

International Workshop on Population Projections using Census Data

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Session I: Introduction

I.1. Objective

Session I introduces the participants to the purpose, the format and the trainers of the workshop. The session will also strengthen participants' understanding of the utility of population projections and will provide an overview about the current global population dynamics, with an emphasis on Asia.

I.2. The need for population projection

Population projections are used by central and local governments to plan for future demands for basic social services like health care, social security, education and infrastructure (water, energy, and transport). Private enterprises use population projections for adapting to changes in demands for certain goods and to the availability of labour. Although population projections can calculate future population and their demographic characteristics only within a certain range of precision (uncertainty), they are an important instrument for policy makers to devise policies that are incorporating various scenarios.

I.3. Population projections for Asia: Background and challenges

The global demographic trend towards low mortality and lower fertility and smaller families is also prevalent in Asia. While following the same general trend, countries in Asia have achieved different stages of the demographic transition and, therefore, face very different challenges. This ranges from Japan with one of the oldest population in the world to Afghanistan with still a very young population, from very large populations such as China and India to relatively small population in, for example, Bhutan and Singapore. Asia is home to the country with the highest life expectancy and at the same time to countries still facing high mortality, especially for infants and children. Asia is also known for large migration flows, especially to countries in Western Asia.

I.4. Population projections: The experience of China

China, as the most populous country in the world, has a significant impact on global demographic trends. It has experienced an accelerated transition from high to low mortality and fertility. It is also experiencing a fast development process to one of the major economic powers in the world.

At the same time, China today has one of the smallest number of children per woman, while life expectancy continues to rise. As a consequence, China's population will age very fast. China is also experiencing high temporary and permanent inter-regional migration flows from rural to urban areas. It is therefore very important to anticipate future trends of the dynamic Chinese population by producing population projections that are consistent, reliable and detailed.

I.5. Resources:

- O'Neill, B. C., Balk, D., Brickman, M., & Ezra, M. (2001)
- United Nations Economic Social Commission for Asia and the Pacific (2011)
- United Nations (2011)

World Population Prospects: The 2010 Revision (Online)

URL: <http://esa.un.org/unpd/wpp/index.htm>

Session II: Main population projection methods

II.1. Objective

Session II covers the basic elements of population projections. First, the basic accounting identity is presented for both close and open populations. Next, two approaches to population projections are discussed: projection by mathematical formulas and projection by the cohort-component method.

Participants are introduced to the basic accounting framework of demographic change.

A simple extrapolation/projection method (total population with assumed growth rate) as a handy tool for the ad-hoc estimation and projection of a population will be presented next. The Cohort-Component method will then be introduced as the standard demographic projection method. This introduction will be illustrated by an example for a single projection interval of a hypothetical country.

II.2. The basic accounting identity of Demography

Populations change over time in size and composition through births and deaths and, if the population is open, migration. If the population at the beginning of a certain time period is known and as well as all components of change over that time period (births, deaths and migration), then the population at the end of the time period is also known. As a consequence, the basic account identity or balance equation is a powerful tool to evaluate the completeness and quality of demographic estimates, and guides population projections.

Balance equation for a closed population

$$\text{Population}(t+n) = \text{Population}(t) + \text{Births}(t, t+n) - \text{Deaths}(t, t+n)$$

Balance equation for an open population

$$\begin{aligned} \text{Population}(t+n) = & \text{Population}(t) + \text{Births}(t, t+n) - \text{Deaths}(t, t+n) \\ & + \text{Immigration}(t, t+n) - \text{Emigration}(t, t+n) \end{aligned}$$

Instead of immigration and emigration, net migration is often used:

$$\text{NetMigration}(t, t+n) = \text{Immigration}(t, t+n) - \text{Emigration}(t, t+n)$$

$$\begin{aligned} \text{Population}(t+n) = & \text{Population}(t) + \text{Births}(t, t+n) - \text{Deaths}(t, t+n) \\ & + \text{NetMigration}(t, t+n) \end{aligned}$$

II.3. Projections by mathematical formulae

Population projections by mathematical formula are usually employed for preliminary or ad-hoc calculations, or if the data for more complex methods are lacking or if the populations are relatively small. Projection by formula are most often used for total populations or totals of subpopulations.

