

3.3.4.2.3.1 Projection of Migrant Births

Migration births are projected using equation (2.17), data in table (3.15), data in table (8) in column (3) in Appendix A, and the results are as follows:

Table (3.16):The Distribution of Migrant Births By Age of Mother at Year 2016

Age of Mother	$NM(t_{2016})$	ASFR's	${}_{NM}B(x,t_{2016}) = [NM(t_{2016}) \times (ASFR's)]$
15-19	3762	0.025	94
20-24	4646	0.102	474
25-29	4726	0.129	609
30-34	3707	0.113	419
35-39	2953	0.074	218
40-44	1854	0.032	59
45-49	1287	0.005	6

Source: Researcher calculations for migrant births at year 2016 using 2011 data

3.3.4.2.3.2 Projection of Local Births

Local births are projected using equation (2.18), data in table (3.14), data in table (8) in column (3) in Appendix A, and the results are as follows:

Table (3.17): The Distribution of Local Births By Age of Mother at Year 2016

Age of Mother	$\hat{P}(t_{2016})$	ASFR's	${}_L B(t_{2016}) = [\hat{P}(t_{2016}) \times (ASFR's)]$
15-19	235125	0.025	5878
20-24	232311	0.102	23695
25-29	225070	0.129	29034
30-34	218080	0.113	24643
35-39	196853	0.074	14567
40-44	168564	0.032	5394
45-49	142996	0.005	715

Source: Researcher calculations for local births at year 2016 using 2011 data

3.3.4.2.3.3 Total Births Calculations

Firstly, total male and female births for both migrant and local resident at 1st class (0-4) at the end of the target year are carried out using equations (2.19) , (2.20) , (2.21), (2.22) ,(2.23), data in table (3.16), (3.17), using the sex ratio at birth for the year 2013 as an approximate value which is equal 0.5086, and the results are as follows:

Table (3.18): The Distribution of Total Male and Female Births By Age of Mother at Year 2016

Age of Mother	$B(x, t_{2016}) = \begin{bmatrix} L B(x, t_{2016}) \\ + \\ NM B(x, t_{2016}) \end{bmatrix}$	R	${}_m B(x, t_{2016}) = [B(x, t_{2016}) \cdot (R)]$	${}_f B(x, t_{2016}) = \begin{bmatrix} B(x, t_{2016}) - \\ {}_m B(x, t_{2016}) \end{bmatrix}$
15-19	5878+94=5972	0.5086	3037	2935
20-24	23695+474=24169	0.5086	12292	11877
25-29	29034+609=29643	0.5086	15076	14567
30-34	24643+419=25062	0.5086	12746	12316
35-39	14567+218=14785	0.5086	7519	7266
40-44	5394+59=5453	0.5086	2773	2680
45-49	715+6=721	0.5086	367	354
Σ	105805	X	53810	51995

Source: Researcher calculations for total births at year 2016 using 2011 data

Secondly, survived or lived male and female births for both migrant and local resident included in 1st class (0 – 4) through the interval 2011 to 2016 are carried out using equations (2.25), (2.26), (2.27), and the results are as follows:

Table (3.19): Survived Male and Female Births Through 2011- 2016

Ages	${}_m B'(x, t_{2011}, t_{2016}) = \sum_{x=15}^{49} {}_m B(x, t_{2011}, t_{2016}) \cdot S(t_{2011})$	${}_f B'(x, t_{2011}, t_{2016}) = \sum_{x=15}^{49} {}_f B(x, t_{2011}, t_{2016}) \cdot S(t_{2011})$	$B'(x, t_{2011}, t_{2016}) = [{}_m B'(x, t_{2011}, t_{2016}) + {}_f B'(x, t_{2011}, t_{2016})]$
0 – 4	$0.96157 \times \left(\begin{matrix} 71487 + 71282 \\ + 72771 + ** 72771 \end{matrix} \right)$	$0.96159 \times \left(\begin{matrix} 68923 + 68872 \\ + 69624 + ** 69624 \end{matrix} \right)$	$277231 + 266401 = 543632$
Σ	277231	266401	

Source: Researcher calculations for survived births at year 2016

* The 1st column is calculated by multiplying the survival rate at age zero in the launch year, which = 0.96157 by the summation of male births at year (2012,2013,2014,2015) due to the annual bulletin for vital statistics births and deaths for Qalyobia.

The 2nd column is calculated by multiplying the survival rate at age zero in the launch year, which = 0.95502 by the summation of female births at year (2012,2013,2014,2015) due to the annual bulletin for vital statistics births and deaths for Qalyobia.

** Assuming that 2015 births are equal to 2014 births for both males and females as 2015 births not accounted until now.

The total Projected Population at year 2016 is carried out using equations (2.24),(2.28), (2.29), data in tables (3.14),(3.15),(3.18),(3.19), and the calculations are listed in table (10) in Appendix B.

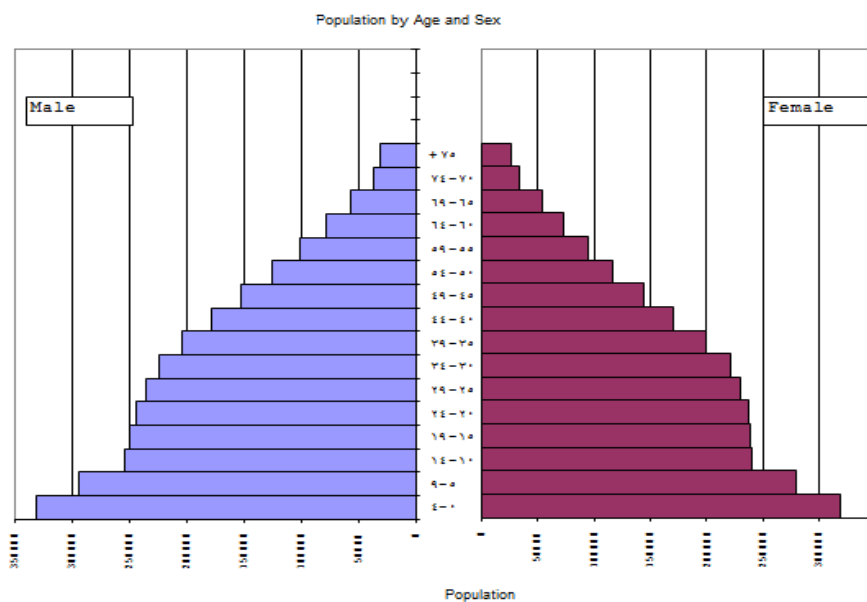
The distribution of Qalyobia population by age and sex at year 2016 is carried out using data in tables (3.14),(3.15),(3.18),(3.19), and the results are as follows:

Table (3.20): The Distribution of Qalyobia Population at Year 2016

Age	Male	Female	Total
0-4	331041	318396	649437
5-9	294476	279717	574193
10-14	254547	240098	494645
15-19	249853	238887	488740
20-24	244567	236957	481524
25-29	235273	229796	465069
30-34	224784	221787	446571
35-39	204212	199806	404018
40-44	178184	170418	348602
45-49	152705	144283	296988
50-54	125854	116882	242736
55-59	101684	94462	196146
60-64	78255	73553	151808
65-69	56865	53420	110285
70-74	36063	33070	69133
75+	31668	26704	58372
Σ	2800031	2678236	5478267

Source: Researcher calculations for the distribution of age and sex population at year 2016

Figure: (3.4) Qalyobia Population Pyramid at Year 2016



It is noticed from fig.(3.4) that, the population pyramid still has a more wider base in the age groups (0 - 4) compared with the population pyramid for Qalyobia in figures (3.1),(3.2),and (3.3) for the years 1996, 2006, and 2011 . This improvement in the first age groups is due to the separately calculations for the migration data beside the fertility and mortality data by using the complete component projection model.

Finally, the projection of Qalyobia population which is implemented into two stages by the complete component projection model show that, the population pyramid at the years 2011 and 2016 have a wider base compared with Qalyobia population pyramid at 1996 and 2006.

3.4 Model Accuracy

The accuracy of the suggested model is tested using the accuracy measures, Δr , and a comparison between the census and calculated data as follows:

The accuracy of the projection model can be determined using the projection error, Δr , defined in equation (2.1). To obtain a homogeneous measure of error in the total projected population, the statistic Δr can be used which it takes the duration and size factors into

account as follows:
$$\Delta r = \frac{100}{T} \ln \left(\frac{\hat{P}(t_2)}{\hat{P}(t_1)} \cdot \frac{P(t_1)}{P(t_2)} \right)$$

Where:

Δr : Error in the projected population

$P(t_1)$: Observed population for projection at launch year

$\hat{P}(t_1)$: Estimated population for projection at launch year

$P(t_2)$: Observed population for projected region

$\hat{P}(t_2)$: Estimated population for projected region

T : Time of projection horizon

Using data of 2006 and 2011, Δr , is calculated as:

$$\therefore \Delta r = \frac{100}{5} \ln \left(\frac{\hat{P}(t_{2011})}{\hat{P}(t_{2006})} \cdot \frac{P(t_{2006})}{P(t_{2011})} \right)$$

$$\therefore \Delta r = \frac{100}{5} \ln \left(\frac{4868361^a}{4336693^b} \times \frac{4251672^c}{4693824^d} \right) = \frac{100}{5} \ln(1.12260)(0.90580) = 0.33\%$$

^a Projected total population of Qalyobia at year 2011 in table (3.13)

^b Adjusted total population of Qalyobia at year 2006 in table (2) in Appendix B

^c Observed total population of Qalyobia at year 2006 in table (1) in Appendix A

^d Observed total population of Qalyobia at year 2011 in table (10) in Appendix A

The value of the accuracy measure , Δr , is very small ,this means that the projection of Qalyobia governorate using the complete component projection model is appropriate. This model can be stated as an excellent model with a high precision in the local population projections.

The model error is very close to zero, this means that the model posses an excellent precision in the population projection process.

Another criterion for testing the model accuracy is the comparison of the total population of the Qalyobia Governorate from the census of 2006 by the projected number using the suggested model. This comparison reveals that, the projected population is greater than the census population by 85021 this difference is which may be due to the migration component developed in the present study. Table (3.21) illustrates these differences.

Table (3.21):Census and Calculated Total and Net Migration of Qalyobia Population at Year 2006

Qalyobia Data	Census Results	Calculated Results	Differences
Total population	^a 4251672	^b 4336693	85021
Internal Net Migration	^c 611287	^d 662462	51175

Source: Central Agency For Public Mobilization And Statistics in 2006 "Final results of the Census of Population and Housing". Cairo, (May,2008), and researcher calculations

^a Data in table (1) in Appendix A

^b Data in table (3.1)

^c Data in table (7a) in Appendix A

^d Data in table (3.5)

Table (3.21) shows that, the Qalyobia total population and net migration data observed by CAPMAS are equal to 4251672 , 611286 respectively, and the calculated Qalyobia total population and net migration data in the present study, are equal to 4336693 , 662462 respectively. The gap between the CAPMAS data and the present study data for the total population may be a result of the migration component.

CHAPTER 4

MODEL EXTENSIONS And RELATED PROJECTIONS

4.1 Introduction

This chapter is devoted to clarify some extensions of the component model with respect to future changes, and other sectoral projections, which have great important uses of the model in the regional planning. Most data users, especially at the local level use projections as a guide for future events and regional planning. The effect of future changes in demographic components has an impact on governmental policies. The present chapter considered the future changes in fertility and mortality components by the synthetic projections. Also, this chapter contained related sectoral projections in education and labor force sectors in Qalyobia Governorate. [See Smith et al. (2013)].

This chapter consists of three sections. Section (4.1) is an introduction. In section (4.2) the model extensions are studied. Section (4.3) is devoted to related projections.

4.2 Model Extensions

Projections can be used not only to analyze the determinants of population change, but also to give the data user an indication of potential future scenarios. The availability of mortality, fertility, and migration data has evolved over the years. We don't anticipate any major changes in the availability or quality of migration data in the present study, but important changes in mortality and fertility data in the foreseeable future are already occurring.

Since we cannot be sure what the future will bring, it is helpful to consider projections based on various combinations of assumptions.

Charting the implications of different combinations of assumptions gives the data user some idea of the potential variation in future population values. These alternative scenarios are often used as an extension of the component model. In the present study, the synthetic projections of the mortality and fertility components introduced in chapter two are discussed and illustrated to the projection period 2006 - 2016.

4.2.1 Mortality Component Extension

The mortality component in the complete component model is considered as constant survival rates. But, this section is devoted to use another approach for mortality component projection as an extension of the mortality component which is called synthetic projection.

Synthetic mortality or survival rates can be created by linking changes in rates for one area to changes projected for a different area. This approach is similar to targeting, but it adopts the rates of change in mortality or survival rates from the model population rather than the rates themselves. The synthetic procedure can be carried out for every subgroup of the population, providing a complete set of projected survival rates. This is a simple, straightforward approach that is used frequently for state and local projections [See Campbell (1996), Department of Rural Sociology (1998), Smith and (Rayer 2012), and Treadway (1997)].

Some demographers use a synthetic approach tying projected changes in county (small area) survival rates to projected changes in state (large area) survival rates as a model population [See Smith and Rayer (2012)].

The synthetic approach can be applied using either survival rates or mortality rates. However, in order to ensure that projected survival rates

do not take on values greater than 1.0, survival rates are often converted into mortality rates before the adjustments are made [See Shryock and Siegel (1973), p. 453].

There are two methods that can be used to project future mortality through using a synthetic approach by tying projected changes in county (small area) survival rates to projected changes in state (large area) survival rates as follows [See Smith and Rayer (2012)]:

The 1st method steps:

- 1- Mortality rates at the launch year are calculated by subtracting county survival rates at the launch year from 1.0.
- 2- Adjustments to the mortality rates at the launch year are made based on the assumption of the mortality decline and [in the present study it is taken to be 1%] changes projected for the model population to obtain county adjusted mortality rates at the target year are calculated.
- 3- Mortality rates at the target year are converted back into survival rates by subtracting the adjusted mortality rates at the target year from 1.0 to obtain the projected survival rates at the target year for the county.

The 2nd method steps:

- 1- Survival rates at the launch year are used as a basis.
- 2- Adjustment factors at the state level are assumed as correction factors for the launch year survival rates and it is calculated by dividing the state survival rates at the target year by the state survival rates at the launch year for all age groups.
- 3- Adjustment factors are multiplied by the county survival rates at the launch year to obtain county survival rates at the target year.

Regardless of whether mortality or survival rates are used, the analyst must make sure that the projected rates are reasonable to the projected population. If survival or mortality rates for the model population are similar to those for the region being projected, the synthetic approach will generally produce reasonable results (at least for short and medium range projection horizons). If the rates are considerably different, however, changes in the model population may overstate or understate likely future changes in the population being projected. In these instances, further adjustments must be made or a different approach is used [See Shryock and Siegel (1973)].

Once, a set of base survival rates has been chosen, the next step is to decide how to project those rates into the future. This will be determined partly by the availability of relevant data, but will also be affected by the analyst's views regarding future mortality trends.

The projection of the mortality component for Qalyobia Governorate at year 2016 using the synthetic projection approach by the 1st and 2nd methods is illustrated as follows:

- 1st method with respect to mortality rates:

Using the Qalyobia Governorate survival rates at year 2006, the projected 2016 survival rates for male and female is illustrated in tables (4.1) and (4.2) respectively.

**Table (4.1): Projected 2016 Survival Rates for Qalyobia Males
Based on 1% Annual Declines in Mortality Rates***

Years Ages	2006 Survival Rates (1)	2006 Mortality Rates (2)	2016 Mortality Rates (3)	2016 Survival Rates (4)
0	0.95561	0.04439	0.04015	0.95985
0-4	0.99237	0.00763	0.00690	0.99310
5-9	0.99719	0.00281	0.00254	0.99746
10-14	0.9969	0.00310	0.00280	0.99720
15-19	0.99586	0.00414	0.00374	0.99626
20-24	0.99502	0.00498	0.00450	0.99550
25-29	0.99364	0.00636	0.00575	0.99425
30-34	0.99189	0.00811	0.00733	0.99267
35-39	0.98777	0.01223	0.01106	0.98894
40-44	0.97971	0.02029	0.01835	0.98165
45-49	0.96605	0.03395	0.03070	0.96930
51-54	0.94173	0.05827	0.05270	0.47300
55-59	0.91017	0.08983	0.08124	0.91876
60-64	0.86389	0.13611	0.12310	0.87690
65-69	0.78471	0.21529	0.19470	0.80530
70-74	0.65904	0.34096	0.30836	0.69164
75-79	0.52133	0.47867	0.43290	0.56710
80+	0.33836	0.66164	0.59837	0.40163

Source: Researcher calculations using column (1) which is extracted from Qalyobia male life tables pages (95,96,97,98, and 99) [Table (2) in Appendix A]. Cairo Demographic Center "CDC" life tables for Egypt governorates projections Cairo, (September ,2000).

*1% annual decline in mortality for 10 years is represented by an adjustment factor of 0.90438 (i.e., 0.99^{10})

Column (2) is calculated as : $[1 - (2006 \text{ Survival Rate})]$

Column (3) is calculated as : $[2006 \text{ Mortality Rate} \times (0.90438)]$

Column (4) is calculated as : $[1 - (2016 \text{ Mortality Rate})]$

The first column in the table (4.1) shows 2006 survival rates for Qalyobia males, these are the same rates shown in column (3) of Table (2) in Appendix A. The second column shows the mortality rates obtained by subtracting each survival rate in column (1) from 1.0. The third column shows the adjusted mortality rates for 2016 after 1% annual reductions have been applied to the mortality rates shown in column (2). The fourth column shows the new survival rates for Qalyobia males at year 2016 implied by the adjusted mortality rates.

**Table (4.2): Projected 2016 Survival Rates for Qalyobia Females
Based on 1% Annual Declines in Mortality Rates***

Years Ages	2006 Survival Rates (1)	2006 Mortality Rates (2)	2016 Mortality Rates (3)	2016 Survival Rates (4)
0	0.95502	0.04498	0.04068	0.95932
0-4	0.99196	0.00804	0.00727	0.99273
5-9	0.99803	0.00197	0.00178	0.99822
10-14	0.99804	0.00196	0.00177	0.99823
15-19	0.99761	0.00239	0.00216	0.99784
20-24	0.9972	0.00280	0.00253	0.99747
25-29	0.99654	0.00346	0.00313	0.99687
30-34	0.99546	0.00454	0.00411	0.99589
35-39	0.99347	0.00653	0.00591	0.99409
40-44	0.98891	0.01109	0.01003	0.98997
45-49	0.97982	0.02018	0.01825	0.98175
51-54	0.96351	0.03649	0.03300	0.96700
55-59	0.93888	0.06112	0.05528	0.94472
60-64	0.88943	0.11057	0.10000	0.90000
65-69	0.80696	0.19304	0.17458	0.82542
70-74	0.64632	0.35368	0.31986	0.68014
75-79	0.43921	0.56079	0.50717	0.49283
80+	0.22949	0.77051	0.69683	0.30317

Source: Researcher calculations using column (1) which is extracted from Qalyobia female life tables pages (88,89,90,91,92,and 93) [Table (3) in Appendix A]. Cairo Demographic Center "CDC" life tables for Egypt Governorates projections Cairo, (September ,2000).

*1% Annual decline in mortality for 10 years is represented by an adjustment factor of 0.90438 (i.e., 0.99^{10})

Column (2) is calculated as : $[1 - (2006 \text{ Survival Rate})]$

Column (3) is calculated as : $[2006 \text{ Mortality Rate} \times (0.90438)]$

Column (4) is calculated as : $[1 - (2016 \text{ Mortality Rate})]$

The first column in the table (4.2) shows 2006 survival rates for Qalyobia females, these are the same rates shown in column (3) of Table (3) in Appendix A. The second column shows the mortality rates obtained by subtracting each survival rate in column (1) from 1.0. The third column shows the adjusted mortality rates for 2016 after 1% annual reductions have been applied to the mortality rates shown in column (2). The fourth column shows the new survival rates for Qalyobia females at year 2016 implied by the adjusted mortality rates.

- 2nd method with respect to survival rates:

Using the Qalyobia Governorate survival rates at year 2006, and the projected Arab Republic of Egypt adjustment factors, the projected 2016 survival rates for male and female at the target year is illustrated in Tables (4.3) and (4.4) respectively.

Table (4.3): Projected 2016 Survival Rates for Qalyobia Males Based on Projected Arab Republic of Egypt Adjustment Factors

Years Ages	Qal.2006 Survival Rates (1)	Egy.2006 Survival Rates (2)	Egy.2016 Survival Rates (3)	Egy. Adjustment Factors (4)	Qal.2016 Survival Rates (5)
0	0.95561	0.97180	0.98116	1.00963	0.96481
0-4	0.99237	0.99418	0.99723	1.00307	0.99542
5-9	0.99719	0.99656	0.99830	1.00175	0.99894
10-14	0.9969	0.99620	0.99801	1.00182	0.99871
15-19	0.99586	0.99482	0.99723	1.00242	0.99827
20-24	0.99502	0.99376	0.99663	1.00289	0.99790
25-29	0.99364	0.99246	0.99591	1.00348	0.99710
30-34	0.99189	0.99042	0.99469	1.00431	0.99617
35-39	0.98777	0.98484	0.99113	1.00639	0.99408
40-44	0.97971	0.97310	0.98324	1.01042	0.98992
45-49	0.96605	0.95120	0.96732	1.01695	0.98242
51-54	0.94173	0.92146	0.94373	1.02417	0.96449
55-59	0.91017	0.89360	0.91952	1.02901	0.93657
60-64	0.86389	0.85238	0.88383	1.03690	0.89577
65-69	0.78471	0.77060	0.81266	1.05458	0.82754
70-74	0.65904	0.67673	0.72668	1.07381	0.70768
75-79	0.52133	0.33373	0.36108	1.08195	0.56405
80+	0.33836

Sources: Researcher calculations using column (1) which is extracted from Qalyobia male life tables pages (95,96,97,98,and 99) [Table (2) in Appendix A]. Cairo Demographic Center "CDC" life tables for Egypt Governorates projections Cairo, (September ,2000).

Column (2) and (3): "Central Agency For Public Mobilization And Statistics "CAPMAS" male population projections of the Egypt States by age, sex, series,2006–2051, pages (50,52,54,56,58,60,62,64,66,and 68). Cairo, (December 2009).

Column (4) Egypt Adjustment Factors are calculated as : Column (3) ÷ Column (2)

Column (5) Qalyobia 2016 survival rates are calculated as : Column (1) × Column (4)

Table (4.4): Projected 2016 Survival Rates for Qalyobia Females Based on Projected Arab Republic of Egypt Adjustment Factors

Years Ages	Qal.2006 Survival Rates (1)	Egy.2006 Survival Rates (2)	Egy.2016 Survival Rates (3)	Egy. Adjustment Factors (4)	Qal.2016 Survival Rates (5)
0	0.95502	0.97441	0.98371	1.00954	0.96413
0-4	0.99196	0.99518	0.99810	1.00293	0.99487
5-9	0.99803	0.99755	0.99908	1.00153	0.99956
10-14	0.99804	0.99767	0.99913	1.00146	0.99950
15-19	0.99761	0.99705	0.99893	1.00189	0.99950
20-24	0.9972	0.99634	0.99864	1.00231	0.99950
25-29	0.99654	0.99510	0.99807	1.00298	0.99951
30-34	0.99546	0.99357	0.99726	1.00371	0.99915
35-39	0.99347	0.99082	0.99561	1.00483	0.99827
40-44	0.98891	0.98551	0.99231	1.00690	0.99573
45-49	0.97982	0.97347	0.98470	1.01154	0.99113
51-54	0.96351	0.94944	0.96900	1.02060	0.98336
55-59	0.93888	0.91934	0.94780	1.03096	0.96795
60-64	0.88943	0.87280	0.91222	1.04516	0.92960
65-69	0.80696	0.78585	0.84219	1.07169	0.86481
70-74	0.64632	0.68456	0.75802	1.10731	0.71568
75-79	0.43921	0.25391	0.27905	1.09901	0.48270
80+	0.22949

Sources: Researcher calculations using column (1) which is extracted from Qalyobia female life tables pages (88,89,90,91,92,and 93) [Table (3) in Appendix A]. Cairo Demographic Center "CDC" life tables for Egypt Governorates projections Cairo, (September,2000).

Column (2) and (3): "Central Agency For Public Mobilization And Statistics "CAPMAS" female population projections of the Egypt States by age, sex, series, 2006–2051, pages (51,53,55,57,59,61,63,65,67, and 69). Cairo, (December 2009).

Column (4) Egypt Adjustment Factors are calculated as : Column (3) ÷ Column (2)

Column (5) Qalyobia 2016 survival rates are calculated as : Column (1) × Column (4)

Tables (4.3) and (4.4) shows Qalyobia males and females 2006 survival rates in column (1), Egypt adjustment factors in column (4), and projected 2016 survival rates for males and females in the Qalyobia Governorate in column (5).

All the adjustment factors shown in tables (4.3), and (4.4) are above 1.0, indicating that, the projected survival rates increase for all age groups.

The differences in the two projection methodologies will not lead to large differences in survival rates unless the projections are based on dramatically different assumptions or extend well into the future.

4.2.2 Fertility Component Extension

The fertility component of the complete component model is considered using the target approach. This section is devoted to use another fertility projection approach as an extension of the complete component fertility projection model which is called synthetic projection.

Synthetic fertility rates can be created by forming ratios of fertility rates in one area to those in another and applying those ratios to the fertility rates projected for the second area (called the model population). Although any two areas could be used, ratios are typically based on a smaller area and the larger area in which it is located (e.g., county and state). Age specific fertility rates (ASFR's) are the measures most commonly used in constructing these ratios.

Synthetic projection implicitly assumes that fertility rates in the population to be projected will change at the same rate as fertility rates in the model population, the analyst must decide whether or not this is a reasonable assumption. This approach has been widely used for state and local projections and the procedures are as follows [See Campbell (1994), (1996) and Wetrogan (1990)]:

- 1-** Divide ASFR's of county at the launch year by ASFR's of the state at the launch year to obtain the adjustment factor.

2- Adjustment factor is multiplied by the projected ASFR's for the state to obtain projected ASFR's for the county at the target year.

Finally, in fact, synthetic approach described above require the use of the analyst's judgment as well as the application of the technique itself. If the rates are considerably different as noted above the expert judgment is typically informed of the evaluation of current mortality rates, past mortality trends, and various socioeconomic, lifestyle, medical, and technological factors that might cause mortality rates to change in the future. Taking this approach even further, projections can be based solely on expert judgment by gathering data from a panel of experts and forming probabilistic projections [See Lutz et al. (1999), and Alders et al. (2007)].

Table (4.5) is devoted to illustrate the synthetic fertility peojection approach for Qalyobia Governorte:

Table (4.5): Qalyobia Projected Age Specific Fertility Rates for Year 2016 Using the Synthetic Approach

Age of Mother	Qal.2006 (1)	Egy.2006 (2)	Adjustment factors (3)	Egy. 2016 (4)	Qal. 2016 (5)
15-19	54	54	$(54 \div 54) = 1$	24	$24 \times 1 = 24$
20-24	143	143	$(143 \div 143) = 1$	98	$98 \times 1 = 98$
25-29	159	159	$(159 \div 159) = 1$	124	$124 \times 1 = 124$
30-34	133	133	$(133 \div 133) = 1$	108	$108 \times 1 = 108$
35-39	87	87	$(87 \div 87) = 1$	71	$71 \times 1 = 71$
40-44	38	38	$(38 \div 38) = 1$	30	$30 \times 1 = 30$
45-49	6	6	$(6 \div 6) = 1$	4	$4 \times 1 = 4$
TFR	3.1	3.1	$(3.1 \div 3.1) = 1$	2.3	$2.3 \times 1 = 2.3$

Source: Central Agency For Public Mobilization And Statistics in 2006 "Final results of the Census of Population and Housing". Cairo , (December,2009).

Column (1): Qalyobia fertility rates, which are listed in [Table (8) in Appendix A].

Column(2); Egypt fertility rates, which are listed in table (3.4) in "CAPMAS" (2009) page 38.

Column(3) = Column (1) \div Column (2)

Column(4): Projected fertility rates of Egypt, which are listed in table (3.4) in "CAPMAS" (2009) page 38.

Column (5) = Column (4) \times Column (3)

Column (1) in table (4.5) illustrates the Qalyobia age specific fertility rates, which are extracted from the medium assumption of the United Nations fertility models and assumed to be the Qalyobia fertility pattern using the targeting approach. Column (2) illustrates the Egypt, age specific fertility rates, which are extracted from the low assumption of the United Nations fertility models, which it is considered as an improvement in fertility pattern for Egypt state, and these rates are equal to the Qalyobia fertility pattern. So that, the adjustment factor is equal to 1.0 as illustrated in column (4) in all age groups which means that, if there is an improvement in the state of Egypt fertility pattern, this pattern can be applied to the Qalyobia Governorate at the target year 2016.

4.3 Related Projections

The most important use of population projections is to provide the basis for many types of decision making in both public and private sectors.

This section is devoted to the method for constructing population-related projections, which have small data requirements and it is relatively easy to apply, making this particularly useful for small-area projections. This approach depends on the participation-ratio method (also known as the participation-rate method, prevalence-ratio method, and incidence-rate method), in which projections of population-related variables are derived from population projections through the use of ratios [See George et al. (2004) and Siegel (2002)].

In this method, current and historical data are used to construct ratios reflecting the proportion of the population having the characteristic of interest (e.g., enrolled in school and labor force). Ratios are typically

constructed separately for each age group and are often broken down by sex as well. They can be projected by holding them constant, extrapolating recent trends, tying them to projected changes in other places, or relying on expert judgment. The projected ratios are then applied to population projections by age and sex to obtain projections of the characteristic of interest. There are three steps in applying this method:

- 1- Determine the launch year participation ratios.
- 2- Determine the target year participation ratios.
- 3- Apply the target year ratios to the projected population.

The present section introduces two applications of the use of population projections as a base for constructing other types of projections.

- The first application:

Population projection is used for school enrollment projections by applying enrollment rates to the appropriate age groups.

- The second application:

Population projection is used for labor force projections by applying the labor force participation ratio (LFPR) to the appropriate age and sex groups.

4.3.1 The Projection of School Enrollment

School enrollment projections are critical for determining future needs for educational facilities, equipment, and staffing. School enrollment can be projected by the participation ratio- method.

To project the school enrollment in the basic education at year 2016 for Qalyobia Governorate, the number of male and female from the ages 6 -14 [where the primary education from ages 6-11 and the preparatory education from ages 12-14] are calculated as follows:

The first step in the school enrollment projection process is to calculate the projected age and sex distribution at the target year 2016 according to the single ages using Sprague Multipliers which are illustrated in table (7a) in Appendix C, the results are illustrated in table (11b) in Appendix B, and the detailed calculations of the single ages are illustrated in table (7c) in Appendix C [See Shryock, H.S. & Siegal, J.S. (1976)].

