Tanzania -
Fertility, education,
future population size and composition

Master's Thesis

By Martha Ecker, BSc BA

Supervisor: Univ. Prof. Wolfgang Lutz, Mag. PhD

Vienna University of Economics and Business

Contact: marthecker@gmail.com

Many thanks go out to Sergei Scherbov, Erich Striessnig, Elke Loichinger, Anne Goujon and Samir K.C. for their help and insights!

I also thank Elisabeth Riedler (who has focused her analysis on the country of Uganda) for her collaboration on the design of the population projection model and data analysis, as well as helpful comments and remarks during the writing process.

Abstract

The goal of this thesis is to explore how different education and fertility scenarios affect long term population growth and composition in Tanzania. Tanzania is an especially interesting and relevant case as the country has passed through a phase of high population growth and is currently already experiencing a slight decline in fertility with an average of 5.4 children per woman today (compared to 5.7 in 2005). Fertility is still considered a very pressing issue in public policy and lowering it is an explicit policy goal.

For this purpose micro data from the Demographic and Heath Surveys (DHS) is analyzed to identify factors determining fertility decisions, including education. In a second step population projections along cohort lines for different scenarios regarding educational development and future fertility are carried out.

The novelty of this approach lies with the education and fertility scenarios chosen for the projections: Whereas education scenarios do not only include a global education trend but also the attainment of the newly suggested Millennium Development Goal (universal primary and secondary education for all in 2030), the fertility scenarios presented includes trends towards decreasing the gap between observed and women's desired family sizes that can be observed today, based on DHS data. Compared to previous studies, the aim of this study is to specify scenarios relevant to Tanzania via the inclusion of policy-relevant scenarios for the country and the combination of micro data, a population projection model and in-depth literature review.

By including **education scenarios**, population projections become on the one hand more accurate as all three fundamental demographic components (fertility, mortality and migration) are strongly affected by education. At the same time their explicit variation will make the impact of different education scenarios on Tanzania's demographic development visible. Tanzanian women with secondary or higher education had less than half as many children as women with no education in 2010, with 3.0 compared to 7.0.

Fertility scenarios make it possible to vary a decisive (and hard to estimate) factor in future population development. The inclusion of three different scenarios geared towards the realization of women's desired family sizes and a thus decrease in unmet need for contraception also provides answers as to how this may affect population growth, in addition to crucial and necessary individual (health) benefits. By using different fertility trends assumed by the United Nations it is also possible to elaborate on the additional leeway in family size (by education) that may be gained from investments in education.

The results provide insights into how improvements in the educational sector, such as reaching the UN Sustainable Development Goal of universal primary and secondary education by 2030 and helping women to realize their desired family size may affect population growth and composition until the year 2060. They show that an increase in female education combined with comprehensive family planning and sexual and reproductive health education may provide to be a good instrument to address the urgent issue of population growth via fewer children per woman and at the same time more productive future generations, providing leverage for demographic challenges to come.

Table of Contents

List of figures

List of tables

Glossary

DHS / TDHS – (Tanzanian) Demographic and Health Survey

SDGs – Sustainable Development Goals

UN – United Nations

UNESCO – United Nations Educational, Scientific and Cultural Organization

ASFR – Age-specific fertility rate: The age-specific fertility rate measures the annual number of births to women of a specified age or age group per 1,000 women in that age group during a certain period (usually the calendar year).

CBR - Crude birth rate: The crude birth rate indicates the number of live births occurring during the year, per 1 000 population estimated at midyear.

CDR - Crude death rate: The crude death rate indicates the number of deaths occurring during the year, per 1 000 population estimated at midyear.

Demographic transition: The demographic transition refers to a process whereby demographic variables change in a systematic way from one state to another. Most often, the process referred to is the transition from high birth and death rates to low birth and death rates.

Parity: The number of children previously born alive to a woman. A woman with a parity of two has given birth to two children, whereas a woman with zero parity has had no live birth.

TFR - Total fertility rate: The total fertility rate (TFR) of a population is the average number of children that would be born to a woman over her lifetime if she were to experience the exact current age-specific fertility rates (ASFRs) through her lifetime, and she were to survive from birth through the end of her reproductive life.

Unmet need (for contraception): The indicator unmet need for contraception is generally defined as the proportion of women who do not want any more children but are not using any form of family planning (unmet need for contraception for limiting) or women who want to postpone their next birth for two years but are not using any form of family planning (unmet need for contraception for spacing).

1. Introduction

The Tanzanian total population was 44.9 million compared to 12.3 million in 1967, which equals an annual growth rate of 2.9 percent.[1] As a result, about 45% percent of the population in 2012 was under 15 years old. Much of the rapid growth is a result of Tanzania's high fertility rate, the average number of children a women has during her life time: The country has passed through a phase of high population growth and is already experiencing a decline in fertility with an average of 5.4 children per woman in 2010[2] (compared to 5.7 in 2005 and 6.3 in 2002). Fertility is therefore still considered a very pressing issue in public policy and lowering it is an explicit policy goal since 1992: For 2015, the aim is to slow down total fertility rate (TFR) to 5.0. [3]

According to the Tanzanian Ministry of Planning, Economy and Empowerment …

> … [a] large young population places a heavy burden on the working-age population and limits the provision of basic needs and social services. For example, cross-national research shows that a large young population is one of the most important determinants of low academic achievement in children: when there are too many children, it is very hard to educate them well. Lack of education also contributes to ongoing high fertility as well as poverty, creating a vicious cycle. With a large young population, there is also an in-built momentum for future population growth (Population Planning Section, 2007).

A number of projections for Tanzania's future population have been produced by the Tanzanian National Statistics Office and demographers at the United Nations (UN), IIASA and other international institutions. The projections presented here are different from most other projections, as they explicitly include the educational status of the population in the process, considering fertility separately for each education group. In addition, this is to our knowledge the first time that the effects of potential trends in achieving women's desired family sizes are explicitly addressed through fertility scenarios.

Including education, in addition to the traditional demographic characteristics of age and sex, the way we look at changes in population and their projection changes (Lutz, Butz, & K.C., 2014, p. 1). The focus on the inclusion of education, however, should not lead the reader to assume that other

[1] According to the 2012 census.

[2] 2012 census data on TFR is not (yet) available.

[3] Main strategic documents are the Tanzania Development Vision 2025 & the Zanzibar Development Vision 2020, as well as the National Strategy for Growth and Reduction of Poverty (NSGRP, commonly known as MKUKUTA) and Zanzibar Strategy for Growth and Reduction of Poverty (ZSGRP commonly known as MKUZA).

factors such as income, wealth or inequality are unimportant. From a methodological point of view, however, the inclusion of educational attainment into population projections - even though not without its own cutbacks and necessary simplifications - is easier to model. In addition, education (especially secondary school attendance) can be seen as one main determinant of socio-economic status, interrelated with other such as wealth, occupation and income.

In order to correctly identify relevant fertility and education scenarios and to provide insights into how these scenarios may be achieved the quantitative population projection model is supported by micro data analysis and in-depth literature review, with the aim of preventing a too narrow look at development, population and reproduction.

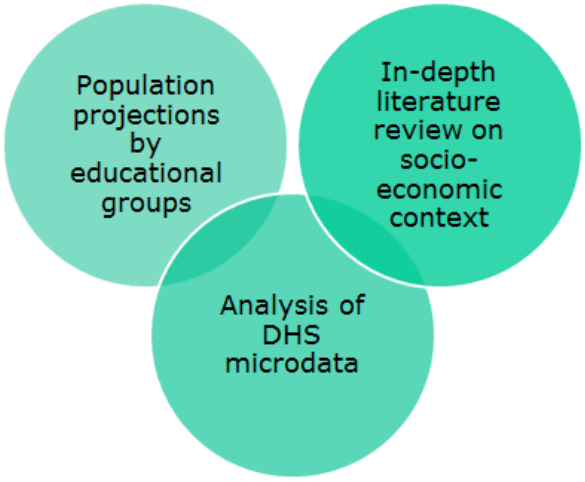


Figure 1: Main components of research.

Figure 1 gives an overview of the three main components of this thesis, which were chosen with the aim of gaining a thorough understanding of Tanzanian population development:

1. **In-depth literature review on socio-economic context**: The literature review focuses on both fertility and its determinants, as well as education in Tanzania. In addition, information gained from a review of Tanzanian policy papers is used for the construction of scenarios used in the population projection model.
2. **Analysis of DHS microdata**: This data is used to establish a base year population by education for the population projection model. In addition, the data set is used to gain insight into the determinants of fertility.

3. **Population projections**: This model is based on information gained from the above two components and aims at providing insights into potential future developments.

The thesis is constructed as follows:

Chapter 2 gives a broader insight into the United Republic of Tanzania and its population, with a focus on the historical development of main demographic variables until today and also contains more detailed information on national policies regarding education and fertility.

Chapter 3 discussed the specific model used for the projection of Tanzania's population by educational groups.

Chapter 4 describes the underlying sources of data used in detail, as well as the development of different scenarios (for education and fertility).

Chapter 5 presents the results: Whereas Chapter 5.1 focuses on the population projection model and compares different scenarios; Chapter 5.2 goes into the analysis of the DHS data set and looks at education and the fertility decline in Tanzania.

Chapter 6 summarizes and discusses the results.

2. The United Republic of Tanzania

The aim of this section is to first give an introduction to Tanzania's history and current demographic developments and challenges. Then it focuses on fertility and education.

2.1 A short history of Tanzania[4]

Colonial period

For at least 2000 years before 1500, the East African coast was in contact with civilizations in the Persian Gulf, China and India, trading luxury items such as ivory and later on gold from Zimbabwe. In mercantile capitalism (1500 onwards), slaves from West Africa were used in the Americas and the Caribbean, first to dig gold and then to grow sugar, cotton, or tobacco. The Portuguese controlled the East African coast. Zanzibar, an island off the Tanzanian coast and an ivory trading hotspot, was effectively colonized by Arabs in the beginning of the 19th century. Zanzibar later became a British protectorate and slavery was slowly abolished, and mainland East Africa was divided into German East Africa and the British colony of Kenya until the First World War. Then German East Africa was further divided under a mandate from the League of Nations, separating it into the administered regions of Tanganyika (Britain) and Ruanda-Burundi (Belgium). Under German rule plantation companies, settlers and small-scale African farmers started producing cotton, coffee, sisal and other crops, and this production was continued under British rule. Prices fell during the depression of the 1930s, and by 1945 today's Tanzania were "incorporated into the world capitalist system as suppliers of raw materials and importers of manufactured goods" (Coulson, 2013, p. 33).

After independence

In 1954 the country of Tanzania was formed, constituting both Tanganyika and Zanzibar. The newly independent state was in a particularly weak position as Kenya had already had a head start in industrialization of forty years. Industrialization through stimulating private investments was unsuccessful, and starting in 1967 nationalizations took place. Julius Kambaragwe Nyere was Tanzania's president in the period from 1962 until 1985, in which he introduced 'Ujaama' (meaning

[4] This section only aims at giving a short overview of Tanzanian history and draws strongly from Coulson (2013). For an in-depth perspective the book itself is highly recommended, especially if one is interested in Julius Nyere's Tanzania of the 1970s.

familyhood), a philosophy with the aim of synthesizing the African tradition with the ideas of the Western world in order to transform and develop his country (Nabudere, 2006). The Arusha Declaration, which was published in 1967, is considered the main policy document and addressed gender inequality as well as setting an implementation program focused on rural development and the establishment of 'Village settlement Schemes' depending on foreign capital. When the policy was implemented on a large scale, however, peasants and pastoralists resisted what in their view was a derogation of their rights to their ancestor's lands. The government resorted to the use of force, and this led to the collapse of the program. This failure, in addition to high inflation and shortages as well as pressure from the World Bank and the IMF, led Nyere to resign in 1985. His successor, Ali Hassan Mwinyi, "was forced to adopt [reforms] in line with the demands of the Bretton Woods institutions in order to obtain new loans"(Nabudere, 2006) in the following decade. The achievements of Ujaama are disputed, and two schools of thought dominate the debate on Nyere's contribution to Tanzania's development: While the first school argues for a complete failure and a waste of economic resources for the sake of ideology the second school concedes that the economic performance of Ujaama was modest, but nevertheless highlights achievements in the provision of health and education, a movement towards greater distributive equality in income and a strong sense of national identity (Nabudere, 2006, p. 197).

Ali Hassan Mwinyi signed Tanzania's first Standby Agreement with the IMF and devalued the Tanzanian Shilling (from 17 Shillings for one US-Dollar to 40 Shillings). Whereas the economic position of the country improved during this time many social achievements such as the previously near-universal primary education suffered, health centers in reach of large parts of the population, water supplies in the countryside were undermined. Ben Mkapa was elected President in the first post-independence election contested by multiple parties. Under his presidency the privatization of most agricultural and manufacturing enterprises under state control took place (Coulson, 2013). A large section of Tanzania's debts were written off under the presidency of Jakaya Kikwete, who has been in office since 2005 (and still is, as of November 2014). Tanzania's economy grew, mainly due to mining and tourism, as well as manufacturing exports to other African countries. Mobile phones spread and the internet became widely available. But whereas there were benefits of growth many of them went to the salaried elite (such as rising public sector wages), poor regions in many parts of the country did not profit at all (Coulson, 2013).

Challenges today

Poverty and inequality: Even though significant economic growth had occurred after 2000 with only a slight dip during the global financial crisis, this has "not translated into income poverty reduction"(Tanzanian Ministry of Finance, 2012). The proportion of the population below the basic needs poverty live was estimated at 33.6% in 2007, with the highest poverty rates in rural areas.

Development aid was oftentimes given through 'basket funding' and technical assistance, but many Nongovernmental Organizations also supported specific projects, such as schools, hospitals or health campaigns. Many "[n]ew organizations, independent of the government, undertook research, consultancy and lobbying. Compared with some of these, the civil servants were ill-equipped – and often found it hard to effectively challenge politicians or to make best use of the plethora of advice coming from the NGOs, the press and consultants commissioned by foreign governments or multilateral agencies"(Coulson, 2013, p. 23).

National economy: The financial crisis led to high demands for Gold, and whereas Tanzania has gold in several places it is oftentimes hard to extract and only available in small quantities. Even though gold mining had nearly stopped in the 1970s gold became the country's main source of foreign currency by 2000 and Tanzania advanced to be one of the three largest exporters of gold, after South Africa and Ghana. At the same time, Tanzania has as of 2010 become the leading non-oil destination for Foreign Direct Investments after South Africa (Coulson, 2013). Tourism is seen by some as one of the economic sectors with great economic potential, as it offers a wide variety of attractions – including 14 national parks, game reserves, word heritage sites such as Mount Kilimanjaro, and the islands of Kilwa Kisiwani, Songo Mnara and Zanzibar (Vice President's Office, Division of Environment, 2012).

Global warming: Low lying coastal areas such as parts of Dar es Salaam are threatened by flooding, and rainfall across the country has become less predictable (Coulson, 2013). Under high-emission projections with an estimated decrease in rainfall by 15% and no adaptation measures, maize yield losses have been estimated to range as high as 165 in 2030, and 25-35% in 2050 (Vice President's Office, Division of Environment, 2012). Even though the country "was able, broadly, to feed its growing population"(Coulson, 2013), agricultural exports have declined and the future of Tanzania's

agriculture also remains an issue of debate – especially when considered together with climate change.