There are numerous mathematical functions that have been used for population projections. The most important, appropriate and versatile function is the exponential function, as population growth (including population decline) is essentially a continuous and compounding process. For populations or processes approaching an (known or assumed) upper limit, the logistic function is an appropriate growth model. For short periods, a simple linear extrapolation is very close to an exponential function.

II.4. Projections by the cohort-component method

The cohort-component method is by far the most popular population projection method. It is used for national and sub-national population projections. The cohort-component method is based upon the balance equation extended for sex and age and is therefore internally consistent. Because it is based on age-structured populations and events (births, deaths, migration), it yields a rich set of demographic indicators.

The mathematics of the cohort-component methods is described extensively in Demography Textbooks (Preston et al. 2001b, pp. 117-137)

II.5. Resources

- George, M. V., Smith, S. K., Swanson, D. A., & Tayman, J. (2004, pp. 561–602)
- Preston, S. H., Heuveline, P., and Guillot, M. (2001a, pp. 117–137)

Session III: Establishing the base population

III.1. Objective

In session III, participants will learn the importance of the base population and its age structure as a starting point for population projections. Participants will be introduced to the main distortions of empirical populations obtained from estimates and/or censuses and relevant methods to adjust or correct the errors.

III.2. Errors in data and their measurement

Significant data errors can be identified by simply plotting the raw population data by age and sex (graphical analysis), such as population pyramids and graphical cohort analysis.

In addition, there are a number of indices that measure quantitatively the deviation of the raw data from expected or normal data distribution by age and sex. They are used to identify such phenomena as age heaping in single year age groups, or distorted age ratios and sex ratios for grouped population data. The US Census Bureau has prepared spreadsheets that can be used for:

- Graphical analysis (PYRAMID.XLS)
- Age and sex ratio (AGESEX.XLS)
- Age preferences/age heaping (SINGAGE.XLS, AGESEX.XLS)

III.3. Basic tools for correcting distorted or incomplete data

After errors in raw data have been identified, the next step is to correct the data appropriately. It is important to be mindful that corrections are to a certain extent ambiguous or arbitrary. Corrective procedures should therefore applied careful and cautiously.

- Smoothing the age and sex distribution (AGESMTH.XLS, BPSTRNG.XLS)
- Splitting the open-ended age group (OPAG.XLS)
- Moving the Census Population to a desired date (MOVEPOP.XLS, ADJAGE.XLS, AGEINT.XLS)

I.3.4. Resources

- Hobbs, F.B. (2004, pp. 125–173)
- United Nations (1952)
- United Nations (1956a)
- United Nations (1956b)
- United Nations (1983)
- United Nations (2008)

Session IV: Projecting the levels of mortality, fertility and migration

IV.1. Objective

Session IV introduces participants to the projection of mortality, fertility and migration levels, including the appropriate models and software tools. It is to guide participants in selecting a suitable model and the corresponding tool for the projection of a particular demographic component.

Two main approaches are available for the preparation of projections of levels of mortality (life expectancy at birth) and fertility (the average number of children per woman, i.e., TFR). The United Nations approach does not model the level of life expectancy and total fertility directly, but their amount of change (increase or decrease) relative to the level. A double-logistic function has been used to allow for a non-symmetric trend of change.

The approach employed by the US Census Bureau (USCB) uses a logistic function to model the level indicators directly. In addition, the USCB models allow the user to set upper and lower limits on the indicators.

Based on available data (national data series or reference estimates from international organizations), a suitable method will be selected to calculate future trajectories of life expectancy or total fertility.

Projecting the level of net migration is not an easy task because of the often erratic migration trends. A discussion of the most common approaches to projecting migration concludes the session.