The second step in the school enrollment projection process is related to calculate the total sum of the male and female students in primary and preparatory schools using the single ages from 6 – 14 illustrated in table (11b) in Appendix B.

The third step in the school enrollment projection process is assume to that, the Qalyobia Governorate enrollment ratio in primary and preparatory education at year 2014 [which is equal to 103.4% and 96.4%, respectively, and are listed in table (10) in Appendix A] will continue unchanged for the target year 2016.

As a final step, the participation ratios are applied to 2016 projections for the corresponding age groups.

School enrollment by grade group, and classrooms projections, for Qalyobia Governorate at year 2016 are shown in table (4.6) as follows:

Table: (4.6): School Enrollment by Grade Group and Classrooms Projections for Qalyobia Governorate at Year 2016

Description	Grade group		2016 Population ^a	2014 Ratio ^b	2016 Enrollment ^c
	Sex	Ages			
Primary School Students	Male	6-11	336,900	103.4	$(336900 \times 103.4) \div 100 = 348,355$
	Female	6-11	318,979	103.4	$(318979 \times 103.4) \div 100 = 329,824$
Total			655,879	103.4	678,179
Preparatory School Students	Male	12-14	149,641	96.4	$(149641 \times 96.4) \div 100 = 144,254$
	Female	12-14	141,202	96.4	$(141202 \times 96.4) \div 100 = 136,118$
Total			290,843	96.4	280,372

Primary School Classrooms				$(678,179) \div 30 = 22600$
Preparatory School Classrooms				$(280372) \div 30 = 9345$

Source: Researcher calculations using:

^aQalyobia 2016 population projections, according to the single ages [Table (11b) in Appendix B]

^bQalyobia Governorate enrollment ratio in primary and preparatory education at year 2014 [Table (10) in Appendix A]

^cQalyobia 2016 Enrollment = $(2016 \text{ population}^a \times 2014 \text{ enrollment ratio}^b) \div 100$

It is noticed from table (4.6) that, the main characteristics of the school enrollment by grade group and classrooms projections for the Qalyobia Governorate at the year 2016 are as follows:

- 1- The male population students of primary schools is equal to 336,900 students.
- 2- The female population students of primary schools is equal to 318,979 students.
- 3- The total population students of primary schools is equal to 655,879 students.
- 4- Projected population number of students in primary schools is equal to 678,179.
- 5- The male population students of preparatory schools is equal to 149,641 students.
- 6- The female population students of preparatory schools is equal to 141,202 students.
- 7- The total population students of preparatory schools is equal to 290,843 students.
- 8- The projected population number of students in preparatory schools is equal to 280,372.
- 9- The required projected classrooms in primary schools are equal to 22600 if it is assumed that, the classroom density is 30 students in each classroom.

10-The required projected classrooms in preparatory school are equal to 9345 if it is assumed that, the classroom density is 30 students in each classroom.

School enrollment by single grade for Qalyobia Governorate at year 2016 are shown in table (4.7), as follows:

Table (4.7): School Enrollment Projections by Single Grade for Qalyobia Governorate at Year 2016

Grade	Age	2016 ^a		2014 Ratio ^b	2016 Enrollment ^c
Grade 1	6	Male	60747	103.4	62812
		Female	57827	103.4	59793
		Total	118574	103.4	122605
Grade 2	7	Male	58923	103.4	60926
		Female	55950	103.4	57852
		Total	114873	103.4	118778
Grade 3	8	Male	57070	103.4	59010
		Female	54067	103.4	55905
		Total	111137	103.4	114915
Grade 4	9	Male	55253	103.4	57132
		Female	52237	103.4	54013
		Total	107490	103.4	111145
Grade 5	10	Male	53414	103.4	55230
		Female	50402	103.4	52116
		Total	103816	103.4	107346
Grade 6	11	Male	51493	103.4	53244
		Female	48496	103.4	50145
		Total	99989	103.4	103389
Total					678,178
Grade 7	12	Male	50151	96.4	48346
		Female	47210	96.4	45510
		Total	97361	96.4	93856
Grade 8	13	Male	49686	96.4	47897
		Female	46860	96.4	45173
		Total	96546	96.4	93070
Grade 9	14	Male	49804	96.4	48011
		Female	47132	96.4	45435
		Total	96936	96.4	93446
Total					280,372

Source: Researcher calculations using:

^aQalyobia 2016 population projections, according to the single ages [Table (11b) in Appendix B]

^bQalyobia Governorate enrollment ratio in primary and preparatory education at year 2014 [Table (10) in Appendix A]

^cQalyobia 2016 Enrollment = $(2016 \text{ population}^a \times 2014 \text{ enrollment ratio}^b) \div 100$

Table (4.7) shows the main characteristics of the male and female students by grade, and the total enrollment in primary and preparatory education to the Qalyobia Governorate at year 2016.

4.3.2 The Projection of Labor Force

Labor force is defined as, persons of both sexes aged 15 to 60 years who are able, willing and desire to participate in the production of economic goods and services. The selection of age 15 to 60 years is attributable to the official age of participation in work and the age of retirement. Also, the selection of age at the entry age to the labor force is based on the (UN) recommendations regarding the tabulation of economically active population by age [See UN (1958)].

The participation-ratio methodology can be used for projecting the labor force in Qalyobia Governorate. This projection is made by applying the calculated labor force participation ratios (LFPR) by age and sex to population projection developed by the present study for Qalyobia.

The projected labor force at year 2016 for Qalyobia Governorate for the ages 15 – 65+ are calculated using three steps as follows:

First, LFPRs for Qalyobia Governorate in 2014 are calculated for each age and sex group as listed in table (12d) in Appendix B using the following formula:

$$\text{LFPR} = \frac{\text{Qalyobia Labor Force at year 2014}}{\text{Qalyobia Population at year 2014}}$$

Second, Qalyobia LFPRs by age and sex group which are calculated at year 2014, assumed to continue unchanged for the target year 2016.

Third, the projected LFPRs are applied to population projections by age at year 2016 in table (3.20). The population and labor force projections are shown in table (4.8) as follows:

Table (4.8): Labor Force Projections By Age for Qalyobia Governorate at Year 2016

Age	Male			Female		
	^a Population (1)	^b LFPR (2)	^c Labor Force (In Hundred) (3)	^a Population (4)	^b LFPR (5)	^c Labor Force (In Hundred) (6)
15-19	249853	0.23786	594	238887	0.10511	251
20-24	244567	0.56115	1372	236957	0.16032	379
25-29	235273	0.67024	1576	229796	0.19454	447
30-39	428996	0.94212	4041	421593	0.26842	1131
40-49	330889	1.02704	3398	314701	0.29655	933
50-59	227538	0.85337	1941	211344	0.25076	529
60-64	78255	0.34714	271	73553	0.04462	328
65+	124596	0.14912	185	113194	0.01111	12
Total			13378			4010

Source :Researcher calculations using Qalyobia population at year 2016

^aQalyobia projected Population at year 2016 in [Table (3.20)]

^bLFPR : Labor Force Participation Ratio [Table (12d) in AppendixB]

^cProjected male and female Qalyobia Labor Force at year 2016 =^aPopulation ×^bLFPR

Applying the listed LFPRs in 2nd and 5th column yields a labor force projection of males, which is equal to 1,337,800, and of females, which is equal to 401,000 at year 2016 for Qalyobia Governorate.

The results obtained in the present sub-section can be used as a measure of accuracy of the suggested model. The observed male and female labor force at the year 2011 by labor force sample survey 2014 and the estimated male and female labor force in the present study at year 2011, are shown in table (4.9) as follows:

Table (4.9): Observed and Estimated Labor Force with Respect to Age for Qalyobia at Year 2011

Age	^a Observed 2011 Labor Force (In Hundred)		Estimated 2011 Labor Force (In Hundred)					
	Male	Female	Male			Female		
			^b Population	^c LFPR	^d Result	^b Population	^c LFPR	^d Result
15-19	474	90	241319	0.20170	486	232733	0.04110	95
20-24	1710	384	231858	0.68675	1592	225555	0.16410	370
25-29	2153	439	222219	0.92403	2053	218669	0.19864	434
30-39	2368	569	220158	1.01446	2233	367034	0.17893	656
40-49	2491	690	282688	0.99640	2816	262469	0.28512	748
50-59	1722	283	191299	0.91596	1752	174191	0.15380	267
60-64	187	24	64837	0.30161	195	59123	0.03934	23
65+	84	6	96519	0.04800	46	86115	0.00588	5
∑	11189	2485			11173			2598

Source: Central Agency For Public Mobilization And Statistics , 2011.

Researcher calculations using observed and estimated Qalyobia population at year 2011.

^a Observed male and female Qalyobia Labor Force (In Hundred) Central Agency For Public Mobilization And Statistics , 2011.

^b Estimated male and female Qalyobia population at year 2011 [Table (3.13)]

^c Observed male and female Qalyobia Labor Force Participation Ratio [Table (12a) in Appendix B]

^d Estimated male and female Qalyobia Labor Force at year 2011 = ^b Population × ^c LFPR

Table (4.9) shows that the gap of the Qalyobia observed and estimated labor force at year 2011, is very small which clarifies that, the present study posses an accurate procedure in calculating the data.

It is noticed that, some of the enrollment rates and labor force participation ratios may exceed one. This result is due to the fact that, Qalyobia Governorate is an attractive area and the net migration in this Governorate is positive.

CHAPTER 5

SUMMARY AND CONCLUSIONS

5.1 Introduction

Population projections are used to predict future population change, to analyze the determinants of population change, to give the data users an indication of potential future scenarios and as a base for constructing other types of projections.

Much of the researches on population projections have focused on projections at the national level. Although these researches have been very valuable, conclusions based on studies of national projections are not always applicable to states and local areas.

5.2 Summary

According to the present study, the commonly used projection methods can be classified as non-component and component methods. Non-component methods includes:

1-Simple methods such as: Linear extrapolation, exponential (or geometric) extrapolation, constant-share, shift-share, and share-of-growth methods. These methods are mathematically simple and require relatively little input data and few modeling skills.

2-More complex methods such as: Regression, logistic, and ARIMA time series models. These methods are considerably more mathematically complex and require more input data and modeling skills than simple trend extrapolation methods. However, they rely primarily on highly aggregated data and do not account for the effects of other variables.

Component models are mathematically complex, highly disaggregated, and require large amounts of input data.

The advantages, disadvantages, and the required data for each method are discussed.

The present study is concerned with the development of a mathematical model for projecting local populations. The model considered in the present study has an advantage over the traditional methods because it is not concerned with the projection of population only, but the considered model is devoted to make a detailed local population projection to each of the demographic components (which are fertility, mortality, and net migration) to clarify the importance of each component in changing the characteristics and region size to help the regional planners in making good plans in light of the results of each component. The suggested model is referred to as the complete component projection model.

The data required by the component method is generally not available for the migration component. Even if available, they are out-dated and their quality is also not reliable. Use of the method requires expertise in demography and understanding of the demographic structure of the population, which may not be available at the migration level.

An application to the suggested model is implemented to Qalyobia Governorate where a separate projection for each component [mortality, net migration and fertility] is carried out to clarify the importance of each component in changing the characteristics and size of the Qalyobia Governorate. Also, to know

the real population numbers of this Governorate without excess or negligence to help in effective regional planning.

The local projection for Qalyobia Governorate is implemented through two stages, the 1st stage at year 2011 and the 2nd stage at year 2016.

Furthermore, the present study is devoted to clarify some extensions of the component model with respect to future changes, and other sectoral projections, which have great important uses of the model in the regional planning. Alternative scenarios are introduced as an extension of the component model. The changes may be occurring in fertility and mortality component data in the foreseeable future. The future changes in the fertility and mortality components are considered by the synthetic projections.

5.3 Conclusions

The application of the suggested model on Qalyobia Governorate, at the year 2011 and 2016 reveals that:

- 1-**The effect of the mortality component on Qalyobia distribution of male and female projected population by age at year 2016 is shown in table (3.14).
- 2-** The effect of the migration component on Qalyobia distribution of male and female projected migrants by age at year 2016 is shown in table (3.15).
- 3-** The effect of the fertility component on Qalyobia distribution of total male and female births by age of mother at year 2016 is shown in table (3.18).
- 4-** All the net migration values of the Qalyobia Governorate [see table (3.5)] are positive values, i.e., the Qalyobia Governorate

has an internal net migration. This result support the results in Mustafa and EL-Rouby in 1992, and in Central Agency for Public Mobilization and Statistics in 2006 that, the Qalyobia Governorate is an attractive area for people in the state of Egypt.

- 5- Net migration is an important component in the population changes of the Qalyobia Governorate since the net migration rate of Qalyobia Governorate in 2006 is equal to 18.6%.
- 6- The total population of the Qalyobia Governorate for the target year 2016 are shown in table (3.20).
- 7- As stated at the end of chapter three that, the measure of the model accuracy is equal to 0.33% , which is a good indicator that, the complete component projection model achieves a good accuracy.
- 8- The projection of school enrollment for the Qalyobia Governorate at the target year 2016 [see tables (4.6) and (4.7)] indicates the following:
 - The male population students of primary schools is equal to 336,900 students.
 - The female population students of primary schools is equal to 318,979 students.
 - The total population students of primary schools is equal to 655,879 students.
 - Projected population number of students in primary schools is equal to 678,179.
 - The male population students of preparatory schools is equal to 149,641 students.
 - The female population students of preparatory schools is equal to 141,202 students.

- The total population students of preparatory schools is equal to 290,843 students.
 - The projected population number of students in preparatory schools is equal to 280,372.
 - The required projected classrooms in primary schools are equal to 22600 if it is assumed that, the classroom density is 30 students in each classroom.
 - The required projected classrooms in preparatory school are equal to 9345 if it is assumed that, the classroom density is 30 students in each classroom.
- 9-** The projected male population at year 2016 in the labor force is equal to 13378 hundred.
- 10-**The projected female population at year 2016 in the labor force is equal to 4010 hundred.

Furthermore, one of the most important conclusions is this study is the comparison of the resulting population pyramids with the population pyramid figures known in the literature. It is known that, the area of any rectangle in any age and sex group in the population pyramid depends on three main factors namely [See Mustafa (1992)]:

- 1-** Fertility
- 2-** Mortality
- 3-** Net migration

Also, the population pyramid in young population has the following characteristics:

- 1-** The pyramid base is a very wide indicating a very high birth rate.
- 2-** Population pyramid in young population has a very narrow

head or sharpened peak due to people dying at each age.

- 3- Population pyramid in developing countries is less higher than in developed countries, this is due to the high level of death.
- 4- Population pyramid in young population has a progressive shape due to high birth rate and people dying at each age which is called triangular -shaped.

A comparison between the four pyramids of the Qalyobia Governorate from year 1996 till the year 2016 [Qalyobia population pyramid at base year 1996 before and after smoothing, Qalyobia population pyramid at launch year 2006 before and after adjustment smoothing, Qalyobia population pyramid year 2011, and Qalyobia population pyramid at year 2016] discussed in the present study reveals that: there is an improvement in the pyramid figures after using the complete component model.

Figure (5.1): Qalyobia Population Pyramid at Base Year 1996 Before Smoothing

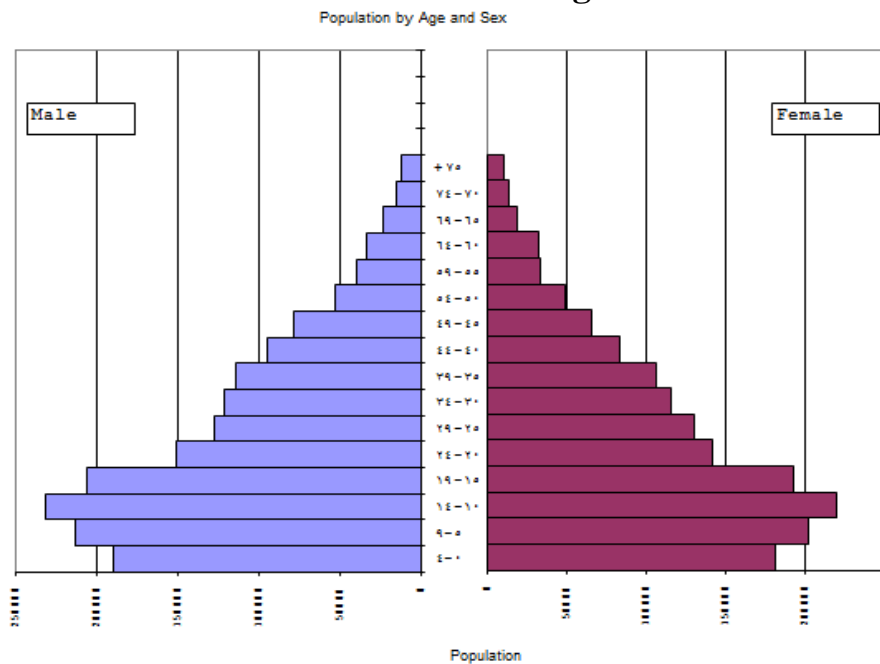
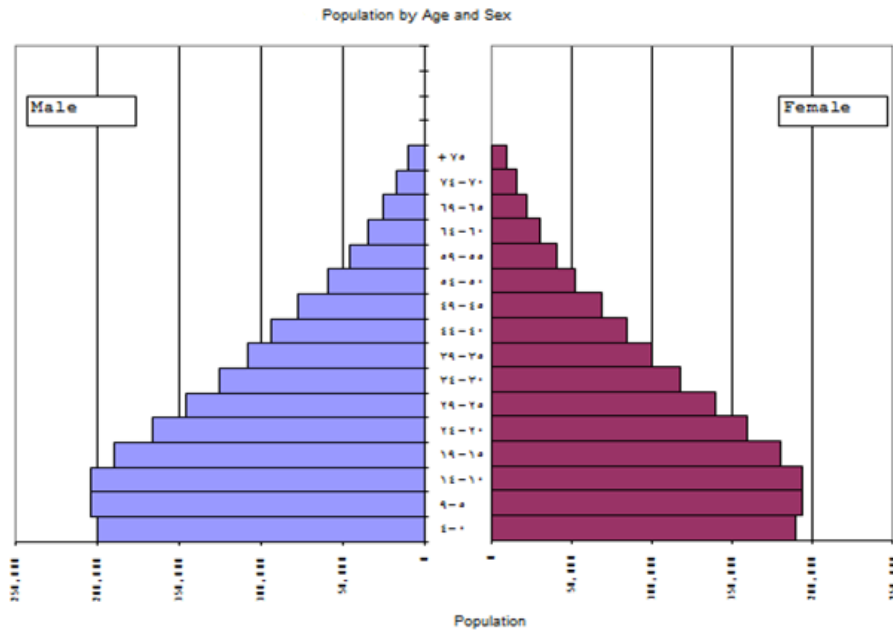


Figure (5.2): Qalyobia Population Pyramid at Base Year 1996 After Smoothing



Comparing the population pyramid for Qalyobia at year 1996 before smoothing and after smoothing by Strong formula [see figures (5.1) and (5.2)]. It is noticed that, more improvement in the shape is represented which reflects the status of the Qalyobia Governorate as a young population.

Figure (5.3): Qalyobia Population Pyramid at Launch Year 2006 Before Adjustment And Smoothing

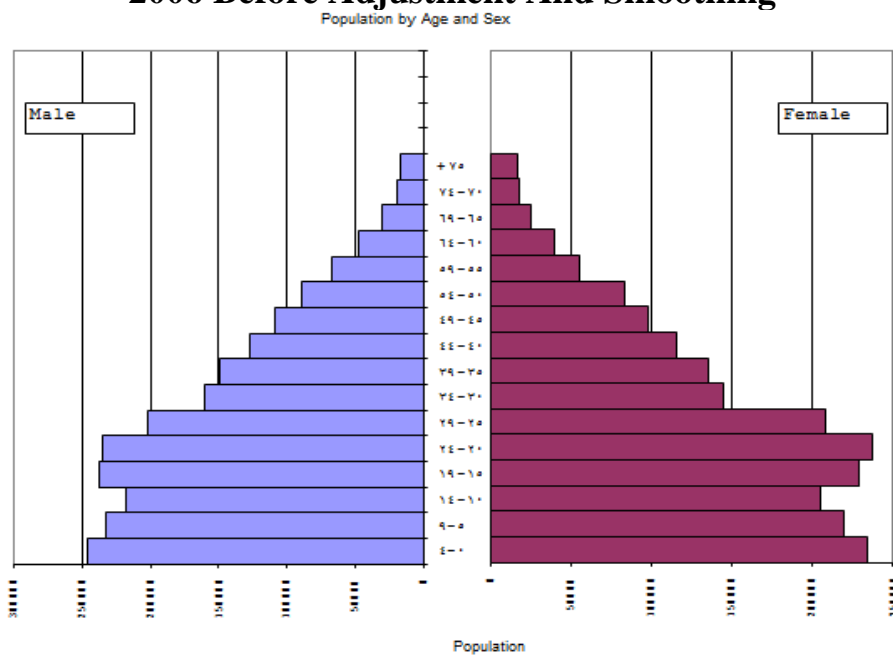
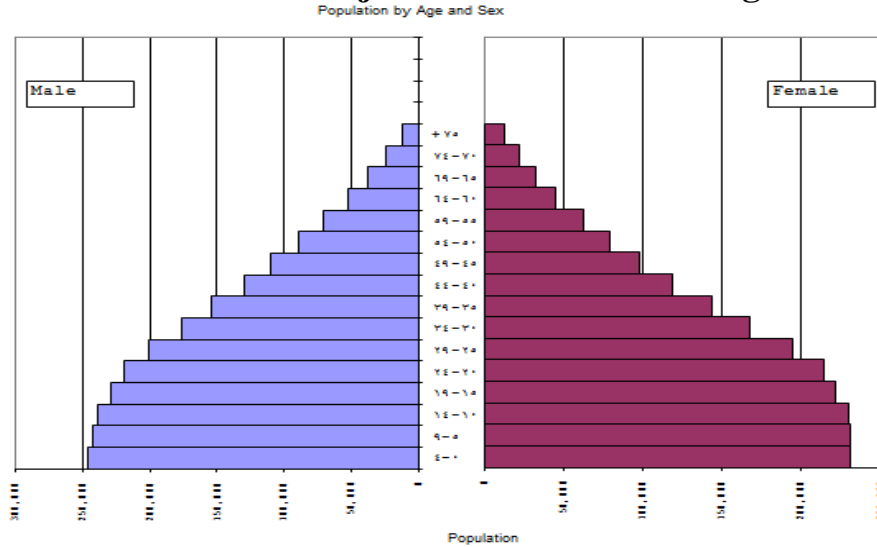


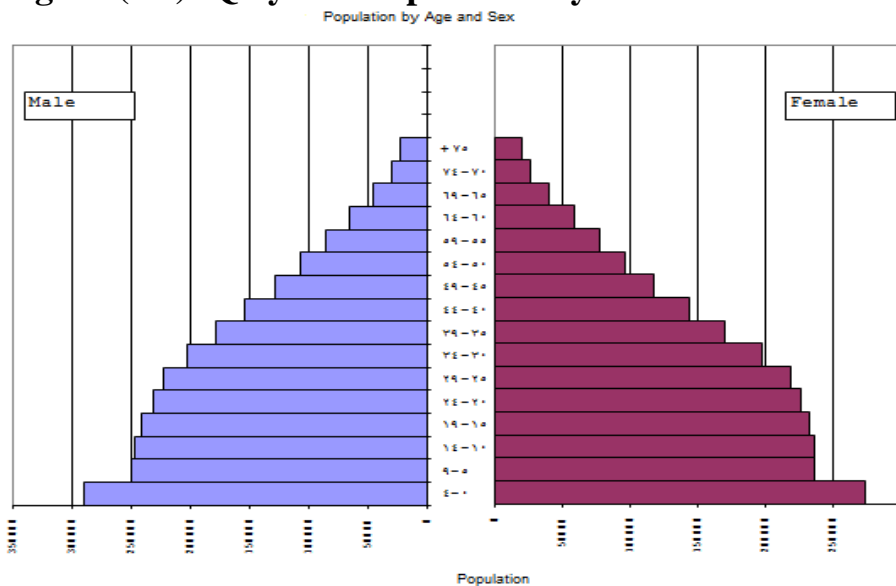
Figure (5.4): Qalyobia Population Pyramid at Launch Year 2006 After Adjustment And Smoothing



Also, the same conclusion in comparing the population pyramids for Qalyobia at year 2006 [see figures (5.3) and (5.4)] is noticed.

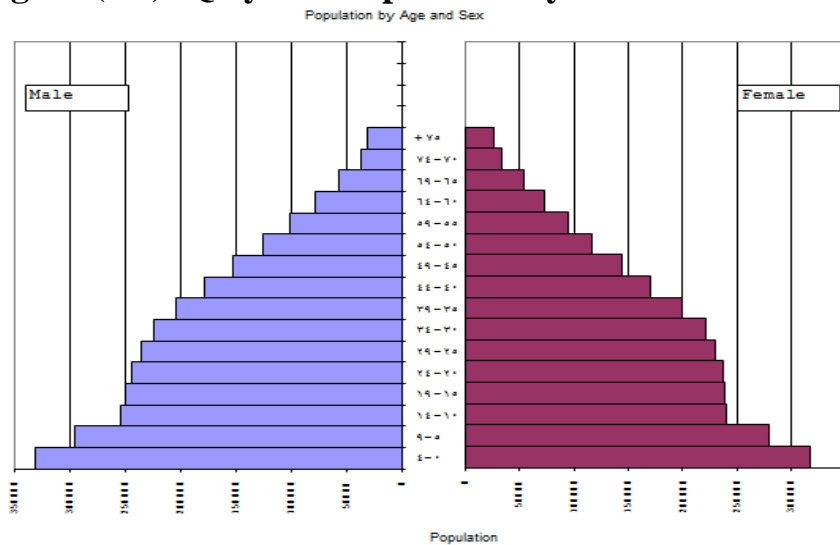
The Qalyobia population pyramid at year 2011 shown in figure (5.5) is shaped as a triangular-shaped which posses a wide base in the first age class which reflects a high birth rate in Qalyobia young population. This small improvement is due to using the migration component besides the fertility and mortality component in calculating the population for Qalyobia at year 2011.

Figure (5.5): Qalyobia Population Pyramid at Year 2011



The Qalyobia population pyramid at year 2016 shown in figure (5.6) is shaped as a triangle which poses a wider base in the first age class (0 – 4) and extended to the second age class (5-9) than the previous one. This more improvement is due to the continuity in separate calculations for the migrant data beside the fertility and mortality data using the complete component projection model.

Figure (5.6): Qalyobia Population Pyramid at Year 2016



From the previous analysis for the Qalyobia pyramids it is concluded that, the continuity in calculating the population in each 5 years in the future by the complete component projection model may lead to better projections for the size of the Qalyobia population.

5.4 Suggestions for Future Research

Some future studies may be summarized in the following points:

- 1- Extensions of the complete component projection model can be studied with respect to the methods of projecting the mortality, fertility, and migration components.
- 2- The stochastic approach can be used in formulating models for the population projection.

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Appendix A

Table (1): Observed Distribution of the Population By Age and Sex for Qalyobia Governorate at Year 2006

Ages	Male	Female	Total
0-4	246107	233783	479890
5-9	233101	219653	452754
10-14	218217	204928	423145
15-19	237828	229006	466834
20-24	235519	237259	472778
25-29	201919	207665	409584
30-34	160570	145025	305595
35-39	148724	135073	283797
40-44	127080	116003	243083
45-49	108252	98064	206316
50-54	88811	83440	172251
55-59	67601	55826	123427
60-64	47815	39594	87409
65-69	30057	25029	55086
70-74	18857	17644	36501
75+	16830	16392	33222
Σ	2187288	2064384	4251672

Source: Central Agency For Public Mobilization And Statistics in 2006 "Final results of the Census of Population and Housing". Cairo , (May,2008)

Table (2): Male Life Tables Survivorship Ratio

		$S(t_{Year})$					
Ages \ Years	Years	1996	2001	2006	2011	2016	2021
		(1)	(2)	(3)	(4)	(5)	(6)
	0	0.93951	0.94835	0.95561	0.96157	0.96649	0.97108
	0-4	0.98781	0.99401	0.99237	0.99386	0.995	0.99599
	5-9	0.99571	0.99654	0.99719	0.99769	0.99808	0.99842
	10-14	0.99541	0.99624	0.9969	0.99741	0.99782	0.99818
	15-19	0.99395	0.99501	0.99586	0.99652	0.99705	0.99754
	20-24	0.99278	0.99403	0.99502	0.99581	0.99644	0.99701
	25-29	0.99082	0.9924	0.99364	0.99464	0.99544	0.99617
	30-34	0.98843	0.99035	0.99189	0.99312	0.99411	0.99502
	35-39	0.98312	0.98568	0.98777	0.98947	0.99086	0.99215
	40-44	0.97301	0.97667	0.97971	0.98223	0.98433	0.98632
	45-49	0.95671	0.96176	0.96605	0.96968	0.97277	0.97575
	50-54	0.92875	0.93569	0.94173	0.94659	0.95148	0.95593
	55-59	0.89381	0.90248	0.91017	0.91694	0.92292	0.92889
	60-64	0.84316	0.85407	0.86389	0.87268	0.88055	0.88853
	65-69	0.75748	0.77169	0.78471	0.79654	0.80729	0.81834
	70-74	0.62661	0.64335	0.65904	0.67358	0.680706	0.70118
	75-79	0.48988	0.50598	0.52133	0.53581	0.54946	0.56402
	80+	0.31945	0.32911	0.33836	0.34713	0.35542	0.36342

Source: Extracted from male life tables pages (95,96,97,98,and 99). Cairo Demographic Center "CDC" life tables for Egypt governorates projections Cairo, (September ,2000).