2.2 Main demographic developments in Tanzania today

This section focuses on an introduction into main socioeconomic issues that are of interest in this thesis, with a focus on:

- Population size and distribution,
- main demographic developments such as the development of fertility and mortality,
- and the educational system

2.2.1 Population size and distribution

With an official population of 44.9 million in 2012,[5] Tanzania is currently has the 6th largest population in Africa (see Figure 2), compared to only 12.3 million in 1967. This equals an annual growth rate of 2.9 percent. Much of the rapid growth is a result of Tanzania's high fertility rate, the average number of children a women has during her life time. The country has passed through a phase of high population growth and is already experiencing a decline in fertility with an average of 5.4 children per woman in 2010[6] (compared to 5.7 in 2005 and 6.3 in 2002). As a result, about 45% percent of the population in 2012 was under 15 years old.

[5] according to the latest census published by the National Statistics Office

[6] 2012 census data on TFR is not yet available

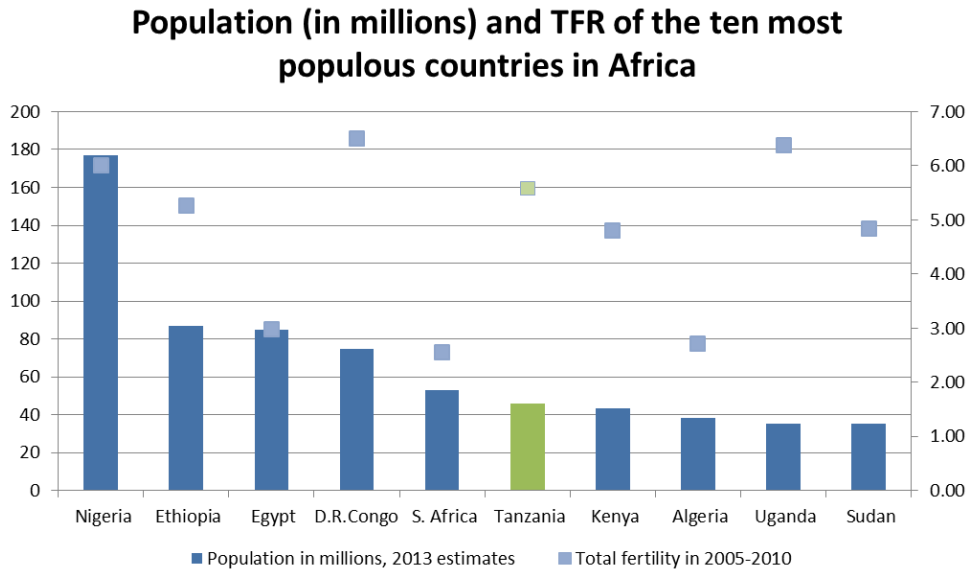


Figure 2: Population and total fertility ratio (TFR) of the top ten most populous African countries in millions. Sources: Population data for 2013 calculated, when available, from the latest national censuses or most recent official estimates. TFR data: United Nations World Population Prospects.

Administratively, the country is divided into 30 regions, with five of them on the semi-autonomous islands of Zanzibar and 25 on the mainland, in the former Tanganyka. Tanzania's average population density is 51 persons per square kilometer, but as can be seen in Figure 3 the population density varies strongly across regions, especially between large urban areas such as Dar es Salaam (3.133 persons/km2) or Mjini Maghrabi (2.581 persons/km2) and regions such as Lindi (12 persons/km2) and Katavi, which contains a large national park (12 persons/km2).

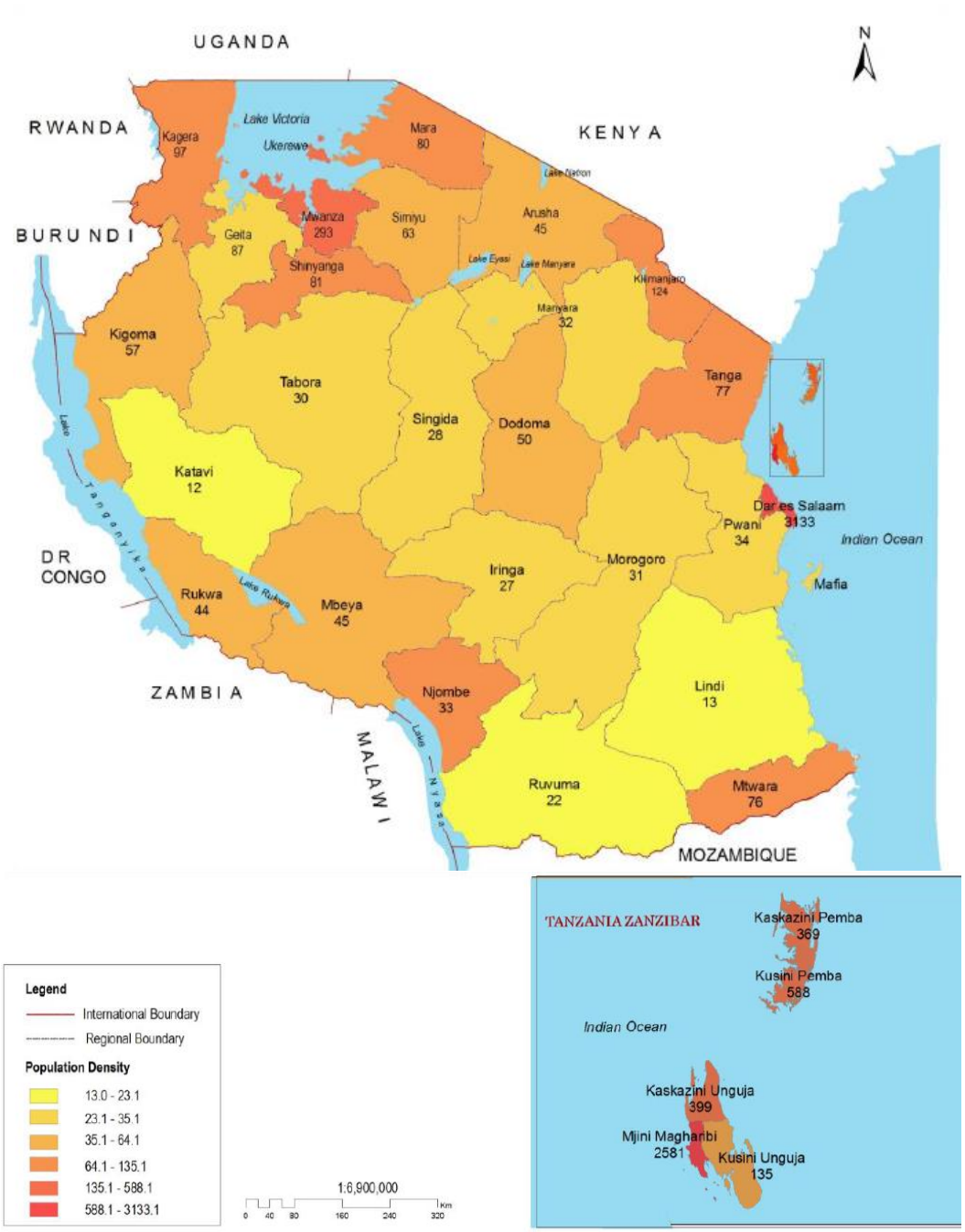


Figure 3: Population density by region, 2012. Source: National Statistics Office 2014.

The average annual population growth rates in the period 2002-2012 was highest in urban areas as well, reaching 5.6% in Dar es Salaam and 4.2% in Mjini Maghrabi (Tanzanian National Bureau of Statistics, 2014). Whereas Dar es Salaam was a small town with only 276 000 inhabitants in 1967 and more than three times that size in 180, it housed around four million people by 2012. This proved to

be a great challenge for urban infrastructure, such as roads, water supply and sewerage, as well as housing (Coulson, 2013).

The demographic transition in Tanzania

Dyson describes the demographic transition as a global phenomenon which is essentially composed of declining mortality and declining fertility. Populations going through this transition increase in size, as mortality decline can be seen as the initiating process causing population growth which leads to "stresses and strains in society" (Dyson, 2010, p. 3), those in turn eventually lead to a decline in fertility. Figure 4 shows the crude death rate (red, left axis), crude birth rate (blue, right axis) as well as total population size in millions (green, right axis), with estimated future values taken from the United Nations (United Nations, 2013). It shows that the death rate has been declining steadily since the 1950s, though it has increased again in the early 1990s (which may in part be attributed to the HIV epidemic as well as a general deterioration of the health system), and has since then again experienced a steady decline. Birth rates, in contrast, have stayed at a level of approximately 50 births per 1000 people per year and started to decline around 1970. Between 2000 and 2008, a stalling in birth rates can also be observed.

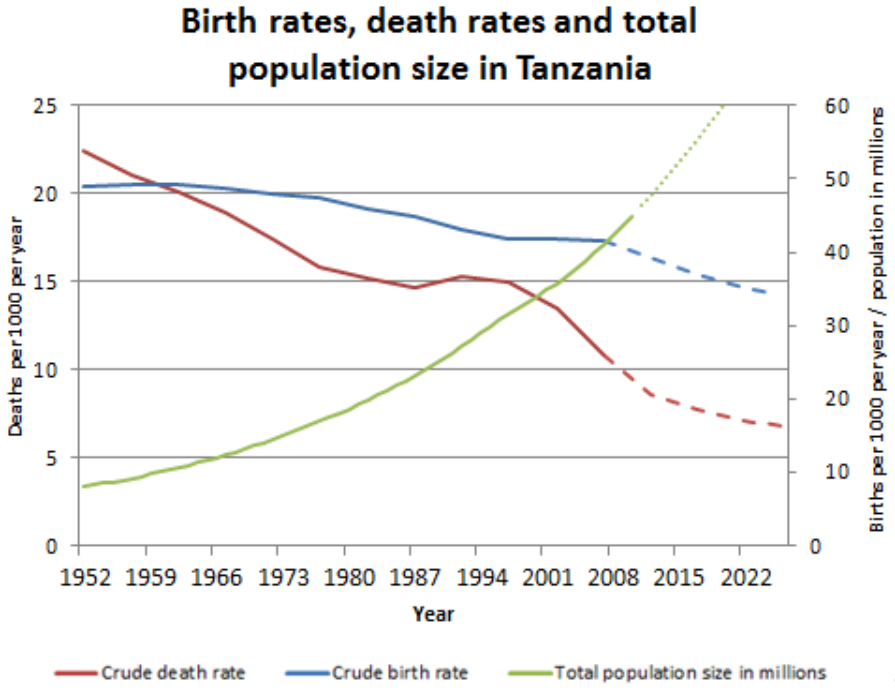


Figure 4: Birth rates, death rates and total population size in Tanzania. Data source: United Nations 2012, own illustration. For the period after 2010 UN estimates (medium fertility scenario) are used.

How the development of fertility may continue is an issue of debate: Whereas a general trend toward declining fertility rates is undisputed, the pace of the fertility decline in Sub-Saharan Africa has been slower than anticipated. Socio-economic development, which has been identified as a key driver of fertility decline, has stagnated for several decades (Bongaarts & Casterline, 2013; Bulatao & Lee, 1983). Currently demographers also discuss whether an alternative type of fertility transition, different from transitions observed in e.g. Europe, Asia or Latin America, can be observed in Africa (Bongaarts & Casterline, 2013; Caldwell, Orubuloye, & Caldwell, 1992; Moultrie, Sayi, & Timaeus, 2012). Bongaarts and Casterline argue that ideal family size in almost all Sub-Saharan African countries are higher than in other countries which were at similar stages in the demographic transition, and the fertility transition is slower than observed elsewhere (2013).

2.2.2 Health and fertility

Health[7]

Life expectancy in Tanzania has increased from 51 years in 2002 to 58 years in 2012, which can be attributed mainly to a decrease in child mortality (Tanzanian Ministry of Finance, 2012). Despite progress in many areas, several important health issues exist and these are of course closely linked to the country's demographic development. In general, a large shortage of skilled health professionals is seen as a main issue by the government, which stated that in rural areas this shortage is estimated to be around 65% (Ministry of Finance and Economic Affairs, 2010).

Malnutrition

Malnutrition in children is currently the single biggest contributor to child mortality in Tanzania, and especially prevalent in rural and poorer households. It is considered "the main inhibitor to educational performance and a key impediment to economic growth through its consequences on health, the ability to learn and labor productivity" (Ministry of Finance and Economic Affairs, 2010, p. 14). Four out of ten children under 5 years have been found to be stunted, and one fifth underweight. Nutrition of young children and women during pregnancy has defined as an important

[7] As the population projection model in this thesis uses UN data for mortality and life expectancy (and the UN model already takes topics such as HIV into account) this chapter mainly serves as an introduction into some of the most pressing health topics in Tanzania today.

priority, as little progress has been made between 2002 and 2012 (Tanzanian Ministry of Finance, 2012).

Water and Sanitation

Water supply services in 2010 in rural areas have increased to 47.9%, whereas in urban areas it is estimated at 81%. Access to basic sanitation has decreased from 93% in 2007 to 86% in 2010 according to survey data, sanitation facilities in schools have also been identified as an area with large need for improvement (Tanzanian Ministry of Finance, 2012).

HIV/AIDS, Malaria and Tuberculosis

In 2011, an estimated 1.6 million people in Tanzania were living with **HIV**. HIV prevalence has declined between 2003/04 and 2011/12, from 7% to 5.3% among adults between the ages of 15 and 49. This decline was significant among males (from 6.3% to 3.9%), but less so among females (from 7.7% to 6.8%), and progress in access to antiretroviral therapy is reported (Tanzanian Ministry of Finance, 2012, United Republic of Tanzania, 2014). According to finger-prick blood samples 9% of children aged 6-59 months tested positive for **malaria**, according to blood smears 4% tested positive. Even though knowledge on how to recognize malaria is widespread among adults and the use of insecticide-treatment mosquito nets has increased significantly, high regional disparities exist (Tanzanian Ministry of Finance, 2012). Even though the **tuberculosis** treatment success rate has improved, a low notification rate (estimated at 59%) is hindering treatment of infected people (Tanzanian Ministry of Finance, 2012).

Maternal health and family planning

Even though child mortality has declined, an age-disaggregation of mortality shows that neonatal mortality is still very high, which points towards a need for better maternal healthcare (Tanzanian Ministry of Finance, 2012).

Other issues

It is estimated that 7.9 million girls and women in Tanzania have undergone female genital mutilation, in 2010, 15% of Tanzanian women were circumcised (Tanzanian National Bureau of Statistics, 2011, UNICEF, 2013). The distribution is regionally very uneven and varies strongly between ethnic groups. The regions of Arusha, Dodoma, Kilimanjaro, Manyara, Mara and Singida

have prevalence rates of 20-70%. Out of the nine regions with the highest prevalence, five have seen a decrease between 2004-50 and 2010, whereas four have seen an increase (28 Too Many, 2013).

Fertility

Lowering fertility has been an explicit public policy goal only since 1992: For 2015, the aim is to slow down total fertility rate (TFR) to 5.0. [8] According to the Tanzanian Ministry of Planning, Economy and Empowerment (Population Planning Section, 2007) …

> … [a] large young population places a heavy burden on the working-age population and limits the provision of basic needs and social services. For example, cross-national research shows that a large young population is one of the most important determinants of low academic achievement in children: when there are too many children, it is very hard to educate them well. Lack of education also contributes to ongoing high fertility as well as poverty, creating a vicious cycle. With a large young population, there is also an in-built momentum for future population growth.

Tanzania's total fertility rate was close to 7 throughout the 1970s, and has in the last decades already seen a decline, with on average 6.3 children per woman in 1991 (see Figure 5). Then, however, a slight increase from 5.6 children in 1999 to 5.7 children in 2004 can be observed. More recently, fertility has again dropped, to around 5.4 children in 2010 (Tanzanian National Bureau of Statistics, 2011).