IV.2. Projecting life expectancy at birth

- **UN Model of life expectancy change**

The UN Model of projecting life expectancy at birth is based on observed rates of improvement of life expectancy and formalized in a double-logistic function. There are five models: very slow, slow, medium, fast and very fast.

The UN method does not require to set a target life expectancy, but to select an appropriate model of life expectancy improvement. The five models are applied separately to males and females. Unreasonable sex-differentials of life expectancy need to be corrected manually.

The UN model is available as Excel spreadsheet named UNPD_MorModel.xlsm

- **U.S. Census Bureau (USCB) approach for projecting life expectancy**

The USCB approach interpolates and extrapolates a given time series of empirical life expectancies at birth by sex by a logistic function. The USCB model requires, as a minimum, two empirical values for each sex, up to a maximum of 17 observations for each sex. The user may also enter an upper and lower asymptote of life expectancy at birth, or leave the default values. The USCB model is available from the PASEX tools as Excel spreadsheet E0LGST.xls.

IV.3. Projecting total fertility

- **UN Model of total fertility change**

The UN fertility model projects the total fertility of a country by applying a user-selected model of fertility decline, implemented as a double-logistic function. The three model of fertility decline are based on past empirical evidence:

1. Slow/Slow for countries that experience an altogether slow transition from high to low fertility.
2. Fast/Slow for countries that have experienced a comparatively fast decline in fertility in the past but have recently shown a slower pace in the reduction of fertility
3. Fast/fast for countries that have and are expected to continue to have a (comparatively) fast pace of fertility decline

The UN model is available as Excel spreadsheet named UNPD_FerModel.xlsm

- **U.S. Census Bureau approach to fertility projections**

The USCB approach to fertility level projection is similar to the model used for the projection of life expectancy. The USCB approach interpolates and extrapolates a given time series of observed or estimated total fertility rates sex by a logistic function. The USCB model requires, as a minimum, two empirical values, and allows the user to enter up to a maximum of 17 observations. The user may also enter an upper and lower asymptote of total fertility, or leave the default values. The USCB model is available from the PASEX tools as Excel spreadsheet TFRLGST.xls.

IV.4. Projecting international net-migration

International migration is traditionally the most challenging part of a population projection exercise. Reliable data on the number of immigrants and emigrants are rarely available, and migration itself often exhibits strong fluctuations that make extrapolations difficult, if not untenable.

In addition, it is not possible to calculate meaningful demographic rates (exposure/occurrence rates) for immigration. The countries of origin for immigrants are not known or not part of the projection exercise. It is also questionable to use the receiving population as the denominator for immigration. Similar considerations apply for net migration. As a consequence, international (net) migration is often formulated in terms of absolute numbers. Because of its irregular fluctuations, (net) migration is often kept constant over time.

IV.5. Resources

- United Nations (2010, p. 121-160)
- Arriaga (1994a, b).

Session V: Projecting the age patterns of mortality, fertility and migration

V.1. Objective

Session V introduces participants to the projection of age patterns of mortality, fertility and migration, including the appropriate models and software tools. Guidance will be provided on selecting a suitable model and the corresponding tool for the projection of the age pattern a particular demographic component.

The Session introduces basic concepts and approaches of projecting the age patterns of mortality, fertility and international migration. A brief discussion of the most popular approaches and models for projecting the age patterns of demographic components is followed by a presentation of available tools. Special emphasize will be given to tools and approaches that are practical and require only moderate input and computing power.

V.2. Projecting the age pattern of mortality

Age patterns of mortality exhibit certain regularities such as a bathtub shape. Such shape represents an age-specific mortality pattern that is relatively high at and immediately after birth, declines to reach a minimum between age 5 to 15, and increases continuously afterwards until reaching very high levels at extended age. Such regularities are helpful in modeling those patterns, as exemplified in several Model Life Table systems or parameterized mortality functions for all or parts of the age range. These models can be used to generate plausible age patterns for mortality, both for past estimates and for the future. There are several tools that have been used widely.