Table (3): Female Life Tables Survivorship Ratio

		$S(t_{Year})$					
Ages \ Years	1996	2001	2006	2011	2016	2021	
	(1)	(2)	(3)	(4)	(5)	(6)	
0	0.93707	0.94697	0.95502	0.96159	0.96696	0.97137	
0-4	0.98603	0.98946	0.99196	0.9938	0.99515	0.99617	
5-9	0.99655	0.99741	0.99803	0.99848	0.99882	0.99907	
10-14	0.99655	0.99741	0.99804	0.99849	0.99883	0.99908	
15-19	0.99573	0.99683	0.99761	0.99819	0.9986	0.99891	
20-24	0.99506	0.9963	0.9972	0.99785	0.99833	0.99869	
25-29	0.99411	0.99551	0.99654	0.99731	0.99788	0.99832	
30-34	0.9926	0.99424	0.99546	0.9964	0.99711	0.99766	
35-39	0.98999	0.99195	0.99347	0.99466	0.99559	0.99632	
40-44	0.98406	0.98675	0.98891	0.99065	0.99206	0.9932	
45-49	0.9723	0.97642	0.97982	0.98262	0.98494	0.98685	
50-54	0.95168	0.95811	0.96351	0.96807	0.9719	0.97511	
55-59	0.92158	0.9309	0.93888	0.94572	0.95157	0.95657	
60-64	0.86838	0.87745	0.88943	0.89995	0.90915	0.91718	
65-69	0.77099	0.78988	0.80696	0.82233	0.83611	0.84838	
70-74	0.59943	0.62358	0.64632	0.66757	0.6873	0.70546	
75-79	0.39413	0.41696	0.43921	0.46072	0.48137	0.50099	
80+	0.20624	0.21796	0.22949	0.24077	0.25172	0.26221	

Source: Extracted from male life tables pages (88,89,90,91,92,and 93). Cairo Demographic Center "CDC" life tables for Egypt governorates projections, Cairo, (September ,2000).

Table (4): Observed Distribution of the Population By Age and Sex for Qalyobia Governorate at Year 1996

Ages	Male	Female	Total
0-4	189931	181411	371342
5-9	213296	201608	414904
10-14	231850	219835	451685
15-19	206074	192655	398729
20-24	151210	141590	292800
25-29	127343	130273	257616
30-34	121660	115477	237137
35-39	113638	106222	219860
40-44	95152	83430	178582
45-49	78617	65759	144376
50-54	52975	49586	102561
55-59	39504	33038	72542
60-64	33828	32050	65878
65-69	23547	18920	42467
70-74	14729	13959	28688
75+	11506	10567	22073
Σ	1704860	1596380	3301240

Source: Central Agency For Public Mobilization And Statistics in 1996 "Final results of the Census of Population and Housing". Cairo ,(December,1998)

Table (5): Qalyobia Births at the Base Period

Year	Male	*Ratio of Males	Female	*Ratio of Females	Total
1996	41687	$\left(\frac{41687}{81029}\right) = 0.5144$	39342	$\left(\frac{39342}{81029}\right) = 0.4855$	81029
1997	42738		40085		82823
1998	44105		41652		85757
1999	45430		43903		89333
2000	46943		44373		91316
2001	47519	$\left(\frac{47519}{92369}\right) = 0.5144$	44850	$\left(\frac{44850}{92369}\right) = 0.4855$	92369
2002	48145		45480		93625
2003	48421		46404		94825
2004	48728		45966		94694
2005	49200		46412		95612
2006	53417	$\left(\frac{53417}{103742}\right) = 0.5149$	50325	$\left(\frac{50325}{103742}\right) = 0.4851$	103742
Σ					1005125
2007	56175		54569		110744
2008	61997		57853		119850
2009	63829		58641		122470
2010	64237		61799		126036
2011	68160	$\left(\frac{68160}{131679}\right) = 0.5176$	63519	$\left(\frac{63519}{131679}\right) = 0.4823$	131679
2012	71487	$\left(\frac{71487}{140410}\right) = 0.5091$	68923	$\left(\frac{68923}{140410}\right) = 0.4908$	140410
2013	71282	$\left(\frac{71282}{140154}\right) = 0.5086$	68872	$\left(\frac{68872}{140154}\right) = 0.4914$	140154
**2014	72771	$\left(\frac{72771}{142395}\right) = 0.5111$	69624	$\left(\frac{69624}{142395}\right) = 0.4889$	142395

Source: Central Agency For Public Mobilization and Statistics, Annual Bulletin For Vital Statistics Births and Deaths. Cairo.

*Researcher Calculations

**Ministry Of Health Information Center

Table (6): Qalyobia Deaths at the Base Period

Year	Male	Female	Total
1996	9614	7896	17510
1997	9660	7958	17618
1998	9737	8335	18072
1999	10078	8510	18588
2000	11001	8731	19732
2001	10691	8199	18890
2002	11043	9251	20294
2003	12474	10641	23115
2004	13192	10819	24011
2005	13313	10344	23657
2006	11923	9700	21623
Σ	122726	100384	223110

Source: Central Agency For Public Mobilization and Statistics, Annual Bulletin For Vital Statistics Births and Deaths. Cairo. Total deaths of Qalyobia governorate from year 1996 up to 2006.

Table (7a): Egyptian Citizens Internal Migration To Qalyobia Governorate

Reasons to In Migrate to Qalyobia Governorate	Sex	Current Governorate of Residence
		Qalyobia Governorate
Work	Male	89375
	Female	4861
	Sub-Total	94236
Education	Male	2691
	Female	2012
	Sub-Total	4703
Marriage	Male	72524
	Female	153920
	Sub-Total	226444
Divorce or Widowhood	Male	534
	Female	3484
	Sub-Total	4018
Companion	Male	79312
	Female	133135
	Sub-Total	212447
Another	Male	53400
	Female	16039
	Sub-Total	69439
Unknown	Male	0
	Female	0
	Sub-Total	0
Total	Male	297836
	Female	313451
	Total	611287

Source: Central Agency For Public Mobilization And Statistics in 2006 "Final results of the Census of Population and Housing". Cairo , (December,2009)

Table (7b): Distribution of the Qalyobia Population According to the Current Governorate of Residence and the Previous Governorate of Residence

Current Governorate of Residence	Sex	Previous Governorate of Residence
		Qalyobia Governorate
Cairo	Male	20742
	Female	26268
	Sub-Total	47010
Alexandria	Male	1069
	Female	992
	Sub-Total	2061
Port said	Male	609
	Female	616
	Sub-Total	1225
Suez	Male	5028
	Female	5333
	Sub-Total	10361
Damietta	Male	135
	Female	147
	Sub-Total	282
Dakahlia	Male	287
	Female	538
	Sub-Total	825
Al Sharqia	Male	3584
	Female	5062
	Sub-Total	8646
Qalyobia	Male	0
	Female	0
	Sub-Total	0
Kafr el-Sheikh	Male	92
	Female	124
	Sub-Total	216
Gharbia	Male	311
	Female	757
	Sub-Total	1068
Monufia	Male	1160
	Female	2267
	Sub-Total	3427

Table (7b): Continued

Beheria	Male	1522
	Female	1355
	Sub-Total	2877
Ismailia	Male	5287
	Female	5319
	Sub-Total	10606
Giza	Male	7873
	Female	9242
	Sub-Total	17115
Beni Suef	Male	117
	Female	157
	Sub-Total	274
Faiyum	Male	32
	Female	118
	Sub-Total	150
Minya	Male	100
	Female	133
	Sub-Total	233
Asyut	Male	77
	Female	136
	Sub-Total	213
Sohag	Male	27
	Female	90
	Sub-Total	117
Qena	Male	89
	Female	144
	Sub-Total	233
Aswan	Male	97
	Female	120
	Sub-Total	217
Luxor	Male	8
	Female	10
	Sub-Total	18
Red Sea	Male	565
	Female	329
	Sub-Total	894
New Valley	Male	87
	Female	88
	Sub-Total	175

Table (7b): Continued

Matruh	Male	332
	Female	284
	Sub-Total	616
North Sinai	Male	404
	Female	344
	Sub-Total	748
South Sinai	Male	812
	Female	331
	Sub-Total	1143
Total	Male	50446
	Female	60304
	Total	110750

Source: Central Agency For Public Mobilization And Statistics in 2006 "Final results of the Census of Population and Housing". Cairo , (December,2009)

Table (7c): Distribution of the Qalyobia Population According to the Current Governorate of Residence and the Previous Governorate of Residence

Previous Governorate of Residence	Sex	Current Governorate of Residence
		Qalyobia Governorate
Cairo	Male	154833
	Female	149446
	Sub-Total	304279
Alexandria	Male	1263
	Female	2098
	Sub-Total	3361
Port said	Male	271
	Female	356
	Sub-Total	627
Suez	Male	863
	Female	1038
	Sub-Total	1901
Damietta	Male	301
	Female	472
	Sub-Total	773
Dakahlia	Male	6450
	Female	8904
	Sub-Total	15354
Al Sharqia	Male	10436
	Female	14578
	Sub-Total	25014
Qalyobia	Male	0
	Female	0
	Sub-Total	0
Kafr el-Sheikh	Male	967
	Female	1424
	Sub-Total	2391
Gharbia	Male	5900
	Female	8113
	Sub-Total	14013
Monufia	Male	20271
	Female	23866
	Sub-Total	44137

Table (7c): Continued

Beheria	Male	1453
	Female	1969
	Sub-Total	3422
Ismailia	Male	713
	Female	1065
	Sub-Total	1778
Giza	Male	6798
	Female	9016
	Sub-Total	15814
Beni Suef	Male	3157
	Female	2907
	Sub-Total	6064
Faiyum	Male	4592
	Female	4354
	Sub-Total	8946
Minya	Male	6719
	Female	5611
	Sub-Total	12330
Asyut	Male	17204
	Female	14559
	Sub-Total	31763
Sohag	Male	14134
	Female	12057
	Sub-Total	26191
Qena	Male	4137
	Female	3751
	Sub-Total	7888
Aswan	Male	1288
	Female	1282
	Sub-Total	2570
Luxor	Male	320
	Female	317
	Sub-Total	637
Red Sea	Male	66
	Female	71
	Sub-Total	137
New Valley	Male	471
	Female	362
	Sub-Total	833

Table (7c): Continued

Matruh	Male	47
	Female	67
	Sub-Total	114
North Sinai	Male	68
	Female	90
	Sub-Total	158
South Sinai	Male	35
	Female	32
	Sub-Total	67
Out of Egypt	Male	1200
	Female	1178
	Sub-Total	2378
Unknown	Male	33879
	Female	44468
	Sub-Total	78347
Sub-Total	Male	297836
	Female	313451
	Sub-Total	611287
Not changed the Qalyobia governorate as a current place of residence until 2006	Male	1882318
	Female	1747524
	Sub-Total	3629842
Qalyobia Total Population	Male	2180154
	Female	2060975
	Total	4241129

Source: Central Agency For Public Mobilization And Statistics in 2006 "Final results of the Census of Population and Housing". Cairo , (December,2009)

**Table (8): Age Specific Fertility Rates for Years (2006-2031)
Medium Assumption**

Age of Mother	2006 (1)	2011 (2)	2016 (3)	2021 (4)	2026 (5)	2031 (6)
15-19	54	32	25	22	17	15
20-24	143	113	102	97	88	83
25-29	159	138	129	125	116	112
30-34	133	120	113	110	102	98
35-39	87	79	74	71	66	63
40-44	38	34	32	30	27	25
45-49	6	5	5	4	4	3
TFR	3.1	2.6	2.4	2.3	2.1	2

Source: Central Agency For Public Mobilization And Statistics in 2006 "Final results of the Census of Population and Housing". Cairo , (December,2009).

**Table (9): Observed Distribution of the Qalyobia Governorate
Population at Year 2011**

	Male	Female	Total
Banha	87202	86899	174101
Markaz Banha	212750	202545	415295
Markaz El-Khanka	249504	231938	481442
Markaz El-Kanater	218306	204637	422943
Markaz Shbeen El-Kanater	241466	226388	467854
Shubra El-Kheima 1 st	260798	248904	509702
Shubra El-Kheima 2 nd	319850	302671	622521
Markaz Tookh	259786	244969	504755
Qalyob	60131	58331	118462
Markaz Qalyob	209070	194873	403943
Markaz Kafr Shukr	84402	79377	163779
El Khosous	166533	154997	321530
El-Obour	24893	23241	48134
Qaha	20063	19300	39363
Σ	2414754	2279070	4693824

Source: Central Agency For Public Mobilization And Statistics in 2011 ". Cairo ,
(July ,2011).

Table (10): Enrollment and Dropping Out Rate of Basic Education for Qalyobia Governorate

Data	Primary	Preparatory
Dropping out Rate Between 2012/2013 and 2013/2014	0.9	3.4
Enrollment Rate at Year 2012/2013	107.4	95.4
Enrollment Rate at Year 2013/2014	103.4	96.4

Source: Annual Bulletin of pre-university education. Central Agency For Public Mobilization And Statistics. Cairo (2015).

APPENDIX B

Table (1): Sex Ratio and Deviations in the Age Groups of the Qalyobia 2006 Census Data

*Ages	*Male (1)	*Female (2)	Sex Ratio% (3)	Deviations From 100 (4)
0-4	246107	233783	105.3	5.3
5-9	233101	219653	106.1	6.1
10-14	218217	204928	106.5	6.5
15-19	237828	229006	103.9	3.9
20-24	235519	237259	99.3	-0.7
25-29	201919	207665	97.2	-2.8
30-34	160570	145025	110.7	10.7
35-39	148724	135073	110.1	10.1
40-44	127080	116003	109.5	9.5
45-49	108252	98,064	110.4	10.4
50-54	88811	83440	106.4	6.4
55-59	67601	55826	121.1	21.1
60-64	47815	39594	120.8	20.8
65-69	30057	25029	120.1	20.1
70-74	18857	17644	106.9	6.9
75+	16830	16392	102.7	2.7

*Source: Central Agency For Public Mobilization And Statistics in 2006 "Final results of the Census of Population and Housing". Cairo , (May,2008).

Table (2): Adjusted Distribution of the Population By Age and Sex for Qalyobia Governorate at the Launch Year 2006

Ages	Male	Female	Total
0-4	251029	238458	489487
5-9	237763	224046	461809
10-14	222581	209026	431607
15-19	242584	233586	476170
20-24	240229	242004	482233
25-29	205957	211818	417775
30-34	163781	147925	311706
35-39	151698	137774	289472
40-44	129621	118323	247944
45-49	110417	100025	210442
50-54	90587	85108	175695
55-59	68953	56942	125895
60-64	48771	40385	89156
65-69	30658	25529	56187
70-74	19234	17996	37230
75+	17166	16719	33885
Σ	2231029	2105664	4336693

Source: Researcher calculations by multiplying the observed Qalyobia census 2006 [Table (1) in Appendix A] by the correction factor $\left(\frac{102}{100}\right)$.

Table (3): Sex Ratio and Deviations in the Age Groups of the Qalyobia 1996 Census Data

Ages	Male (1)	Female (2)	Sex Ratio% (3)	Deviations From 100 (4)
0-4	189931	181411	104.7	4.7
5-9	213296	201608	105.8	5.8
10-14	231850	219835	105.5	5.5
15-19	206074	192655	107.0	7.0
20-24	151210	141590	106.8	6.8
25-29	127343	130273	97.8	-2.2
30-34	121660	115477	105.4	5.4
35-39	113638	106222	107.0	7.0
40-44	95152	83430	114.1	14.1
45-49	78617	65759	119.6	19.6
50-54	52975	49586	106.8	6.8
55-59	39504	33038	119.6	19.6
60-64	33828	32050	105.5	5.5
65-69	23547	18920	124.5	24.5
70-74	14729	13959	105.5	5.5
75+	11506	10567	108.9	8.9

Source: Central Agency For Public Mobilization And Statistics in 1996 "Final results of the Census of Population and Housing". Cairo , (December,1998).

Table(4a):Male Net Migration Data and Net Migration Rates at the Base Period

Ages	$NM_x^A(t_{1996}, t_{2006}) = \left(\frac{1+S(t_{1996})}{2S(t_{1996})} \right) [P_{x+n}(t_{2006}) - S(t_{1996}) \cdot P_x(t_{1996})]$	Net Migration Data	Net Migration Rates
5-9	$\left(\frac{1+0.98781}{2(0.98781)} \right) [242882 - (0.98781) \cdot (199614)]$	45983	$\frac{45983}{1840208} = 0.025$
10-14	$\left(\frac{1+0.99571}{2(0.99571)} \right) [238727 - (0.99571) \cdot (203613)]$	36065	$\frac{36065}{1840208} = 0.020$
15-19	$\left(\frac{1+0.99541}{2(0.99541)} \right) [228930 - (0.99541) \cdot (204521)]$	25406	$\frac{25406}{1840208} = 0.014$
20-24	$\left(\frac{1+0.99395}{2(0.99395)} \right) [219167 - (0.99395) \cdot (189977)]$	30431	$\frac{30431}{1840208} = 0.017$
25-29	$\left(\frac{1+0.99278}{2(0.99278)} \right) [200280 - (0.99278) \cdot (165743)]$	35863	$\frac{35863}{1840208} = 0.019$
30-34	$\left(\frac{1+0.99082}{2(0.99082)} \right) [176400 - (0.99082) \cdot (145860)]$	32026	$\frac{32026}{1840208} = 0.017$
35-39	$\left(\frac{1+0.98843}{2(0.98843)} \right) [153835 - (0.98843) \cdot (125343)]$	30117	$\frac{30117}{1840208} = 0.016$
40-44	$\left(\frac{1+0.98312}{2(0.98312)} \right) [130124 - (0.98312) \cdot (108403)]$	23753	$\frac{23753}{1840208} = 0.013$
45-49	$\left(\frac{1+0.97301}{2(0.97301)} \right) [109331 - (0.97301) \cdot (93602)]$	18508	$\frac{18508}{1840208} = 0.010$
50-54	$\left(\frac{1+0.95671}{2(0.95671)} \right) [89281 - (0.95671) \cdot (77434)]$	15543	$\frac{15543}{1840208} = 0.008$
55-59	$\left(\frac{1+0.92857}{2(0.92857)} \right) [70811 - (0.92857) \cdot (59283)]$	16369	$\frac{16369}{1840208} = 0.009$
60-64	$\left(\frac{1+0.89381}{2(0.89381)} \right) [51819 - (0.89381) \cdot (46103)]$	11242	$\frac{11242}{1840208} = 0.006$
65-69	$\left(\frac{1+0.84316}{2(0.84316)} \right) [37133 - (0.84316) \cdot (34233)]$	9038	$\frac{9038}{1840208} = 0.005$
70-74	$\left(\frac{1+0.75748}{2(0.75748)} \right) [23995 - (0.75748) \cdot (24896)]$	5959	$\frac{5959}{1840208} = 0.003$
75+	$\left(\frac{1+0.62661}{2(0.62661)} \right) [12405 - (0.62661) \cdot (16672)]$	2541	$\frac{2541}{1840208} = 0.001$
Σ		338844	$\frac{338844}{1985119 + 1695297} = \frac{338844}{2} = 18.4\%$

* $\Sigma M_{1996}(75+) = 1704860 - 9563 = 1695297$, $\Sigma M_{2006}(0-4) = 2231029 - 245910 = 1985119$

Source: Researcher calculations for male net migration data and net migration rates at the base period using 2006 and 1996 smoothed data

Table(4b):Female Net Migration Data and Net Migration Rates at the Base Period

Ages	$NM_x^A(t_{1996}, t_{2006}) = \left(\frac{1+S(t_{1996})}{2S(t_{1996})} \right) [P_{x+n}(t_{2006}) - S(t_{1996}) \cdot P_x(t_{1996})]$	Net Migration Data	Net Migration Rates
5-9	$\left(\frac{1+0.98603}{2(0.98603)} \right) [231093 - (0.98603) \cdot (189769)]$	44286	$\frac{44286}{1730725} = 0.026$
10-14	$\left(\frac{1+0.99655}{2(0.99655)} \right) [229518 - (0.99655) \cdot (193250)]$	36998	$\frac{36998}{1730725} = 0.021$
15-19	$\left(\frac{1+0.99655}{2(0.99655)} \right) [221662 - (0.99655) \cdot (193909)]$	28471	$\frac{28471}{1730725} = 0.016$
20-24	$\left(\frac{1+0.99573}{2(0.99573)} \right) [214772 - (0.99573) \cdot (180458)]$	35159	$\frac{35159}{1730725} = 0.020$
25-29	$\left(\frac{1+0.99506}{2(0.99506)} \right) [194937 - (0.99506) \cdot (158783)]$	37030	$\frac{37030}{1730725} = 0.021$
30-34	$\left(\frac{1+0.99411}{2(0.99411)} \right) [167726 - (0.99411) \cdot (139200)]$	29433	$\frac{29433}{1730725} = 0.017$
35-39	$\left(\frac{1+0.9926}{2(0.9926)} \right) [143713 - (0.9926) \cdot (118164)]$	26522	$\frac{26522}{1730725} = 0.015$
40-44	$\left(\frac{1+0.98999}{2(0.98999)} \right) [118382 - (0.98999) \cdot (100520)]$	18963	$\frac{18963}{1730725} = 0.011$
45-49	$\left(\frac{1+0.98406}{2(0.98406)} \right) [98110 - (0.98406) \cdot (83995)]$	15579	$\frac{15579}{1730725} = 0.009$
50-54	$\left(\frac{1+0.9723}{2(0.9723)} \right) [79682 - (0.9723) \cdot (68473)]$	13292	$\frac{13292}{1730725} = 0.007$
55-59	$\left(\frac{1+0.95168}{2(0.95168)} \right) [62659 - (0.95168) \cdot (52016)]$	13490	$\frac{13490}{1730725} = 0.008$
60-64	$\left(\frac{1+0.92158}{2(0.92158)} \right) [44900 - (0.92158) \cdot (40423)]$	7972	$\frac{7972}{1730725} = 0.005$
65-69	$\left(\frac{1+0.86383}{2(0.86383)} \right) [32384 - (0.86383) \cdot (30458)]$	6552	$\frac{6552}{1730725} = 0.004$
70-74	$\left(\frac{1+0.77099}{2(0.77099)} \right) [21742 - (0.77099) \cdot (22436)]$	5104	$\frac{5104}{1730725} = 0.003$
75+	$\left(\frac{1+0.59943}{2(0.59943)} \right) [12973 - (0.59943) \cdot (15343)]$	5037	$\frac{5037}{1730725} = 0.003$
Σ		323618	** $\frac{323618}{\frac{1587197+1874253}{2}} = \frac{323618}{1730725} = 18.7\%$

** $\sum F_{1996}(75+) = 1596380 - 9183 = 1587197, \sum F_{2006}(0-4) = 2105664 - 231411 = 1874253$

Source: Researcher calculations for female net migration data and net migration rates at the base period using 2006 and 1996 smoothed data

Table (5a) : The Distribution of Female Projected Population By Age at Year 2011

Starting Age	$P(t_{2006})$	$S(t_{2006})$	$\hat{P}(t_{2011}) = P(t_{2006}) \cdot S(t_{2006})$	Final Age
-(0-4)		0.95502		0-4
0-4	231411	0.99196	229550	5-9
5-9	231093	0.99803	230638	10-14
10-14	229518	0.99804	229068	15-19
15-19	221662	0.99761	221132	20-24
20-24	214772	0.9972	214171	25-29
25-29	194937	0.99654	194263	30-34
30-34	167726	0.99546	166965	35-39
35-39	143713	0.99347	142775	40-44
40-44	118382	0.98891	117069	45-49
45-49	98110	0.97982	96130	50-54
50-54	79682	0.96351	76774	55-59
55-59	62659	0.93888	58829	60-64
60-64	44900	0.88943	39935	65-69
65-69	32384	0.80696	26133	70-74
70-74	21742	0.64632	14052+5698=19750 21742 × 0.64632 = 14052 12973 × 0.43921 = 5698	75+
75+	12973	0.43921		

Source: Researcher calculations for female mortality projection at year 2011 using 2006 smoothed data

Table (5b) : The Distribution of Male Projected Population By Age at Year 2011

Starting Age	$P(t_{2006})$	$S(t_{2006})$	$\hat{P}(t_{2011}) = P(t_{2006}) \cdot S(t_{2006})$	Final Age
-(0-4)		0.95561		0-4
0-4	245910	0.99237	244034	5-9
5-9	242882	0.99719	242199	10-14
10-14	238727	0.9969	237987	15-19
15-19	228930	0.99586	227982	20-24
20-24	219167	0.99502	218076	25-29
25-29	200280	0.99364	199006	30-34
30-34	176400	0.99189	174969	35-39
35-39	153835	0.98777	151954	40-44
40-44	130124	0.97971	127484	45-49
45-49	109331	0.96605	105619	50-54
50-54	89281	0.94173	84078	55-59
55-59	70811	0.91017	64450	60-64
60-64	51819	0.86389	44766	65-69
65-69	37133	0.78471	29139	70-74
70-74	23995	0.65904	15814+6467=22281 23995 × 0.65904 = 15814 12405 × 0.52133 = 6467	75+
75+	12405	0.52133		

Source: Researcher calculations for male mortality projection at year 2011 using 2006 smoothed data

Table (6a) : The Distribution of Female Projected Migrants By Age at Year 2011

Final Age	$\hat{P}(t_{2011})$	$NMR(t_{1996}, t_{2006})$	$NM(t_{2011}) = \hat{P}(t_{2011}) \cdot NMR(t_{1996}, t_{2006})$
0-4			
5-9	229550	0.026	5968
10-14	230638	0.021	4843
15-19	229068	0.016	3665
20-24	221132	0.020	4423
25-29	214171	0.021	4498
30-34	194263	0.017	3302
35-39	166965	0.015	2504
40-44	142775	0.011	1571
45-49	117069	0.009	1054
50-54	96130	0.007	673
55-59	76774	0.008	614
60-64	58829	0.005	294
65-69	39935	0.004	160
70-74	26133	0.003	78
75+	19750	0.003	59

Source: Researcher calculations for female migrant projection at year 2011

Table (6b): The Distribution of Male Projected Migrants By Age at Year 2011

Final Age	$\hat{P}(t_{2011})$	$NMR(t_{1996}, t_{2006})$	$NM(t_{2011}) = \hat{P}(t_{2011}) \cdot NMR(t_{1996}, t_{2006})$
0-4			
5-9	244034	0.025	6100
10-14	242199	0.020	4844
15-19	237987	0.014	3332
20-24	227982	0.017	3876
25-29	218076	0.019	4143
30-34	199006	0.017	3383
35-39	174969	0.016	2800
40-44	151954	0.013	1975
45-49	127484	0.010	1275
50-54	105619	0.008	845
55-59	84078	0.009	757
60-64	64450	0.006	387
65-69	44766	0.005	224
70-74	29139	0.003	87
75+	22281	0.001	22

Source: Researcher calculations for male migrant projection at year 2011

Table (7): Total Projected Population at Year 2011

Age	$\hat{P}(t_{2011})$	$NM(t_{2011})$	$* B''(x, t_{2011})$	$P(t_{2011}) = \hat{p}(t_{2011}) + NM(t_{2011}) + B''(x, t_{2011})$
0-4			563399	563399
5-9	473584	12068		485652
10-14	472837	9687		482524
15-19	467055	6997		474052
20-24	449114	8299		457413
25-29	432247	8641		440888
30-34	393269	6685		399954
35-39	341934	5304		347238
40-44	294729	3546		298275
45-49	244553	2329		246882
50-54	201749	1518		203267
55-59	160852	1371		162223
60-64	123279	681		123960
65-69	84701	384		85085
70-74	55272	165		55437
75+	42031	81		42112

Source: Researcher calculations for total population at year 2011

$$* B''(t_{2011}) = 53762 + 551942 + 235307 + 222388 = 563399$$

Table (8a): The Distribution of Female Projected Population By Age at Year 2016

Starting Age	$P(t_{2011})$	$S(t_{2011})$	$\hat{P}(t_{2016}) = P(t_{2011}) \cdot S(t_{2011})$	Final Age
-(0-4)		0.96159		0-4
0-4	274330	0.9938	272629	5-9
5-9	235518	0.99848	235160	10-14
10-14	235481	0.99849	235125	15-19
15-19	232733	0.99819	232311	20-24
20-24	225555	0.99785	225070	25-29
25-29	218669	0.99731	218080	30-34
30-34	197565	0.9964	196853	35-39
35-39	169469	0.99466	168564	40-44
40-44	144346	0.99065	142996	45-49
45-49	118123	0.98262	116070	50-54
50-54	96803	0.96807	93712	55-59
55-59	77388	0.94572	73187	60-64
60-64	59123	0.89995	53207	65-69
65-69	40095	0.82233	32971	70-74
70-74	26211	0.66757	17498+9126=26624	75+
75+	19809	0.46072	26211 × 0.66757 = 17498 19809 × 0.46072 = 9126	

Source: Researcher calculations for female mortality projection at year 2016 using data of year 2011

Table (8b) : The Distribution of Male Projected Population By Age at Year 2016

Starting Age	$P(t_{2011})$	$S(t_{2011})$	$\hat{P}(t_{2016}) = P(t_{2011}) \cdot S(t_{2011})$	Final Age
-(0-4)		0.96157		0-4
0-4	289069	0.99386	287294	5-9
5-9	250134	0.99769	249556	10-14
10-14	247043	0.99741	246403	15-19
15-19	241319	0.99652	240479	20-24
20-24	231858	0.99581	230886	25-29
25-29	222219	0.99464	221027	30-34
30-34	202389	0.99312	200996	35-39
35-39	177769	0.98947	175897	40-44
40-44	153929	0.98223	151193	45-49
45-49	128759	0.96968	124855	50-54
50-54	106464	0.94659	100777	55-59
55-59	84835	0.91694	77788	60-64
60-64	64837	0.87268	56582	65-69
65-69	44990	0.79654	35836	70-74
70-74	29226	0.67358	19686+11950=31636	75+
75+	22303	0.53581	29226 × 0.67358 = 19686 22303 × 0.53581 = 11950	

Source: Researcher calculations for male mortality projection at year 2016 using data of 2011

Table (9a) : The Distribution of Female Projection Migrants By Age at Year 2016

Final Age	$\hat{P}(t_{2016})$	$NMR(t_{2006}, t_{2011})$	$NM(t_{2016}) = \hat{P}(t_{2016}) \cdot NMR(t_{2006}, t_{2011})$
0-4			
5-9	272629	0.026	7088
10-14	235160	0.021	4938
15-19	235125	0.016	3762
20-24	232311	0.020	4646
25-29	225070	0.021	4726
30-34	218080	0.017	3707
35-39	196853	0.015	2953
40-44	168564	0.011	1854
45-49	142996	0.009	1287
50-54	116070	0.007	812
55-59	93712	0.008	750
60-64	73187	0.005	366
65-69	53207	0.004	213
70-74	32971	0.003	99
75+	26624	0.003	80

Source: Researcher calculations for female migrant projection at year 2016 using 2011 data

Table (9b): The Distribution of Male Projection Migrants By Age at Year 2016

Final Age	$\hat{P}(t_{2016})$	$NMR(t_{2006}, t_{2011})$	$NM(t_{2016}) = \hat{P}(t_{2016}) \cdot NMR(t_{2006}, t_{2011})$
0-4			
5-9	287294	0.025	7182
10-14	249556	0.020	4991
15-19	246403	0.014	3450
20-24	240479	0.017	4088
25-29	230886	0.019	4387
30-34	221027	0.017	3757
35-39	200996	0.016	3216
40-44	175897	0.013	2287
45-49	151193	0.010	1512
50-54	124855	0.008	999
55-59	100777	0.009	907
60-64	77788	0.006	467
65-69	56582	0.005	283
70-74	35836	0.003	227
75+	31636	0.001	32

Source: Researcher calculations for male migrant projection at year 2016

Table (10): Total Projected Population at Year 2016

Final Age	$\hat{P}(t_{2016})$	$NM(t_{2016})$	$B''(t_{2016})$	$P(t_{2016}) = \hat{P}(t_{2016}) + NM(t_{2016}) + B''(t_{2016})$
0-4			*649437	649437
5-9	559932	14270		574193
10-14	484716	9929		494645
15-19	481528	7212		488740
20-24	472790	8734		481524
25-29	455956	9113		465069
30-34	439107	7464		446571
35-39	397849	6169		404018
40-44	344461	4141		348602
45-49	294189	2799		296988
50-54	240925	1811		242736
55-59	194489	1657		196146
60-64	150975	833		151808
65-69	109789	496		110285
70-74	68807	326		69133
75+	58260	112		58372

Source: Researcher calculations for total population at year 2016

* $B''(t_{2016}) = 53810 + 51995 + 277231 + 266401 = 649437$

Table (11a): Qalyobia Population at 2011 According to the Single Ages

Ages	Male	Female	Total
0	64164	61004	125168
1	60414	57209	117623
2	57332	54111	111443
3	54854	51646	106500
4	52918	49747	102665
5	51461	48350	99811
6	50421	47389	97810
7	49735	46798	96533
8	49341	46513	95854
9	49176	46468	95644
10	49238	46660	95898
11	49526	47086	96612
12	49673	47368	97041
13	49495	47316	96810
14	49112	47051	96162
15	48833	46894	95727
16	48603	46790	95394
17	48324	46623	94,947
18	47976	46369	94,346
19	47583	46056	93639
20	47164	45713	92877
21	46696	45306	92002
22	46286	44986	91272
23	45984	44822	90805
24	45729	44729	90458
25	45422	44565	89987
26	45092	44374	89466
27	44624	43987	88611
28	43951	43312	87263
29	43130	42431	85562
30	42296	41534	83829
31	41430	40600	82031
32	40517	39586	80104
33	39564	38495	78059
34	38582	37350	75931
35	37566	36167	73734
36	36515	34936	71451
37	35498	33780	69279
38	34549	32760	67309
39	33640	31825	65465

Table (11a): Continued

40	32715	30872	63587
41	31795	29932	61727
42	30837	28942	59779
43	29818	27863	57681
44	28764	26736	55501
45	27724	25638	53361
46	26682	24546	51228
47	25688	23528	49216
48	24768	22621	47388
49	23898	21791	45689
50	23028	20966	43994
51	22171	20158	42329
52	21308	19360	40668
53	20424	18559	38983
54	19532	17761	37293
55	18655	16981	35636
56	17785	16213	33998
57	16938	15461	32399
58	16124	14727	30851
59	15332	14,005	29338
60	14550	13,295	27845
61	13786	12608	26395
62	13001	11881	24882
63	12173	11085	23258
64	11327	10254	21581
65	10513	9456	19969
66	9731	8681	18412
67	8971	7955	16926
68	8237	7299	15535
69	7,539	6704	14243
70	6892	6147	13039
71	6302	5637	11938
72	5774	5182	10957
73	5318	4788	10106
74	4940	4457	9397
75+	22303	19809	42112
Σ	2497756	2370605	4868361

Source: Researcher calculations by using Sprague multipliers depending on Qalyobia 2011 projected population.