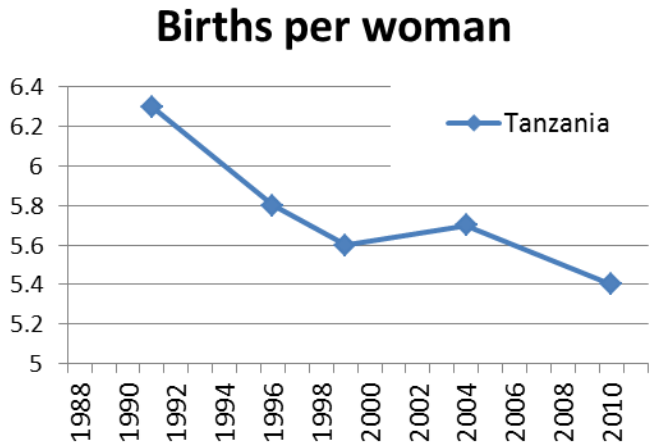


Figure 5: Births per woman in Tanzania over time.

Data source: TDHS 2010, own illustration.

[8] Main strategic documents are the Tanzania Development Vision 2025 & the Zanzibar Development Vision 2020, as well as the National Strategy for Growth and Reduction of Poverty (NSGRP, commonly known as MKUKUTA) and Zanzibar Strategy for Growth and Reduction of Poverty (ZSGRP commonly known as MKUZA).

The official attitude towards fertility and population growth has been very positive from the independence onwards (which happened in 1961 in mainland Tanzania), authorities deemed poverty to be the root problem (United Nations, 1989). Official family planning initiatives, which started at the end of the 1980s, focused on improving mother and child health through child spacing. A National Population Policy was announced in 1992 (President's Office, 1992), which aimed at embedding the aim of reducing fertility in a wider development program, including the empowerment of women and further expanding services in education (Kravdal, 2001). These ideas have continued to play a major role (President's Office, 1998), and are also part of the National Strategy for Growth and Reduction of Poverty II today (Ministry of Finance and Economic Affairs, 2010).

Richey (2003) argues that the control of population size has been a part of recommended structural adjustments given to African countries, which in Tanzania led to a retreat of the state from the heath care sector towards a system of public health care focused on supplying contraceptives. She identifies global players such as the World Bank, USAID, and UNFPA, the first of which described the role of population policy to limit fertility in 1994 as "the most critical issue to address" in poor countries and argued that "donor influence has to be used judiciously to increase political and public sensitivity to the health and welfare hazards of unrestrained reproduction" (Richey, 2003, p. 274). During the beginning of Tanzania's independent political history the state saw its population "problems" in the areas of migration from rural to urban areas and public service provision, especially regarding education and health. This holistic approach to development, which was focused broadly on poverty, shifted in later years towards an understanding more compatible with that of donors and lenders. Richey states that in practice Tanzanian population policy in the 1990s has been dominated by donor interests, for example focusing on the availability of contraceptives in hospitals: "One of the most startling contradictions between family planning supplies and those for all health needs is that contraceptive pills are likely to be the only pills found in state clinics" (Richey, 2003, p. 285). She conducted interviews in Swahili in 10 clinic sites and combined the information gained with national survey data. She concludes that while contraceptives are readily available at clinic sites (supplied by donors), the overall Tanzanian heath system is deteriorated: Issues include the supply of clean water (even declining in the 1990s), electricity, the availability of blood pressure cuffs (necessary to screen patients before prescribing hormonal contraceptives), and a lack of proper lightning and disposable supplies (sterile gloves etc.).

Reproductive health

Reproductive health and family planning also face several challenges: Even though Tanzania was one of the first sub-Saharan countries to offer contraceptives in 1959 (Richey, 2003), it is difficult for Tanzanian women to achieve their fertility desire. One indicator for this is the difference between Tanzanian women's total TFR of 5.4 children and their wanted fertility rate (4.7 children). The 2010 TDHS shows that 26% of recent births were unplanned, which is a slight increase compared to the year 2004/5. The unmet need for family planning in 2010 was 25% and had not changed since 2004/5: 16% of women had an unmet need for spacing, and 9% an unmet need for limiting child birth(Tanzanian National Bureau of Statistics, 2011).

The prevalence of contraceptives has risen, but is still very low (26% of married women and 44% of sexually active unmarried women use a modern contraceptive). One out of every four married women and one out of three unmarried women (in reproductive age) are estimated to have an unmet for contraception, and this share has remained almost the same since 1999. The share of unmet need is even higher among women with less education, rural residence or low economic status (Tanzanian National Bureau of Statistics, 2011). In 2010, 34% of married women were using a contraceptive method, 27% of which were using a modern method. Injectables were used by 11%, followed by the pill and traditional methods with 7% each. The use of any method increases greatly with education, as 22% of married women with no education and 52% of women with at least secondary education used them. Women in the Lake and Western zones were also less likely to use contraception. The government and parastatal facilities are the main sources of contraceptives, whereas public and private hospitals are used for female sterilization. Male condoms are mainly bought at pharmacies and shops (Tanzanian National Bureau of Statistics, 2011, p. 22).

Abortion in Tanzania is – even though restricted by law and only permitted if performed to save a woman's life – widely practiced and mostly carried out in an unsafe manner, thus contributing to high maternal morbidity and mortality rates. 16% of maternal deaths are due to complications from abortions according to the Ministry of Health and Social Welfare, a small-scale review of 62 maternal deaths in a regional hospital even showed a quarter of deaths because of abortions (Woog & Pembe, 2013). Even though progress has been made, the maternal mortality ratio is still one of the highest in the world, with 454 per 100 000 live births. Costs of obtaining a safe abortion are high, and many

women turn to self-inducing an abortion or untrained providers (traditional birth attendants, pharmaceutical retailers).

2.2.3 Tanzania's educational system

A historical perspective on Tanzania's educational system

During colonial times access to basic education was limited and very unequally distributed, the system was racially segregated and Christians had better access to education than other religious groups with many schools having been established by missionaries (Al-Samarrai, 2001). In 1947, below ten percent of school-age children were enrolled in primary school and below one percent in secondary school, with no female having ever progressed beyond the level of primary education (Cameron & Dodd, 1970).

After Independence in 1961, the new government made public education a national priority, trying to dismantle the educational structure inherited from the colonial administration and facing a scarcity of sufficiently skilled workforce to replace previous expatriates. Two clear priorities emerged: Providing basic education to a socialist Tanzania and strengthening secondary education to prepare a new public workforce. The Education Act passed in 1978 made education compulsory for children aged 7 to 13, but enrollment rates kept fluctuating between around 70% to 95% until 2000 (Dennis & Stahley, 2012): Under President Nyere primary school enrolment had reached 97%, but it fell sharply in the 1980s, when the economic crisis reversed this trend (Al-Samarrai, 2001). It increased again after 2000's abolishment of primary school fees (Coulson, 2013). In 2010 about 19,1 percent of women aged 15-49 did not have any formal education, compared to 9,5% of men (Tanzanian National Bureau of Statistics, 2011).

Tanzania's educational system today

Expenditure in education has increased in recent years, from 2.5% of GDP in 2000 to 4.3% in 2008 (UNESCO Dakar Office, 2012). Tanzania implemented the Primary Education Development Program (PEDP) in 2011 and abolished public school fees in order to increase access to primary education. Enrollment has increased drastically, but even though schooling is now mandatory for children between the ages of 7 and 15 around 15-20% of children still did not attend school in 2012, and many children start school relatively late (Dennis & Stahley, 2012). Reasons mentioned in the scientific literature include other costs associated with education, such as direct household

expenditures on books or school uniforms, but also families' opportunity costs of their children being in school (Dennis & Stahley, 2012). Private households are estimated to cover a quarter of primary public costs, which is especially problematic when it comes to the poorest households (UNESCO Dakar Office, 2012). UNESCO, however, is positive that Tanzania is on the right track to achieve Universal Primary Education by 2015, though late entry ages remain an issue (UNESCO Dakar Office, 2012)

There has also been a political initiative aimed at a secondary and higher education, though many challenges remain:

> In 2005, the government announced that there would be a secondary school in every political ward. A very rapid expansion in secondary education, especially after 2006, and proportionately an even bigger expansion in university places, led to declining standards. The fact that both secondary and university education was supposedly conducted in English, when English teaching in many schools was in crisis, was just one of the causes (Coulson, 2013).

Challenges facing education policy today

Issues regarding education mentioned in the "National Strategy for Growth and Reduction of Poverty II"(Ministry of Finance and Economic Affairs, 2010) include inequality in the distribution of resources and teachers both within and across regions (with hard-to-reach rural regions at a disadvantage), the challenge of increasing transition rates to secondary education as well as high dropout rates (especially for girls in secondary school). As a result of higher dropout rates for girls, a clear gender gap in enrolment during the last years of secondary education and post-secondary education can be observed. The strategy also highlights that the dropout rate of girls due to pregnancy increased from 6.5% in 2006 to 10.3% in 2008, out of all reasons to drop out (Ministry of Finance and Economic Affairs, 2010). The quality of the school environment is described as follows: "A general poor infrastructure and inadequate teachers at ordinary and advanced secondary schools levels" (Ministry of Finance and Economic Affairs, 2010), especially in the sciences where inadequate facilities are supplied. Technical and vocational education and training have also received a lower share of public funds than in previous years, which has led to a "majority of the youth" who are "left behind with low basic skills and reduced employability". A gender gap in post-secondary is also attested as females account for only 32% of enrolled university students.

UNESCO highlights increased enrollment numbers in all levels of education, and states that higher education in particular has helped Tanzania to catch up to comparable countries. Key challenges for the coming years are seen in achieving greater efficiency gains in the use of public education resources, increasing the public resources allocated to secondary education, ensuring that children enter primary education at the right age, improving retention in post-primary education, supporting pro-poor schooling, ensuring gender parity in education, and improving pedagogical quality in basic education. The reduction of disparities at a regional and district level, as well as between schools is another important goal. For higher education, an improvement of the funding mechanisms is essential, in addition to inefficiency badly distributed student loans: 28% of the budget is allocated to student loans, but only 10% of recipients come from the poorest quintile (UNESCO Dakar Office, 2012).

3. Population projection model

This chapter aims at explaining the model used for Tanzania's population projections based on education.

3.1 Education as a third dimension in population projections

Gender and age are generally considered to be the two most important demographic dimensions, as migration, fertility and mortality differ largely depending on those fundamental characteristics of a person:

- **Gender**: First of all gender is essential in explaining the reproductive process, but mortaility and migration have also been shown to vary significantly with gender (Lutz & KC, 2011).

- **Age**: Fertility also varies with age, but it is most importantly the "main driver of maturation in the young" and plays a large role regarding school attendance and employment (Lutz & KC, 2011).

Country-level fertility statistics conceal differences in reproductive behavior among socioeconomic groups within countries, but demographic literature has identified a large number of factors influencing reproductive behavior: Fertility is generally found to be higher in rural than urban areas, higher among women with low education compared to better-educated females and higher in low-income households. Differences may also exist with regards to religion, employment, marital status, number of children, living arrangement, occupation, and health status (Bongaarts, 2003; KC, 2009; Merrick, 2001; United Nations, 1987).

In theory, education has long been identified as a main parameter in demographic projections, as fertility has been shown to differ strongly by female education (see Chapter 2) and is also of specific interest insofar as education policy is a rather direct way to address this issue. Lutz et al. argure that education, "among all of the demographic characteristics, it is the most important source of observable population heterogeneity after age and sex, and should therefore be routinely added to many types of population analyses" (Lutz & Butz, 2014). This claim is based on three main criteria necessary for an additional standard characteristic: (1) feasibility regarding available data and methodology, (2) importance in altering population dynamicy, and (3) the dimension should be in its own right interesting to the user and desirable as an explicit output parameter (Lutz, Goujon, &

Doblhammer-Reiter, 1998; Lutz & KC, 2011): "Education is of overwhelming social, economic, and cultural importance even without considering its demographic implications. It has far-reaching sigificance on both the individual and societal level" (Lutz et al., 1998).

Educational differentials in fertility are among the best established and also most widely studied (classic references include Caldwell, 1980; Cleland & Wilson, 1987; Cochrane, 1979), especially women's fertility. Lutz & K.C. argue that female education is one of the most important determinants of fertility at an individual level: Women with more education have fewer children and at later stages in life (Lutz & KC, 2010). Female education was found to be positively associated with demand for and use of contraceptives and negatively associated with fertility and desired family size: "As education rises, fertility is lower at a given level of contraceptive use, contraceptive use is higher at a given level of demand, and demand is higher at a given level of desired family size"(Bongaarts, 2010). Explanations for this phenomenon usually include better-educated women marrying later and less often, access to family planning services as well as a better and more effective use of contraceptives by them, a higher autonomy in reproductive decision making and "higher opportunity costs on unintended childbearing" (Bongaarts, 2010; Jejeebhoy, 1995; Shapiro & Gebreselassie, 2008). Jejeebhoy argues that children may also be less necessary as an insurance when a woman is able to earn a living on her own or can even save money for the future (Jejeebhoy, 1995). The effects of years of schooling have been shown to remain significant even after controlling for many other socioeconomic and behavioral factors (Cleland, 2002; United Nations, 1987, United Nations, 1995). Bongaarts also shows that educational differentials in fertility vary based on a country's stage in the fertility transition (Bongaarts, 2010): He argues that educational differences in unwanted fertility are larger at the beginning of the transition, then tend to decline as differentials in unwanted fertility tend to rise but will remain substantial when less developed countries reach the end of their transition. The leader-hypothesis states that this widening of differentials in fertility is because of the early onset of the fertility transition among the more educated, who are then followed by the less educated. K.C and Potancokova show that these fertility differentials seems to start narrowing down once TFR drops below 4 children per woman (K.C. & Potancokova, 2013). Other studies have indicated that women's education is also positively related to age at first birth (Bongaarts, 2010).

3.2 Characteristics of the population projection model[9]

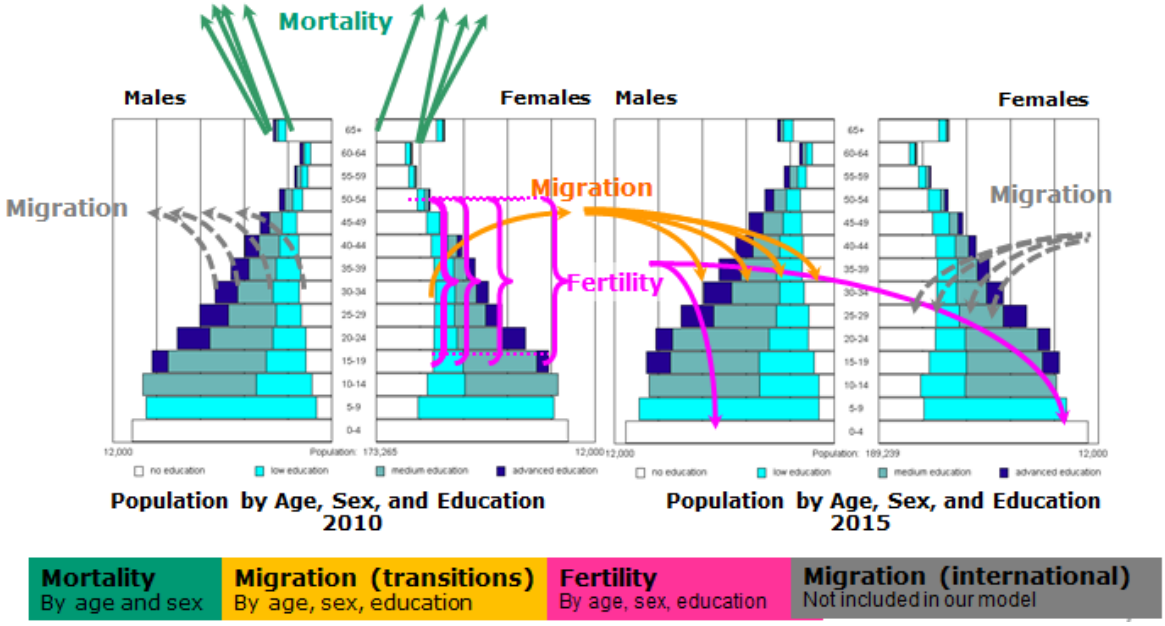


Figure 6: Design of population projections with educational subgroups. Own adaptation of Lutz 2013.