- **UN Tools for generating age patterns of mortality**

The United Nations software package MORTPAK provides an easy-to-use tool for generating (model) life tables. Its module “MATCH” calculates United Nations, Coale-Demeny or user-designated model life tables corresponding to levels of mortality that is provided as input. In addition, if the user provides a country-specific mortality pattern, MATCHG can generate country-specific model life table system.

- **U.S. Census Bureau spreadsheets**

USCB has developed spreadsheets that interpolate life tables, one for each sex. The procedure interpolates between two “pivotal” life tables, based on the probabilities of dying ${}_nq_x$. Normally, users could use an empirical life table for the country for a period close to the base year of the projection. A second pivotal life table acts as an upper limit for age patterns of mortality. The user may use the ultimate life table that comes with the spreadsheets or provide a country-specific limit life table, if available. The spreadsheets then generate a life table with a desired level of mortality that is between the life expectancies of the base and the ultimate life table. Repeated application of the procedure will generate a set of age-specific mortality rates ${}_nm_x$ or probabilities of dying ${}_nq_x$.

The USCB models are available from the PASEX tools as Excel spreadsheets INTPLTM.xls for males and INTPLTF.xls for females.

- **Futures Institute Spectrum package**

Spectrum's DemProj module translates automatically inputted life expectancies of mortality into corresponding age patterns of mortality based on the known model life tables. This is especially useful for countries with incomplete mortality statistics.

V.3. Projecting the age pattern of fertility

Age patterns of fertility exhibit regularities that are helpful in modeling those patterns and to use these models to generate plausible age patterns for future fertility. There are two models that have been used widely.

- **UN Model for generating age patterns of fertility**

The UN model uses characteristic age-patterns of fertility associated with select levels of fertility for generating a series of age patterns by interpolating between an empirical base pattern and a target pattern. The target patterns of fertility models are based on empirical data and are indexed by the mean age at childbirth. The UN model is available as Excel spreadsheet named UNPD_ASFR.xlsm

- **US Census Bureau approach:**

The tool available from the USCB estimates age-specific fertility rates (ASFR's) corresponding to a desired total fertility rate, based on empirical patterns of age-specific fertility rates. The USCB model is available from the PASEX tools as Excel spreadsheet ASFRPATT.xls.

V.4. Projecting age patterns of migration.

Migration is the demographic process least amenable for modeling. However, while the total amount of migration may fluctuate erratically, the age patterns of migration have shown some regularities.

- **The UN approach for generating age patterns of (net) international migration.**

The UN approach is based on models of typical net migration schedules, namely family migration, male labor migration and female labor migration. The model splits total net migration for both sexes combined into age groups, by sex. The UN model is available as Excel spreadsheet named UNPD_Migration.xlsm

- **Alternative approaches**

If the available tools for translating total net migration figures into age groups are not producing outputs that correspond to a country's experience, demographers have sometimes splitted total net migration figures into age according to the underlying population. Such an approach is simple, but one has to be aware that such age patterns of net migration are age-neutral, while in most cases is not a realistic assumption.

If the age pattern of (net) migration for a year close to the base year is available, the proportionate age pattern of (net) migration can be used to split projected total (net) migration figures.

V.5. Resources

- United Nations (2010, p. 121-160).
- Arriaga (1994a, b).
- United Nations (2003). MORTPAK for Windows.

Session VI: Population projections for national populations

VI.1. Objective

Session VI is to train participants in the preparation and execution of actual population projections, using the cohort-component projection for a whole country. Main available projection software tools and their specific strengths and limitations is introduced, as well as the data needed for preparing population projection and the steps necessary to perform a population projection.

This session builds upon the topics learned in the preceding sessions, and applies them to a concrete example using a selected cohort-component projection software. First, the selected software tool is introduced to the group, using PowerPoint presentations and live software runs. This is followed by individual/small group exercises by the participants.

This session provides participants with the opportunity to prepare national population projections, using their own data or data from the United Nations.