Table (11b): Qalyobia Population at 2016 According to the Single Ages

Ages	Male	Female	Total
0	67675	65406	133081
1	67308	64896	132205
2	66544	64001	130545
3	65444	62784	128228
4	64069	61307	125377
5	62484	59635	122118
6	60747	57827	118575
7	58923	55950	114873
8	57070	54067	111136
9	55253	52237	107490
10	53414	50402	103814
11	51493	48496	99988
12	50151	47210	97361
13	49686	46860	96546
14	49804	47132	96935
15	49900	47390	97290
16	50093	47751	97845
17	50184	48005	98187
18	50009	47974	97983
19	49668	47768	97434
20	49425	47662	9088
21	49234	47615	96849
22	48985	47490	96476
23	48655	47252	95908
24	48268	46937	95205
25	47858	46594	94452
26	47403	46189	93592
27	46989	45854	92843
28	46660	45652	92312
29	46363	45507	91870
30	46012	45288	91300
31	45634	45034	90668
32	45124	44595	89719
33	44425	43887	88312
34	43589	42983	86572
35	42732	42058	84789
36	41842	41097	82939
37	40895	40047	80942
38	39893	38904	78797
39	38850	37700	76551

Table (11b): Continued

40	37775	36460	74235
41	36662	35169	71831
42	35582	33960	69542
43	34569	32899	67468
44	33596	31929	65525
45	32605	30940	63545
46	31616	29965	61581
47	30590	28936	59526
48	29506	27810	57316
49	28388	26632	55020
50	27282	25483	52765
51	26175	24341	50515
52	25111	23274	48385
53	24117	22326	46442
54	23170	21458	44628
55	22224	20592	42816
56	21291	19743	41034
57	20352	18898	39249
58	19392	18043	37435
59	18425	17186	35612
60	17474	16347	33822
61	16532	15521	32053
62	15617	14703	30320
63	14740	13893	28633
64	13891	13089	26980
65	13072	12312	25395
66	12313	11584	23943
67	11479	10783	22308
68	10511	9859	20358
69	9490	8883	18281
70	8580	7999	16452
71	7777	7206	14869
72	7081	6502	13526
73	6516	5910	12484
74	6108	5453	11802
75+	31668	26704	58372
Σ	2801269	2676998	5478267

Source: Researcher calculations by using Sprague multipliers depending on Qalyobia 2016 projected population.

Table (12a):Labor Force Participation Ratio By Age for Qalyobia at Year 2011

Age	Male			Female		
	^a Population	^b Labor Force	^c LFPR	^a Population	^b Labor Force	^c LFPR
15-19	235000	47400	0.20170	219000	9000	0.04110
20-24	249000	171000	0.68675	234000	38400	0.16410
25-29	233000	215300	0.92403	221000	43900	0.19864
30-39	332000	336800	1.01446	318000	56900	0.17893
40-49	250000	249100	0.99640	242000	69000	0.28512
50-59	188000	172200	0.91596	184000	28300	0.15380
60-64	62000	18700	0.30161	61000	2400	0.03934
65+	100000	4800	0.04800	102000	600	0.00588

Source :Researcher calculations using Qalyobia population at year 2011.

^aQalyobia Population at year 2011

^bQalyobia Labor Force at year 2011

$$^c\text{LFPR} = \frac{\text{Qalyobia Labor Force at year 2011}}{\text{Qalyobia Population at year 2011}}$$

Table (12b):Labor Force Participation Ratio By Age for Qalyobia at Year 2012

Age	Male			Female		
	^a Population	^b Labor Force	^c LFPR	^a Population	^b Labor Force	^c LFPR
15-19	233000	53800	0.23090	218000	9300	0.04266
20-24	249000	154300	0.61968	234000	39000	0.16667
25-29	240000	185000	0.77083	228000	53400	0.23421
30-39	349000	330100	0.94585	336000	70400	0.20952
40-49	255000	266000	1.04314	246000	55300	0.22480
50-59	195000	162500	0.83333	190000	39400	0.20737
60-64	65000	26300	0.40462	65000	900	0.01385
65+	105000	11900	0.11333	107000	2400	0.02243

Source :Researcher calculations using Qalyobia population at year 2012.

$$^c\text{LFPR} = \frac{\text{Qalyobia Labor Force at year 2012}}{\text{Qalyobia Population at year 2012}}$$

Table (12c):Labor Force Participation Ratio By Age for Qalyobia at Year 2013

Age	Male			Female		
	^a Population	^b Labor Force	^c LFPR	^a Population	^b Labor Force	^c LFPR
15-19	237000	64600	0.27257	230000	18100	0.07870
20-24	254000	156400	0.61575	246000	45200	0.18374
25-29	246000	165900	0.67439	232000	41600	0.17931
30-39	360000	334200	0.92833	334000	83000	0.24850
40-49	263000	281200	1.06920	254000	52900	0.20827
50-59	202000	180800	0.89505	193000	39100	0.20259
60-64	68000	25000	0.36765	64000	2900	0.04531
65+	112000	11300	0.10089	106000	700	0.00660

Source :Researcher calculations using Qalyobia population at year 2013.

$${}^c\text{LFPR} = \frac{\text{Qalyobia Labor Force at year 2013}}{\text{Qalyobia Population at year 2013}}$$

Table (12d):Labor Force Participation Ratio By Age for Qalyobia at Year 2014

Age	Male			Female		
	^a Population	^b Labor Force	^c LFPR	^a Population	^b Labor Force	^c LFPR
15-19	243000	57800	0.23786	235000	24700	0.10511
20-24	260000	145900	0.56115	252000	40400	0.16032
25-29	252000	168900	0.67024	238000	46300	0.19454
30-39	368000	346700	0.94212	342000	91800	0.26842
40-49	270000	277300	1.02704	261000	77400	0.29655
50-59	208000	177500	0.85337	197000	49400	0.25076
60-64	70000	24300	0.34714	65000	2900	0.04462
65+	114000	17000	0.14912	108000	1200	0.01111

Source :Researcher calculations using Qalyobia population at year 2014.

$${}^c\text{LFPR} = \frac{\text{Qalyobia Labor Force at year 2014}}{\text{Qalyobia Population at year 2014}}$$

Table (12e): Labor Force Participation Ratio By Age for Qalyobia Through Year 2011 to 2014

Age	Male Labor Force				Female Labor Force			
	2011	2012	2013	2014	2011	2012	2013	2014
15-19	20.2	23.1	27.3	23.7	4.1	4.2	7.8	10.5
20-24	68.6	62	61.6	56.1	16.4	16.7	18.4	16
25-29	92.4	77.1	67.4	67	19.8	23.4	17.9	19.5
30-39	101.4	94.6	92.8	94.2	17.9	20.9	24.8	26.8
40-49	99.6	104.3	106.9	102.7	28.5	22.5	20.8	29.6
50-59	91.6	83.3	89.5	85.3	15.4	20.7	20.3	25.1
60-64	30.2	40.5	36.7	34.7	3.9	1.4	4.5	4.5
65+	4.8	11.3	10.1	14.9	0.6	2.2	0.7	1.1

Source :Researcher calculations for Qalyobia labor force participation ratio.

APPENDIX C

**Table (1): Smoothing of the Adjusted Age and Sex Distribution
at Launch Year 2006 Using Strong Formula**

Age	Adjusted Census Population		Smoothed Population		Adjusted Population		Five- year Age Groups	
	10-year Age Groups						Launch year 2006	
Sex	Male	Female	Male	Female	Male	Female	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total 0 – 75+	2231029	2105664					2231029	2105664
Total 10 - 69	1705837	1608445	1700987	1605618	1705837	1608445	1705837	1608445
0-4	488792	462504	488792	462504	488792	462504	245910	231411
5-9							242882	231093
10-14	465165	442612	466327	*450388	467657	451180	238727	229518
15-19							228930	221662
20-24	446186	453822	418254	408989	419447	409709	219167	214772
25-29							200280	194937
30-34	315479	285699	329296	310892	330235	311439	176400	167726
35-39							153835	143713
40-44	240038	218348	238774	216111	239455	216492	130124	118382
45-49							109331	98110
50-54	159540	142050	159637	142091	160092	142341	89281	79682
55-59							70811	62659
60-64	79429	65914	88700	77148	88952	77284	51819	44900
65-69							37133	32384
70-74	36400	34715	36400	34715	36400	34715	23995	21742
75+							12405	12973

Source: Researcher calculations using adjusted Qalyobia census 2006 [Table (2) in Appendix B] to illustrate Strong formula calculations using PAS computer program.

Notes:

a) Columns 1 and 2: Census population.

b) Columns 3 and 4: Each 10-year group is smoothed by using Strong moving average formula as follows:

$${}_{10}P_x = \left(\frac{{}_{10}P_{x-10} + 2{}_{10}P_x + {}_{10}P_{x+10}}{4} \right)$$

c) Columns 5 and 6 : The smoothed 10-year group in columns 3 and 4 are adjusted to census total by multiplying each value in column 3 by adjustment factor $\left(\frac{1705837}{1700987} \right) = 1.00285$ and each value in

column 4 by adjustment factor $\left(\frac{1608445}{1605618} \right) = 1.00176$

d) Columns 7 and 8 : Age groups in columns 5 and 6 are separated into 5 – year age groups using Arriaga's formula and divided into two age groups as follows:

Examples of intermediate calculations as follows:

$${}_{10}P_X = \left({}_{10}P_{X-10} + 2{}_{10}P_X + {}_{10}P_{X+10} \right) / 4$$

$${}_{10}P_X = (462504 + 2(442612) + 453822) / 4 = *450388$$

Using Arriaga's formula to divide the ten age groups into two five age groups as listed in column (7) and (8).

$$\left. \begin{aligned} {}_5P_{X+5} &= \left(8{}_{10}P_X + 5{}_{10}P_{X+10} - {}_{10}P_{X+20} \right) / 24 \text{ Classes}(0-4), (5-9) \\ {}_5P_X &= \left({}_{10}P_X - {}_5P_{X+5} \right) \end{aligned} \right\} X = 0$$

$$\left. \begin{aligned} {}_5P_X &= \left(8{}_{10}P_X + 5{}_{10}P_{X-10} - {}_{10}P_{X-20} \right) / 24 \text{ Classes}(70-74), (75+) \\ {}_5P_{X+5} &= \left({}_{10}P_X - {}_5P_X \right) \end{aligned} \right\} X = 70$$

$$\left. \begin{aligned} {}_5P_{X+5} &= \left(11{}_{10}P_X + 2{}_{10}P_{X+10} - {}_{10}P_{X-10} \right) / 24 \text{ Classes}(10-14), (60-69) \\ {}_5P_X &= \left({}_{10}P_X - {}_5P_{X+5} \right) \end{aligned} \right\} X = 10, 20, 30, 40, 50, 60$$

$${}_5P_{X+5} = \left(8{}_{10}P_X + 5{}_{10}P_{X+10} - {}_{10}P_{X+20} \right) / 24 \text{ Classes}(0-4), (5-9), X = 0$$

$$(5-9) = 8(0-9) + 5(10-19) - {}_{10}P_{X+20} / 24$$

$$(5-9) = 8(488792) + 5(467657) - 419447 / 24$$

$$\underline{(5-9) = 242882} \rightarrow \text{Male in column (7)}$$

$${}_5P_X = \left({}_{10}P_X - {}_5P_{X+5} \right)$$

$$\underline{(0-4) = 488792 - 242882 = 245910} \rightarrow \text{Male in column (7)}$$

$${}_5P_X = \left(8{}_{10}P_X + 5{}_{10}P_{X-10} - {}_{10}P_{X-20} \right) / 24 \text{ Classes}(70-74), (75+), X = 70$$

$${}_5P_X = 8(36400) + 5(88952) - (160092) / 24$$

$$\underline{(70-74) = 23995} \rightarrow \text{Male in column (7)}$$

$${}_5P_{X+5} = \left({}_{10}P_X - {}_5P_X \right)$$

$$\underline{(75+) = 36400 - 88952 = 12405} \rightarrow \text{Male in column (7)}$$

$${}_5P_{X+5} = \left({}_{10}P_X + 2{}_{10}P_{X+10} - {}_{10}P_{X-10} \right) / 24 \text{ Class}(10-14), X = 10$$

$$(X+5)_{\text{upto}}(X+9) = 11((X)_{\text{upto}}(X+9)) + 2((X+10)(X+19)) - ((X-10)(X-1)) / 24$$

$$\therefore X = 10$$

$$\therefore (10+5)_{\text{upto}}(10+9) = 11((10)_{\text{upto}}(10+9)) + 2((10+10)_{\text{upto}}(10+19)) - ((10-10)_{\text{uoto}}(10-1)) / 24$$

$$(15)_{\text{upto}}(19) = 11((10)_{\text{upto}}(19)) + 2((20)_{\text{upto}}(29)) - ((0)_{\text{upto}}(9)) / 24$$

$$(15-19) = 11(10-19) + 2(20-29) - (0-9) / 24$$

From column 5 we can get :

$$(15-19) = 11(467657) + 2(419447) - (488792) / 24$$

$$(15-19) = 228930 \rightarrow \text{Male in column (7)}$$

$${}_5P_X = ({}_{10}P_X - {}_5P_{X+5})$$

$$((X)_{\text{upto}}(X+4)) = ((X)_{\text{upto}}(X+9)) - ((X+5)_{\text{upto}}(X+9))$$

$$\therefore X = 10$$

$$\therefore ((10)_{\text{upto}}(10+4)) = ((10)_{\text{upto}}(10+9)) - ((10+5)_{\text{upto}}(10+9))$$

$$(10-14) = (10-19) - (15-19)$$

$$(10-14) = 467657 - 228930$$

$$(10-14) = 238727 \rightarrow \text{Male in column (7)}$$

$${}_5P_{X+5} = \left({}_{10}P_X + 2{}_{10}P_{X+10} - {}_{10}P_{X-10} \right) / 24 \text{ Class}(10-14), X = 20$$

$$(X+5)_{\text{upto}}(X+9) = 11((X)_{\text{upto}}(X+9)) + 2((X+10)(X+19)) - ((X-10)(X-1)) / 24$$

$$\therefore X = 20$$

$$\therefore (20+5)_{\text{upto}}(20+9) = 11((20)_{\text{upto}}(20+9)) + 2((20+10)_{\text{upto}}(20+19)) - ((20-10)_{\text{uoto}}(20-1)) / 24$$

$$(25)_{\text{upto}}(29) = 11((20)_{\text{upto}}(29)) + 2((30)_{\text{upto}}(39)) - ((10)_{\text{upto}}(19)) / 24$$

$$(25-29) = 11(20-29) + 2(30-39) - (10-19) / 24$$

From column 5 we can get :

$$(25-29) = 11(419447) + 2(330235) - (467657) / 24$$

$$(25-29) = 200280 \rightarrow \text{Male in column (7)}$$

$${}_5P_X = ({}_{10}P_X - {}_5P_{X+5})$$

$$((X)_{\text{upto}}(X+4)) = ((X)_{\text{upto}}(X+9)) - ((X+5)_{\text{upto}}(X+9))$$

$$\therefore X = 20$$

$$\therefore ((20)_{\text{upto}}(20+4)) = ((20)_{\text{upto}}(20+9)) - ((20+5)_{\text{upto}}(20+9))$$

$$(20-24) = (20-29) - (25-29)$$

$$(20-24) = 419447 - 200280$$

$$(20-24) = 219167 \rightarrow \text{Male in column (7)}$$

**Table(2): Smoothed Age and Sex Distribution for Year 2006
According to Five Different Methods of Smoothing**

Age	Smoothed									
	Carrier Farrag		K-King Newton		Arriaga		United Nations		Strong	
	(1)	(1)	(2)	(2)	(3)	(3)	(4)	(4)	(5)	(5)
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
0-4					247543	235034			245910	231411
5-9					241249	227470			242882	231093
10-14	235234	221830	235245	221849	235149	221201	228496	215020	238727	229518
15-19	229931	220782	229920	220763	230016	221411	239585	231507	228930	221662
20-24	233913	239315	232448	236718	234776	240454	238131	240294	219167	214772
25-29	212273	214507	213738	217104	211410	213368	205083	206659	200280	194937
30-34	169939	155877	170624	157567	169472	155467	168661	157331	176400	167726
35-39	145540	129822	144855	128132	146007	130232	148388	133181	153835	143713
40-44	130223	118686	129765	118152	129871	118338	130644	118837	130124	118382
45-49	109815	99662	110273	100196	110167	100010	110272	101204	109331	98110
50-54	90728	81580	89808	80552	89800	80549	90310	82515	89281	79682
55-59	68812	60470	69732	61498	69740	61501	69118	59115	70811	62659
60-64	46968	38702	47411	39665	46638	38729	48521	39414	51819	44900
65-69	32461	27212	32018	26249	32791	27185	30780	25947	37133	32384
70-74					22034	19385			23995	21742
75+					14366	15330			12405	12973
Total 10-69	1705837	1608445	1705837	1608445	1705837	1608445	1707989	1611023	1705837	1608445
Total 0-75+					2231029	2105664			2231029	2105664

Source: Researcher calculations using adjusted Qalyobia census 2006 [Table (2) in Appendix B] to calculate smoothed data by the different five methods using PAS computer program.

Table (3a): Sex Ratios of the Adjusted and Smoothed Populations for Year 2006

		Smoothed				
Age	Adjusted	Carrier Farrag	K.-King Newton	Arriaga	United Nations	Strong
0-4	105.3			105.3		106.3
5-9	106.1			106.1		105.1
10-14	106.5	106.0	106.0	106.3	106.3	104.0
15-19	103.9	104.1	104.1	103.9	103.5	103.3
20-24	99.3	97.7	98.2	97.6	99.1	102.0
25-29	97.2	99.0	98.4	99.1	99.2	102.7
30-34	110.7	109.0	108.3	109.0	107.2	105.2
35-39	110.1	112.1	113.1	112.1	111.4	107.0
40-44	109.5	109.7	109.8	109.7	109.9	109.9
45-49	110.4	110.2	110.1	110.2	109.0	111.4
50-54	106.4	111.2	111.5	111.5	109.4	112.0
55-59	121.1	113.8	113.4	113.4	116.9	113.0
60-64	120.8	121.4	119.5	120.4	123.1	115.4
65-69	120.1	119.3	122.0	120.6	118.6	114.7
70-74	106.9			113.7		110.4
75+	102.7			93.7		95.6

Source: Researcher calculations using adjusted and smoothed age and sex distribution for year 2006 by dividing males number by females number using sex ratio formula

Table (3b): Sex Ratios Differences from Ages 10 to 69 for Year 2006

		Smoothed				
Age	Adjusted	Carrier Farrag	K.-King Newton	Arriaga	United Nations	Strong
10-14	2.63	1.90	1.89	2.42	2.78	0.73
15-19	4.59	6.40	5.95	6.25	4.39	1.23
20-24	2.03	1.22	0.25	1.44	0.14	0.69
25-29	13.49	10.06	9.84	9.93	7.96	2.43
30-34	0.61	3.09	4.76	3.10	4.22	1.87
35-39	0.56	2.39	3.22	2.37	1.48	2.88
40-44	0.84	0.47	0.23	0.41	0.97	1.52
45-49	3.95	1.03	1.43	1.33	0.49	0.61
50-54	14.66	2.58	1.90	1.91	7.47	0.96
55-59	0.33	7.56	6.14	7.03	6.18	2.40
60-64	0.67	2.07	2.45	0.20	4.48	0.75
Sex ratio score	$\frac{44.36}{11} = 4.03$	$\frac{38.77}{11} = 3.52$	$\frac{38.06}{11} = 3.46$	$\frac{36.39}{11} = 3.31$	$\frac{40.56}{11} = 3.69$	$\frac{16.07}{11} = 1.46$

Source: Researcher calculations using data in table (3a) in Appendix C

Table (3c): Age Ratios of the Adjusted and Smoothed Populations for Year 2006

Age and Sex	Adjusted	Smoothed				
		Carrier Farrag	K.-King Newton	Arriaga	United Nations	Strong
MALE						
5-9	100.4			100.0		100.2
10-14	92.7			99.8		101.2
15-19	104.8	98.0	98.3	97.9	102.7	100.0
20-24	107.1	105.8	104.8	106.4	107.1	102.1
25-29	102.0	105.1	106.1	104.6	100.8	101.3
30-34	91.6	95.0	95.2	94.8	95.4	99.6
35-39	103.4	97.0	96.4	97.6	99.2	100.4
40-44	98.9	102.0	101.7	101.4	101.0	98.9
45-49	100.3	99.4	100.4	100.3	99.8	99.7
50-54	101.0	101.6	99.8	99.8	100.7	99.1
55-59	99.0	99.9	101.6	102.2	99.6	100.4
60-64	97.9	92.8	93.2	91.0	97.1	96.0
65-69	90.2			95.5		98.0
70-74	80.4			93.4		96.9

FEMALE						
5-9	100.1			99.7		100.3
10-14	91.4			98.6		101.4
15-19	103.6	95.8	96.3	95.9	101.7	99.8
20-24	108.7	110.0	108.1	110.6	109.7	103.1
25-29	108.6	108.6	110.1	107.8	103.9	101.9
30-34	84.6	90.5	91.3	90.5	92.6	99.1
35-39	103.5	94.6	92.9	95.1	96.4	100.5
40-44	99.5	103.4	103.5	102.8	101.4	97.9
45-49	98.3	99.5	100.8	100.6	100.5	99.1
50-54	108.4	101.9	99.6	99.7	102.9	99.1
55-59	90.7	100.5	102.3	103.1	97.0	100.6
60-64	97.9	88.3	90.4	87.3	92.7	94.5
65-69	87.5			93.6		97.2
70-74	85.2			91.2		95.9

Source: Researcher calculations using adjusted and smoothed age and sex distribution for year 2006

Table (3d): Age Ratios Deviations from Ages 15 to 64 for Year 2006

Age	Smoothed											
	Adjusted		Carrier-Farrag		K.-King-Newton		Arriaga		United Nations		Strong	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
15-19	4.83	3.58	1.98	4.25	1.68	3.72	2.10	4.08	2.69	1.69	0.01	0.22
20-24	7.12	8.67	5.79	9.96	4.79	8.12	6.37	10.61	7.10	9.68	2.13	3.11
25-29	1.96	8.64	5.12	8.56	6.05	10.13	4.59	7.78	0.83	3.95	1.26	1.93
30-34	8.41	15.37	5.01	9.46	4.84	8.72	5.17	9.51	4.57	7.41	0.37	0.94
35-39	3.41	3.49	3.03	5.43	3.55	7.06	2.45	4.87	0.84	3.55	0.37	0.46
40-44	1.10	0.48	1.99	3.44	1.73	3.49	1.39	2.80	1.02	1.40	1.11	2.09
45-49	0.28	1.66	0.60	0.47	0.44	0.85	0.30	0.57	0.19	0.52	0.34	0.93
50-54	1.01	8.44	1.58	1.89	0.22	0.36	0.17	0.26	0.69	2.94	0.88	0.87
55-59	1.04	9.25	0.05	0.55	1.64	2.31	2.23	3.12	0.43	3.03	0.37	0.59
60-64	2.08	2.06	7.24	11.72	6.81	9.59	9.03	12.66	2.86	7.33	3.99	5.52
Age ratio score	$\frac{31.24}{10} = 3.12$	$\frac{61.64}{10} = 6.17$	$\frac{32.39}{10} = 3.24$	$\frac{55.73}{10} = 5.57$	$\frac{31.75}{10} = 3.17$	$\frac{54.35}{10} = 5.43$	$\frac{33.8}{10} = 3.38$	$\frac{56.26}{10} = 5.63$	$\frac{21.22}{10} = 2.12$	$\frac{41.5}{10} = 4.15$	$\frac{10.83}{10} = 1.08$	$\frac{16.71}{10} = 1.67$

Source: Researcher calculations for age ratio score using data in tables (3b) and (3c)

**Table(4): Smoothed Age and Sex Distribution for Year 1996
According to Five Different Methods of Smoothing**

Age	Smoothed									
	Carrier Farrag		K-King Newton		Arriaga		United Nations		Strong	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
0-4					189190	180738			199614	189769
5-9					214037	202281			203613	193250
10-14	229079	215077	226754	213192	230797	216736	228427	215775	204521	193909
15-19	208845	197413	211170	199298	207127	195754	203271	190023	189977	180458
20-24	150070	146460	151941	147856	149522	145971	155766	148269	165743	158783
25-29	128483	125403	126612	124007	129031	125892	127825	127008	145860	139200
30-34	124581	119149	124198	118517	124579	118982	120885	117233	125343	118164
35-39	110717	102550	111100	103182	110719	102717	112354	103864	108403	100520
40-44	96981	83751	95811	83287	96222	83163	96619	84823	93602	83995
45-49	76788	65438	77958	65902	77547	66026	76596	65650	77434	68473
50-54	52604	46825	53514	47451	52552	46723	54578	48473	59283	52016
55-59	39875	35799	38965	35173	39927	35901	40006	35765	46103	40423
60-64	33168	29325	32828	29116	32745	29008	32674	29049	34233	30458
65-69	24207	21645	24547	21854	24630	21962	23668	20602	24896	22436
70-74					16845	15351			16672	15343
75+					9390	9175			9563	9183
Total 10-69	1275398	1188835	1275398	1188835	1275398	1188835	1272670	1186533	1275398	1188835
Total 0-75+					1704860	1596380			1704860	1596380

Source: Researcher calculations using observed Qalyobia census 1996 [Table (4) in Appendix A] to calculate smoothed data by the different five methods using PAS computer program.

Table (5): Smoothing of the Age Distribution At Base Year 1996 Using Strong Formula

Age	Census Population		Smoothed Population		Adjusted Population		Five- year Age Groups	
	10-year Age Groups						Launch year 2006	
Sex	Male	Female	Male	Female	Male	Female	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total 0 -75+	1704860	1596380					1704860	1596380
Total 10-69	1275398	1188835	1258939	1174856	1275398	1188835	1275398	1188835
0-4	403227	383019	403227	383019	403227	383019	199614	189769
5-9							203613	193250
10-14	437924	412490	389407	*369966	394498	374367	204521	193909
15-19							189977	180458
20-24	278553	271863	307582	294479	311603	297983	165743	158783
25-29							145860	139200
30-34	235298	221699	230730	216113	233746	218684	125343	118164
35-39							108403	100520
40-44	173769	149189	168829	150675	171036	152468	93602	83995
45-49							77434	68473
50-54	92479	82624	104026	91352	105386	92439	59283	52016
55-59							46103	40423
60-64	57375	50970	58366	52273	59129	52894	34233	30458
65-69							24896	22436
70-74	26235	24526	26235	24526	26235	24526	16672	15343
75+							9563	9183

Source: Researcher calculations using observed Qalyobia census 1996 [Table (4) in Appendix A] to illustrate Strong formula calculations using PAS computer program.