Figure 6 gives an overview of how and why population's composition changes from one time period to the next in the model presented (in this example in 5 year intervals) and illustrates the three basic determinants of population change included:

- **Fertility**: Women in reproductive age (usually 15-45 years) give birth to the youngest age group in the following period
- **Mortality**: people in the last, open-end age group (in this graph 65+) leaving the population.
- **Migration**:
  - **Internal migration (transitions between educational groups):** People in one educational category moving to another educational category in the follwing time period (e.g. from no education to primary education).

[9] This section draws from class material presented by Wolfgang Lutz (Specialization Area Demography), (Ledent & Zeng, 2006) and (KC, 2009).

- **International migration:** people moving to or from other countries (not included in this model).

Stocks and flows

A population's composition is determined by the distribution of individuals across states, of which an individual can only occupy one at any point in time (e.g. either be married or not married). Occupancies of states change as the result of two processes: interstate transitions (e.g. moving from not married to married) or entrances and exits (either migration or birth/death).

The **life table** is a description of the size and composition of a (synthetic) cohort, and shows its changes over time. **Projection models** show how the population composition (stock) at a point in time depends on the initial population and transitions by people (flows).

The dynamics of a population are based on both transition rates and transition probabilities:

- Rates relate the number of transitions made by people to the duration at risk of a transition.
- Probabilities relate transitions to the population at risk at the beginning of an interval.

It is therefore necessary to have data on population stocks (the population by at age and sex, and other variables of interest to be included in the model) and flows (at minimum birth and death rates, but also migration and again other variables of interest).

First, transition rates are calculated from the data and then in a second step used as transition probabilities. This approach is straightforward in case transition rates vary in between but not within age intervals, or when they are uniformly distributed during an interval. As these transition rates and probabilities are estimated from the data, issues of censoring (e.g. individuals entering or leaving the population during the period of observation for a reason unrelated to the transitions studied) can arise.

This data preparation of stocks and flows is presented in the next chapter (chapter 4).

4. Data and data preparation

The data needed for the population projection model is taken from a variety of sources, which are described in depth in this section. As several adjustments had to be made in order to transform the data into the format needed for the projection model, this section focuses on the preparation of this data as well as how education and fertility scenarios were conceived and carried out in detail.

4.1 Preparation of base year population

The base year population is divided by three main characteristics:

- Age (5 year intervals)
- Sex (male/female)
- Education (no education, primary, secondary and tertiary)

The adjusted population pyramid for males and females by age and educational attainment is presented in Figure 7 (find the educational categories in the next chapter, Figure 8 on page 33).

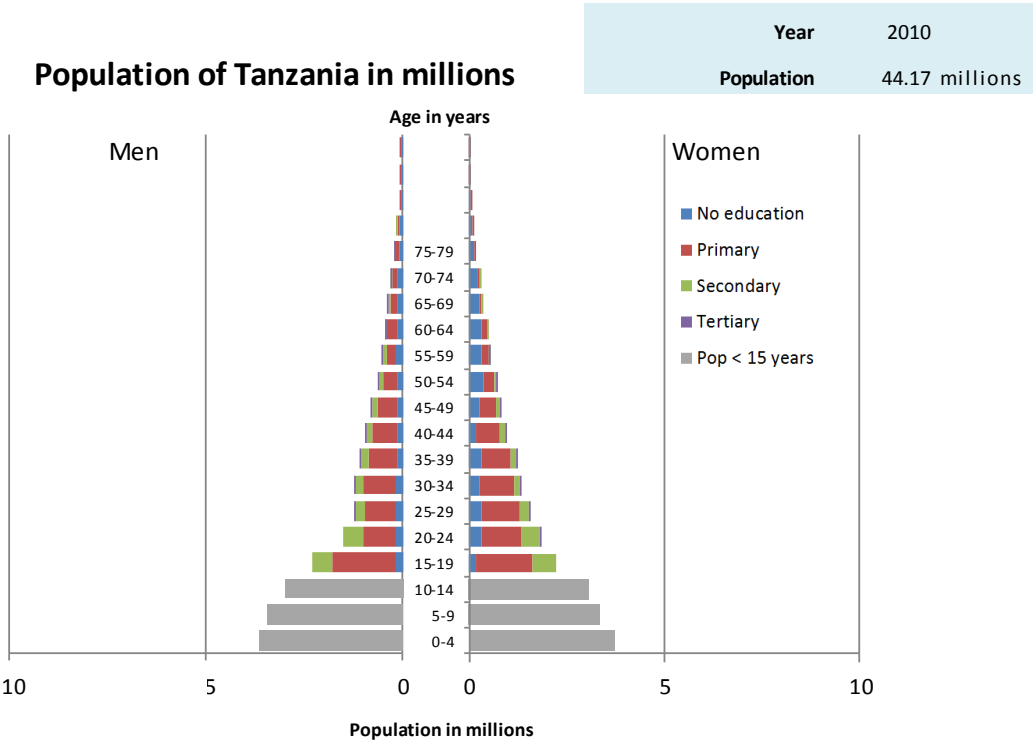


Figure 7: Tanzania's base year population by educational group in 2010. Data source: TDHS 2010, own calculations and illustration.

4.2 Education data

The main challenge regarding the education variable in DHS data is that there are inconsistencies in the definition of education categories both within and across countries (K.C. & Potancokova, 2013). We therefore harmonized the education variable to the UNESCO's definition, which is summarized in Figure 8, and built four broad educational categories. In addition we allowed for early entry into each educational category by one year.

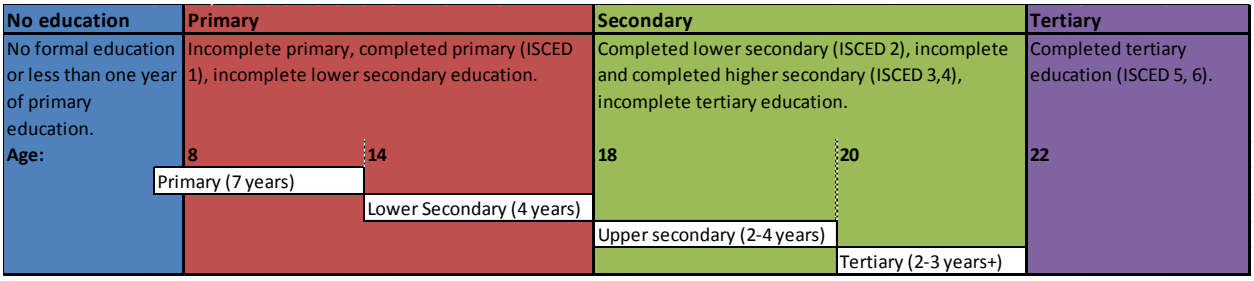


Figure 8: Categorization of DHS data by educational categories according to ISCED. Source: ISCED, Own illustration.

4.2.1 Base year

The educational composition of the base year population (both male and female) is presented in Figure 9[10]. The most prominent difference between men and women can be seen when comparing the shares of persons aged 45+: Whereas around 90% of women aged 70+ have no formal education, this number is around 70% for men. But the youngest cohort in the graph shows that this may change drastically in the future: In the youngest age group in this graph the share of girls who have attained primary education at the age of 5-9 is already slightly above that of boys, with 55% to 49%. Secondary education in higher age groups is however, much more frequent for males.

What is (in)visible for both males and females is the very low share of people with tertiary education, which is, even though in absolute numbers, much higher for males than females (4.4% of males with secondary education move to tertiary, but only 0,9% of females).

[10] The information contained here is identical to Figure 7, but expressed as educational shares of each age group.

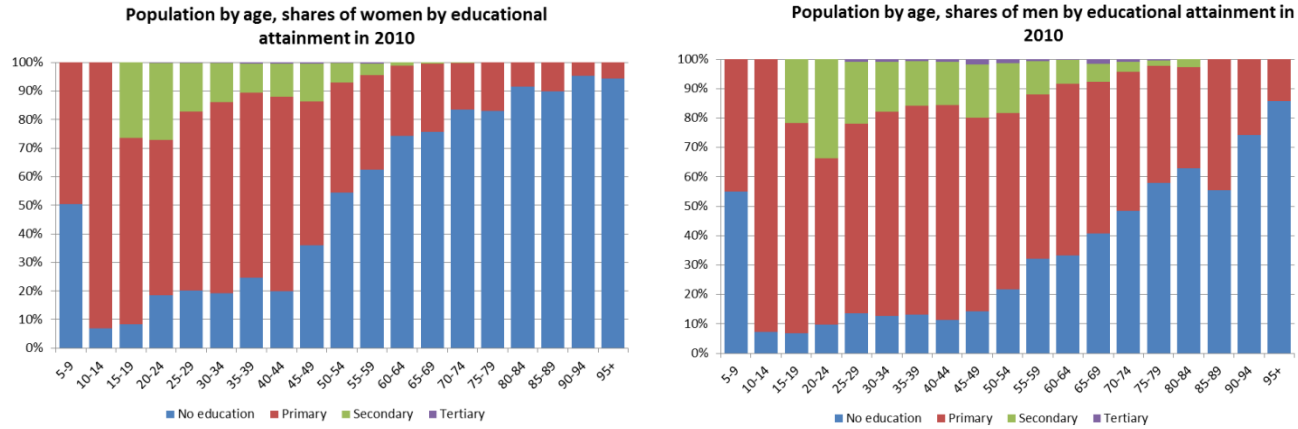


Figure 9: Shares of educational attainment categories by age groups, males and females. Source: Data from TDHS 2010, own calculations and illustration.

4.2.2 Education transitions[11]

While the base year can be considered the population stock, as a next step flows between educational groups need to be calculated, which happen based on so-called transition rates. These transition rates stand for the probability that a person in period *t* with education *a* will have education *b* at time *t*=1.

The best way to calculate transition rates would be to have detailed enrolment rates by age, sex and level of education, but this data is not available for Tanzania. A more crude method of estimation is therefore necessary: The main idea is that one can base education transition rates from period *t* to period *t*+1 on the difference in the educational distribution between cohorts.

In the case of four educational categories (1=no education, 2=primary education, 3=secondary education, 4=tertiary education), transition rates were thus calculated as follows:

$$T_{1,2}(5-9) = \frac{popr_2\ (5-9)}{popr_1\ (0-4)}$$

$$T_{1,2}(10-14) = 1 - \frac{popr_1\ (10-14)}{popr_1\ (5-9)}$$

[11] The calculation of transition rates is based on personal talks with Anne Goujon from the Wittgenstein center, as well as her personal notes and examples.

$$T_{2,3}(15-19) = \frac{popr_3\,(15-19)}{popr_2\,(10-14)}$$

$$T_{2,3}(20-24) = \frac{popr_3\,(20-24)\ -\ popr_3\,(15-19)}{popr_2\,(15-19)}$$

$$T_{3,4}(20-24) = \frac{popr_4\,(20-24)}{popr_3\,(15-19)}$$

$$T_{3,4}(25-29) = \frac{popr_3\,(25-29)\ -\ popr_3\,(20-24)}{popr_2\,(20-24)}$$

Where T_{ij} stands for the transition rate from state *i* to state *j* (educational group) and $popr_i$ represents the proportion of the population in state *i*.

The educational transition rates in the base year, calculated based on the method described above, are presented below.

Transition rates between educational groups, Tanzania 2010

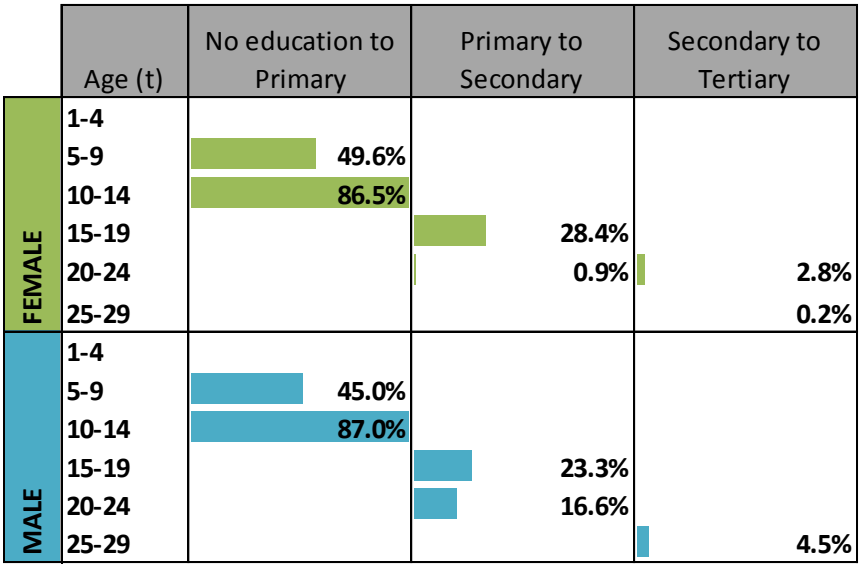


Figure 10: Educational transition rates based on Tanzania's 2010 population. Source: TDHS 2010, own calculations and illustration.

Whereas transition rates from no education to primary education are rather similar across genders, clear gender differences are visible when it comes to obtaining secondary and tertiary education: If women obtain secondary education, they do so at an earlier age (age group 15-19), where they have a

higher transition rate than men. 16.6% of men, however, also obtain secondary education at a later age (20-24), this chance is below 1% for women (who have already finished at least one year of primary education). Regarding tertiary education, both timing and transition rate vary significantly. Women, again, manage most of the transition an age group earlier than men, if at all.

Assuming that these transition rates stay equal, the probabilities that a Tanzanian girl/boy entering the educational system obtains a certain education are as follows (Figure 11): Even though the chance that a girl would obtain at least one year of completed primary education is slightly larger than for boys (with 93.2% compared to 92.9%), she would be less likely to obtain secondary or even tertiary education, and 67 out of 100 girls would stop at primary education, compared to 59% of boys.

Overall probability of ending up with a certain educational attainment, based on 2010 transition rates

	No education	Primary education	Secondary education	Tertiary education	Total
FEMALE	6.8%	66.8%	25.5%	0.9%	100.0%
MALE	7.1%	59.3%	32.0%	1.5%	100.0%

Figure 11: Probabilities of obtaining a certain education based on transition rates from 2010. Source: Own calculations based on 2010 TDHS, own illustration.

Keep in mind, however, that this data is always based on the educational definition as described in Figure 8 on page 33. The data was cross-checked with other sources (such as Barro & Lee, 2010), but, due to differences in classification, comparisons are not easy and should be treated with caution. The gender gap in enrollment into tertiary education has also been identified in other studies, with only 32% of enrolled university students being female (Ministry of Finance and Economic Affairs, 2010).

4.2.3 Education scenarios

> Making assumptions about future educational development over the course of several decades is a seemingly impossible task. However, it is not intrinsically more difficult than making assumptions about reproductive behavior or mortality. […] In any case, the notion that we can avoid making assumptions about future educational attainment trends is a fallacy; since fertility is influenced by education levels, population projections inevitably make implicit assumptions about the population's future educational attainment, even if these remain unstated. In our view, it is preferable to be explicit about these assumptions (Lutz et al., 1998, p. 46).