VI.2. Tools for the preparation of national population projections

A number of free software tools for cohort-component projections are available. In addition, many National Statistical Offices and other institutions use proprietary software tools for their special purposes.

For this workshop, the Spectrum system of policy models from the Future Institute is chosen as a robust, comprehensive and user-friendly software tool. From the numerous components of Spectrum, two are being used:

DemProj: This component projects the population for an entire country or region by age and sex, based on assumptions about fertility, mortality, and migration. A full set of demographic indicators can be displayed for up to 100 years into the future. Urban and rural projections can also be prepared. DemProj also supplies the data needed to make a population projection from the estimates produced by the United Nations Population Division.

AIM: AIM, the AIDS Impact Model, projects the consequences of the HIV epidemic, including the number of people living with HIV, new infections, and AIDS deaths by age and sex; as well as the new cases of tuberculosis and AIDS orphans. AIM is used by UNAIDS to make the national and regional estimates it releases every two years.

VI.3. Preparing the data and formulating assumptions

Sessions III-V above have prepared participants to create a national population projections, using data from their country or working with data available in Spectrum (the United Nations *2010 Revision of World Population Prospects*). Most of these preparations are done in Excel spreadsheets. These data can then be copied from Excel into spectrum. In addition, Spectrum itself has functions to help users to prepare data for projections: the user can copy input data forward, extrapolate between data or multiply data with a factor.

VI.4. Dealing with uncertainty: Variants and illustrative scenarios

Population projections are constrained by the imperfect knowledge of current and future demographic settings and trends. Although the demographic momentum inherent in demographic dynamics has

allowed demographers to produce demographic projection with a comparatively high quality, it is impossible to make a perfect projection. A traditional and well accepted way to incorporate uncertainty into population projections is the preparation of projections variants that show a certain range of results that is deemed plausible. Another, more recent approach is using the ubiquitous computer power of modern computing equipment to create probabilistic projections consisting of many possible demographic pathways. It should be noted that the probabilistic approach is still a field under development.

Scenarios are yet another way to illustrate future demographic trends. Scenarios are created by describing a future in a qualitative way, and then constructing corresponding demographic trends. Scenarios are then the answer to a “What if?” question.

A variant of the scenario approach is to ask counter-intuitive questions. For example, what would happen if all families would immediately adopt replacement-level fertility. This is not a realistic assumption but can be used to illustrate the demographic momentum. Another example is to question how large immigration should be to guarantee stationary population for currently declining populations.

VI.5. Resources

- O’Neil et al. (2001). A Guide to Global Population Projections.
- Futures Institute (2012). Spectrum Suite.
- Preston, S. H., Heuveline, P., and Guillot, M. (2001b). Population Projection
- United Nations (1989). The cohort component method for making population projections. In *Projection methods for integrating population variables into development planning. Module One: Conceptual issues and methods for preparing demographic projections.*

Spectrum Demo Videos:

URL: <http://www.youtube.com/user/spectrummodel>

Session VII: Presentation of the results of projections

VII.1. Objective

Session VII creates awareness about the importance of an appropriate and user-oriented communication of projection results. The Session will refresh and add skills in presenting population projection results using adequate tools. Participants will understand the importance of appropriate and objective communication of the complete results of population projection results; the central role of the underlying assumptions, and the inherent uncertainty of population projections depending on the projection horizon. The Session also guides participants in selecting and using appropriate and appealing tabular and graphical elements for the presentation of projection results.

This session starts with a presentation of ways to present the results of population projections, including relevant assumptions and limitations.

This session then provides participants with an opportunity to present and discuss the results of population projections that they have prepared during previous sessions.

A final segment will be devoted to questions and answers, clarifications and other issues.

VII.2. Guidelines and tools for the presentation of results

The presentation provides general guidelines on presenting statistics to the general public. Particular aspects that are relevant to presenting the population projection results are further discussed.