Notes:

a) Columns 1 and 2: Census population.

b) Columns 3 and 4: Each 10-year group is smoothed by using Strong moving average formula as follows:

$${}_{10}P_x = \left(\frac{{}_{10}P_{x-10} + 2{}_{10}P_x + {}_{10}P_{x+10}}{4} \right)$$

c) Columns 5 and 6 : The smoothed 10-year group in columns 3 and 4 are adjusted to census total by multiplying each value in column 3 by adjustment factor $\left(\frac{1275398}{1258939} \right) = 1.01307$ and each value in

column 4 by adjustment factor $\left(\frac{1188835}{1174856} \right) = 1.01190$

d) Columns 7 and 8 :Age groups in columns 5 and 6 are separated into 5 – year age groups using Arriaga's formula and divided into two age groups as follows:

Examples of intermediate calculations as follows:

$${}_{10}P_X = \left({}_{10}P_{X-10} + 2{}_{10}P_X + {}_{10}P_{X+10} \right) / 4$$

$${}_{10}P_X = (383019 + 2(412490) + 271863) / 4 = *369966$$

Using Arriaga's formula to divide the ten age groups into two five age groups as listed in column (7) and (8).

$$\left. \begin{aligned} {}_5P_{X+5} &= (8{}_{10}P_X + 5{}_{10}P_{X+10} - {}_{10}P_{X+20}) / 24 \text{ Classes}(0-4), (5-9) \\ {}_5P_X &= ({}_{10}P_X - {}_5P_{X+5}) \end{aligned} \right\} X = 0$$

$$\left. \begin{aligned} {}_5P_X &= (8{}_{10}P_X + 5{}_{10}P_{X-10} - {}_{10}P_{X-20}) / 24 \text{ Classes}(70-74), (75+) \\ {}_5P_{X+5} &= ({}_{10}P_X - {}_5P_X) \end{aligned} \right\} X = 70$$

$$\left. \begin{aligned} {}_5P_{X+5} &= (11{}_{10}P_X + 2{}_{10}P_{X+10} - {}_{10}P_{X-10}) / 24 \text{ Classes}(10-14), (60-69) \\ {}_5P_X &= ({}_{10}P_X - {}_5P_{X+5}) \end{aligned} \right\} X = 10, 20, 30, 40, 50, 60$$

$${}_5P_{X+5} = (8{}_{10}P_X + 5{}_{10}P_{X+10} - {}_{10}P_{X+20}) / 24 \text{ Classes}(0-4), (5-9), X = 0$$

$$(5-9) = 8(0-9) + 5(10-19) - {}_{10}P_{X+20} / 24$$

$$(5-9) = 8(403227) + 5(394498) - 311603 / 24$$

$$(5-9) = 203613 \rightarrow \text{Male in column (7)}$$

$${}_5P_X = ({}_{10}P_X - {}_5P_{X+5})$$

$$(0-4) = 403227 - 203613 = 199614 \rightarrow \text{Male in column (7)}$$

$${}_5P_X = (8{}_{10}P_X + 5{}_{10}P_{X-10} - {}_{10}P_{X-20}) / 24 \text{ Classes}(70-74), (75+), X = 70$$

$${}_5P_X = 8(26235) + 5(59129) - (105386) / 24$$

$$(70-74) = 16672 \rightarrow \text{Male in column (7)}$$

$${}_5P_{X+5} = ({}_{10}P_X - {}_5P_X)$$

$$(75+) = 26235 - 16672 = 9563 \rightarrow \text{Male in column (7)}$$

$${}_5P_{X+5} = \left({}_{10}P_X + 2{}_{10}P_{X+10} - {}_{10}P_{X-10} \right) / 24 \text{ Class}(10-14), X = 10$$

$$(X+5)_{\text{upto}}(X+9) = 11((X)_{\text{upto}}(X+9)) + 2((X+10)(X+19)) - ((X-10)(X-1)) / 24$$

$$\therefore X = 10$$

$$\therefore (10+5)_{\text{upto}}(10+9) = 11((10)_{\text{upto}}(10+9)) + 2((10+10)_{\text{upto}}(10+19)) - ((10-10)_{\text{uoto}}(10-1)) / 24$$

$$(15)_{\text{upto}}(19) = 11((10)_{\text{upto}}(19)) + 2((20)_{\text{upto}}(29)) - ((0)_{\text{upto}}(9)) / 24$$

$$(15-19) = 11(10-19) + 2(20-29) - (0-9) / 24$$

From column 5 we can get :

$$(15-19) = 11(394498) + 2(311603) - (403227) / 24$$

$$(15-19) = 189977 \rightarrow \text{Male in column (7)}$$

$${}_5P_X = ({}_{10}P_X - {}_5P_{X+5})$$

$$((X)_{\text{upto}}(X+4)) = ((X)_{\text{upto}}(X+9)) - ((X+5)_{\text{upto}}(X+9))$$

$$\therefore X = 10$$

$$\therefore ((10)_{\text{upto}}(10+4)) = ((10)_{\text{upto}}(10+9)) - ((10+5)_{\text{upto}}(10+9))$$

$$(10-14) = (10-19) - (15-19)$$

$$(10-14) = 394498 - 189977$$

$$(10-14) = 204521 \rightarrow \text{Male in column (7)}$$

$${}_5P_{X+5} = \left({}_{10}P_X + 2{}_{10}P_{X+10} - {}_{10}P_{X-10} \right) / 24 \text{ Class}(10-14), X = 20$$

$$(X+5)_{\text{upto}}(X+9) = 11((X)_{\text{upto}}(X+9)) + 2((X+10)(X+19)) - ((X-10)(X-1)) / 24$$

$$\therefore X = 20$$

$$\therefore (20+5)_{\text{upto}}(20+9) = 11((20)_{\text{upto}}(20+9)) + 2((20+10)_{\text{upto}}(20+19)) - ((20-10)_{\text{uoto}}(20-1)) / 24$$

$$(25)_{\text{upto}}(29) = 11((20)_{\text{upto}}(29)) + 2((30)_{\text{upto}}(39)) - ((10)_{\text{upto}}(19)) / 24$$

$$(25-29) = 11(20-29) + 2(30-39) - (10-19) / 24$$

From column 5 we can get :

$$(25-29) = 11(311603) + 2(233746) - (394498) / 24$$

$$(25-29) = 145860 \rightarrow \text{Male in column (7)}$$

$${}_5P_X = ({}_{10}P_X - {}_5P_{X+5})$$

$$((X)_{\text{upto}}(X+4)) = ((X)_{\text{upto}}(X+9)) - ((X+5)_{\text{upto}}(X+9))$$

$$\therefore X = 20$$

$$\therefore ((20)_{\text{upto}}(20+4)) = ((20)_{\text{upto}}(20+9)) - ((20+5)_{\text{upto}}(20+9))$$

$$(20-24) = (20-29) - (25-29)$$

$$(20-24) = 311603 - 145860$$

$$(20-24) = 165743 \rightarrow \text{Male in column (7)}$$

Table (6a): Sex Ratios of the Observed and Smoothed Populations for Year 1996

Age	Observed	Smoothed				
		Carrier Farrag	K.-King Newton	Arriaga	United Nations	Strong
0-4	104.7			104.7		105.2
5-9	105.8			105.8		105.4
10-14	105.5	106.5	106.4	106.5	105.9	105.5
15-19	107.0	105.8	106.0	105.8	107.0	105.3
20-24	106.8	102.5	102.8	102.4	105.1	104.4
25-29	97.8	102.5	102.1	102.5	100.6	104.8
30-34	105.4	104.6	104.8	104.7	103.1	106.1
35-39	107.0	108.0	107.7	107.8	108.2	107.8
40-44	114.1	115.8	115.0	115.7	113.9	111.4
45-49	119.6	117.3	118.3	117.4	116.7	113.1
50-54	106.8	112.3	112.8	112.5	112.6	114.0
55-59	119.6	111.4	110.8	111.2	111.9	114.1
60-64	105.5	113.1	112.7	112.9	112.5	112.4
65-69	124.5	111.8	112.3	112.1	114.9	111.0
70-74	105.5			109.7		108.7
75+	108.9			102.3		104.1

Source: Researcher calculations using observed and smoothed age and sex distribution for year 1996 by dividing males number by females number using sex ratio formula

Table (6b): Sex Ratios Differences from Ages 10 to 69 for Year 1996

Age	Observed	Smoothed				
		Carrier Farrag	K.-King Newton	Arriaga	United Nations	Strong
10-14	1.50	0.72	0.40	0.68	1.11	0.20
15-19	0.17	3.33	3.19	3.38	1.92	0.89
20-24	9.04	0.01	0.66	0.06	4.41	0.40
25-29	7.60	2.10	2.69	2.21	2.47	1.29
30-34	1.63	3.41	2.88	3.09	5.06	1.77
35-39	7.07	7.83	7.36	7.91	5.73	3.60
40-44	5.50	1.55	3.26	1.74	2.77	1.65
45-49	12.72	5.00	5.52	4.97	4.08	0.88
50-54	12.74	0.95	2.00	1.26	0.74	0.08
55-59	14.02	1.72	1.97	1.67	0.62	1.66
60-64	18.91	1.27	0.42	0.74	2.41	1.43
Sex ratio score	$\frac{90.90}{11} = 8.26$	$\frac{27.89}{11} = 2.54$	$\frac{30.35}{11} = 2.76$	$\frac{27.71}{11} = 2.52$	$\frac{31.32}{11} = 2.85$	$\frac{13.85}{11} = 1.26$

Source :Researcher calculations using data in table (6a) in Appendix C

Table (6c): Age Ratios of the Observed and Smoothed Populations for Year 1996

		Smoothed				
Age and Sex	Observed	Carrier Farrag	K.-King Newton	Arriaga	United Nations	Strong
MALE						
5-9	101.1			101.9		100.8
10-14	110.6			109.6		103.9
15-19	107.6	110.2	111.5	108.9	105.8	102.6
20-24	90.7	89.0	90.0	89.0	94.1	98.7
25-29	93.3	93.6	91.7	94.1	92.4	100.2
30-34	101.0	104.2	104.5	103.9	100.7	98.6
35-39	104.8	99.9	101.0	100.3	103.3	99.0
40-44	99.0	103.4	101.4	102.2	102.3	100.7
45-49	106.1	102.7	104.4	104.2	101.3	101.3
50-54	89.7	90.2	91.5	89.5	93.6	96.0
55-59	91.0	93.0	90.3	93.6	91.7	98.6
60-64	107.3	103.5	103.4	101.4	102.6	96.4
65-69	97.0			99.3		97.8
70-74	84.0			99.0		96.8

FEMALE						
5-9	100.5			101.8		100.7
10-14	111.5			108.9		103.8
15-19	106.6	109.2	110.4	107.9	104.4	102.3
20-24	87.7	90.7	91.5	90.8	93.5	99.3
25-29	101.4	94.4	93.1	95.0	95.7	100.5
30-34	97.7	104.5	104.3	104.1	101.6	98.6
35-39	106.8	101.1	102.3	101.6	102.8	99.4
40-44	97.0	99.7	98.5	98.6	100.1	99.4
45-49	98.9	100.2	100.8	101.7	98.5	100.7
50-54	100.4	92.5	93.9	91.7	95.6	95.5
55-59	80.9	94.0	91.9	94.8	92.3	98.0
60-64	123.4	102.1	102.1	100.3	103.1	96.9
65-69	82.2			99.0		98.0
70-74	94.7			98.6		97.0

Source: Researcher calculations using observed and smoothed age and sex distribution for year 1996

Table (6d): Age Ratios Deviations from Ages 15 to 64 for Year 1996

Age	Observed		Smoothed									
	Male	Female	Carrier-Farrag		K.-King-Newton		Arriaga		United Nations		Strong	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
15-19	7.59	6.61	10.17	9.21	11.53	10.40	8.92	7.94	5.82	4.40	2.62	2.33
20-24	9.30	12.31	11.02	9.26	10.04	8.53	11.04	9.23	5.91	6.46	1.30	0.65
25-29	6.66	1.35	6.44	5.57	8.30	6.89	5.85	4.97	7.59	4.33	0.22	0.52
30-34	0.97	2.34	4.16	4.54	4.49	4.33	3.92	4.09	0.66	1.56	1.41	1.42
35-39	4.83	6.81	0.06	1.08	1.00	2.26	0.29	1.63	3.31	2.81	0.98	0.55
40-44	1.01	2.98	3.44	0.29	1.36	1.49	2.22	1.43	2.27	0.08	0.74	0.59
45-49	6.15	1.13	2.67	0.23	4.41	0.82	4.25	1.67	1.32	1.50	1.30	0.69
50-54	10.30	0.38	9.82	7.49	8.46	6.11	10.53	8.32	6.38	4.41	4.02	4.47
55-59	8.98	19.06	7.02	5.98	9.74	8.12	6.38	5.19	8.30	7.73	1.40	1.97
60-64	7.30	23.37	3.52	2.10	3.37	2.11	1.45	0.26	2.63	3.07	3.57	3.09
Age ratio score	$\frac{63.09}{10} = 6.31$	$\frac{76.34}{10} = 7.63$	$\frac{58.32}{10} = 5.83$	$\frac{47.75}{10} = 4.58$	$\frac{62.70}{10} = 6.27$	$\frac{51.06}{10} = 5.11$	$\frac{54.85}{10} = 5.49$	$\frac{44.73}{10} = 4.47$	$\frac{44.19}{10} = 4.42$	$\frac{36.35}{10} = 3.63$	$\frac{17.56}{10} = 1.75$	$\frac{16.28}{10} = 1.63$

Source: Researcher calculations for age ratio score using data in tables (6b) and (6c)

Table (7a): Sprague Multipliers

Sprague multipliers						Sprague multipliers (used for calculations)				
Interpolated subgroup	Coefficients to be applied to:									
	G1	G2	G3	G4	G5					
	First Panel									
First fifth of G1	0.3616	-0.2768	0.1488	-0.0336	0					
Second fifth of G1	0.264	-0.096	0.04	-0.008	0	0.3616	0.0336	-0.0128	0	0
Third fifth of G1	0.184	0.04	-0.032	0.008	0					
Fourth fifth of G1	0.12	0.136	-0.072	0.016	0					
Last fifth of G1	0.0704	0.1968	-0.0848	0.0176	0	-0.2768	0.2272	0.0848	-0.0144	0.0176
	Next-to-first panel									
First fifth of G2	0.0336	0.2272	-0.0752	0.0144	0	0.1488	-0.0752	0.1504	0.0912	-0.0848
Second fifth of G2	0.008	0.232	-0.048	0.008	0	-0.0336	0.0144	-0.024	0.1408	0.1968
Third fifth of G2	-0.008	0.216	-0.008	0	0	0	0	0.0016	-0.0176	0.0704
Fourth fifth of G2	-0.016	0.184	0.04	-0.008	0	0.264	0.008	-0.0016	0	0
Last fifth of G2	-0.0176	0.1408	0.0912	-0.0144	0	-0.096	0.232	0.0144	-0.008	0.016
	Middle panel									
First fifth of G3	-0.0128	0.0848	0.1504	-0.024	0.0016	-0.008	0.008	-0.0416	0.184	0.136
Second fifth of G3	-0.0016	0.0144	0.2224	-0.0416	0.0064	0	0	0.0064	-0.016	0.12
Third fifth of G3	0.0064	-0.0336	0.2544	-0.0336	0.0064	0.184	-0.008	0.0064	0	0
Fourth fifth of G3	0.0064	-0.0416	0.2224	0.0144	-0.0016	0.04	0.216	-0.0336	0	0.008
Last fifth of G3	0.0016	-0.024	0.1504	0.0848	-0.0128	-0.032	-0.008	0.2544	-0.008	-0.032
	Next-to-last panel									
First fifth of G4	0	-0.0144	0.0912	0.1408	-0.0176	0.008	0	-0.0336	0.216	0.04
Second fifth of G4	0	-0.008	0.04	0.184	-0.016	0	0	0.0064	-0.008	0.184
Third fifth of G4	0	0	-0.008	0.216	-0.008	0	0	0.0064	-0.008	0.184
Fourth fifth of G4	0	0.008	-0.048	0.232	0.008	0.12	-0.016	0.0064	0	0
Last fifth of G4	0	0.0144	-0.0752	0.2272	0.0336	0.136	0.184	-0.0416	0.008	-0.008
	Last panel									
First fifth of G5	0	0.0176	-0.0848	0.1968	0.0704	-0.072	0.04	0.2224	-0.048	0.04
Second fifth of G5	0	0.016	-0.072	0.136	0.12	0.016	-0.008	0.0144	0.232	-0.096
Third fifth of G5	0	0.008	-0.032	0.04	0.184	0	0	-0.0016	0.008	0.264
Fourth fifth of G5	0	-0.008	0.04	-0.096	0.264	0	0	-0.0016	0.008	0.264
Last fifth of G5	0	-0.0336	0.1488	-0.2768	0.3616	0.0704	-0.0176	0.0016	0	0
						0.1968	0.1408	-0.024	0.0144	-0.0336
						-0.0848	0.0912	0.1504	-0.0752	0.1488
						0.0176	-0.0144	0.0848	0.2272	-0.2768
						0	0	-0.0128	0.0336	0.3616

Source: Shryock, HS and Siegal, JS. 1976. The Methods and Materials of Demography (condensed Edition by Edward G Stockwell); Page 555

Source: Shryock, H.S. & Siegal, J.S. (1976). The Methods and Materials of Demography (Condensed Edition by Edward G Stockwell):Page 555

Table (7b): Calculations of Qalyobia Population at 2011 According to the Single Ages By Using Sprague Multipliers

Ages	Male	Female
0	$289682 \times 0.3616 = 104749 +$ $250134 \times -0.2768 = -69237 +$ $247043 \times 0.1488 = 36760 +$ $241319 \times -0.0336 = -8108 +$ $231858 \times 0 = 0$ $= 64164$	$273717 \times 0.3616 = 98976 +$ $235518 \times -0.2768 = -65191 +$ $235481 \times 0.1488 = 35040 +$ $232733 \times -0.0336 = -7820 +$ $225555 \times 0 = 0$ $= 61004$
1	$289682 \times 0.264 = 76476 +$ $250134 \times -0.096 = -24013 +$ $247043 \times 0.04 = 9882 +$ $241319 \times -0.008 = -1931 +$ $231858 \times 0 = 0$ $= 60414$	$273717 \times 0.264 = 72261 +$ $235518 \times -0.096 = -22610 +$ $235481 \times 0.04 = 9419 +$ $232733 \times -0.008 = -1862 +$ $225555 \times 0 = 0$ $= 57209$
2	$289682 \times 0.184 = 53301 +$ $250134 \times 0.04 = 10005 +$ $247043 \times -0.032 = -7905 +$ $241319 \times 0.008 = 1931 +$ $231858 \times 0 = 0$ $= 57332$	$273717 \times 0.184 = 50364 +$ $235518 \times 0.04 = 9421 +$ $235481 \times -0.032 = -7535 +$ $232733 \times 0.008 = 1862 +$ $225555 \times 0 = 0$ $= 54111$
3	$289682 \times 0.12 = 34762 +$ $250134 \times 0.136 = 34018 +$ $247043 \times -0.072 = -17787 +$ $241319 \times 0.016 = 3861 +$ $231858 \times 0 = 0$ $= 54854$	$273717 \times 0.12 = 32846 +$ $235518 \times 0.136 = 32030 +$ $235481 \times -0.072 = -16955 +$ $232733 \times 0.016 = 3724 +$ $225555 \times 0 = 0$ $= 51646$
4	$289682 \times 0.0704 = 20394 +$ $250134 \times 0.1968 = 49226 +$ $247043 \times -0.0848 = -20949 +$ $241319 \times 0.0176 = 4247 +$ $231858 \times 0 = 0$ $= 52918$	$273717 \times 0.0704 = 19270 +$ $235518 \times 0.1968 = 46350 +$ $235481 \times -0.0848 = -19969 +$ $232733 \times 0.0176 = 4096 +$ $25555 \times 0 = 0$ $= 49747$
5	$289682 \times 0.0336 = 9733 +$ $250134 \times 0.2272 = 56830 +$ $247043 \times -0.0752 = -18578 +$ $241319 \times 0.0144 = 3475 +$ $231858 \times 0 = 0$ $= 51461$	$273717 \times 0.0336 = 9197 +$ $235518 \times 0.2272 = 53510 +$ $235481 \times -0.0752 = -17708 +$ $232733 \times 0.0144 = 3351 +$ $225555 \times 0 = 0$ $= 48350$
6	$289682 \times 0.008 = 2317 +$ $250134 \times 0.232 = 58031 +$ $247043 \times -0.048 = -11858 +$ $241319 \times 0.008 = 1931 +$ $231858 \times 0 = 0$ $= 50421$	$273717 \times 0.008 = 2190 +$ $235518 \times 0.232 = 54640 +$ $235481 \times -0.048 = -11303 +$ $232733 \times 0.008 = 1862 +$ $225555 \times 0 = 0$ $= 47389$

7	$289682 \times -0.008 = -2317 +$ $250134 \times 0.216 = 54029 +$ $247043 \times -0.008 = -1976 +$ $241319 \times 0 = 0$ $231858 \times 0 = 0$ $= 49735$	$273717 \times -0.008 = -2190 +$ $235518 \times 0.216 = 50872 +$ $235481 \times -0.008 = -1884 +$ $232733 \times 0 = 0$ $225555 \times 0 = 0$ $= 46798$
8	$289682 \times -0.016 = -4635 +$ $250134 \times 0.184 = 46025 +$ $247043 \times 0.04 = 9882 +$ $241319 \times -0.008 = -1931 +$ $231858 \times 0 = 0$ $= 49341$	$273717 \times -0.016 = -4379 +$ $235518 \times 0.184 = 43335 +$ $235481 \times 0.04 = 9419 +$ $232733 \times -0.008 = -1862 +$ $225555 \times 0 = 0$ $= 46513$
9	$289682 \times -0.0176 = -5089 +$ $250134 \times 0.1408 = 35219 +$ $247043 \times 0.0912 = 22530 +$ $241319 \times -0.0144 = -3475 +$ $231858 \times 0 = 0$ $= 49176$	$273717 \times -0.0176 = -4817 +$ $235518 \times 0.1408 = 33161 +$ $235481 \times 0.0912 = 21476 +$ $232733 \times -0.0144 = -3351 +$ $225555 \times 0 = 0$ $= 46468$
10	$289682 \times -0.0128 = -3708 +$ $250134 \times 0.0848 = 21211 +$ $247043 \times 0.1504 = 37155 +$ $241319 \times -0.024 = -5792 +$ $231858 \times 0.0016 = 371$ $= 49238$	$273717 \times -0.0128 = -3504 +$ $235518 \times 0.0848 = 19972 +$ $235481 \times 0.1504 = 35416 +$ $232733 \times -0.024 = -5586 +$ $225555 \times 0.0016 = 361$ $= 46660$
11	$289682 \times -0.0016 = -463 +$ $250134 \times 0.0144 = 3602 +$ $247043 \times 0.2224 = 54942 +$ $241319 \times -0.0416 = -10039 +$ $231858 \times 0.0064 = 1484$ $= 49526$	$273717 \times -0.0016 = -438 +$ $235518 \times 0.0144 = 3391 +$ $235481 \times 0.2224 = 52371 +$ $232733 \times -0.0416 = -9682 +$ $225555 \times 0.0064 = 1444$ $= 47086$
12	$289682 \times 0.0064 = 1854 +$ $250134 \times -0.0336 = -8405 +$ $247043 \times 0.2544 = 62848 +$ $241319 \times -0.0336 = -8108 +$ $231858 \times 0.0064 = 1484$ $= 49673$	$273717 \times 0.0064 = 1752 +$ $235518 \times -0.0336 = -7913 +$ $235481 \times 0.2544 = 59906 +$ $232733 \times -0.0336 = -7820 +$ $225555 \times 0.0064 = 1444$ $= 47369$
13	$289682 \times 0.0064 = 1854 +$ $250134 \times -0.0416 = -10406 +$ $247043 \times 0.2224 = 54942 +$ $241319 \times 0.0144 = 3475 +$ $231858 \times -0.0016 = -371$ $= 49495$	$273717 \times 0.0064 = 1752 +$ $235518 \times -0.0416 = -9798 +$ $235481 \times 0.2224 = 52371 +$ $232733 \times 0.0144 = 3351 +$ $225555 \times -0.0016 = -361$ $= 47316$

14	$289682 \times 0.0016 = 463 +$ $250134 \times -0.024 = -6003 +$ $247043 \times 0.1504 = 37155 +$ $241319 \times 0.0848 = 20464 +$ $231858 \times -0.0128 = -2968$ $= 49112$	$273717 \times 0.0016 = 438 +$ $235518 \times -0.024 = -5652 +$ $235481 \times 0.1504 = 35416 +$ $232733 \times 0.0848 = 19736 +$ $225555 \times -0.0128 = -2887$ $= 47051$
15	$250134 \times -0.0128 = -3202 +$ $247043 \times 0.0848 = 20949 +$ $241319 \times 0.1504 = 36294 +$ $231858 \times -0.024 = -5565 +$ $222219 \times 0.0016 = 356$ $= 48833$	$235518 \times -0.0128 = -3015 +$ $235481 \times 0.0848 = 19969 +$ $232733 \times 0.1504 = 35003 +$ $225555 \times -0.024 = -5413 +$ $218669 \times 0.0016 = 350$ $= 46894$
16	$250134 \times -0.0016 = -400 +$ $247043 \times 0.0144 = 3557 +$ $241319 \times 0.2224 = 53669 +$ $231858 \times -0.0416 = -9645 +$ $222219 \times 0.0064 = 1422$ $= 48603$	$235518 \times -0.0016 = -377 +$ $235481 \times 0.0144 = 3391 +$ $232733 \times 0.2224 = 51760 +$ $225555 \times -0.0416 = -9383 +$ $218669 \times 0.0064 = 1399$ $= 46790$
17	$250134 \times 0.0064 = 1601 +$ $247043 \times -0.0336 = -8301 +$ $241319 \times 0.2544 = 61392 +$ $231858 \times -0.0336 = -7790 +$ $222219 \times 0.0064 = 1422$ $= 48324$	$235518 \times 0.0064 = 1507 +$ $235481 \times -0.0336 = -7912 +$ $232733 \times 0.2544 = 59207 +$ $225555 \times -0.0336 = -7579 +$ $218669 \times 0.0064 = 1399$ $= 46623$
18	$250134 \times 0.0064 = 1601 +$ $247043 \times -0.0416 = -10277 +$ $241319 \times 0.2224 = 53669 +$ $231858 \times 0.0144 = 3339 +$ $222219 \times -0.0016 = -356$ $= 47976$	$235518 \times 0.0064 = 1507 +$ $235481 \times -0.0416 = -9796 +$ $232733 \times 0.2224 = 51760 +$ $225555 \times 0.0144 = 3248 +$ $218669 \times -0.0016 = -350$ $= 46369$
19	$250134 \times 0.0016 = 400 +$ $247043 \times -0.024 = -5929 +$ $241319 \times 0.1504 = 36294 +$ $231858 \times 0.0848 = 19662 +$ $222219 \times -0.0128 = -2844$ $= 47583$	$235518 \times 0.0016 = 377 +$ $235481 \times -0.024 = -5652 +$ $232733 \times 0.1504 = 35003 +$ $225555 \times 0.0848 = 19127 +$ $218669 \times -0.0128 = -2799$ $= 46056$
20	$247043 \times -0.0128 = -3162 +$ $241319 \times 0.0848 = 20464 +$ $231858 \times 0.1504 = 34871 +$ $222219 \times -0.024 = -5333 +$ $202389 \times 0.0016 = 324$ $= 47164$	$235481 \times -0.0128 = -3014 +$ $232733 \times 0.0848 = 19736 +$ $225555 \times 0.1504 = 33923 +$ $218669 \times -0.024 = -5248 +$ $197565 \times 0.0016 = 316$ $= 45713$
21	$247043 \times -0.0016 = -395 +$ $241319 \times 0.0144 = 3475 +$ $231858 \times 0.2224 = 51565 +$ $222219 \times -0.0416 = -9244 +$ $202389 \times 0.0064 = 1295$ $= 46696$	$235481 \times -0.0016 = -377 +$ $232733 \times 0.0144 = 3351 +$ $225555 \times 0.2224 = 50163 +$ $218669 \times -0.0416 = -9097 +$ $197565 \times 0.0064 = 1264$ $= 45306$

22	$247043 \times 0.0064 = 1581 +$ $241319 \times -0.0336 = -8108 +$ $231858 \times 0.2544 = 58985 +$ $222219 \times -0.0336 = -7467 +$ $202389 \times 0.0064 = 1295$ $= 46286$	$235481 \times 0.0064 = 1507 +$ $232733 \times -0.0336 = -7820 +$ $225555 \times 0.2544 = 57381 +$ $218669 \times -0.0336 = -7347 +$ $197565 \times 0.0064 = 1264$ $= 44986$
23	$247043 \times 0.0064 = 1581 +$ $241319 \times -0.0416 = -10039 +$ $231858 \times 0.2224 = 51565 +$ $222219 \times 0.0144 = 3200 +$ $202389 \times -0.0016 = -324$ $= 45984$	$235481 \times 0.0064 = 1507 +$ $232733 \times -0.0416 = -9682 +$ $225555 \times 0.2224 = 50163 +$ $218669 \times 0.0144 = 3149 +$ $197565 \times -0.0016 = -316$ $= 44822$
24	$247043 \times 0.0016 = 395 +$ $241319 \times -0.024 = -5792 +$ $231858 \times 0.1504 = 34871 +$ $222219 \times 0.0848 = 18844 +$ $202389 \times -0.0128 = -2591$ $= 45729$	$235481 \times 0.0016 = 377 +$ $232733 \times -0.024 = -5586 +$ $225555 \times 0.1504 = 33923 +$ $218669 \times 0.0848 = 18543 +$ $197565 \times -0.0128 = -2529$ $= 44729$
25	$241319 \times -0.0128 = -3089 +$ $231858 \times 0.0848 = 19662 +$ $222219 \times 0.1504 = 33422 +$ $202389 \times -0.024 = -4857 +$ $177769 \times 0.0016 = 284$ $= 45422$	$232733 \times -0.0128 = -2979 +$ $225555 \times 0.0848 = 19127 +$ $218669 \times 0.1504 = 32888 +$ $197565 \times -0.024 = -4742 +$ $169469 \times 0.0016 = 271$ $= 44565$
26	$241319 \times -0.0016 = -386 +$ $231858 \times 0.0144 = 3339 +$ $222219 \times 0.2224 = 49422 +$ $202389 \times -0.0416 = -8419 +$ $177769 \times 0.0064 = 1138$ $= 45092$	$232733 \times -0.0016 = -372 +$ $225555 \times 0.0144 = 3248 +$ $218669 \times 0.2224 = 48632 +$ $197565 \times -0.0416 = -8219 +$ $169469 \times 0.0064 = 1085$ $= 44374$
27	$241319 \times 0.0064 = 1544 +$ $231858 \times -0.0336 = -7790 +$ $222219 \times 0.2544 = 56533 +$ $202389 \times -0.0336 = -6800 +$ $177769 \times 0.0064 = 1138$ $= 44624$	$232733 \times 0.0064 = 1489 +$ $225555 \times -0.0336 = -7579 +$ $218669 \times 0.2544 = 55629 +$ $197565 \times -0.0336 = -6638 +$ $169469 \times 0.0064 = 1085$ $= 43987$
28	$241319 \times 0.0064 = 1544 +$ $231858 \times -0.0416 = -9645 +$ $222219 \times 0.2224 = 49422 +$ $202389 \times 0.0144 = 2914 +$ $177769 \times -0.0016 = -284$ $= 43951$	$232733 \times 0.0064 = 1489 +$ $225555 \times -0.0416 = -9383 +$ $218669 \times 0.2224 = 48632 +$ $197565 \times 0.0144 = 2845 +$ $169469 \times -0.0016 = -271$ $= 43321$
29	$241319 \times 0.0016 = 386 +$ $231858 \times -0.024 = -5565 +$ $222219 \times 0.1504 = 33422 +$ $202389 \times 0.0848 = 17163 +$ $177769 \times -0.0128 = -2275$ $= 43130$	$232733 \times 0.0016 = 372 +$ $225555 \times -0.024 = -5413 +$ $218669 \times 0.1504 = 32888 +$ $197565 \times 0.0848 = 16754 +$ $169469 \times -0.0128 = -2169$ $= 42431$