Of course, the education scenarios presented in this chapter should not be taken as forecasts, but rather as illustrations of how different trends may shape the future. The four scenarios presented below thus describe different assumed developments of transition rates between educational groups.

Scenario A: "Constant Enrollment Rates"

This scenario assumes constant enrollment rates in all levels of education. Even though the scenario may seem overly pessimistic, for Tanzania this would already mean an increase of enrollment numbers in the next decades.

Scenario B: "Likely"

In this case, a 'global education trend' is used, which is based on median parameter estimates of the Wittgenstein Centre's global population projections:

> [W]hile not interpretable as the 'most likely' scenario in a probabilistic sense, it can be interpreted as the scenario that reality is equally likely to exceed of l=fall short of. In policy terms, this may be interpreted as 'business-as-usual'. This does not, however, imply a static perspective (Lutz et al., 2014, p. 427).

For this scenario, data on estimated total population shares in 2060 (Global Education Trend/ Medium/SSP2) was obtained from the Wittgenstein Centre for Demography and Global Human Capital (Wittgenstein Centre for Demography and Global Human Capital, 2014). Shares of the educational categories 'primary', 'secondary' and 'tertiary' by cohort in the age group 25-29 were used to calculate transition rates, which were then implemented at ages 10-14 (no education → primary), 15-19 (primary → secondary) and 20-24 (secondary →tertiary). As a starting point, DHS data for 2010 was also transformed into direct transition rates (see Figure 11). Values for the periods between 2010 and 2060 were obtained by linear interpolation from these two points in time.

Scenario C: "Sustainable Development Goals"

The currently proposed Sustainable Development Goals (SDGs) for education focuses, among other topics, on universal primary and secondary education until 2030: "[B]y 2030, ensure that all

girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes" (Open Working Group of the General Assembly on Sustainable Development Goals, 2014). This means, in our model, that education transition rates into primary for both males and females are set to 100% from 2025 and transition rates into secondary education to 100% from 2030 onwards. For the periods until 2025/2030 transitions rates are interpolated (based on currently observed education transitions). For tertiary education, transition rates in line with the 'Likely' scenario are applied.

Scenario D: "Fast Track"

This scenario is a combination of **UN goals for primary and secondary education** (scenario C) and an **increase in tertiary education based on the Wittgenstein Centre's 'Fast Track' scenario**:

- The currently proposed Sustainable Development Goals (SDGs) for education, which include universal primary and secondary education until 2030 have been implemented into the model as follows: Education transition rates into primary for both males and females are set to 100% from 2025 and transition rates into secondary education to 100% from 2030 onwards. For the periods until 2030 transitions rates are interpolated (based on currently observed education transitions).

- For tertiary education a 'Fast Track' scenario is applied. This means that the most rapid education expansion parameters that have been observed in the past will be used. In this case, Tanzania's enrollment rate from secondary into tertiary education is assumed to follow the educational path of Eastern and Southeastern countries such as Singapore and South Korea (Lutz & Butz, 2014, p. 488). Data on estimated total population shares in 2060 (Fast Track/Rapid Development/SSP1) was obtained from the Wittgenstein Centre for Demography and Global Human Capital (Wittgenstein Centre for Demography and Global Human Capital, 2014). The share of the educational categories 'tertiary' and 'secondary' by cohort in the age group 25-29 were used to calculate transition rates from the 'secondary' education group. Values between 2010 and 2060 were obtained by linear interpolation from these two points in time (see Figure 11).

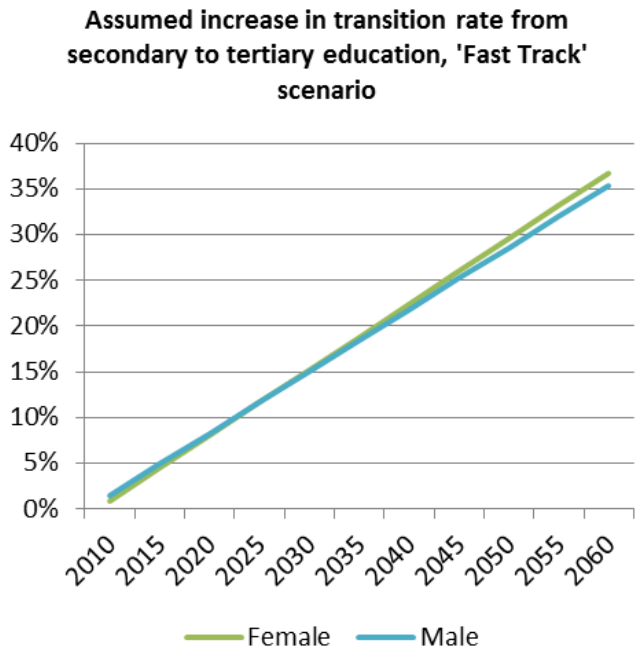


Figure 12: Assumed increase in transition rate from secondary to tertiary education in 'Fast Track' scenario. Source: TDHS 2010, Wittgenstein Centre 2014, own calculations and illustration.

4.3 Fertility data

4.3.1 Base year

Information on age-specific fertility by age, sex and educational group was taken from the Demographic Health Survey (DHS). As the educational data, the fertility data needed to be harmonized and sorted into educational groups according to ISCED educational standards (see Figure 8 on page 33 for details on educational categories).

Different fitting models were considered for smoothing the fertility data: Relational models refer to a standard fertility distribution, but as we are interested in the distribution of fertility by educational category this information is not available. Therefore a parametric model, the Gamma model, was chosen to compare smoothed 5 year fertility data with the original aggregates (from the TDHS). For details on the Gamma model please refer to the Appendix. It was however decided that the original information regarding ASFR by education contained in the TDHS would be used instead of the smoothened values obtained from the Gamma model as taking 5 year aggregates already leads to a

smoother fertility curve across ages: Whereas Figure 13 shows an erratic observed ASFR for women with no formal education, in Figure 14 smoothed ASFRs by 5 year age groups are not significantly different from the aggregated observed values. By using values obtained from the Gamma model we would have to introduce additional assumptions about women's fertility behavior, such as assuming that fertility rises directly to the peak and then decreases. While this may be true for ASFRs this assumption does not necessarily need to hold for education-specific ASFRs.

Figure 13 compares ASFR values for the group of females with no formal education for single years, whereas Figure 14 shows 5 year aggregate values. Comparisons for primary and secondary education groups can be found in the appendix (pages 80 and 81).

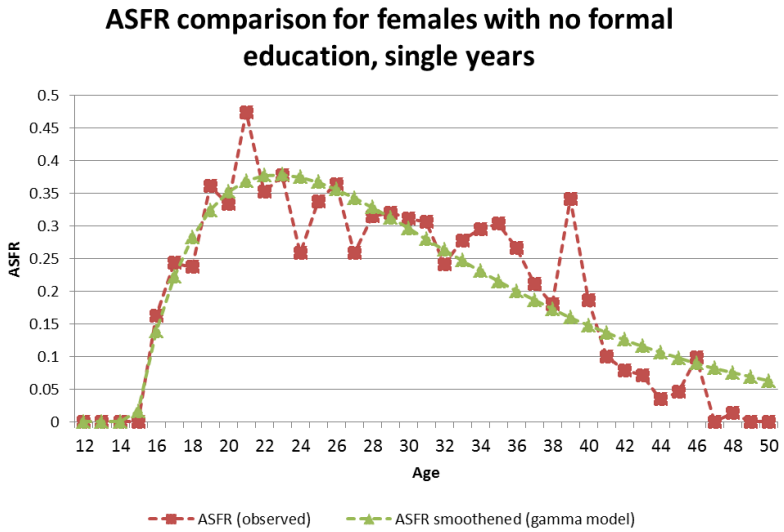


Figure 13: Women with no formal education, comparison of single year ASFRs before and after smoothing (Gamma model). Source: TDHS 2010, own calculations and illustration.

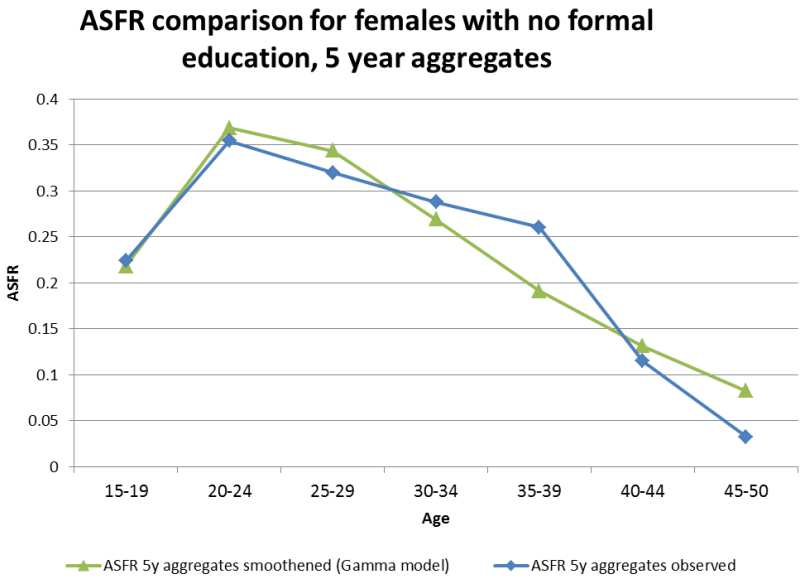


Figure 14: Women with no formal education, comparison of five year ASFRs before and after smoothing (Gamma model). Source: TDHS 2010, own calculations and illustration.

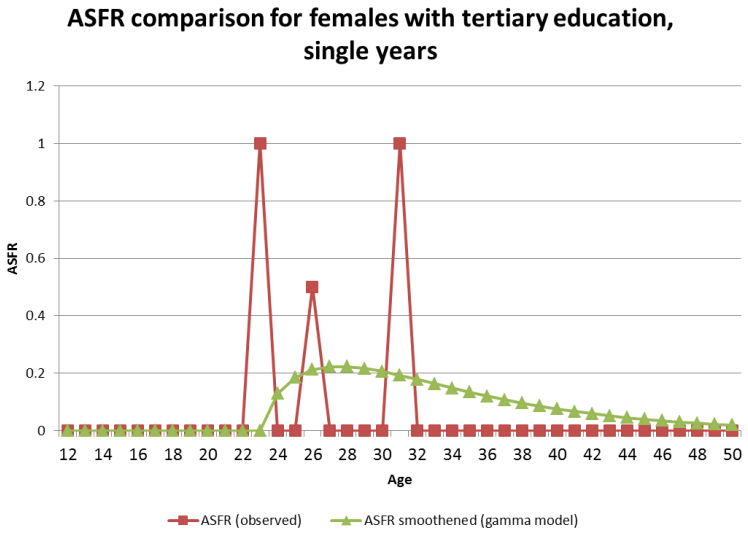


Figure 15: Women with completed tertiary education, comparison of single year ASFRs before and after smoothing (Gamma model). Source: TDHS 2010, own calculations and illustration.

The most problematic group for Tanzania is the last educational group (competed tertiary education), as the sample of women is rather small (26), which becomes especially obvious when looking at the observed ASFR in Figure 15. When using the Gamma model the earliest age of childbearing is used as a starting point (per definition not below 23, as only women aged 23+ may have already earned a tertiary degree). For reasons of comparison we have also asked Samir K.C. to

supply us with the data used by Samir K.C. from the Wittgenstein Centre ('KC data', see Figure 37 in the Appendix for the comparison). We decided against using this data and instead resorted to the use of scaling the age-specific fertility distribution of women with secondary education according to the relative ratios of observed education-specific fertility. The reasons are as follows:

- To avoid inconsistencies in our approach.
- Their definition of tertiary education varies from ours[12], in addition we have no full understanding of the decisions and models behind these numbers.
- We intend to look at effects of increases in education on population in Tanzania. Therefore, assuming significantly lower fertility for women with tertiary education could possibly result in biased outcomes. Therefore we chose conservative values so as to not overestimate the effect that an increased share of women with tertiary education may have on population size.

Figure 16 gives an overview of age-specific fertility by education. A more detailed description and analysis can be found in chapter 5.1.

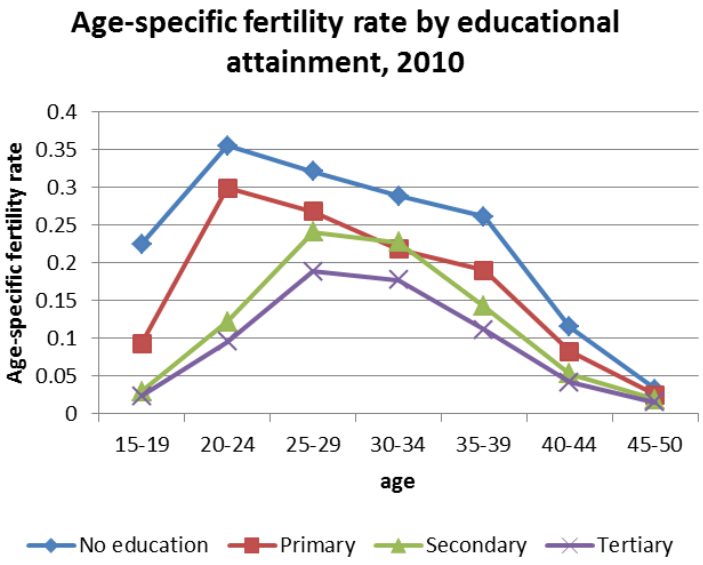


Figure 16: Women's age-specific fertility rate by educational attainment and age. Source: TDHS 2010, own calculations and illustration.

[12] Their definition of 'post-secondary' includes ISCED category 4, whereas our definition of 'tertiary' only considers ISCED 5 and 6.

4.3.2 Fertility scenarios

Similar to the scenarios presented for educational attainment, the four scenarios presented here do not necessarily reflect the most likely cases, but aim at illustrating how different developments in fertility may affect the future of Tanzania's population. Three scenarios focus on what the impact of achieving women's desired fertility may be and how this desired family size may look like in the future, whereas the last scenario is mainly to illustrate how suggested TFR developments by the United Nations would play out in this model.

Scenario 1: "100% of desired number of children instantly"

In this scenario, all women manage to reach their desired number of children starting in 2015 (which is not very realistic, but should be seen as an extreme case). The age- and education-specific fertility rate necessary to reach this desired overall TFR is calculated by applying the relative ratio between women's desired number of children to the observed TFR in 2010. In addition, a downward trend in women's desired family size as described in Figure 17 below is introduced (for theoretical musings on why a continuing downwards fertility trend may be sensible please consult chapter Chapter 0 - on page 52 regarding factors that drive the perception of desired fertility).

Figure 17 shows the desired number of children women wish to have. The solid lines give the desired number of children for women who are today aged 45-49 (who were 15-19 in 1980) and so on, the dotted lines show a linear trend derived from those observed values. A comparison of the observed TFR and desired family sizes of 15-19 year in 2010 shows that whereas young women with no or primary education wish for only 2/3 of the current family size, for women with secondary or tertiary education desired and actual family size are roughly equal. While this may not necessarily be a good approximation for the long term future (here convergence assumptions would need to be introduced) the values obtained until 2045 would range, depending on women's educational background, from 3.3 to 1.7 children.[13]

[13] For comparison: the UN assumes an overall TFR of 3.54 (medium) or 3.04 (low) depending on the fertility scenario.