Population projection usually generates a large amount of data. It is important to find a balance between the data on one hand and the objective and context of the exercise. Any presentation of projection results should also deal with the following elements:

- Describing background, motivation and objectives
- Explaining the assumptions
- Documenting data sources
- Describing major findings
- Presenting summary and recommendations

Reports presenting the results of population projection exercises could have the following structure

- Title Page
- Table of Contents
- Executive Summary
- Methodology
- Findings
- Conclusion and Recommendations.

Often, results of population projections published in a number of different documents:

- Press release
- Executive summary
- Full report, if necessary with a number of annexes.

VII.3. Presentation of country projections by participants

VII.4. Resources

- O'Neil et al. (2001). A Guide to Global Population Projections.

Resources

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URL: <http://www.census.gov/population/international/software/pas/pasdocs.html>
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- Popoff, C., and Judson, D. H. (2004). Some Methods of Estimation for Statistically Underdeveloped Areas. In J. S. Siegel and D. A. Swanson (Eds.), *The methods and materials of demography* (2nd ed. Ppp. 603–641). Elsevier Academic Press.
- Preston, S. H., Heuveline, P., and Guillot, M. (2001a). Population Projection. In *Demography: Measuring and Modeling Population Processes*. (pp. 117–137). Oxford and Malden, MA: Blackwell Publishers.
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- United Nations (1956a). Manuals on Methods of Estimating Population. *Manual II: Methods of Appraisal of Quality of Basic Data for Population Estimates*. Sales No. E.56. XIII.2.
- United Nations (1956b). Manuals on Methods of Estimating Population. *Manual III: Methods for Population Projections by Sex and Age*. Sales No. E.56.XIII.3.
- United Nations (1980). *Patterns of urban and rural population growth*. POPULATION STUDIES, No. 68, Sales No. E.79.XIII.9
- United Nations (1983). *Manuals X. Indirect Techniques for Demographic Estimation*. Sales No. E.83.XIII.2.
- United Nations (1989a). *Projection methods for integrating population variables into development planning*. Module One: Conceptual issues and methods for preparing demographic projections. ST/ESA/SER.R/90.

- United Nations (2008). *Principles and Recommendations for Population and Housing Censuses. Revision 2*, Statistical Papers, No. 67/Rev. 2, Sales No. E.07.XVII.8.
- United Nations (2010). *World Population Prospects: The 2006 Revision*, Vol. III, Analytical Report, New York
URL: http://www.un.org/esa/population/publications/WPP2006RevVol_III/WPP2006RevVol_III_final.pdf
- United Nations (2011). *World Population Prospects: The 2010 Revision, Highlights and Advance Tables*.
URL: http://esa.un.org/unpd/wpp/Documentation/pdf/WPP2010_Highlights.pdf
- United Nations (2012). *World Urbanization Prospects, The 2011 Revision. Methodology*. New York.
URL: <http://www.census.gov/population/international/software/pas/pasdocs.html>
- United Nations Economic Social Commission for Asia and the Pacific (2011). 2011 ESCAP Population Data Sheet. Bangkok.
URL: <http://www.unescap.org/publications/detail.asp?id=1465Session>
- Willekens F, Rogers A, 1978, Spatial population analysis: methods and computer programs, RR- 78-18, International Institute for Applied Systems Analysis, Laxenburg, Austria.
- World Population Prospects: The 2010 Revision (Online)
URL: <http://esa.un.org/unpd/wpp/index.htm>

Software

Spectrum v. 4.51

Spectrum can be downloaded from: <http://www.futuresinstitute.org/spectrum.aspx>

MORTPAK v. 4.3

MORTPAK can be obtained from the United Nations Population Division

United States Census Bureau Population Analysis System (PASEX).

PASEX consists of 45 spreadsheets for population analysis. The PASEX documentation is contained in the second volume of the manual *Population Analysis with Microcomputers*. (Arriaga, 1994b). It can be downloaded from: <http://www.census.gov/population/international/software/pas/pasdocs.html>. For a brief description, see Annex A.