30	$231858 \times -0.0128 = -2968 +$ $222219 \times 0.0848 = 18844 +$ $202389 \times 0.1504 = 30439 +$ $177769 \times -0.024 = -4266 +$ $153929 \times 0.0016 = 246$ $= 42296$	$225555 \times -0.0128 = -2887 +$ $218669 \times 0.0848 = 18543 +$ $197565 \times 0.1504 = 29714 +$ $169469 \times -0.024 = -4067 +$ $144346 \times 0.0016 = 231$ $= 41534$
31	$231858 \times -0.0016 = -371 +$ $222219 \times 0.0144 = 3200 +$ $202389 \times 0.2224 = 45011 +$ $177769 \times -0.0416 = -7395 +$ $153929 \times 0.0064 = 985$ $= 41430$	$225555 \times -0.0016 = -361 +$ $218669 \times 0.0144 = 3149 +$ $197565 \times 0.2224 = 43938 +$ $169469 \times -0.0416 = -7050 +$ $144346 \times 0.0064 = 924$ $= 40600$
32	$231858 \times 0.0064 = 1484 +$ $222219 \times -0.0336 = -7467 +$ $202389 \times 0.2544 = 51488 +$ $177769 \times -0.0336 = -5973 +$ $153929 \times 0.0064 = 985$ $= 40517$	$225555 \times 0.0064 = 1444 +$ $218669 \times -0.0336 = -7347 +$ $197565 \times 0.2544 = 50261 +$ $169469 \times -0.0336 = -5694 +$ $144346 \times 0.0064 = 924$ $= 39586$
33	$231858 \times 0.0064 = 1484 +$ $222219 \times -0.0416 = -9244 +$ $202389 \times 0.2224 = 45011 +$ $177769 \times 0.0144 = 2560 +$ $153929 \times -0.0016 = -246$ $= 39564$	$225555 \times 0.0064 = 1444 +$ $218669 \times -0.0416 = -9097 +$ $197565 \times 0.2224 = 43938 +$ $169469 \times 0.0144 = 2440 +$ $144346 \times -0.0016 = -231$ $= 38495$
34	$231858 \times 0.0016 = 371 +$ $222219 \times -0.024 = -5333 +$ $202389 \times 0.1504 = 30439 +$ $177769 \times 0.0848 = 15075 +$ $153929 \times -0.0128 = -1970$ $= 38582$	$225555 \times 0.0016 = 361 +$ $218669 \times -0.024 = -5248 +$ $197565 \times 0.1504 = 29714 +$ $169469 \times 0.0848 = 14371 +$ $144346 \times -0.0128 = -1848$ $= 37350$
35	$222219 \times -0.0128 = -2844 +$ $202389 \times 0.0848 = 17163 +$ $177769 \times 0.1504 = 26736 +$ $153929 \times -0.024 = -3694 +$ $128759 \times 0.0016 = 206$ $= 37566$	$218669 \times -0.0128 = -2799 +$ $197565 \times 0.0848 = 16754 +$ $169469 \times 0.1504 = 25488 +$ $144346 \times -0.024 = -3464 +$ $118123 \times 0.0016 = 189$ $= 36167$
36	$222219 \times -0.0016 = -356 +$ $202389 \times 0.0144 = 2914 +$ $177769 \times 0.2224 = 39536 +$ $153929 \times -0.0416 = -6403 +$ $128759 \times 0.0064 = 824$ $= 36515$	$218669 \times -0.0016 = -350 +$ $197565 \times 0.0144 = 2845 +$ $169469 \times 0.2224 = 37690 +$ $144346 \times -0.0416 = -6005 +$ $118123 \times 0.0064 = 756$ $= 34936$
37	$222219 \times 0.0064 = 1422 +$ $202389 \times -0.0336 = -6800 +$ $177769 \times 0.2544 = 45224 +$ $153929 \times -0.0336 = -5172 +$ $128759 \times 0.0064 = 824$ $= 35498$	$218669 \times 0.0064 = 1399 +$ $197565 \times -0.0336 = -6638 +$ $169469 \times 0.2544 = 43113 +$ $144346 \times -0.0336 = -4850 +$ $118123 \times 0.0064 = 756$ $= 33780$

38	$222219 \times 0.0064 = 1422 +$ $202389 \times -0.0416 = -8149 +$ $177769 \times 0.2224 = 39536 +$ $153929 \times 0.0144 = 2217 +$ $128759 \times -0.0016 = -206$ $= 34549$	$218669 \times 0.0064 = 1399 +$ $197565 \times -0.0416 = -8219 +$ $169469 \times 0.2224 = 37690 +$ $144346 \times 0.0144 = 2079 +$ $118123 \times -0.0016 = -189$ $= 32760$
39	$222219 \times 0.0016 = 356 +$ $202389 \times -0.024 = -4857 +$ $177769 \times 0.1504 = 26736 +$ $153929 \times 0.0848 = 13053 +$ $128759 \times -0.0128 = -1648$ $= 33640$	$218669 \times 0.0016 = 350 +$ $197565 \times -0.024 = -4742 +$ $169469 \times 0.1504 = 25488 +$ $144346 \times 0.0848 = 12241 +$ $118123 \times -0.0128 = -1512$ $= 31825$
40	$202389 \times -0.0128 = -2591 +$ $177769 \times 0.0848 = 15075 +$ $153929 \times 0.1504 = 23151 +$ $128759 \times -0.024 = -3090 +$ $106464 \times 0.0016 = 170$ $= 32715$	$197565 \times -0.0128 = -2529 +$ $169469 \times 0.0848 = 14371 +$ $144346 \times 0.1504 = 21710 +$ $118123 \times -0.024 = -2835 +$ $96803 \times 0.0016 = 155$ $= 30872$
41	$202389 \times -0.0016 = -324 +$ $177769 \times 0.0144 = 2560 +$ $153929 \times 0.2224 = 34234 +$ $128759 \times -0.0416 = -5356 +$ $106464 \times 0.0064 = 681$ $= 31795$	$197565 \times -0.0016 = -316 +$ $169469 \times 0.0144 = 2440 +$ $144346 \times 0.2224 = 32103 +$ $118123 \times -0.0416 = -4914 +$ $96803 \times 0.0064 = 620$ $= 29932$
42	$202389 \times 0.0064 = 1295 +$ $177769 \times -0.0336 = -5973 +$ $153929 \times 0.2544 = 39160 +$ $128759 \times -0.0336 = -4326 +$ $106464 \times 0.0064 = 681$ $= 33837$	$197565 \times 0.0064 = 1264 +$ $169469 \times -0.0336 = -5694 +$ $144346 \times 0.2544 = 36722 +$ $118123 \times -0.0336 = -3696 +$ $96803 \times 0.0064 = 620$ $= 28942$
43	$202389 \times 0.0064 = 1295 +$ $177769 \times -0.0416 = -7395 +$ $153929 \times 0.2224 = 34234 +$ $128759 \times 0.0144 = 1854 +$ $106464 \times -0.0016 = -170$ $= 29818$	$197565 \times 0.0064 = 1264 +$ $169469 \times -0.0416 = -7050 +$ $144346 \times 0.2224 = 32103 +$ $118123 \times 0.0144 = 1701 +$ $96803 \times -0.0016 = -155$ $= 27863$
44	$202389 \times 0.0016 = 324 +$ $177769 \times -0.024 = -4266 +$ $153929 \times 0.1504 = 23151 +$ $128759 \times 0.0848 = 10919 +$ $106464 \times -0.0128 = -1363$ $= 28764$	$197565 \times 0.0016 = 316 +$ $169469 \times -0.024 = -4067 +$ $144346 \times 0.1504 = 21710 +$ $118123 \times 0.0848 = 10017 +$ $96803 \times -0.0128 = -1239$ $= 26736$
45	$177769 \times -0.0128 = -2275 +$ $153929 \times 0.0848 = 13053 +$ $128759 \times 0.1504 = 19365 +$ $106464 \times -0.024 = -2555 +$ $84835 \times 0.0016 = 136$ $= 27724$	$169469 \times -0.0128 = -2169 +$ $144346 \times 0.0848 = 12241 +$ $118123 \times 0.1504 = 17766 +$ $96803 \times -0.024 = -2323 +$ $77388 \times 0.0016 = 124$ $= 25638$

46	$177769 \times -0.0016 = -284 +$ $153929 \times 0.0144 = 2217 +$ $128759 \times 0.2224 = 28636 +$ $106464 \times -0.0416 = -4429 +$ $84835 \times 0.0064 = 543$ $= 26682$	$169469 \times -0.0016 = -271 +$ $144346 \times 0.0144 = 2079 +$ $118123 \times 0.2224 = 26271 +$ $96803 \times -0.0416 = -4027 +$ $77388 \times 0.0064 = 495$ $= 24546$
47	$177769 \times 0.0064 = 1138 +$ $153929 \times -0.0336 = -5172 +$ $128759 \times 0.2544 = 32756 +$ $106464 \times -0.0336 = -3577 +$ $84835 \times 0.0064 = 543$ $= 25688$	$169469 \times 0.0064 = 1085 +$ $144346 \times -0.0336 = -4850 +$ $118123 \times 0.2544 = 30050 +$ $96803 \times -0.0336 = -3253 +$ $77388 \times 0.0064 = 495$ $= 23528$
48	$177769 \times 0.0064 = 1138 +$ $153929 \times -0.0416 = -6403 +$ $128759 \times 0.2224 = 28636 +$ $106464 \times 0.0144 = 1533 +$ $84835 \times -0.0016 = -136$ $= 24768$	$169469 \times 0.0064 = 1085 +$ $144346 \times -0.0416 = -6005 +$ $118123 \times 0.2224 = 26271 +$ $96803 \times 0.0144 = 1394 +$ $77388 \times -0.0016 = -124$ $= 22621$
49	$177769 \times 0.0016 = 284 +$ $153929 \times -0.024 = -3694 +$ $128759 \times 0.1504 = 19365 +$ $106464 \times 0.0848 = 9028 +$ $84835 \times -0.0128 = -1086$ $= 23898$	$169469 \times 0.0016 = 271 +$ $144346 \times -0.024 = -3464 +$ $118123 \times 0.1504 = 17766 +$ $96803 \times 0.0848 = 8209 +$ $77388 \times -0.0128 = -991$ $= 21791$
50	$153929 \times -0.0128 = -1970 +$ $128759 \times 0.0848 = 10919 +$ $106464 \times 0.1504 = 16012 +$ $84835 \times -0.024 = -2036 +$ $64837 \times 0.0016 = 104$ $= 23028$	$144346 \times -0.0128 = -1848 +$ $118123 \times 0.0848 = 10017 +$ $96803 \times 0.1504 = 14559 +$ $77388 \times -0.024 = -1857 +$ $59123 \times 0.0016 = 95$ $= 20966$
51	$153929 \times -0.0016 = -246 +$ $128759 \times 0.0144 = 1854 +$ $106464 \times 0.2224 = 23678 +$ $84835 \times -0.0416 = -3529 +$ $64837 \times 0.0064 = 415$ $= 22171$	$144346 \times -0.0016 = -231 +$ $118123 \times 0.0144 = 1701 +$ $96803 \times 0.2224 = 21529 +$ $77388 \times -0.0416 = -3219 +$ $59123 \times 0.0064 = 378$ $= 20158$
52	$153929 \times 0.0064 = 985 +$ $128759 \times -0.0336 = -4326 +$ $106464 \times 0.2544 = 27084 +$ $84835 \times -0.0336 = -2850 +$ $64837 \times 0.0064 = 415$ $= 21308$	$144346 \times 0.0064 = 924 +$ $118123 \times -0.0336 = -3969 +$ $96803 \times 0.2544 = 24627 +$ $77388 \times -0.0336 = -2600 +$ $59123 \times 0.0064 = 378$ $= 19360$
53	$153929 \times 0.0064 = 985 +$ $128759 \times -0.0416 = -5356 +$ $106464 \times 0.2224 = 23678 +$ $84835 \times 0.0144 = 1222 +$ $64837 \times -0.0016 = -104$ $= 20424$	$144346 \times 0.0064 = 924 +$ $118123 \times -0.0416 = -4914 +$ $96803 \times 0.2224 = 21529 +$ $77388 \times 0.0144 = 1114 +$ $59123 \times -0.0016 = -95$ $= 18559$

54	$153929 \times 0.0016 = 246 +$ $128759 \times -0.024 = -3090 +$ $106464 \times 0.1504 = 16012 +$ $84835 \times 0.0848 = 7194 +$ $64837 \times -0.0128 = -830$ $= 19532$	$144346 \times 0.0016 = 231 +$ $118123 \times -0.024 = -2835 +$ $96803 \times 0.1504 = 14559 +$ $77388 \times 0.0848 = 6563 +$ $59123 \times -0.0128 = -757$ $= 17761$
55	$128759 \times -0.0128 = -1648 +$ $106464 \times 0.0848 = 9028 +$ $84835 \times 0.1504 = 12759 +$ $64837 \times -0.024 = -1556 +$ $44990 \times 0.0016 = 72$ $= 18655$	$118123 \times -0.0128 = -1512 +$ $96803 \times 0.0848 = 8209 +$ $77388 \times 0.1504 = 11639 +$ $59123 \times -0.024 = -1419 +$ $40095 \times 0.0016 = 64$ $= 16981$
56	$128759 \times -0.0016 = -206 +$ $106464 \times 0.0144 = 1533 +$ $84835 \times 0.2224 = 18867 +$ $64837 \times -0.0416 = -2697 +$ $44990 \times 0.0064 = 288$ $= 17785$	$118123 \times -0.0016 = -189 +$ $96803 \times 0.0144 = 1394 +$ $77388 \times 0.2224 = 17211 +$ $59123 \times -0.0416 = -2460 +$ $40095 \times 0.0064 = 257$ $= 16213$
57	$128759 \times 0.0064 = 824 +$ $106464 \times -0.0336 = -3577 +$ $84835 \times 0.2544 = 2182 +$ $64837 \times -0.0336 = -2179 +$ $44990 \times 0.0064 = 288$ $= 16938$	$118123 \times 0.0064 = 756 +$ $96803 \times -0.0336 = -3253 +$ $77388 \times 0.2544 = 19688 +$ $59123 \times -0.0336 = -1987 +$ $40095 \times 0.0064 = 257$ $= 15461$
58	$128759 \times 0.0064 = 824 +$ $106464 \times -0.0416 = -4429 +$ $84835 \times 0.2224 = 18867 +$ $64837 \times 0.0144 = 934 +$ $44990 \times -0.0016 = -72$ $= 16124$	$118123 \times 0.0064 = 756 +$ $96803 \times -0.0416 = -4027 +$ $77388 \times 0.2224 = 17211 +$ $59123 \times 0.0144 = 851 +$ $40095 \times -0.0016 = -64$ $= 14727$
59	$128759 \times 0.0016 = 206 +$ $106464 \times -0.024 = -2555 +$ $84835 \times 0.1504 = 12759 +$ $64837 \times 0.0848 = 5498 +$ $44990 \times -0.0128 = -576$ $= 15332$	$118123 \times 0.0016 = 189 +$ $96803 \times -0.024 = -2323 +$ $77388 \times 0.1504 = 11639 +$ $59123 \times 0.0848 = 5014 +$ $40095 \times -0.0128 = -513$ $= 14005$
60	$106464 \times -0.0128 = -1363 +$ $84835 \times 0.0848 = 7194 +$ $64837 \times 0.1504 = 9751 +$ $44990 \times -0.024 = -1080 +$ $29226 \times 0.0016 = 47$ $= 14550$	$96803 \times -0.0128 = -1239 +$ $77388 \times 0.0848 = 6563 +$ $59123 \times 0.1504 = 8892 +$ $40095 \times -0.024 = -962 +$ $26211 \times 0.0016 = 42$ $= 13295$
61	$106464 \times -0.0016 = -170 +$ $84835 \times 0.0144 = 1222 +$ $64837 \times 0.2224 = 14420 +$ $44990 \times -0.0416 = -1872 +$ $29226 \times 0.0064 = 187$ $= 13786$	$96803 \times -0.0016 = -155 +$ $77388 \times 0.0144 = 1114 +$ $59123 \times 0.2224 = 13149 +$ $40095 \times -0.0416 = -1668 +$ $26211 \times 0.0064 = 168$ $= 12608$

62	$106464 \times 0.0064 = 681 +$ $84835 \times -0.0336 = -2850 +$ $64837 \times 0.2544 = 16495 +$ $44990 \times -0.0336 = -1512 +$ $29226 \times 0.0064 = 187$ $= 13001$	$96803 \times 0.0064 = 620 +$ $77388 \times -0.0336 = -2600 +$ $59123 \times 0.2544 = 15041 +$ $40095 \times -0.0336 = -1347 +$ $26211 \times 0.0064 = 168$ $= 11881$
63	$106464 \times 0.0064 = 681 +$ $84835 \times -0.0416 = -3529 +$ $64837 \times 0.2224 = 14420 +$ $44990 \times 0.0144 = 648 +$ $29226 \times -0.0016 = -47$ $= 12173$	$96803 \times 0.0064 = 620 +$ $77388 \times -0.0416 = -3219 +$ $59123 \times 0.2224 = 13149 +$ $40095 \times 0.0144 = 577 +$ $26211 \times -0.0016 = -42$ $= 11085$
64	$106464 \times 0.0016 = 170 +$ $84835 \times -0.024 = -2036 +$ $64837 \times 0.1504 = 9751 +$ $44990 \times 0.0848 = 3815 +$ $44990 \times -0.0128 = -374$ $= 11327$	$96803 \times 0.0016 = 155 +$ $77388 \times -0.024 = -1857 +$ $59123 \times 0.1504 = 8892 +$ $40095 \times 0.0848 = 3400 +$ $26211 \times -0.0128 = -336$ $= 10254$
65	$84835 \times -0.0128 = -1086 +$ $64837 \times 0.0848 = 5498 +$ $44990 \times 0.1504 = 6766 +$ $29226 \times -0.024 = -701 +$ $22303 \times 0.0016 = 36$ $= 10513$	$77388 \times -0.0128 = -991 +$ $59123 \times 0.0848 = 5014 +$ $40095 \times 0.1504 = 6030 +$ $26211 \times -0.024 = -629 +$ $19809 \times 0.0016 = 32$ $= 9456$
66	$84835 \times -0.0016 = -136 +$ $64837 \times 0.0144 = 934 +$ $44990 \times 0.2224 = 10006 +$ $29226 \times -0.0416 = -1216 +$ $22303 \times 0.0064 = 143$ $= 9731$	$77388 \times -0.0016 = -124 +$ $59123 \times 0.0144 = 851 +$ $40095 \times 0.2224 = 8917 +$ $26211 \times -0.0416 = -1090 +$ $19809 \times 0.0064 = 127$ $= 8681$
67	$84835 \times 0.0064 = 543 +$ $64837 \times -0.0336 = -2179 +$ $44990 \times 0.2544 = 11445 +$ $29226 \times -0.0336 = -982 +$ $22303 \times 0.0064 = 143$ $= 8971$	$77388 \times 0.0064 = 495 +$ $59123 \times -0.0336 = -1987 +$ $40095 \times 0.2544 = 10200 +$ $26211 \times -0.0336 = -881 +$ $19809 \times 0.0064 = 127$ $= 7955$
68	$84835 \times 0.0064 = 543 +$ $64837 \times -0.0416 = -2697 +$ $44990 \times 0.2224 = 10006 +$ $29226 \times 0.0144 = 421 +$ $22303 \times -0.0016 = -36$ $= 8237$	$77388 \times 0.0064 = 459 +$ $59123 \times -0.0416 = -2460 +$ $40095 \times 0.2224 = 8917 +$ $26211 \times 0.0144 = 377 +$ $19809 \times -0.0016 = -32$ $= 7299$
69	$84835 \times 0.0016 = 136 +$ $64837 \times -0.024 = -1556 +$ $44990 \times 0.1504 = 6766 +$ $29226 \times 0.0848 = 2478 +$ $22303 \times -0.0128 = -285$ $= 7539$	$77388 \times 0.0016 = 124 +$ $59123 \times -0.024 = -1419 +$ $40095 \times 0.1504 = 6030 +$ $26211 \times 0.0848 = 2223 +$ $19809 \times -0.0128 = -245$ $= 6704$

70	$84835 \times 0 = 0 +$ $64837 \times -0.0144 = -9334 +$ $44990 \times 0.0912 = 4103 +$ $29226 \times 0.1408 = 4115 +$ $22303 \times -0.0176 = -393$ $= 6892$	$77388 \times 0 = 0 +$ $59123 \times -0.0144 = -851 +$ $40095 \times 0.0912 = 3657 +$ $26211 \times 0.1408 = 3691 +$ $19809 \times -0.0176 = -349$ $= 6147$
71	$84835 \times 0 = 0 +$ $64837 \times -0.0084 = -519 +$ $44990 \times 0.044 = 1800 +$ $29226 \times 0.184 = 5378 +$ $22303 \times -0.016 = -357$ $= 6302$	$77388 \times 0 = 0 +$ $59123 \times -0.0084 = -473 +$ $40095 \times 0.044 = 1604 +$ $26211 \times 0.184 = 4823 +$ $19809 \times -0.016 = -317$ $= 5637$
72	$84835 \times 0 = 0 +$ $64837 \times 0 = 0 +$ $44990 \times -0.008 = -360 +$ $29226 \times 0.216 = 6313 +$ $22303 \times -0.008 = -178$ $= 5774$	$77388 \times 0 = 0 +$ $59123 \times 0 = 0 +$ $40095 \times -0.008 = -321 +$ $26211 \times 0.216 = 5662 +$ $19809 \times -0.008 = -158$ $= 5182$
73	$84835 \times 0 = 0 +$ $64837 \times 0.008 = 519 +$ $44990 \times -0.048 = -2160 +$ $29226 \times 0.232 = 6780 +$ $22303 \times 0.008 = 178$ $= 5318$	$77388 \times 0 = 0 +$ $59123 \times 0.008 = 473 +$ $40095 \times -0.048 = -1925 +$ $26211 \times 0.232 = 6081 +$ $219809 \times 0.008 = 158$ $= 4788$
74	$84835 \times 0 = 0 +$ $64837 \times 0.0144 = 934 +$ $44990 \times -0.0752 = -3383 +$ $29226 \times 0.2272 = 6640 +$ $22303 \times 0.0336 = 749$ $= 4940$	$77388 \times 0 = 0 +$ $59123 \times 0.0144 = 851 +$ $40095 \times -0.0752 = -3015 +$ $26211 \times 0.2272 = 5955 +$ $219809 \times 0.0336 = 666$ $= 4457$
75+	22303	19809

Source: Researcher calculations by using Sprague multipliers depending on Qalyobia 2011 projected population.

Table (7c): Calculations of Qalyobia Population at 2016 According to the Single Ages By Using Sprague Multipliers

Ages	Male	Female
0	$331041 \times 0.3616 = 119704 +$ $294476 \times -0.2768 = -81511 +$ $254547 \times 0.1488 = 37877 +$ $249853 \times -0.0336 = -8395 +$ $244567 \times 0 = 0$ $= 67675$	$318396 \times 0.3616 = 115132 +$ $279717 \times -0.2768 = -77426 +$ $240098 \times 0.1488 = 35727 +$ $238887 \times -0.0336 = -8027 +$ $236957 \times 0 = 0$ $= 65406$
1	$331041 \times 0.264 = 87395 +$ $294476 \times -0.096 = -28270 +$ $254547 \times 0.04 = 10182 +$ $249853 \times -0.008 = -1999 +$ $244567 \times 0 = 0$ $= 67308$	$318396 \times 0.264 = 84056 +$ $279717 \times -0.096 = -26853 +$ $240098 \times 0.04 = 9604 +$ $238887 \times -0.008 = -1911 +$ $236957 \times 0 = 0$ $= 64896$
2	$331041 \times 0.184 = 60912 +$ $294476 \times 0.04 = 11779 +$ $254547 \times -0.032 = -8146 +$ $249853 \times 0.008 = 1999 +$ $244567 \times 0 = 0$ $= 66544$	$318396 \times 0.184 = 58585 +$ $279717 \times 0.04 = 11188 +$ $240098 \times -0.032 = -7683 +$ $238887 \times 0.008 = 1911 +$ $236957 \times 0 = 0$ $= 64001$
3	$331041 \times 0.12 = 39725 +$ $294476 \times 0.136 = 40048 +$ $254547 \times -0.072 = -18327 +$ $249853 \times 0.016 = 3998 +$ $244567 \times 0 = 0$ $= 65444$	$318396 \times 0.12 = 38207 +$ $279717 \times 0.136 = 38042 +$ $240098 \times -0.072 = -17287 +$ $238887 \times 0.016 = 3822 +$ $236957 \times 0 = 0$ $= 62784$
4	$331041 \times 0.0704 = 23305 +$ $294476 \times 0.1968 = 57953 +$ $254547 \times -0.0848 = -21586 +$ $249853 \times 0.0176 = 4397 +$ $244567 \times 0 = 0$ $= 64069$	$318396 \times 0.0704 = 22415 +$ $279717 \times 0.1968 = 55048 +$ $240098 \times -0.0848 = -20360 +$ $238887 \times 0.0176 = 4204 +$ $236957 \times 0 = 0$ $= 61307$
5	$331041 \times 0.0336 = 11123 +$ $294476 \times 0.2272 = 66905 +$ $254547 \times -0.0752 = -19142 +$ $249853 \times 0.0144 = 3598 +$ $244567 \times 0 = 0$ $= 62484$	$318396 \times 0.0336 = 10698 +$ $279717 \times 0.2272 = 63552 +$ $240098 \times -0.0752 = -18055 +$ $238887 \times 0.0144 = 3440 +$ $236957 \times 0 = 0$ $= 59635$
6	$331041 \times 0.008 = 2648 +$ $294476 \times 0.232 = 68318 +$ $254547 \times -0.048 = -12218 +$ $249853 \times 0.008 = 1999 +$ $244567 \times 0 = 0$ $= 60747$	$318396 \times 0.008 = 2547 +$ $279717 \times 0.232 = 64894 +$ $240098 \times -0.048 = -11525 +$ $238887 \times 0.008 = 1911 +$ $236957 \times 0 = 0$ $= 57827$

7	$331041 \times -0.008 = -2648 +$ $294476 \times 0.216 = 63607 +$ $254547 \times -0.008 = -2036 +$ $249853 \times 0 = 0$ $244567 \times 0 = 0$ $= 58923$	$318396 \times -0.008 = -2547 +$ $279717 \times 0.216 = 60418 +$ $240098 \times -0.008 = -1921 +$ $238887 \times 0 = 0$ $236957 \times 0 = 0$ $= 55950$
8	$331041 \times -0.016 = -5297 +$ $294476 \times 0.184 = 54184 +$ $254547 \times 0.04 = 10182 +$ $249853 \times -0.008 = -1999 +$ $244567 \times 0 = 0$ $= 57070$	$318396 \times -0.016 = -5094 +$ $279717 \times 0.184 = 51468 +$ $240098 \times 0.04 = 9604 +$ $238887 \times -0.008 = -1911 +$ $236957 \times 0 = 0$ $= 54067$
9	$331041 \times -0.0176 = -5826 +$ $294476 \times 0.1408 = 41462 +$ $254547 \times 0.0912 = 23215 +$ $249853 \times -0.0144 = -3598 +$ $244567 \times 0 = 0$ $= 55253$	$318396 \times -0.0176 = -5604 +$ $279717 \times 0.1408 = 39384 +$ $240098 \times 0.0912 = 21897 +$ $238887 \times -0.0144 = -3440 +$ $236957 \times 0 = 0$ $= 52237$
10	$331041 \times -0.0128 = -4237 +$ $294476 \times 0.0848 = 24972 +$ $254547 \times 0.1504 = 38284 +$ $249853 \times -0.024 = -5996 +$ $244567 \times 0.0016 = 391$ $= 53414$	$318396 \times -0.0128 = -4075 +$ $279717 \times 0.0848 = 23720 +$ $240098 \times 0.1504 = 36111 +$ $238887 \times -0.024 = -5733 +$ $236957 \times 0.0016 = 379$ $= 50402$
11	$331041 \times -0.0016 = -529 +$ $294476 \times 0.0144 = 4240 +$ $254547 \times 0.2224 = 56611 +$ $249853 \times -0.0416 = -10394 +$ $244567 \times 0.0064 = 1565$ $= 51493$	$318396 \times -0.0016 = -509 +$ $279717 \times 0.0144 = 4028 +$ $240098 \times 0.2224 = 53398 +$ $238887 \times -0.0416 = -9938 +$ $236957 \times 0.0064 = 1517$ $= 48496$
12	$331041 \times 0.0064 = 2118 +$ $294476 \times -0.0336 = -9894 +$ $254547 \times 0.2544 = 64757 +$ $249853 \times -0.0336 = -8395 +$ $244567 \times 0.0064 = 1565$ $= 50151$	$318396 \times 0.0064 = 2037 +$ $279717 \times -0.0336 = -9398 +$ $240098 \times 0.2544 = 61081 +$ $238887 \times -0.0336 = -8027 +$ $236957 \times 0.0064 = 1517$ $= 47210$
13	$331041 \times 0.0064 = 2118 +$ $294476 \times -0.0416 = -12250 +$ $254547 \times 0.2224 = 56611 +$ $249853 \times 0.0144 = 3598 +$ $244567 \times -0.0016 = -391$ $= 49686$	$318396 \times 0.0064 = 2037 +$ $279717 \times -0.0416 = -11636 +$ $240098 \times 0.2224 = 53398 +$ $238887 \times 0.0144 = 3440 +$ $236957 \times -0.0016 = -379$ $= 46860$