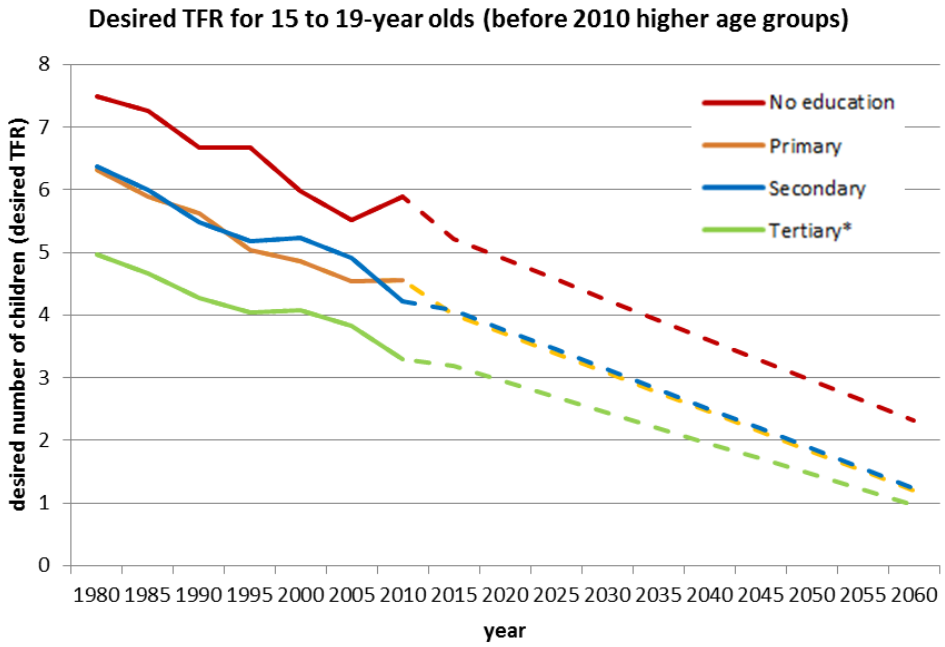


Figure 17: Desired TFR for Tanzanian women aged 15-19 (before 2010 older age groups used). Source: TDHS 2010, own calculations and illustration. * Tertiary values obtained from secondary via relative ratios.

The necessary assumption behind this scenario is thus that a woman's desired family size stays constant over her lifetime. This is of course a strong simplification. Several studies have found that parity also affects a woman's desired family size through "rationalization": Reaching higher parity levels at an early age may influence women to revise their stated family size preferences upwards, as they might be reluctant to provide an ideal family size that is below their current number of children (Bongaarts, 2010, 2011). It can therefore be argued that the observed desired family size among older women (who already have several living children) cannot be compared to the desired family size of younger women, and that the observed difference in desired family size is at least in part due to differences in parity. One suggested way to further investigate this relationship and to account for parity would be to also include previous DHS data sets, or to look into desired family size by age and parity.

Scenario 2: "100% of desired number of children slowly"

This scenario is similar to scenario 1, but here young women manage to reach their desired number of children starting in 2015, one age group more each period. This means for example that the desired family size of women aged 15-19 in 2010 will be realized for this cohort in 2015, and in 2020

both women aged 15-19 and 20-24 will start having fewer children in line with their desired family size. Meanwhile, fertility for women in older age groups (in 2015 those aged 20+) also decreases, but it is assumed that the ratio between desired children and born children will keep existing, thus lowering births less in this group.

The age- and education-specific fertility rates necessary to reach this desired overall TFR is calculated by applying the relative ratio between women's desired number of children to the observed TFR in 2010. In addition, a downward trend in women's desired family size as described in Figure 17 is introduced.

The reason behind introducing this slow trend is that a sudden break in behavior presented in Scenario 1 is unlikely to happen, whereas a slow introduction starting with the younger cohorts is assumed to be more likely: Younger women may still be at a point where their fertility decisions have not yet been fully formed, and where both radio campaigns or educational programs on family planning and contraception at school may have the largest effect, as these have been shown to be the main sources of information about contraception in a study on school girls in Dar es Salaam (Kagashe & Honest, 2013).

Scenario 3: "Moving towards the desired number of children"

In this scenario, the general idea of scenario 1 is kept, however we assume that this desired TFR is not fully realized: Whereas women with no or only primary educational background are assumed to stay above this desired number of children by 20% in 2020, 10% in 2040, and reach it by 2060 (currently they are above it by on average 33%), women with secondary and higher educational background do not reach their desired family size. They are assumed to constantly stay below it by 10% (women with tertiary education start at this level, whereas for women with secondary education this trend is introduced by 2020 (and values until then are interpolated), as the desired number roughly equals fertility for women with secondary education.

This assumption is in line with literature on education and fertility as well as the results from section 5.1: Women with no education have less knowledge about contraception and the highest unmet need for family planning, and are thus the most likely to stay significantly above their desired family size. As the category 'primary education' is defined here as having at least one year of primary education and the ratio between desired and actual fertility is similar to that of women with no

formal education this group is also assumed to behave similarly. Women with secondary and tertiary education, on the other hand, have been shown to even stay below their desired family size, as finishing her education and higher opportunity costs of having children may interfere with a woman's reaching her desired family size (see Bongaarts, 2010 for a comparison of 30 African countries).

Scenario 4a: "UN medium fertility"

For this scenario the overall TFR is set to the fertility assumptions presented by the United Nations for their "medium fertility" scenario (United Nations, 2013). Then, an optimization procedure is used to adjust education-specific ASFRs to this goal. By applying relative ratios and thus assuming that the ratios between education-specific TFRs stay the same (e.g. that the TFR for tertiary equals 78% of the TFR for secondary), education- specific ASFRs are thus scaled so as to fit the overall TFR goal. The assumed TFR scenario is depicted in Figure 18.

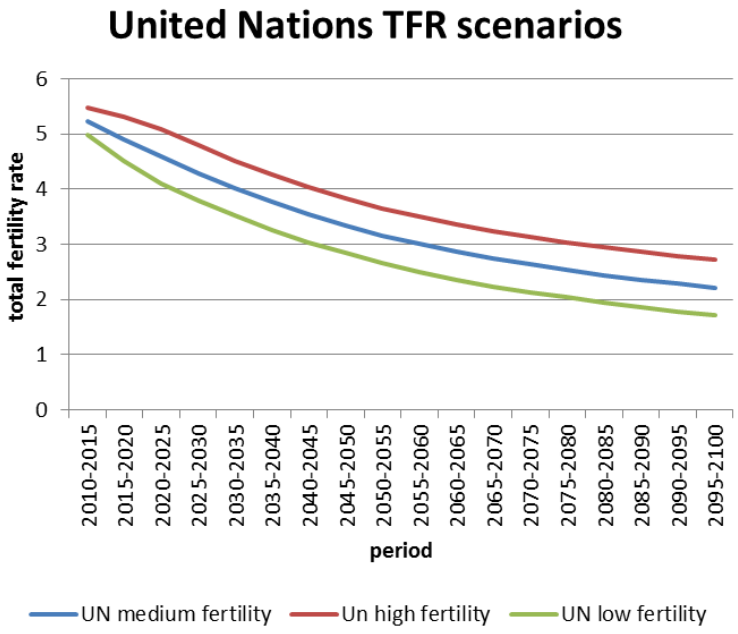


Figure 18: Total fertility rates used by the United Nations (2012) for three scenarios. Source: United Nations (2012), own illustration.

Scenario 4b: "UN high fertility"

Similar to scenario 4, the overall TFR is set to the fertility assumptions presented by the United Nations for their "high fertility" scenario (United Nations, 2013), which lies 0.5 children above their

"medium fertility" scenario. In a next step, an optimization procedure is used to adjust education-specific ASFRs to this goal. The assumed TFR scenario is depicted in Figure 18.

Scenario 4c: "UN low fertility"

Similar to scenario 4, the overall TFR is set to the fertility assumptions presented by the United Nations for their "low fertility" scenario (United Nations, 2013), which lies 0.5 children below their "medium fertility" scenario. In a next step, an optimization procedure is used to adjust education-specific ASFRs to this goal. The assumed TFR scenario is depicted in Figure 18.

4.4 Mortality data

Mortality data (qx and ax) for the population projections was taken from the United Nations Population Division (see United Nations, 2013 for a detailed methodology). In a further step, the Brass mortality model was used to extend this mortality data in order to be able to include higher age groups (see Appendix for details).

4.5 Data quality

As the information on the base year population by education for Tanzania is not available from the National Statistics Office it is not possible to compare whether the sample used in the TDHS correctly represents the educational distribution of the population. Insofar as distribution by age (in single years) and sex is concerned Figure 19 shows that the population distribution by these categories in the TDHS 2010 is similar to that of the 2012 census, even though it is smoother (females are depicted in the positive and males in the negative range). Taking into consideration that TDHS data was also aggregated into 5-year groups it is assumed that the formal educational distribution of the population in the TDHS is representative of the formal educational distribution of the Tanzanian population in 2010. The necessarily assumed accuracy of DHS data regarding education is thus one of the main weaknesses of this data and the population projection model.

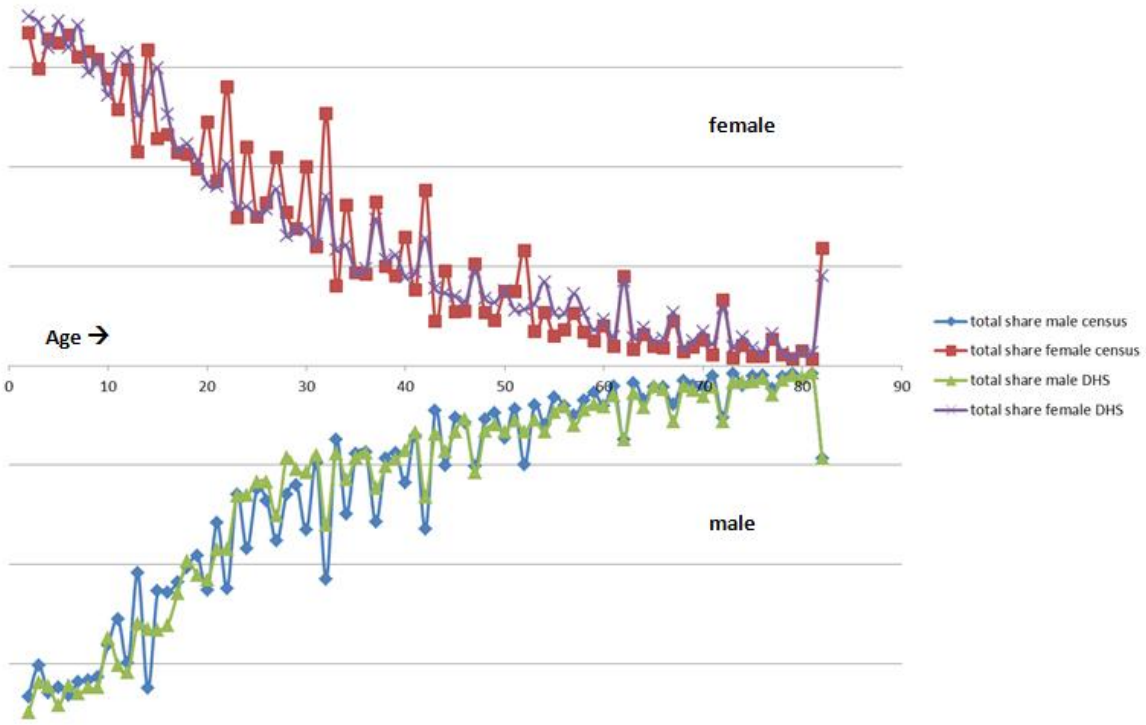


Figure 19: Comparison of relative shares populations by age (single years) and sex. Data source: TDHS 2010 and 2012 Census sample, own illustration.

5. Results

This results section is divided into two main parts:

- **Chapter 5.1** discusses fertility in Tanzania and the role of education in it by analyzing TDHS 2010 micro data along Coale's preconditions for a lasting fertility decline (Coale, 1973).
- **Chapter 5.2** then focuses on the results of the education-specific population projection model.

The educational definitions used in the results section always refer to the categories described in Figure 8 (on page 33).

5.1 Education and fertility decline in Tanzania

5.1.1 Fertility and education in Tanzania today

Ayoub (2005) investigates the economic relationships between women's schooling, fertility rates and contraceptive use in Tanzania and finds that women's schooling and other socioeconomic variables are important in explaining reproductive behavior: Higher female education is found to be consistently associated with lower fertility levels and higher contraceptive use. Table 1 gives an overview of fertility indicators by education:

Table 1: Women's fertility by educational attainment, Tanzania 2010. Source: TDHS 2010, final report.

Educational attainment[14]	Total Fertility Rate (TFR)	% of women currently pregnant	Mean number of children ever born to women age 40-49
No education	7.0	12.7	6.8
Primary incomplete	6.0	10.3	6.3
Primary complete	5.5	10.0	5.7
Secondary+	3.0	3.7	4.1

Note: Total fertility rates are for the period 1 to 36 months prior to interview.

[14] These educational categories differ from the ones used in the rest of the analysis and the population projection model.

A review of the scientific literature gives an indication of what to expect regarding the relationship between education, fertility desires and actual fertility (Castro Martin & Juarez, 1995; Cochrane, 1979; Jejeebhoy, 1995): Women with at least primary education usually incorporate fewer child deaths into their planning, and consider fewer children as desirable than women with no or less than primary education. In addition, women with higher educational attainment are on, average, in a better position to use family planning and thus control fertility. This is reflected in Figure 20 below: Women's age-specific fertility rate in 2010 differs significantly by educational attainment over all age groups between 15 and 50. For women with no or primary education, the fertility peak is at a very young age (20-24). For secondary education, the peak age groups are 25-34, which is in line with the idea that enrolled women may prefer not to have a child yet, as it may prove difficult to complete the education. Young women who have the opportunity to contribute financially to their parents' household may also be married later (Kravdal, 2001). This is also why the only intersection of education-specific ASFR lines happens in age group 30-34, where fertility in lower educational groups has already decreased, but is still high for women with secondary education, who may have delayed childbirth due to educational or occupational reasons.

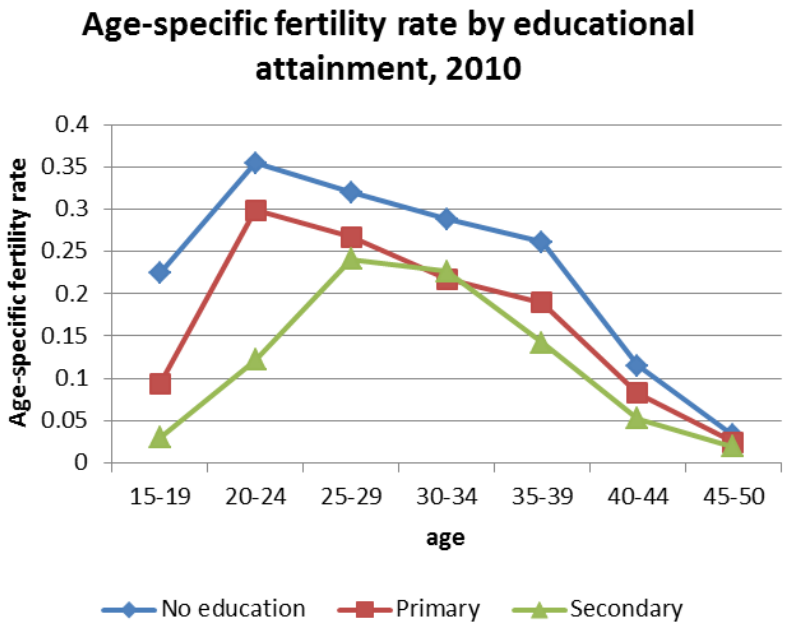


Figure 20: Women's age-specific fertility rate by educational attainment and age. Source: TDHS 2010, own calculations and illustration.