United Nations Models in Excel

The United Nations Tools in Excel are implementations of various models used by the United Nations Population Division for projecting demographic indicators. For a brief description, see Annex B.

Annex A: Population Analysis System (PASEX)¹

PASEX (Population Analysis Software in Excel) currently consists of 45 spreadsheets. The PASEX documentation is contained in Volume II of the manual Population Analysis with Microcomputers.

A brief explanation of the calculation performed by each of the spreadsheets is presented here, grouped by main demographic topics.

Age Structure

There are 11 spreadsheets for the analysis of the age structure of the population. They are, in alphabetical order:

ADJAGE Adjusts any population total by sex to a given age structure.

AGEINT Interpolates between two population age structures. The user can specify if the interpolation is to be linear or exponential.

AGESEX Analyzes the age reporting in a population age and sex distribution. Calculates age and sex ratio indices and the United Nations age/sex accuracy index.

AGESMTH Smooths a population age distribution using several methods.

BASEPOP Prepares the age and sex distribution of a population for making a projection, using a strong smoothing process.

BPSTRNG Prepare the age and sex distribution of a population for making a projection, using a strong smoothing process.

GRPOP-YB Makes a graph using population age structures for two or three dates, by year of birth of each cohort.

MOVEPOP Moves the population age distribution pertaining to a specific date to another date.

OPAG Distributes open-ended age groups (younger than 80+) into 5-year age groups up to 80 years and over.

PYRAMID Makes an age pyramid by sex, with absolute numbers and percentages of the population data.

SINGAGE Calculates the Whipple, Myers, and Bachi indices of age heaping based on enumerated population by single years of age.

Mortality

There are 15 spreadsheets for analyzing the mortality of a population. Some spreadsheets were prepared for populations with acceptable data, while others assume that only limited data are available. Although the set of mortality spreadsheets is the largest, we did not include those techniques developed and published by the United Nations in the MORTPAK package. The analysis of mortality may require the use of both the U.S. Census Bureau spreadsheets (PASEX) and the MORTPAK package. The PASEX spreadsheets related to mortality are:

ADJMX Adjusts a pattern of mortality rates by age for both sexes combined or for each sex (age-specific death rates or central death rates from an empirical or existing life table) for obtaining a user-specified number of deaths in a population.

BTHSRV Estimates infant mortality rates based on information on the number of children born during a year prior to the census and the number still alive at the census date.

EOLGST Fits a logistic function to values of life expectancies at birth for each sex simultaneously, given two or more observed values of life expectancies and the two asymptotes of the logistic.

GRBAL Uses the technique developed by Brass for estimating the completeness of reporting of deaths over 5 years of age in relation to a population (Brass, 1975).

¹ URL: <http://www.census.gov/population/international/software/pas/pasdocs.html>

INTPLTM and INTPLTF Interpolate male and female life tables, respectively, between the values of two given sets of "pivotal" life tables.

LOGITQX and LOGITLX These two spreadsheets are used for smoothing functions of a life table, using logits of the $q(x)$ and $l(x)$ functions of a life table.

LTMXQXAD Constructs a life table from age-specific death rates or from the probabilities of dying between two specific ages.

LTNTH Selects a Coale-Demeny model life table, region North, that will reproduce a given crude death rate pertaining to a given population age structure.

LTPOPDTH Constructs and smooths a life table for both sexes or one sex at a time, using population and death data.

LTSTH Is the same as LTNTH, but using region South of the Coale-Demeny model life tables.

LTWST Is the same as LTNTH, but using region West of the Coale-Demeny model life tables.

PREBEN Estimates the level of mortality for ages 5 years and above during an intercensal period (Preston-Bennett, 1983).

PRECOA Uses the technique developed by Preston and Coale for evaluating an available age distribution of deaths in relation to the population.

There are 13 spreadsheets for analyzing the fertility of a population. Most spreadsheets are for populations whose registration of births is not complete.