14	$331041 \times 0.0016 = 529 +$ $294476 \times -0.024 = -7067 +$ $254547 \times 0.1504 = 38284 +$ $249853 \times 0.0848 = 21188 +$ $244567 \times -0.0128 = -3130$ $= 49804$	$318396 \times 0.0016 = 509 +$ $279717 \times -0.024 = -6713 +$ $240098 \times 0.1504 = 36111 +$ $238887 \times 0.0848 = 20258 +$ $236957 \times -0.0128 = -3033$ $= 47132$
15	$294476 \times -0.0128 = -3769 +$ $254547 \times 0.0848 = 21585 +$ $249853 \times 0.1504 = 37578 +$ $244567 \times -0.024 = -5870 +$ $235273 \times 0.0016 = 376$ $= 49900$	$279717 \times -0.0128 = -3580 +$ $240098 \times 0.0848 = 20360 +$ $238887 \times 0.1504 = 35929 +$ $236957 \times -0.024 = -5687 +$ $229796 \times 0.0016 = 368$ $= 47390$
16	$294476 \times -0.0016 = -471 +$ $254547 \times 0.0144 = 3665 +$ $249853 \times 0.2224 = 55567 +$ $244567 \times -0.0416 = -10174 +$ $235273 \times 0.0064 = 1506$ $= 50093$	$279717 \times -0.0016 = -448$ $240098 \times 0.0144 = 3457 +$ $238887 \times 0.2224 = 53128 +$ $236957 \times -0.0416 = -9857 +$ $229796 \times 0.0064 = 1471$ $= 47751$
17	$294476 \times 0.0064 = 1885 +$ $254547 \times -0.0336 = -8553 +$ $249853 \times 0.2544 = 63563 +$ $244567 \times -0.0336 = -8217 +$ $235273 \times 0.0064 = 1506$ $= 50184$	$279717 \times 0.0064 = 1790 +$ $240098 \times -0.0336 = -8067 +$ $238887 \times 0.2544 = 60773 +$ $236957 \times -0.0336 = -7962 +$ $229796 \times 0.0064 = 1471$ $= 48005$
18	$294476 \times 0.0064 = 1885 +$ $254547 \times -0.0416 = -10589 +$ $249853 \times 0.2224 = 55567 +$ $244567 \times 0.0144 = 3522 +$ $235273 \times -0.0016 = -376$ $= 50009$	$279717 \times 0.0064 = 1790 +$ $240098 \times -0.0416 = -9988 +$ $238887 \times 0.2224 = 53128 +$ $236957 \times 0.0144 = 3412 +$ $229796 \times -0.0016 = -368$ $= 47974$
19	$294476 \times 0.0016 = 471 +$ $254547 \times -0.024 = -6109 +$ $249853 \times 0.1504 = 37578 +$ $244567 \times 0.0848 = 20739 +$ $235273 \times -0.0128 = -3011$ $= 49668$	$279717 \times 0.0016 = 448 +$ $240098 \times -0.024 = -5762 +$ $238887 \times 0.1504 = 35929 +$ $236957 \times 0.0848 = 20094 +$ $229796 \times -0.0128 = -2941$ $= 47768$
20	$254547 \times -0.0128 = -3258 +$ $249853 \times 0.0848 = 21188 +$ $244567 \times 0.1504 = 36783 +$ $235273 \times -0.024 = -5647 +$ $224784 \times 0.0016 = 360$ $= 49425$	$240098 \times -0.0128 = -3073 +$ $238887 \times 0.0848 = 20258 +$ $236957 \times 0.1504 = 35638 +$ $229796 \times -0.024 = -5515 +$ $221787 \times 0.0016 = 355$ $= 47662$
21	$254547 \times -0.0016 = -407 +$ $249853 \times 0.0144 = 3598 +$ $244567 \times 0.2224 = 54392 +$ $235273 \times -0.0416 = -9787 +$ $224784 \times 0.0064 = 1439$ $= 49234$	$240098 \times -0.0016 = -384 +$ $238887 \times 0.0144 = 3440 +$ $236957 \times 0.2224 = 52699 +$ $229796 \times -0.0416 = -9560 +$ $221787 \times 0.0064 = 1419$ $= 47615$

22	$254547 \times 0.0064 = 1629 +$ $249853 \times -0.0336 = -8395 +$ $244567 \times 0.2544 = 62218 +$ $235273 \times -0.0336 = -7905 +$ $224784 \times 0.0064 = 1439$ $= 48985$	$240098 \times 0.0064 = 1537 +$ $238887 \times -0.0336 = -8027 +$ $236957 \times 0.2544 = 60282 +$ $229796 \times -0.0336 = -7721 +$ $221787 \times 0.0064 = 1419$ $= 47490$
23	$254547 \times 0.0064 = 162910394 +$ $249853 \times -0.0416 = -10039 +$ $244567 \times 0.2224 = 54392 +$ $235273 \times 0.0144 = 3388 +$ $224784 \times -0.0016 = -360$ $= 48655$	$240098 \times 0.0064 = 1537 +$ $238887 \times -0.0416 = -9938 +$ $236957 \times 0.2224 = 52699 +$ $229796 \times 0.0144 = 3309 +$ $221787 \times -0.0016 = -355$ $= 47252$
24	$254547 \times 0.0016 = 407 +$ $249853 \times -0.024 = -5996 +$ $244567 \times 0.1504 = 36783 +$ $235273 \times 0.0848 = 19951 +$ $224784 \times -0.0128 = -2877$ $= 48268$	$240098 \times 0.0016 = 384 +$ $238887 \times -0.024 = -5733 +$ $236957 \times 0.1504 = 35638 +$ $229796 \times 0.0848 = 19487 +$ $221787 \times -0.0128 = -2839$ $= 46937$
25	$249853 \times -0.0128 = -3198 +$ $244567 \times 0.0848 = 20739 +$ $235273 \times 0.1504 = 35385 +$ $224784 \times -0.024 = -5395 +$ $204212 \times 0.0016 = 327$ $= 47858$	$238887 \times -0.0128 = -3058 +$ $236957 \times 0.0848 = 20094 +$ $229796 \times 0.1504 = 34561 +$ $221787 \times -0.024 = -5323 +$ $199806 \times 0.0016 = 320$ $= 46594$
26	$249853 \times -0.0016 = -400 +$ $244567 \times 0.0144 = 3522 +$ $235273 \times 0.2224 = 52325 +$ $224784 \times -0.0416 = -9351 +$ $204212 \times 0.0064 = 1307$ $= 47403$	$238887 \times -0.0016 = -382 +$ $236957 \times 0.0144 = 3412 +$ $229796 \times 0.2224 = 51107 +$ $221787 \times -0.0416 = -9226 +$ $199806 \times 0.0064 = 1279$ $= 46189$
27	$249853 \times 0.0064 = 1599 +$ $244567 \times -0.0336 = -8217 +$ $235273 \times 0.2544 = 59853 +$ $224784 \times -0.0336 = -7553 +$ $204212 \times 0.0064 = 1307$ $= 46989$	$238887 \times 0.0064 = 1529 +$ $236957 \times -0.0336 = -7962 +$ $229796 \times 0.2544 = 58460 +$ $221787 \times -0.0336 = -7452 +$ $199806 \times 0.0064 = 1279$ $= 45854$
28	$249853 \times 0.0064 = 1599 +$ $244567 \times -0.0416 = -10174 +$ $235273 \times 0.2224 = 52325 +$ $224784 \times 0.0144 = 3237 +$ $204212 \times -0.0016 = -327$ $= 46660$	$238887 \times 0.0064 = 1529 +$ $236957 \times -0.0416 = -9857 +$ $229796 \times 0.2224 = 51107 +$ $221787 \times 0.0144 = 3194 +$ $199806 \times -0.0016 = -320$ $= 45652$
29	$249853 \times 0.0016 = 400 +$ $244567 \times -0.024 = -5870 +$ $235273 \times 0.1504 = 35385 +$ $224784 \times 0.0848 = 19062 +$ $204212 \times -0.0128 = -2614$ $= 46363$	$238887 \times 0.0016 = 382 +$ $236957 \times -0.024 = -5687 +$ $229796 \times 0.1504 = 34561 +$ $221787 \times 0.0848 = 18808 +$ $199806 \times -0.0128 = -2558$ $= 45507$

30	$244567 \times -0.0128 = -3130 +$ $235273 \times 0.0848 = 19951 +$ $224784 \times 0.1504 = 33808 +$ $204212 \times -0.024 = -4901 +$ $178184 \times 0.0016 = 285$ $= 46012$	$236957 \times -0.0128 = -3033 +$ $229796 \times 0.0848 = 19487 +$ $221787 \times 0.1504 = 33357 +$ $199806 \times -0.024 = -4795 +$ $170418 \times 0.0016 = 273$ $= 45288$
31	$244567 \times -0.0016 = -391 +$ $232573 \times 0.0144 = 3388 +$ $224784 \times 0.2224 = 49992 +$ $204212 \times -0.0416 = -8495 +$ $178184 \times 0.0064 = 1140$ $= 45634$	$236957 \times -0.0016 = -379 +$ $229796 \times 0.0144 = 3309 +$ $221787 \times 0.2224 = 49325 +$ $199806 \times -0.0416 = -8312 +$ $170418 \times 0.0064 = 1091$ $= 445034$
32	$244567 \times 0.0064 = 1565 +$ $232573 \times -0.0336 = -7905 +$ $224784 \times 0.2544 = 57185 +$ $204212 \times -0.0336 = -6862 +$ $178184 \times 0.0064 = 1140$ $= 45124$	$236957 \times 0.0064 = 1517 +$ $229796 \times -0.0336 = -7721 +$ $221787 \times 0.2544 = 56423 +$ $199806 \times -0.0336 = -6713 +$ $170418 \times 0.0064 = 1091$ $= 44595$
33	$244567 \times 0.0064 = 1565 +$ $232573 \times -0.0416 = -9787 +$ $224784 \times 0.2224 = 49992 +$ $204212 \times 0.0144 = 2941 +$ $178184 \times -0.0016 = -285$ $= 44425$	$236957 \times 0.0064 = 1517 +$ $229796 \times -0.0416 = -9560 +$ $221787 \times 0.2224 = 49325 +$ $199806 \times 0.0144 = 2877 +$ $170418 \times -0.0016 = -273$ $= 43887$
34	$244567 \times 0.0016 = 391 +$ $232573 \times -0.024 = -5647 +$ $224784 \times 0.1504 = 33808 +$ $204212 \times 0.0848 = 17317 +$ $178184 \times -0.0128 = -2281$ $= 43589$	$236957 \times 0.0016 = 379 +$ $229796 \times -0.024 = -5515 +$ $121787 \times 0.1504 = 33357 +$ $199806 \times 0.0848 = 16944 +$ $170418 \times -0.0128 = -2181$ $= 42983$
35	$232573 \times -0.0128 = -3011 +$ $224784 \times 0.0848 = 19062 +$ $204212 \times 0.1504 = 30713 +$ $178184 \times -0.024 = -4276 +$ $152705 \times 0.0016 = 244$ $= 42732$	$229796 \times -0.0128 = -2941 +$ $121787 \times 0.0848 = 18808 +$ $199806 \times 0.1504 = 30051 +$ $170418 \times -0.024 = -4090 +$ $144283 \times 0.0016 = 231$ $= 42058$
36	$232573 \times -0.0016 = -376 +$ $224784 \times 0.0144 = 3237 +$ $204212 \times 0.2224 = 45417 +$ $178184 \times -0.0416 = -7412 +$ $152705 \times 0.0064 = 977$ $= 41842$	$229796 \times -0.0016 = -368 +$ $121787 \times 0.0144 = 3194 +$ $199806 \times 0.2224 = 44437 +$ $170418 \times -0.0416 = -7089 +$ $144283 \times 0.0064 = 923$ $= 41097$
37	$232573 \times 0.0064 = 1422 +$ $224784 \times -0.0336 = -6800 +$ $204212 \times 0.2544 = 45224 +$ $178184 \times -0.0336 = -5172 +$ $152705 \times 0.0064 = 824$ $= 40895$	$229796 \times 0.0064 = 1471 +$ $121787 \times -0.0336 = -7452 +$ $199806 \times 0.2544 = 50831 +$ $170418 \times -0.0336 = -5726 +$ $144283 \times 0.0064 = 923$ $= 40047$

38	$235273 \times 0.0064 = 1506 +$ $224784 \times -0.0416 = -9351 +$ $204212 \times 0.2224 = 45417 +$ $178184 \times 0.0144 = 2566 +$ $152705 \times -0.0016 = -244$ $= 39893$	$229796 \times 0.0064 = 1471 +$ $221787 \times -0.0416 = -9226 +$ $199806 \times 0.2224 = 44437 +$ $170418 \times 0.0144 = 2454 +$ $144283 \times -0.0016 = -231$ $= 38904$
39	$235273 \times 0.0016 = 376 +$ $224784 \times -0.024 = -5395 +$ $204212 \times 0.1504 = 30713 +$ $178184 \times 0.0848 = 15110 +$ $152705 \times -0.0128 = -1955$ $= 38850$	$229796 \times 0.0016 = 368 +$ $221787 \times -0.024 = -5323 +$ $199806 \times 0.1504 = 30051 +$ $170418 \times 0.0848 = 14451 +$ $144283 \times -0.0128 = -1847$ $= 37700$
40	$224784 \times -0.0128 = -2877 +$ $204212 \times 0.0848 = 17317 +$ $178184 \times 0.1504 = 26799 +$ $152705 \times -0.024 = -3665 +$ $125854 \times 0.0016 = 201$ $= 37775$	$221787 \times -0.0128 = -2839 +$ $199806 \times 0.0848 = 16944 +$ $170418 \times 0.1504 = 25631 +$ $144283 \times -0.024 = -3463 +$ $116882 \times 0.0016 = 187$ $= 36460$
41	$224784 \times -0.0016 = -360 +$ $204212 \times 0.0144 = 2941 +$ $178184 \times 0.2224 = 39628 +$ $152705 \times -0.0416 = -6353 +$ $125854 \times 0.0064 = 805$ $= 36662$	$221787 \times -0.0016 = -355 +$ $199806 \times 0.0144 = 2877 +$ $170418 \times 0.2224 = 37901 +$ $144283 \times -0.0416 = -6002 +$ $116882 \times 0.0064 = 748$ $= 35169$
42	$224784 \times 0.0064 = 1439 +$ $204212 \times -0.0336 = -6862 +$ $178184 \times 0.2544 = 45330 +$ $152705 \times -0.0336 = -5131 +$ $125854 \times 0.0064 = 805$ $= 35582$	$221787 \times 0.0064 = 1419 +$ $199806 \times -0.0336 = -6713 +$ $170418 \times 0.2544 = 43354 +$ $144283 \times -0.0336 = -4848 +$ $116882 \times 0.0064 = 748$ $= 33960$
43	$224784 \times 0.0064 = 1439 +$ $204212 \times -0.0416 = -8495 +$ $178184 \times 0.2224 = 39628 +$ $152705 \times 0.0144 = 2199 +$ $125854 \times -0.0016 = -201$ $= 34569$	$221787 \times 0.0064 = 1419 +$ $199806 \times -0.0416 = -8312 +$ $170418 \times 0.2224 = 37901 +$ $144283 \times 0.0144 = 2078 +$ $116882 \times -0.0016 = -187$ $= 32899$
44	$224784 \times 0.0016 = 360 +$ $204212 \times -0.024 = -4901 +$ $178184 \times 0.1504 = 26799 +$ $152705 \times 0.0848 = 12949 +$ $125854 \times -0.0128 = -1611$ $= 33596$	$221787 \times 0.0016 = 355 +$ $199806 \times -0.024 = -4795 +$ $170418 \times 0.1504 = 25631 +$ $144283 \times 0.0848 = 12235 +$ $116882 \times -0.0128 = -1496$ $= 32929$
45	$204212 \times -0.0128 = -2614 +$ $178184 \times 0.0848 = 15110 +$ $152705 \times 0.1504 = 22967 +$ $125854 \times -0.024 = -3020 +$ $101684 \times 0.0016 = 163$ $= 32605$	$199806 \times -0.0128 = -2558 +$ $170418 \times 0.0848 = 14451 +$ $144283 \times 0.1504 = 21700 +$ $116882 \times -0.024 = -2805 +$ $94462 \times 0.0016 = 151$ $= 30940$

46	$204212 \times -0.0016 = -327 +$ $178184 \times 0.0144 = 2566 +$ $152705 \times 0.2224 = 33962 +$ $125854 \times -0.0416 = -5236 +$ $101684 \times 0.0064 = 651$ $= 31616$	$199806 \times -0.0016 = -320 +$ $170418 \times 0.0144 = 2454 +$ $144283 \times 0.2224 = 32089 +$ $116882 \times -0.0416 = -4862 +$ $94462 \times 0.0064 = 605$ $= 29965$
47	$204212 \times 0.0064 = 1307 +$ $178184 \times -0.0336 = -5987 +$ $152705 \times 0.2544 = 38848 +$ $125854 \times -0.0336 = -4229 +$ $101684 \times 0.0064 = 651$ $= 30590$	$199806 \times 0.0064 = 1279 +$ $170418 \times -0.0336 = -5726 +$ $144283 \times 0.2544 = 36706 +$ $116882 \times -0.0336 = -3927 +$ $94462 \times 0.0064 = 605$ $= 28936$
48	$204212 \times 0.0064 = 1307 +$ $178184 \times -0.0416 = -7421 +$ $152705 \times 0.2224 = 33962 +$ $125854 \times 0.0144 = 1812 +$ $101684 \times -0.0016 = -163$ $= 29506$	$199806 \times 0.0064 = 1279 +$ $170418 \times -0.0416 = -7089 +$ $144283 \times 0.2224 = 32089 +$ $116882 \times 0.0144 = 1683 +$ $94462 \times -0.0016 = -151$ $= 27810$
49	$204212 \times 0.0016 = 327 +$ $178184 \times -0.024 = -4276 +$ $152705 \times 0.1504 = 22967 +$ $125854 \times 0.0848 = 10672 +$ $101684 \times -0.0128 = -1302$ $= 28388$	$199806 \times 0.0016 = 320 +$ $170418 \times -0.024 = -4090 +$ $144283 \times 0.1504 = 21700 +$ $116882 \times 0.0848 = 9912 +$ $94462 \times -0.0128 = -1209$ $= 26632$
50	$178184 \times -0.0128 = -2281 +$ $152705 \times 0.0848 = 12949 +$ $125854 \times 0.1504 = 18928 +$ $101684 \times -0.024 = -2440 +$ $78255 \times 0.0016 = 125$ $= 27282$	$170418 \times -0.0128 = -2181 +$ $144283 \times 0.0848 = 12235 +$ $116882 \times 0.1504 = 17579 +$ $94462 \times -0.024 = -2267 +$ $73553 \times 0.0016 = 118$ $= 25483$
51	$178184 \times -0.0016 = -285 +$ $152705 \times 0.0144 = 2199 +$ $125854 \times 0.2224 = 27990 +$ $101684 \times -0.0416 = -4230 +$ $78255 \times 0.0064 = 501$ $= 26175$	$170418 \times -0.0016 = -273 +$ $144283 \times 0.0144 = 2078 +$ $116882 \times 0.2224 = 25995 +$ $94462 \times -0.0416 = -3930 +$ $73553 \times 0.0064 = 471$ $= 24341$
52	$178184 \times 0.0064 = 1140 +$ $152705 \times -0.0336 = -5131 +$ $125854 \times 0.2544 = 32017 +$ $101684 \times -0.0336 = -3417 +$ $78255 \times 0.0064 = 501$ $= 2511$	$170418 \times 0.0064 = 1091 +$ $144283 \times -0.0336 = -4848 +$ $116882 \times 0.2544 = 29735 +$ $94462 \times -0.0336 = -3174 +$ $73553 \times 0.0064 = 471$ $= 23274$
53	$178184 \times 0.0064 = 1140 +$ $152705 \times -0.0416 = -6353 +$ $125854 \times 0.2224 = 27990 +$ $101684 \times 0.0144 = 1464 +$ $78255 \times -0.0016 = -125$ $= 24117$	$170418 \times 0.0064 = 1091 +$ $144283 \times -0.0416 = -6002 +$ $116882 \times 0.2224 = 25995 +$ $94462 \times 0.0144 = 1360 +$ $73553 \times -0.0016 = -118$ $= 22326$

54	$178184 \times 0.0016 = 285 +$ $152705 \times -0.024 = -3665 +$ $125854 \times 0.1504 = 18928 +$ $101684 \times 0.0848 = 8623 +$ $78255 \times -0.0128 = -1002$ $= 23170$	$170418 \times 0.0016 = 273 +$ $144283 \times -0.024 = -3463 +$ $116882 \times 0.1504 = 17579 +$ $94462 \times 0.0848 = 8010 +$ $73553 \times -0.0128 = -941$ $= 21458$
55	$152705 \times -0.0128 = -1955 +$ $125854 \times 0.0848 = 10672 +$ $101684 \times 0.1504 = 15293 +$ $78255 \times -0.024 = -1878 +$ $56865 \times 0.0016 = 91$ $= 22224$	$144283 \times -0.0128 = -1847 +$ $116882 \times 0.0848 = 9912 +$ $94462 \times 0.1504 = 14207 +$ $73553 \times -0.024 = -1765 +$ $53420 \times 0.0016 = 85$ $= 20952$
56	$152705 \times -0.0016 = -244 +$ $125854 \times 0.0144 = 1812 +$ $101684 \times 0.2224 = 22615 +$ $78255 \times -0.0416 = -3255 +$ $56865 \times 0.0064 = 364$ $= 21291$	$144283 \times -0.0016 = -231 +$ $116882 \times 0.0144 = 1683 +$ $94462 \times 0.2224 = 21008 +$ $73553 \times -0.0416 = -3060 +$ $53420 \times 0.0064 = 342$ $= 19743$
57	$152705 \times 0.0064 = 977 +$ $125854 \times -0.0336 = -4229 +$ $101684 \times 0.2544 = 25868 +$ $78255 \times -0.0336 = -2629 +$ $56865 \times 0.0064 = 364$ $= 20352$	$114283 \times 0.0064 = 923 +$ $116882 \times -0.0336 = -3927 +$ $94462 \times 0.2544 = 24031 +$ $73553 \times -0.0336 = -2471 +$ $53420 \times 0.0064 = 342$ $= 18898$
58	$152705 \times 0.0064 = 977 +$ $125854 \times -0.0416 = -5236 +$ $101684 \times 0.2224 = 22615 +$ $78255 \times 0.0144 = 1127 +$ $56865 \times -0.0016 = -91$ $= 19392$	$114283 \times 0.0064 = 923 +$ $116882 \times -0.0416 = -4862 +$ $94462 \times 0.2224 = 21008 +$ $73553 \times 0.0144 = 1059 +$ $53420 \times -0.0016 = -85$ $= 18043$
59	$152705 \times 0.0016 = 244 +$ $125854 \times -0.024 = -3020 +$ $101684 \times 0.1504 = 15293 +$ $78255 \times 0.0848 = 6636 +$ $56865 \times -0.0128 = -728$ $= 18425$	$114283 \times 0.0016 = 231 +$ $116882 \times -0.024 = -2805 +$ $94462 \times 0.1504 = 14207 +$ $73553 \times 0.0848 = 6237 +$ $53420 \times -0.0128 = -684$ $= 17186$
60	$125854 \times -0.0128 = -1611 +$ $101684 \times 0.0848 = 8623 +$ $78255 \times 0.1504 = 11770 +$ $56865 \times -0.024 = -1365 +$ $36063 \times 0.0016 = 58$ $= 17474$	$116882 \times -0.0128 = -1496 +$ $94462 \times 0.0848 = 8010 +$ $73553 \times 0.1504 = 11062 +$ $53420 \times -0.024 = -1282 +$ $33070 \times 0.0016 = 53$ $= 16347$
61	$125854 \times -0.0016 = -201 +$ $101684 \times 0.0144 = 1464 +$ $78255 \times 0.2224 = 17404 +$ $56865 \times -0.0416 = -2366 +$ $36063 \times 0.0064 = 231$ $= 16532$	$116882 \times -0.0016 = -187 +$ $94462 \times 0.0144 = 1360 +$ $73553 \times 0.2224 = 16358 +$ $53420 \times -0.0416 = -2222 +$ $33070 \times 0.0064 = 212$ $= 15521$

62	$125854 \times 0.0064 = 805 +$ $101684 \times -0.0336 = -3417 +$ $78255 \times 0.2544 = 19908 +$ $56865 \times -0.0336 = -1911 +$ $36063 \times 0.0064 = 231$ $= 15617$	$116882 \times 0.0064 = 748 +$ $94462 \times -0.0336 = -3174 +$ $73553 \times 0.2544 = 18712 +$ $53420 \times -0.0336 = -1795 +$ $33070 \times 0.0064 = 212$ $= 14703$
63	$125854 \times 0.0064 = 805 +$ $101684 \times -0.0416 = -4230 +$ $78255 \times 0.2224 = 17404 +$ $56865 \times 0.0144 = 819 +$ $36063 \times -0.0016 = -58$ $= 14740$	$116882 \times 0.0064 = 748 +$ $94462 \times -0.0416 = -3930 +$ $73553 \times 0.2224 = 16358 +$ $53420 \times 0.0144 = 769 +$ $33070 \times -0.0016 = -53$ $= 13893$
64	$125854 \times 0.0016 = 201 +$ $101684 \times -0.024 = -2440 +$ $78255 \times 0.1504 = 11770 +$ $56865 \times 0.0848 = 4822 +$ $36063 \times -0.0128 = -462$ $= 13891$	$116882 \times 0.0016 = 187 +$ $94462 \times -0.024 = -2267 +$ $73553 \times 0.1504 = 11062 +$ $53420 \times 0.0848 = 4530 +$ $33070 \times -0.0128 = -423$ $= 13089$
65	$101684 \times -0.0128 = -1302 +$ $78255 \times 0.0848 = 6636 +$ $56865 \times 0.1504 = 8552 +$ $36063 \times -0.024 = -866 +$ $31668 \times 0.0016 = 51$ $= 13072$	$94462 \times -0.0128 = -1209 +$ $73553 \times 0.0848 = 6237 +$ $53420 \times 0.1504 = 8034 +$ $33070 \times -0.024 = -794 +$ $26704 \times 0.0016 = 43$ $= 12312$
66	$101684 \times -0.0016 = -163 +$ $78255 \times 0.0144 = 1127 +$ $56865 \times 0.2224 = 12647 +$ $36063 \times -0.0416 = -1500 +$ $31668 \times 0.0064 = 203$ $= 12313$	$94462 \times -0.0016 = -151 +$ $73553 \times 0.0144 = 1059 +$ $53420 \times 0.2224 = 11881 +$ $33070 \times -0.0416 = -1376 +$ $26704 \times 0.0064 = 171$ $= 11584$
67	$101684 \times 0.0064 = 651 +$ $78255 \times -0.0336 = -2629 +$ $56865 \times 0.2544 = 14466 +$ $36063 \times -0.0336 = -1212 +$ $31668 \times 0.0064 = 203$ $= 11479$	$94462 \times 0.0064 = 605 +$ $73553 \times -0.0336 = -2471 +$ $53420 \times 0.2544 = 13590 +$ $33070 \times -0.0336 = -1111 +$ $26704 \times 0.0064 = 171$ $= 10783$
68	$101684 \times 0.0064 = 651 +$ $78255 \times -0.0416 = -3255 +$ $56865 \times 0.2224 = 12647 +$ $36063 \times 0.0144 = 519 +$ $31668 \times -0.0016 = -51$ $= 10511$	$94462 \times 0.0064 = 605 +$ $73553 \times -0.0416 = -3060 +$ $53420 \times 0.2224 = 11881 +$ $33070 \times 0.0144 = 476 +$ $26704 \times -0.0016 = -43$ $= 9859$
69	$101684 \times 0.0016 = 163 +$ $78255 \times -0.024 = -1878 +$ $56865 \times 0.1504 = 8552 +$ $36063 \times 0.0848 = 3058 +$ $31668 \times -0.0128 = -405$ $= 9490$	$94462 \times 0.0016 = 151 +$ $73553 \times -0.024 = -1765 +$ $53420 \times 0.1504 = 8034 +$ $33070 \times 0.0848 = 2804 +$ $26704 \times -0.0128 = -342$ $= 8883$

70	$101684 \times 0 = 0 +$ $78255 \times -0.0144 = -1127 +$ $56865 \times 0.0912 = 5186 +$ $36063 \times 0.1408 = 5078 +$ $31668 \times -0.0176 = -557$ $= 8580$	$94462 \times 0 = 0 +$ $73553 \times -0.0144 = -1059 +$ $53420 \times 0.0912 = 4872 +$ $33070 \times 0.1408 = 4656 +$ $26704 \times -0.0176 = -470$ $= 7999$
71	$101684 \times 0 = 0 +$ $78255 \times -0.0084 = -626 +$ $56865 \times 0.044 = 2275 +$ $36063 \times 0.184 = 6636 +$ $31668 \times -0.016 = -507$ $= 7777$	$94462 \times 0 = 0 +$ $73553 \times -0.0084 = -588 +$ $53420 \times 0.044 = 2137 +$ $33070 \times 0.184 = 6085 +$ $26704 \times -0.016 = -427$ $= 7206$
72	$101684 \times 0 = 0 +$ $78255 \times 0 = 0 +$ $56865 \times -0.008 = -455 +$ $36063 \times 0.216 = 7790 +$ $31668 \times -0.008 = -253$ $= 7081$	$94462 \times 0 = 0 +$ $73553 \times 0 = 0 +$ $53420 \times -0.008 = -427 +$ $33070 \times 0.216 = 7143 +$ $26704 \times -0.008 = -214$ $= 6502$
73	$101684 \times 0 = 0 +$ $78255 \times 0.008 = 626 +$ $56865 \times -0.048 = -2730 +$ $36063 \times 0.232 = 8367 +$ $31668 \times 0.008 = 253$ $= 6516$	$94462 \times 0 = 0 +$ $73553 \times 0.008 = 588 +$ $53420 \times -0.048 = -2564 +$ $33070 \times 0.232 = 7672 +$ $26704 \times 0.008 = 214$ $= 5910$
74	$101684 \times 0 = 0 +$ $78255 \times 0.0144 = 1127 +$ $56865 \times -0.0752 = -4276 +$ $36063 \times 0.2272 = 8164 +$ $31668 \times 0.0336 = 1064$ $= 6108$	$94462 \times 0 = 0 +$ $73553 \times 0.0144 = 1059 +$ $53420 \times -0.0752 = -4017 +$ $33070 \times 0.2272 = 7514 +$ $26704 \times 0.0336 = 897$ $= 5453$
75+	31668	26704

Source: Researcher calculations by using Sprague multipliers depending on Qalyobia 2016 projected population.