5.1.2 Preconditions for a lasting fertility decline by education

Coale highlights three preconditions that need to be met in a country in order to achieve a long lasting fertility decline(Coale, 1973): (I) Fertility must be within the calculus of conscious choice, (II) Effective techniques of fertility reduction must be known and available, and (III) Reduced fertility must be perceived to be advantageous.

The aim of this section is to look at whether these preconditions are met in Tanzania by using data obtained from the Demographic Health Survey 2010, with a focus on whether differences between educational exist and what that may mean in terms of policy.

Fertility must be within the calculus of conscious choice

The first precondition states that fertility must be within the calculus of conscious choice. Figure 21 shows that 3,8% of Tanzanian women with no formal education do not give a numeric response when asked about their desired number of children and thus family size, whereas this is the case for only 0,9% of women with completed lower secondary education. The interpretation of 'conscious choice' is critical in order to understand what this precondition implies, and Coale defines it as follows: "Potential parents must consider it an acceptable mode of thought and form of behavior to balance advantages and disadvantages before deciding to have another child – unlike, for example, most present day Hutterites or Amish, who would consider such calculations immoral, and consequently do not control marital fertility" (Coale, 1973).

Van de Walle even states that "a decline in fertility is not very far away when people start conceptualizing their family size, and it cannot take place without such conceptualizing" (Vann de Walle, 1992:501). It can thus be assumed that, even though the share of women giving non-numerical answers is rather low for all educational groups, Tanzanian women with less formal education are nearly four times as likely to consider fertility control (societally) inacceptable as women with secondary education.

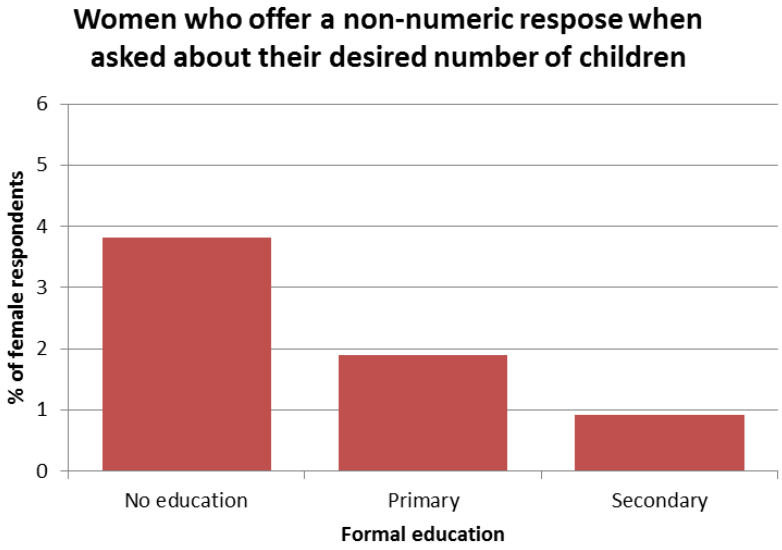


Figure 21: Shares of Tanzanian women who offer a non-numeric response when asked about their desired number of children, by formal category of education. Source: Data from TDHS 2010, own calculations. [15]

Effective techniques of fertility reduction must be known and available

The second precondition for a lasting fertility decline states that means of birth control must both be known and available for effective use. Figure 22 shows that in Tanzania modern contraceptive methods are widely known across educational groups and that only very small fractions of women with no (4,6%) or only primary education (0,9%) are not aware of contraceptive methods. A closer look at the group of women with no formal education reveals that this share is highest among the youngest age group (age 15-19) with 14.5% (Figure 23).

[15] The last educational group has a very small sample size (26 women), therefore results might not be reliable for the group with tertiary education and are not depicted (3.85%) . Sample size for other educational categories: no education (1.912), primary education (6.360), secondary education (1.841).

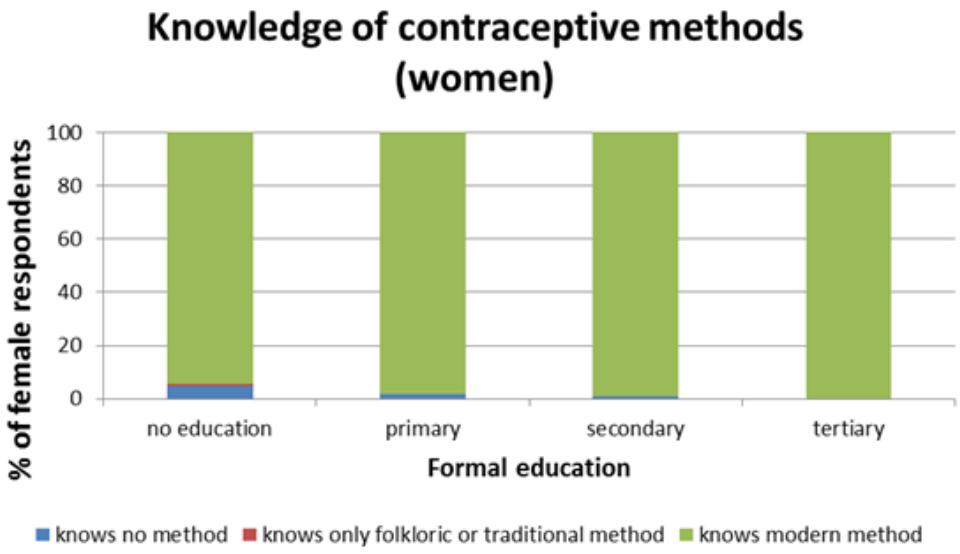


Figure 22: Knowledge of contraceptive methods, Tanzanian women by formal educational category. Source: Data from TDHS 2010, own calculations.

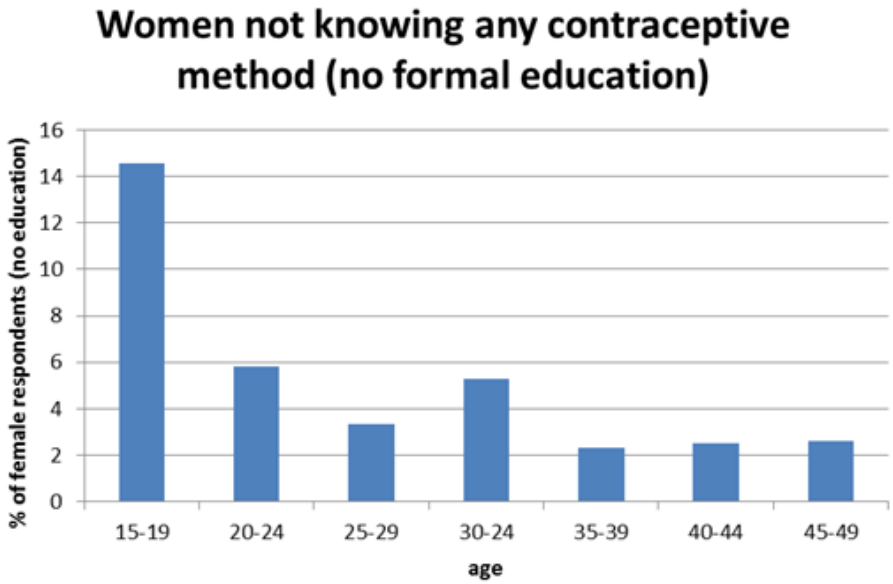


Figure 23: Share of women with no formal education who do not know any contraceptive method, by age. Source: Data from TDHS 2010, own calculations.

Figure 24 gives an overview of women with self-defined unmet need (latent demand) for family planning by formal education and shows that unmet need exists across all educational groups even though it decreases with education (24% of women with no education have unmet need, compared to 20% of women with primary or secondary education and only 10% of women with tertiary

education).This tendency reflected in the results is in line with the findings that women with higher education have better access to family planning (Bongaarts, 2010; Jejeebhoy, 1995).

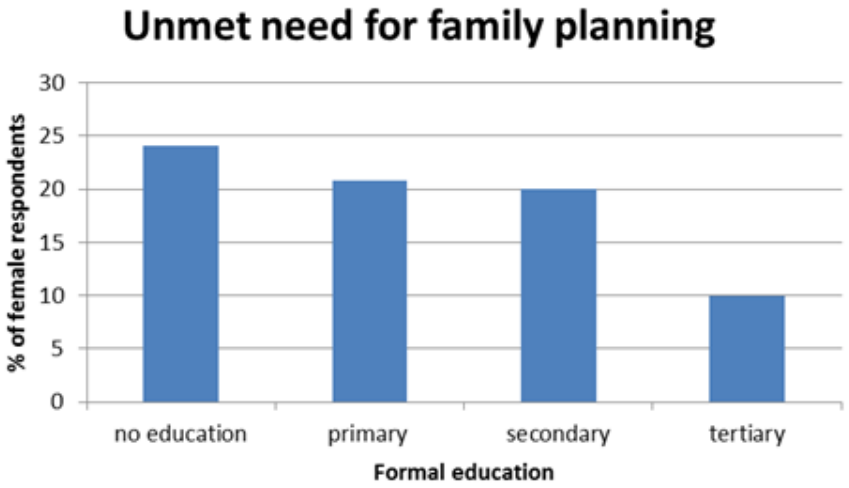


Figure 24: Unmet need[16] for family planning by formal education. Source: Data from TDHS 2010, own calculations.

Therefore, it is necessary to look closely at what women with unmet need for family planning see as the main reasons for not using contraceptives. Unfortunately, the sample size is too small to get accurate differences by education, thus only aggregate statements can be made. Figure 25 shows that the main reason, given by 34% of women with unmet demand, is that they are afraid of side effects (34%) and have health concerns (10%), followed by partner opposition with 13% and own opposition with 10%. Issues such as religious reasons, an interference with the body's processes, access or the costs of the contraceptive are not seen as a large factor (named by less than 2.5% of women with unmet demand).

[16] Unmet need/demand was calculated by dividing the sum of women with unmet need for spacing and limiting by women aged 15-49 who are neither sexually inactive nor infecund/menopausal.

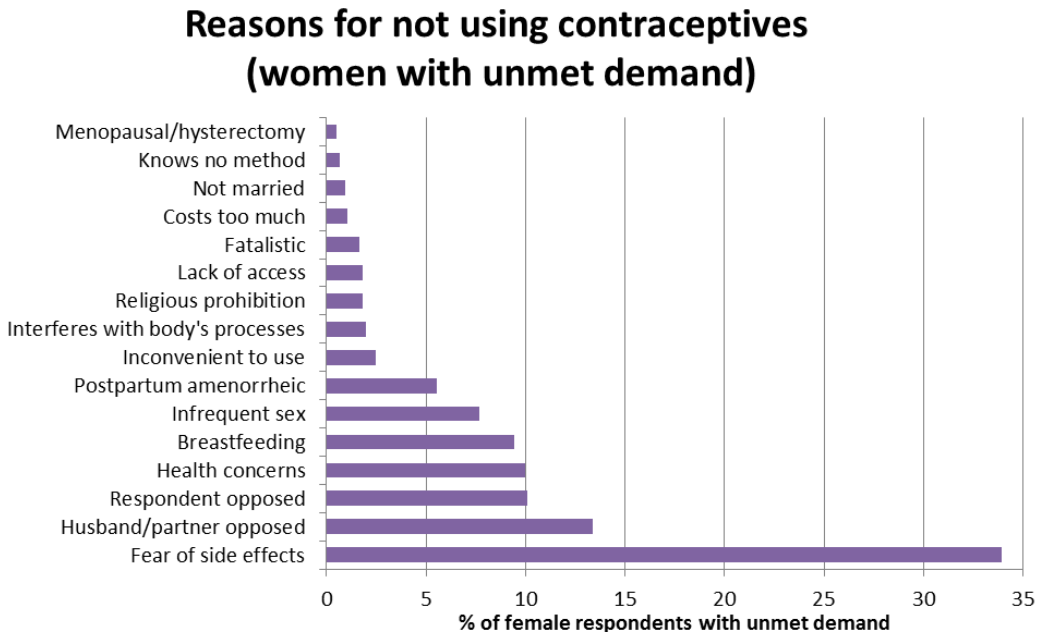


Figure 25: Reasons given by women with unmet demand for not using contraceptives (multiple answers possible). Source: Data from TDHS 2010, own calculations.

One open question is thus whether this fear of side effects stems from missing knowledge about how contraceptives work, or whether women truly do fear to bear the consequences that may arise from the use of e.g. hormonal contraception or intrauterine devices (IUDs). Only 5% of the women covered in this DHS have some type of health insurance, and this is again unevenly distributed across educational groups (1.5%/no education, 4%/primary education, 10.5%/secondary education, 36% tertiary education). If one also takes into account Richey's (2003) research into the Tanzanian health system, who e.g. found that blood pressure cuffs were unavailable in the 1990s (it is necessary to screen patients before prescribing hormonal contraceptives), one conclusion to be reached is that even though contraceptives may be physically available there is a large need to integrate these family planning measures into a functional overall health system, as the use of contraception without the necessary and appropriate overall healthcare also poses dangers and is thus not very well-received by women.

The second most important reason is that the husband or partner opposes to the use of contraception. Kravdal notes that Tanzanian women "are supposed to have particularly little influence over their lives compared to men" (2001, p. 109), which may be especially true for the relatively large share of Muslim population. As women's own opposition, however, also plays an

important role and motivations behind these oppositions cannot be grasped, there is not enough information to support or discard this hypothesis.

Reduced fertility must be perceived to be advantageous

This section shows how desired family size in Tanzania varies both across educational groups and over time.

Wanted children and education are usually inversely related (Bongaarts, 2003), which is reflected in Figure 26: It shows that what a woman in Tanzania considers her desired number of children (excluding non-numeric responses) differs by educational category and is decreasing over cohorts. Women aged 15-19 have a desire for a smaller family; with 1.6 to 2.4 children less than women aged 40-44. Furthermore it is very interesting to see is that this trend of decreasing desired family size of younger women is strongest with women who have attained secondary education (note the downward slope in age groups 15-19 to 20-24), stays constant between 15-19 and 20-24 for women with primary education, and has even slightly increased in the case of women with no education aged 15-19 when compared to those aged 20-24. As women at different ages are compared, however, rationalization of their own family size most likely contributes to the higher values for women in older age groups. They may revise their family preferences so as to not stay below their current family size (Bongaarts, 2010, 2011).

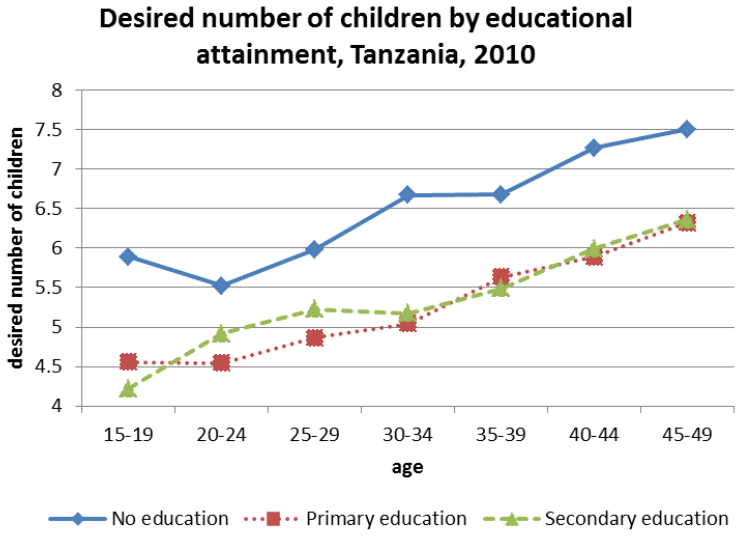


Figure 26: Desired number of children for Tanzanian women by educational attainment. Source: Data from TDHS 2010, own calculations.