ADJASFR Adjusts a given pattern of age-specific fertility rates to reproduce a desired total number of births.

ARFE-2 and ARFE-3 Use a technique developed by Arriaga for estimating fertility rates based on information on the average number of children ever born and a pattern of fertility.

ASFRPATT Provides age-specific fertility rates pertaining to a given total fertility rate.

CBR-GFR Calculates the crude birth rate and the general fertility rate based on a desired total fertility rate.

CBR-TFR Estimates the crude birth rate and the total fertility rate, based on the general fertility rate.

PFRATIO Uses the P/F ratio technique, originally developed by Brass, for adjusting reported age-specific fertility rates to the "actual" level of fertility.

RELEFERT Uses Rele's technique for estimating the gross reproduction rate of a population for one or two 5-year periods prior to the census date.

REL-GMPZ Uses the technique developed by Brass and associates "for the evaluation and adjustment of fertility estimates obtained from retrospective reports of birth histories or features of birth histories."

REVCBR Calculates crude birth rates during two or three 5-year periods prior to the census date, based on the age structure of the population.

TFR-GFR Estimates the total fertility rate and the general fertility rate based on a crude birth rate.

TFRLGST Fits a logistic function to two or more values of total fertility rates, and interpolates and extrapolates. It requires asymptotic values.

TFRSINE Fits a sine function to two values of total fertility rates, and interpolates and extrapolates.

Internal Migration

There is one spreadsheet that estimates intercensal migration between two areas.

CSRMIG Provides intercensal net migration estimates between two areas.

Urbanization and Distribution of the Population

There is one spreadsheet providing several indices for analyzing the urbanization process in a population.

URBINDEX Calculates several urbanization and population distribution indices.

Other Spreadsheets

There are four additional spreadsheets that can be used for several purposes; they are:

CTBL32 Uses a technique for adjusting information in a table to a set of desired marginal totals (totals of rows and/or columns).

FITLGSTC Fits a logistic function to three (or a multiple of three) observed equidistant values of any index. It does not need asymptotic values.

LOGISTIC Fits a logistic function to values of any index given two or more observed values of the index and the two asymptotes of the logistic.

SP Constructs a stable population based on life tables by sex and age-specific fertility rates (or the intrinsic growth rate).

Annex B: United Nations Projection Models in Excel

The United Nations Projection Tools in Excel are implementations of various models used by the United Nations Population Division for projecting demographic indicators. A brief explanation of the calculation performed by each of the spreadsheets is presented here, grouped by main demographic topics.

Fertility

There are 2 spreadsheets for the projection of fertility, one for the level of fertility, expressed as Total Fertility, and one for age patterns of fertility, expressed as proportionate age-specific fertility rates:

- **UNPD_FerModel_v1** Implements the United Nations Model of Fertility Decline. The model consists of a double logistic function and three different parameter sets for three different pathways of fertility decline. For a description, see http://www.un.org/esa/population/publications/WPP2006RevVol_III/WPP2006RevVol_III_final.pdf
- **UNPD_ASFR** The spreadsheet interpolated between an observed, user-supplied base pattern of fertility and 15 different target age patterns of fertility. The target age patterns were obtained from typical observed empirical patterns and are indexed by the Mean Age at Childbearing (MAC).

Mortality

There is one spreadsheet for projecting the level of mortality, expressed as life expectancy at birth for males and females. For the projection of the age pattern of mortality, the United Nations MORTPAK software package can be used. The Excel spreadsheet related to mortality is:

- **UNPD_MorModel_v.1** The United Nations model of increasing life expectancy at birth is based on a double-logistic function and five different parameter sets for five different pathways of mortality decline (Increase in life expectancy).

International Migration

There is one spreadsheet that can be used for the calculation of model migration schedules, especially created for net-migration.

- **UNPD_Migration Age Patterns** The United Nations model age patterns of net migration are based on observed empirical age patterns and allow for the distribution of total net migration figures into age patterns typical for family migration, female labor migration and male labor migration.