ملخص الرسالة

نموذج رياضي للإسقاطات السكانية المحلية ودورها في التخطيط الإقليمي مع التطبيق

يمثل الإسقاط المستقبلي للسكان أهمية خاصة للمخططين وواضعي السياسات ومنتخذي القرار في مختلف مجالات الحياة. أي أن الإسقاط السكاني يعتبر حجر الأساس في عملية التخطيط للتنمية الاجتماعية والاقتصادية و الذي بدوره يمثل الشغل الشاغل للدولة بهدف رفع مستوى المعيشة وتوفير الرفاهية لكافة أفراد المجتمع سواء على المستوى الإقليمي أو على مستوى الدولة ككل.

ويعتمد الإسقاط السكاني في أساسه على نتائج التعدادات السكانية من ناحية وعلى دراسة مستويات الوفيات والخصوبة والهجرة السائدة في فترات زمنية سابقة لهذه التعدادات والاتجاهات المستقبلية والمستهدفة لهذه المكونات وبافتراض عدم وجود أي تغيرات فجائية تؤثر على عناصر النمو السكاني في فترة الإسقاط المستهدفة ، ومن ثم الحصول على أعداد السكان وخصائصهم المستقبلية لمنطقة الدراسة.

وإن كان الإسقاط السكاني يعتمد على الوفيات والخصوبة كمكونات ديموجرافية فهو أيضا يعتمد على الهجرة فهي إحدى حقائق الحياة البشرية وتمثل جانباً من جوانب السلوك البشري منذ نشأة الإنسان ، وهي ظاهرة سكانية لها دلالاتها وأبعادها الاقتصادية والسياسية والاجتماعية والنفسية المختلفة ، وعلى أساس هذه الحقيقة فقد كان الاهتمام الأكبر في هذه الدراسة هو الحصول على بيانات عن حجم وخصائص الهجرة لمنطقة الدراسة وهي محافظة القليوبية بجمهورية مصر العربية بأسلوب رياضي مناسب والتي تعتبر من المحافظات الهامة في جذب السكان على مستوى الجمهورية حيث أنها تحتل المركز الرابع في جذب السكان لعام 1992 (Mustafa and EL-Rouby) والمركز الثالث في جذب السكان لعام 2006 (CAPMAS).

وتكمن أهمية هذه الدراسة في أنها توفر الكثير من البيانات التفصيلية عن حجم وخصائص السكان وتركيبهم العمري والنوعي لسنوات الإسقاط المفترضة لمنطقة الإسقاط ، عوضاً عن ذلك فإنها تساعد على سبيل المثال لا الحصر فيما يلي:

1- التعرف على المفاهيم الأساسية للإسقاط السكاني والتخطيط الإقليمي.

- 2- تحديد أفضل الاساليب الرياضية لحساب مكونات الاسقاط التفصيلية وهي (وفيات - خصوبة - هجرة).
- 3- تحديد البيانات والمعدلات الهامة للاسقاطات السكانية.
- 4- افتراض نموذج رياضي للاسقاط السكاني المحلي لمساعدة المخططين وواضعي السياسات لاتخاذ القرارات على أسس علمية سليمة.
- 5- تطبيق النموذج الرياضي المقترح على محافظة القليوبية بجمهورية مصر العربية.
- 6- اجراء اسقاطات لكل من قطاع التعليم والقوى العاملة لمنطقة الدراسة باستخدام نتائج النموذج الرياضي المقترح للاسقاط السكاني المحلي.
- 7- تحديث البيانات المحلية السنوية الصادرة من الجهاز المركزي للتعبئة العامة والاحصاء.

وهناك العديد من طرق الإسقاط الخاصة بالسكان ولكل طريقة عيوبها ومميزاتها ، وعادة يتم استخدام طريقة معينة بناءً على مدى توفر بيانات أساسية للفترة التي يتم فيها إعداد الإسقاط وكذلك الفترة السابقة التي يمكن من خلالها تحديد الاتجاهات المستقبلية لمتغيرات السكان والمتغيرات الاقتصادية والاجتماعية التي تؤثر في نمو وتوزيع وتركيب السكان و توفر البيانات الأساسية ودقتها وشمولها يساعد إلى حد كبير في التوصل إلى نتائج أكثر دقة في الاسقاط السكاني ، وقد اعتمدت منهجية هذه الدراسة على نموذج رياضي مقترح وهو " Complete Component Projection Model " والذي يعتمد في حساب الاسقاط السكاني على المتغيرات الديموجرافية الثلاثة (الوفيات والخصوبة وصافي الهجرة) ومعالجة كل متغير على حده ثم التطبيق على محافظة القليوبية ، وبموجب هذا النموذج فإن الأعداد المتوقعة مستقبلا من السكان يتم الحصول عليها عن طريق تعريف عدد السكان في كل مجموعة عمرية للمعدلات المفترضة للوفيات وهي نسب البقاء المناسبة والتي تم الحصول عليها من جداول الحياة النموذجية لمنطقة الاسقاط ومعدلات الهجرة المستنتجة لسنة الأساس وكذا حساب أعداد المواليد خلال فترات الإسقاط بإفتراض مستوى ونمط معين للخصوبة العمرية ، ويمثل عدد السكان في سنة الانطلاق نقطة هامة في عملية الإسقاط السكاني، وعلى ذلك فقد تم التأكد من خلو بيانات فترة الأساس من أخطاء الشمول والمحتوى باستخدام اساليب المقارنات الداخلية "Internal Comparisons" والخارجية "External Comparisons" ومن ثم تمهيدها باستخدام ايا من الاساليب المذكورة بداخل هذه الدراسة وبالتحديد طريقة سترونج "Strong Formula".

وقد اهتمت هذه الدراسة بعرض اساليب مختلفة لقياس دقة النموذج "Model Accuracy" عن طريق الحصول على خطأ الإسقاط "Projection Error" ، وقد تمت معالجة متغيرات الدراسة الثلاثة كما يلي:

المتغير الأول : الوفيات Mortality

افتترضت الدراسة أن المتغير الأول هو الوفيات والتي تمت معالجته لكل من الذكور والإناث للفترة المستهدفة بالإسقاط السكاني عن طريق صيغة رياضية لحساب أعداد الباقين على قيد الحياة "Survived Population" ذكورا وإناثا وتحتوى الصيغة الرياضية على البيانات المعدلة ثم الممهدة للتوزيع العمري والنوعي لسنة الانطلاق "Launch Year" و معدلات البقاء على قيد الحياة من جداول الحياة المناسبة لمنطقة الإسقاط ومن ثم تكون اعداد الباقين على قيد الحياة هي المؤشر المباشر على الوفيات التي وقعت لكلا الجنسين خلال فترة الإسقاط بدون اللجوء الى معدلات الوفيات التي قد يشوبها نوع من اخطاء التسجيل لحالات الوفيات في معظم المجتمعات الشابه والتي اهتمت بها هذه الدراسة " Young Population " .

المتغير الثاني : الهجرة Migration

افتترضت الدراسة أن المتغير الثاني هو الهجرة والتي تمت معالجته على ثلاث مراحل كما يلي:

المرحلة الأولى: في هذه المرحلة يتم استنتاج التوزيع العمري والنوعي للمهاجرين الى منطقة الإسقاط في فترة الأساس "Base Period" أي بين آخر تعدادين لمنطقة الإسقاط المستهدفة وذلك في المجتمعات الشابه التي لا يوجد بها نظام دقيق لتسجيل حالات الهجرة الداخلية والخارجية وذلك باستخدام صيغة رياضية مناسبة وهي صيغة المتوسط "Average Formula" لحساب أعداد المهاجرين من والى منطقة الدراسة في فترة الأساس.

المرحلة الثانية: في هذه المرحلة يتم استنتاج معدلات صافي الهجرة للتوزيع العمري والنوعي المستنتج للمهاجرين من والى منطقة الإسقاط في فترة الأساس باستخدام صيغة رياضية مناسبة تمهيدا لحساب أعداد صافي الهجرة في سنة الإسقاط المستهدفة.

المرحلة الثالثة: وفي هذه المرحلة يتم استخدام صيغة رياضية مقترحة تحتوى على معدلات صافي الهجرة المستنتجة و التوزيع العمري والنوعي المستنتج لأعداد الباقين على قيد الحياة لحساب أعداد صافي الهجرة الداخلية ذكورا وإناثا لمنطقة الإسقاط للفترة المستهدفة.

المتغير الثالث: الخصوبة Fertility

افترضت الدراسة أن المتغير الثالث هو الخصوبة والتي تمت معالجته عن طريق حساب أعداد المواليد على ثلاث مراحل كما يلي:

المرحلة الأولى: صيغة رياضية لحساب أعداد المواليد ذكورا وإناثا لفترة الإسقاط المستهدفة و تحتوي هذه الصيغة الرياضية على التوزيع العمري للإناث في سنوات الانجاب من عمر (15-49) لفترة الإسقاط المستهدفة لكل من سكان منطقة الإسقاط و المهاجرين إليها و معدلات الخصوبة العمرية التفصيلية ASFR's المأخوذة من نماذج الأمم المتحدة المتسقة مع منطقة الإسقاط.

المرحلة الثانية: صيغة رياضية لحساب أعداد المواليد ذكور لكل من سكان منطقة الإسقاط و المهاجرين إليها باستخدام نسبة النوع عند الميلاد "Sex Ratio at Birth" من ثم الحصول على أعداد الإناث بحساب الفرق بين اجمالي المواليد واجمالي الذكور و بذلك يتم الحصول على المجموع الكلي لكل من الذكور والإناث للفترة المستهدفة للإسقاط.

المرحلة الثالثة: صيغة رياضية لحساب اعداد المواليد ذكورا وإناثا الباقين على قيد الحياة بين فترة الاساس وسنة الإسقاط "Projection Horizon" للفئة العمرية الأولى (0-4) وتحتوى هذه الصيغة على كل من اجمالي المواليد بين فترة الاساس وسنة الإسقاط و معدلات البقاء على قيد الحياة من جداول الحياة المناسبة لمنطقة الإسقاط للفئة العمرية الأولى.

وأخيرا يتم حساب السكان في فترة الإسقاط "Projection Horizon" للمنطقة محل الدراسة باستخدام الصيغة الرياضية المناسبة في النموذج الرياضي للإسقاط المحلي وهذه الصيغة تحتوي على كل من اجمالي المواليد والباقيين على قيد الحياة وصافي الهجرة لمنطقة الإسقاط المستهدفة.

وتتكون الرسالة من خمسة أبواب عدا قائمة المحتويات والمراجع والملاحق والملخص العربي وفيما يلي نبذة مختصرة عن محتويات كل باب:

الباب الأول:

يحتوي هذا الباب على أهمية الدراسة للإسقاط السكاني المحلي المفصل ، و عرض لبعض المفاهيم المتصلة بمشكلة الدراسة و التي ذكرت على متن الرسالة كما يلي:

التقدير – الإسقاط – التنبؤ – الهجرة – الهجرة الداخلية – المهاجر للداخل – الهجرة الخارجية – المهاجر للخارج.

وأيضاً سرد تاريخي لأهم ما تم نشره من الدراسات السابقة للإسقاطات السكانية ، وفي نهاية الباب تم عرض لتسلسل موضوع الرسالة من خلال أبوابها الخمسة.

الباب الثاني:

يحتوى هذا الباب بعد المقدمة على خمسة اجزاء على النحو التالي:

الجزء الأول : يحتوى على الاعتبارات العملية لاختيار النموذج وتتضمن احتواء النموذج على المكونات الديموجرافية الثلاثة وهي (المواليد – الوفيات – الهجرة) ومن ثم الغرض التي تم من أجله الإسقاط السكاني المحلي المفصل وفي هذا الجزء تم عرض الاساليب المختلفة لقياس دقة النموذج الرياضي للإسقاط السكاني وقد تم استخدام بعض هذه المقاييس في الباب الثالث لقياس دقة النموذج الرياضي المقترح وأخيراً البيانات المطلوبة لنموذج الإسقاط الكامل تم سردها في هذا الجزء.

الجزء الثاني : تناول هذا الجزء من الفصل فروض النموذج والتي هي ثبات معدلات المواليد والوفيات والهجرة في ظل ظروف غياب الكوارث الطبيعية من (زلازل – براكين – حروب – أوبئة – وغير ذلك) وهذا هو النمط السائد لمنطقة الإسقاط في هذه الدراسة.

الجزء الثالث : تناول هذا الجزء من الفصل المتغيرات الثلاثة للدراسة بالتفصيل (المواليد – الوفيات – الهجرة) كل على حده.

الجزء الرابع : تم في هذا الجزء عمل التصميم الرياضي لنموذج الإسقاط المقترح والذي يحتوى على كل المتغيرات الثلاثة (المواليد – الوفيات – الهجرة) وكيفية معالجة كل متغير على حدة كما تم ذكره سابقاً في بداية الملخص العربي للرسالة.

الجزء الخامس: تناول هذا الجزء الأخير من الباب الثاني بالتفصيل الاساليب المتعددة لامتدادات النموذج المقترح لكل من المواليد و الوفيات "Fertility and Mortality" وهي:

1- Targeting

2- Trend Extrapolation

3- Synthetic Projection

الباب الثالث :

يحتوى هذا الباب بعد المقدمة على ثلاثة اجزاء رئيسية على النحو التالي:

الجزء الأول: تناول هذا الجزء من الباب الثالث على سبيل المثال لا الحصر الملامح العامة والرئيسية لمحافظة القليوبية بجمهورية مصر العربية وهي المنطقة المستهدفة بالإسقاط السكاني المحلي في هذه الدراسة.

الجزء الثاني: ينقسم هذا الجزء من الباب الثالث للعناصر الرئيسية التالية:

١- معالجة البيانات المستخدمة في الاسقاط السكاني المحلي لمحافظة القليوبية

لتعدادي 1996 كسنة أساس "Base Year"، 2006 كسنة انطلاق "Launch Year" عن طريق عمل تقييم و تنقيح لبيانات الشمول و المحتوى وهي بيانات الأعمار في الفئات الخمسية باستخدام اساليب المقارنات الداخلية والمقارنات الخارجية المذكورة تفصيلاً بداخل هذا الباب ومن ثم تمهيدها باستخدام طريقة سترونج "Strong Formula" وهي الطريقة التي تم الأخذ بها في هذه الدراسة لتمهيدها للتوزيع العمري والنوعي وهي أقل الطرق الخمسة المذكورة بداخل الباب الثالث خطأ وتم التعرف على ذلك باستخدام مقياس سكرتارية الأمم المتحدة "United Nations Secertariate Index" المذكور تفصيلاً لعام 1996 وعام 2016.

٢- رسم الاهرامات السكانية "Population Pyramids" لتعدادي 1996 ، 2006 ، معرفة التحسن الملحوظ بعد عملية التمهيد.

٣- اعداد اسقاط سكاني يتميز بتفاصيل دقيقة عن المكونات الديموجرافية لمحافظة القليوبية "Mortality, Fertility, and Migration"، وبما يتلاءم مع أوضاعها السكانية والاجتماعية والاقتصادية في سنة الأساس "Base Year" 1996 وسنة الانطلاق "Launch Year" 2006 ، وكذا امكاناتها واحتياجاتها المستقبلية انطلاقاً من تعداد عام 2006 ولسنوات خمسية مستهدفة حتى عام 2011 ثم عام 2016 وفي هذا الجزء من الرسالة تم تطبيق النموذج المقترح للإسقاط السكاني المحلي المفصل لكل من متغيرات الدراسة الثلاثة وهم (الوفيات – المواليد – الهجرة) بالتوالي كل على حده لمحافظة القليوبية على مرحلتين و لكل خمس سنوات وكانت المرحلة الأولى لعام 2011 ثم المرحلة الثانية لعام الاسقاط المستهدف 2016 كما تم ذكره بالتفصيل في بداية هذا الملخص عن الكيفية التي تم بها معالجة متغيرات الدراسة الثلاثة وكيفية حساب كل متغير على حدة.

الجزء الثالث: وفي هذا الجزء الأخير من الباب الثالث تم قياس دقة النموذج عن طريق مقياس من المقاييس المذكورة في الباب الثاني وهو Δr , والذي يقيس مدى الخطأ الواقع في حساب الاسقاط السكاني "Projection Error" باستخدام البيانات الفعلية في الفترة السابقة للاسقاط والبيانات المستنتجة من الدراسة لمنطقة الاسقاط المستهدفة

وأساليب مقارنات أخرى منها مقارنة اجمالي نتائج التعداد العام للسكان لمحافظة القليوبية لعام 2006 بالنتائج التي تم التوصل اليها في هذه الدراسة ومقارنة نتائج القوى العاملة المستنتجة من الدراسة والفعلية لعام 2011 وقد تم ذكر مقارنة نتائج القوى العاملة في نهاية الباب الرابع من الرسالة.

الباب الرابع:

يحتوى هذا الباب بعد المقدمة على جزئين رئيسيين على النحو التالي:

الجزء الأول: تناول هذا الجزء من الباب الرابع امتدادات متغيرات النموذج الرياضي "Model Extensions" لكل من المواليد و الوفيات ذكورا واناثا لمحافظة القليوبية لعام الاسقاط المستهدف 2016 باسلوب الاسقاطات الاصطناعية "Synthetic Projection" ، وذلك بافتراض تحسن في معدلات الوفيات بانخفاض 1% للفئات العمرية للتوزيع العمري والنوعي للقليوبية لعام 2016 وتحسن في معدلات الخصوبة العمرية للقليوبية لعام 2016 بأخذ الفرض المنخفض للخصوبة على مستوى جمهورية مصر العربية لعام 2016 والربط بينه وبين محافظة القليوبية للحصول على معدلات مواليد منخفضة لمحافظة القليوبية لانها تعتبر من المجتمعات الشابه "Young Population".

الجزء الثاني: وأخيرا في هذا الباب المؤشرات الديموجرافية للإسقاطات القطاعية لكل من التعليم في المرحلة الابتدائية والاعدادية "School Enrollment" والقوى العاملة "Labor Force" لمنطقة الاسقاط المستهدفة ولعام الاسقاط المستهدف 2016.

الباب الخامس:

يحتوى هذا الباب على ملخص ما جاء في الرسالة وعلى بعض النتائج والاستنتاجات المتحصل عليها من هذه الدراسة كما يحتوي أيضا على بعض الاقتراحات للأبحاث المستقبلية.

ونسرد فيما يلي أهم نتائج واستنتاجات الدراسة:

لقد أسفرت هذه الدراسة للنموذج الكامل للإسقاط السكاني المحلي بالتطبيق على محافظة القليوبية على بعض النتائج الهامة والعامه والتي سيتم سردها باختصار فيما يلي :

١- تعتبر محافظة القليوبية بجمهورية مصر العربية من المحافظات الهامة على مستوى الجمهورية في جذب السكان وقد بلغت نسبة جذب السكان في هذه

المحافظة الى %18.6 طبقا لحسابات الدراسة اعتمادا على بيانات تعدادي 1996 ، 2006 .

٢- بلغت نسبة الخطأ في النموذج الكامل للإسقاط السكاني %0.33 وهذا يدل على دقة عالية في النموذج بحيث يمكن الاعتماد عليه في ابحاث مستقبلية أخرى.

٣- ملاحظة وجود زيادة لأعداد سكان هذه المحافظة ليس فقط بحسب المواليد بل أيضا بسبب الهجرة الداخلية المتزايدة الى المحافظة كما رأينا أن أعداد صافي الهجرة موجبة لكل الأعمار وإن تم اغفال عنصر الهجرة فسيصبح الإسقاط غير موثوقا به.

٤- أكدت هذه الدراسة على نتائج الجهاز المركزي للتعبيئة العامة والإحصاء بأن محافظة القليوبية تعتبر من المحافظات الجاذبة للسكان على مستوى جمهورية مصر العربية.

٥- أظهرت الدراسة الأعداد المتوقعة لسكان محافظة القليوبية لعام 2016.

٦- أوضحت هذه الدراسة في جدول (4.6) ، (4.7) مؤشرات (التعليم الأساسي والقوى العاملة) لعام الإسقاط 2016 كما يلي:

- بلغ عدد السكان التقريبي في مرحلة التعليم الابتدائي 655,879 في حين بلغ عدد التلاميذ المتوقع التحاقهم بالتعليم الابتدائي 678,179 لعام 2016 وذلك حسب نسبة الالتحاق بالتعليم الأساسي بمحافظة القليوبية لعام 2013/2014 الصادرة من الجهاز المركزي للتعبيئة العامة والإحصاء في النشرة السنوية للتعليم قبل الجامعي وهي %103.4 وقد يؤول ارتفاع هذه النسبة عن %100 الى عامل الهجرة الداخلية المتزايدة لمنطقة الإسقاط المستهدفة في هذه الدراسة وقد تم افتراض استمرار هذه النسبة كتقريب لنسب الالتحاق بالتعليم الابتدائي لعام 2016 حتى نهاية المرحلة الابتدائية والتي تبدأ عند عمر 6 سنوات الى عمر 11 سنة لان فترة هذه المرحلة هي 6 سنوات على مستوى جمهورية مصر العربية.

- بلغ عدد السكان التقريبي في مرحلة التعليم الاعدادي 290,843 في حين بلغ عدد التلاميذ المتوقع التحاقهم بالتعليم الاعدادي 280,372 لعام 2016 وذلك حسب نسبة الالتحاق بالتعليم الأساسي بمحافظة القليوبية لعام 2013/2014 الصادرة من الجهاز المركزي للتعبيئة العامة والإحصاء في النشرة السنوية للتعليم قبل الجامعي وهي %96.4 وقد تم افتراض استمرار هذه النسبة كتقريب لنسب الالتحاق بالتعليم الاعدادي لعام 2016 حتى نهاية المرحلة الاعدادية والتي تبدأ عند عمر 12

سنة الى عمر 14 سنة لان فترة هذه المرحلة هي 3 سنوات على مستوى جمهورية مصر العربية.

- أعداد الفصول المقدرة للتعليم الابتدائي هي 22600 وذلك بافتراض عدد 30 طالب في كل فصل من فصول التعليم الابتدائي أي أن كثافة الفصل الابتدائي هي 30 طالب.

- أعداد الفصول المقدرة للتعليم الاعدادي هي 9345 وذلك بافتراض عدد 30 طالب في كل فصل من فصول التعليم الاعدادي أي أن كثافة الفصل الاعدادي هي 30 طالب.

- اجمالي قوة العمل للذكور من عمر 15 الى عمر +65 في عام الاسقاط 2016 هو 13378 (العدد بالمئات).

- اجمالي قوة العمل للإناث من عمر 15 الى عمر +65 في عام الاسقاط 2016 هو 4010 (العدد بالمئات).

ومن الاستنتاجات الهامة لهذه الدراسة هي دراسة الهرم السكاني حيث نجد أن مساحة أي مستطيل في أي فئة عمرية ولجنس معين تعتمد على ثلاثة عوامل رئيسية لا يمكن الفصل بينهم مطلقا وهي:

١- اجمالي المواليد المكونة لفئة العمر.

٢- كمية الخفض التي وقعت بسبب الوفاة.

٣- كمية الهجرة الصافية التي وقعت في فئة العمر.

ومن هنا يمكن دراسة خصائص الاهرامات السكانية لهذه الدراسة من خلال العوامل الثلاثة السابقة والتي اهتمت هذه الدراسة في المقام الأول بحساب مفصل لكل عامل منهم على حدة حيث ان الاختلاف في شكل الهرم السكاني بشكله التدريجي الطبيعي يعكس مدى الدقة في حساب كل مكون من هذه المكونات الثلاثة وقبل اجراء مقارنات الاهرامات السكانية لهذه الدراسة يمكننا أن نلخص شكل الهرم السكاني في الدول النامية (غير المتقدمة) فيما يلي :

١- قاعدة الهرم (فئة العمر 0 - 4) في الدول النامية أو المجتمعات الشابه "Young

Population" أكثر اتساعا منها في الدول المتقدمة ويعكس ذلك ارتفاع مستوى

الخصوبة في الدول النامية عنه في الدول المتقدمة.

٢- الهرم أكثر حدة (أقرب في شكله للمثلث) للدول النامية أو المجتمعات الشابة عنه في الدول المتقدمة ويعكس ذلك ارتفاع مستوى الوفاة (في جميع الأعمار تقريبا) في الدول النامية عنه في الدول المتقدمة.

٣- الهرم أقل ارتفاعا (بصفة عامة) في الدول النامية أو المجتمعات الشابة عنه في الدول المتقدمة وهذا يعكس أيضا ارتفاع مستوى الوفاة (بصفة عامة) في الدول النامية عنه في الدول المتقدمة مما ينعكس على توقع الحياة عند الميلاد.

٤- قمة الهرم (فئات الأعمار المتقدمة) أضيق في الدول النامية أو المجتمعات الشابة عنها في الدول المتقدمة وهذا أيضا من أثر ارتفاع مستوى الوفاة في الدول النامية عنه في الدول المتقدمة.

وبعد هذا التوضيح يمكننا عمل مقارنة بين الأهرامات الأربعة لمحافظة القليوبية من عام الأساس 1996 الى عام الاسقاط 2016 كما يلي :

١- الهرم السكاني لمحافظة القليوبية للتوزيع العمري والنوعي الممهد لتعداد عام الأساس 1996:

نلاحظ أن الهرم السكاني لمحافظة القليوبية لتعداد عام 1996 الممهد في شكل (3.2) لم يحقق الصورة المطلوبة للهرم السكاني في المجتمعات الشابة من حيث اتساع قاعدة الهرم حيث نجد أن قاعدة الهرم فيه اقل اتساعا من الاعمار المتقدمة وهذا يرجع الى استخدام عاملين فقط من العوامل الديموجرافية (الخصوبة – الوفيات) دون أخذ عامل الهجرة في الاعتبار وهذا لا يكفي تماما لإعطاء الصورة الكاملة و الحقيقية لأي منطقة سكنية تتأثر بالهجرة مثل تأثرها بالمواليد والوفيات كما أكدت و أوضحت هذه الدراسة.

٢- الهرم السكاني لمحافظة القليوبية للتوزيع العمري والنوعي المنقح و الممهد لتعداد عام الانطلاق 2006:

نلاحظ أن الهرم السكاني لمحافظة القليوبية لتعداد عام 2006 المنقح والممهد في شكل (3.1) حقق بشكل مقبول الصورة المطلوبة للهرم السكاني في المجتمعات الشابة من حيث الاتساع القليل جدا في قاعدة الهرم عن سابقه في تعداد عام 1996 حيث نجد أن قاعدة الهرم هنا اكثر اتساعا قليلا من الاعمار المتقدمة وهذا يرجع الى استخدام العوامل الديموجرافية وهم (الخصوبة – الوفيات – الهجرة) ليس في عملية التعداد بل في عملية تنقيح البيانات في هذه

الدراسة حيث تم تنقيح البيانات باستخدام بيانات اجمالية عن الهجرة الداخلية والخارجية لمحافظة القليوبية لعام 2006 و ليست بيانات تفصيلية أي ان استخدام عنصر الهجرة جنبا الى جنب مع عنصري الخصوبة والوفيات له أهمية كبيرة جدا في اعطاء الصورة الكاملة و الحقيقية لأي منطقة سكنية تتأثر بالمواليد والوفيات والهجرة مثل محافظة القليوبية.

٣- الهرم السكاني لمحافظة القليوبية للتوزيع العمري والنوعي المقدر لعام 2011:

نلاحظ أن الهرم السكاني لمحافظة القليوبية لعام 2011 المقدر في شكل (3.3) حقق بشكل واضح الصورة المطلوبة للهرم السكاني في المجتمعات الشابه من حيث الاتساع الواضح في قاعدة الهرم عن سابقه في عام 2006 حيث نجد أن قاعدة الهرم هنا اكثر اتساعا من الاعمار المتقدمة وهذا يرجع الى استخدام البيانات التفصيلية لكل من (الخصوبة – الوفيات – الهجرة) في عملية الإسقاط باستخدام النموذج المقترح للإسقاطات السكانية المحلية في هذه الدراسة حيث تم استنتاج البيانات التفصيلية لكل من العوامل الديموجرافية الثلاثة بدون اغفال أي عامل مطلقا من الخصوبة و الوفيات و صافي الهجرة لعام 2011 أي ان استخدام عنصر الهجرة جنبا الى جنب مع عنصري الخصوبة والوفيات له أهمية كبيرة جدا في اعطاء الصورة الكاملة و الحقيقية لأي منطقة سكنية تتأثر بالمواليد والوفيات والهجرة.

٤- الهرم السكاني لمحافظة القليوبية للتوزيع العمري والنوعي لعام الإسقاط 2016:

نلاحظ أن الهرم السكاني لمحافظة القليوبية لعام الإسقاط 2016 في شكل (3.4) حقق بشكل كبير و واضح الصورة المطلوبة للهرم السكاني في المجتمعات الشابه من حيث الاتساع الواضح في قاعدة الهرم عن سابقه في عام 2011 حيث نجد أن قاعدة الهرم هنا اكثر اتساعا في فئة العمر الاولى والثانية وهذا يرجع الى استخدام البيانات التفصيلية لكل من (الخصوبة – الوفيات – الهجرة) في عملية الإسقاط باستخدام النموذج المقترح للإسقاطات السكانية المحلية في هذه الدراسة حيث تم استنتاج البيانات التفصيلية لكل من العوامل الديموجرافية الثلاثة بدون اغفال أي عامل مطلقا من الخصوبة و الوفيات و

صافي الهجرة للقليوبية لعام 2016 أي ان استخدام عنصر الهجرة جنبا الى جنب مع عنصري الخصوبة والوفيات له أهمية كبيرة جدا في اعطاء الصورة الكاملة و الحقيقية لمحافظة القليوبية.

ونستنتج مما سبق أن هناك تحسن ملحوظ للفئتين الاولى (4- 0) والثانية (9- 5) من الهرم السكاني لعام 2016 أي ان الاستمرار في استخدام النموذج المقترح للإسقاطات السكانية المحلية في هذه الدراسة يؤدي الى التحسن الكبير في الحصول على الصورة الحقيقية والكاملة للسكان في هذه المحافظة على مر السنين بفرض ثبات الظروف والمعدلات الحالية.



كلية تجارة بنها
قسم الإحصاء والرياضة والتأمين

نموذج رياضي للإسقاطات السكانية المحلية ودورها في التخطيط الإقليمي مع التطبيق

رسالة مقدمة من الباحث

عبدالله محمد محمود سرج

ماجستير الإحصاء

مدرس مساعد بقسم الإحصاء والرياضة والتأمين بكلية تجارة بنها

للحصول على درجة دكتوراه الفلسفة في الإحصاء

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فرع البنات – جامعة الأزهر

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