Explanations of why the advantages of reduced fertility are perceived differently depending on a woman's education include higher opportunity costs on unintended childbearing, such as a salary income (Bongaarts, 2010; Shapiro & Gebreselassie, 2008). Jejeebhoy (1995) also argues that children may be less necessary as an insurance when a woman is able to earn a living on her own or can save money for the future.

Regarding the visible trend over time, there are also several factors to which a change in attitude towards family size has been attributed: Place of residence and thus urbanization may play a large role, as costs of raising children most likely increase in urban households (urban housing is more expensive and children are of less value in household production than in rural areas, where they can help in farming) and it has been suggested that migration to urban areas entails an adaptation to new norms that accord with reduced fertility (Goldstein, 1983; White, Muhidin, Andrzejewski, & Tagoe, 2008). Fuchs and Goujon argue that attitudes towards children in transitional societies such as Tanzania change mainly due to the import of Western culture through mass education and the mass media (Fuchs & Goujon, 2014), and Caldwell (1982) distinguishes between Westernization (of institutions, values and aspirations) and economic modernization, and uses the case of Sri Lanka as an example that these two need not occur together. Mass media may further increase the impact of education, so that even a smaller amount of education can result in a decline in fertility (Fuchs & Goujon, 2014). Mass education, on the other hand, may even lead to 'spillover effects' so that even uneducated women who live in an educated society show differing fertility behaviors. Another suggestion is that the share of the population most exposed to new ideas, be it because of their education or their area of residence, function as trendsetters of population change (Bongaarts, 2011). The idea of ideational change also plays a large role in modern theories of fertility transition, such as cultural factors, family organization and parents' education. These factors are stated to be even more important to how family ideals are diffused than economic wellbeing and female employment (Cleland & Wilson, 1987; Fuchs & Goujon, 2014; Lesthaeghe & Surkyn, 1988).

5.2 Population projection model

First, a short overview of the results for all scenarios is given. Four scenario combinations – ranging from optimistic to pessimistic are then described in more detail. In a further step, results for the different UN fertility scenarios are summarized. Population pyramids for all scenarios can be found in the Appendix (page 84).

5.2.1 Overall results

Scenario overview

An overview of the different scenarios regarding fertility and education is given below in Figure 27. The four scenarios that are described in more detail were selected so as to reflect the range of potential developments, thus they include a pessimistic, an optimistic, a likely as well as a UN scenario. [17] A figure categorizing all scenarios by whether they are more on the optimistic side (e.g. assuming that universal primary and secondary education will be reached by 2030), moderate (following a global education trend) or pessimistic (assuming constant enrollment rates at all educational levels) can be found in the appendix.

Overview scenario combinations			EDUCATION SCENARIO			
			A: Constant Enrollment Rates	B: Likely	C: Sustainable Development Goals	D: Fast Track
FERTILITY SCENARIO	1: 100% desired number of children instantly		1A	1B	1C	**1D**
	2: 100% desired number of children slowly		2A	2B	**2C**	2D
	3: Moving towards the desired number of children		**3A**	**3B**	3C	3D
	4	4a: Solver UN medium fertility	4aA	4aB	4aC	4aD
		4b: Solver UN high fertility	4bA	4bB	4bC	4bD
		4c: Solver UN low fertility	4cA	4cB	4cC	4cD
Scenarios:			Pessimistic	Likely	UN goals	Optimistic

Figure 27: Overview of scenario combinations.

[17] For details on the calculation of and assumptions behind education scenarios please see chapter 4.2.3, for fertility scenarios chapter 4.3.2.

Summarized results

Figure 28 gives an overview of the projected total population size over time from all possible (4x6) combinations of fertility and education transition scenarios:

- The three scenario categories that aimed at reaching an overall TFR set by the United Nations stand out and are close together despite variations in education transitions (Scenario 4a in orange and 4b in blue), which is to be expected as the aim for these scenarios was to vary education-specific fertility rates.

- The grey paths the middle include several scenarios, such as 4c (UN low fertility), 2 (100% desired number of children slowly), and 3 (moving towards the desired number of children).

Figure 28 gives an overview of the outcome from all possible (4x6) combinations of fertility and education transition scenarios:

- The scenarios that aimed at reaching an overall TFR set by the United Nations stand out and are close together despite variations in the education transitions (Scenario 4a in orange and 4b in blue), which is to be expected as the aim for these scenarios was to vary education-specific fertility rates.

- The grey paths the middle include several scenarios, such as 4c (UN low fertility), 2 (100% desired number of children slowly), and 3 (moving towards the desired number of children).

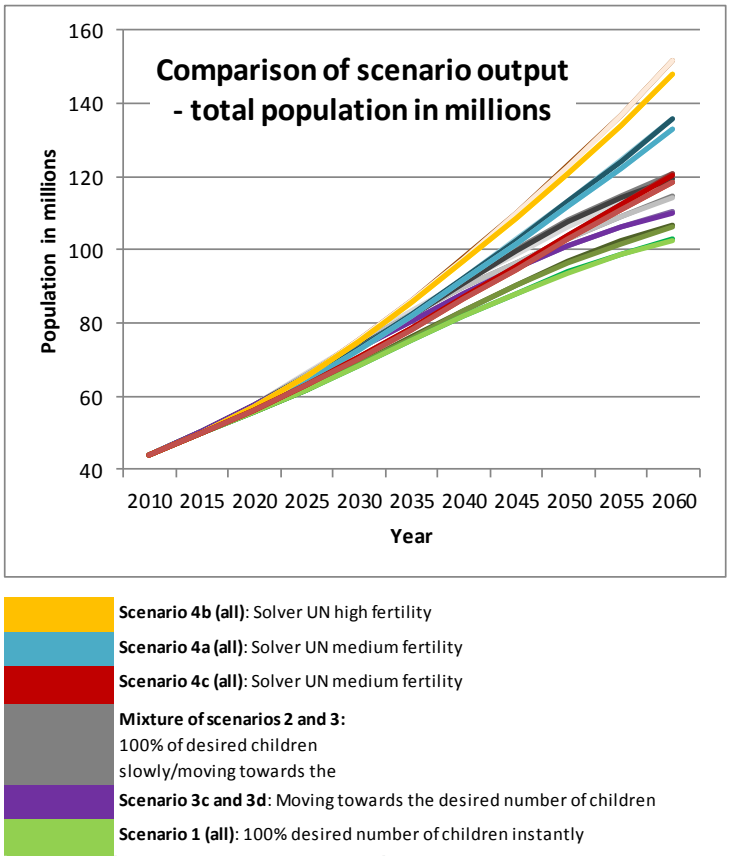


Figure 28: Comparison of all scenarios, grouped by fertility scenario.

Table 2 summarizes the projected population sizes, median age, the share of the population below the age of 15, and the share of the population aged 65+ for the periods 2030 and 2060 by scenario. It shows that the large variations between scenarios regarding the overall population composition are strongly determined by the fertility assumptions behind the projections (as variations between e.g. scenarios 1A-1D are small, but larger between 1A and 2A). Table 3 gives an overview of how the shares of educational groups (in the population age 25+) are estimated to develop until 2030 and 2060, for all scenario combinations.

	2010				2030				2060			
Scenario	Population size in millions	median age	Proportion below age 15	Proportion age 65+	Population size in millions	median age	Proportion below age 15	Proportion age 65+	Population size in millions	median age	Proportion below age 15	Proportion age 65+
1A	44.17	17.42	45.86%	4.49%	68.776	23.78	35.23%	4.59%	106.912	30.82	22.76%	8.01%
1B					68.748	23.81	35.20%	4.59%	106.081	31.10	22.42%	8.08%
1C					68.395	24.16	34.87%	4.62%	102.801	32.12	21.89%	8.33%
1D					68.388	24.16	34.86%	4.62%	102.403	32.26	21.68%	8.37%
2A					74.847	20.81	40.48%	4.22%	119.162	30.53	23.67%	7.19%
2B					74.862	20.82	40.49%	4.22%	118.311	30.79	23.32%	7.24%
2C					74.508	21.17	40.21%	4.24%	114.465	31.80	22.71%	7.48%
2D					74.502	21.18	40.20%	4.24%	114.005	31.93	22.49%	7.51%
3A					73.390	21.40	39.30%	4.30%	120.607	30.23	23.50%	7.10%
3B					73.391	21.43	39.30%	4.30%	119.534	30.54	23.08%	7.17%
3C					72.839	22.01	38.84%	4.33%	110.558	32.13	20.97%	7.75%
3D					72.833	22.01	38.83%	4.34%	110.150	32.27	20.77%	7.78%
4aA					72.931	21.19	38.92%	4.33%	135.795	25.98	30.46%	6.31%
4aB					72.925	21.20	38.91%	4.33%	135.583	26.03	30.39%	6.32%
4aC					72.744	21.37	38.76%	4.34%	132.933	26.56	29.83%	6.44%
4aD					72.743	21.37	38.76%	4.34%	132.900	26.57	29.82%	6.45%
4bA					75.279	20.72	40.82%	4.19%	151.783	24.83	33.24%	5.64%
4bB					75.272	20.73	40.82%	4.19%	151.483	24.89	33.15%	5.66%
4bC					75.072	20.89	40.66%	4.21%	147.874	25.48	32.42%	5.79%
4bD					75.071	20.90	40.66%	4.21%	147.830	25.49	32.41%	5.80%
4cA					70.583	22.71	36.88%	4.47%	120.618	28.57	27.39%	7.10%
4cB					70.577	22.72	36.88%	4.47%	120.479	28.61	27.34%	7.11%
4cC					70.416	22.87	36.73%	4.48%	118.637	29.04	26.96%	7.22%
4cD					70.415	22.87	36.73%	4.48%	118.614	29.05	26.96%	7.22%

Table 2: Main indicators for all 24 population projection scenario combinations.

Population age 25+: highest educational attainment (shares)	2010				2030				2060			
Scenario	No education	Primary	Secondary	Tertiary	No education	Primary	Secondary	Tertiary	No education	Primary	Secondary	Tertiary
1A	29.7%	57.4%	12.3%	0.59%	13.8%	61.6%	23.6%	0.92%	7.8%	62.6%	28.4%	1.10%
1B					13.1%	63.8%	22.3%	0.81%	6.0%	63.3%	27.2%	3.47%
1C					13.1%	60.3%	25.5%	1.00%	3.4%	23.2%	63.9%	9.41%
1D					13.1%	60.3%	25.2%	1.32%	3.4%	23.2%	58.9%	14.46%
2A					13.8%	61.6%	23.6%	0.92%	7.7%	62.7%	28.5%	1.10%
2B					13.1%	63.8%	22.3%	0.81%	5.9%	63.2%	27.3%	3.62%
2C					13.1%	60.3%	25.5%	1.00%	3.1%	20.9%	66.1%	9.97%
2D					13.1%	60.3%	25.2%	1.32%	3.1%	20.9%	60.7%	15.35%
3A					13.8%	61.6%	23.6%	0.92%	7.8%	62.6%	28.5%	1.10%
3B					13.1%	63.8%	22.3%	0.81%	5.9%	63.2%	27.3%	3.59%
3C					13.1%	60.3%	25.5%	1.00%	3.2%	21.5%	65.5%	9.79%
3D					13.1%	60.3%	25.2%	1.32%	3.2%	21.5%	60.2%	15.06%
4aA					13.8%	61.6%	23.6%	0.92%	7.8%	62.6%	28.5%	1.10%
4aB					13.1%	63.8%	22.3%	0.81%	5.9%	63.2%	27.3%	3.64%
4aC					13.1%	60.3%	25.5%	1.00%	3.1%	21.1%	65.8%	10.04%
4aD					13.1%	60.3%	25.2%	1.32%	3.1%	21.1%	60.4%	15.46%
4bA					13.8%	61.6%	23.6%	0.92%	7.7%	62.7%	28.5%	1.10%
4bB					13.1%	63.8%	22.3%	0.81%	5.8%	63.1%	27.4%	3.73%
4bC					13.1%	60.3%	25.5%	1.00%	3.0%	20.1%	66.6%	10.34%
4bD					13.1%	60.3%	25.2%	1.32%	3.0%	20.1%	61.0%	15.93%
4cA					13.8%	61.6%	23.6%	0.92%	7.8%	62.6%	28.5%	1.10%
4cB					13.1%	63.8%	22.3%	0.81%	6.0%	63.3%	27.2%	3.54%
4cC					13.1%	60.3%	25.5%	1.00%	3.3%	22.2%	64.8%	9.71%
4cD					13.1%	60.3%	25.2%	1.32%	3.3%	22.2%	59.6%	14.93%

Table 3: Shares of educational groups in 2010, 2030 and 2030 for all 24 population projections scenario combinations.

5.2.2 Detailed results

To illustrate the range of results four scenarios have been chosen: 1D (optimistic), 2C (UN goals), 3A (pessimistic), and 3B (likely).

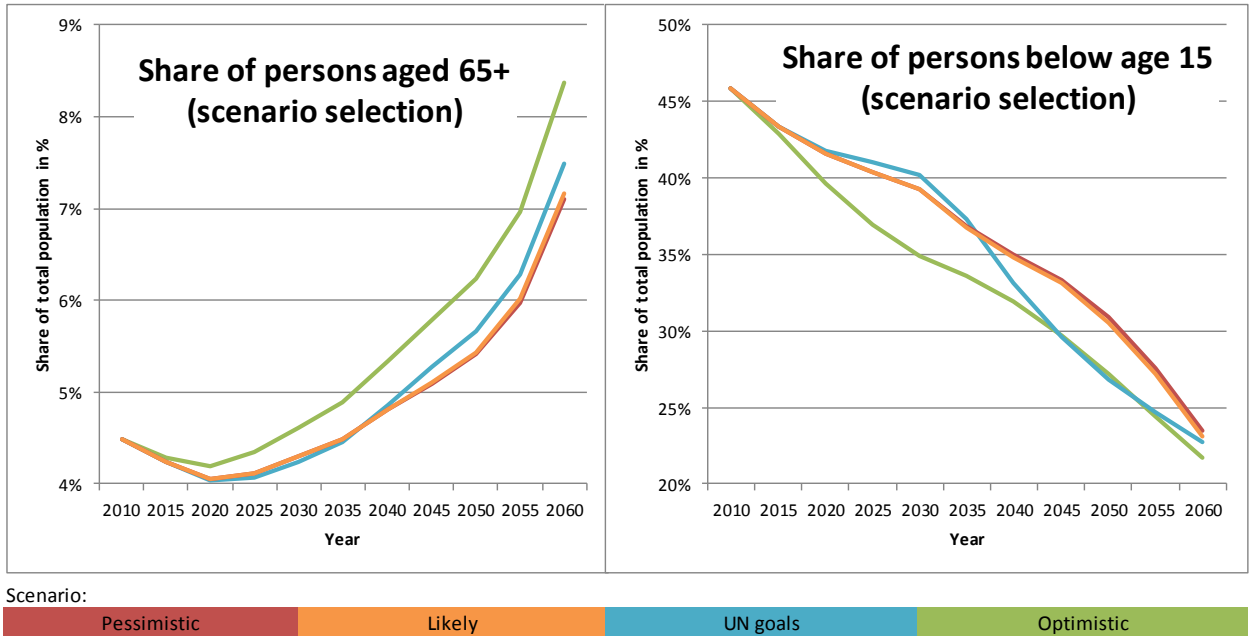


Figure 29: Development of the share of persons aged 65+ and below 15 for scenarios 1D, 2C, 3A, 3B.

Figure 29 compares the projected shares of people aged 65+ and the shares of the young (below age 15). In both cases the optimistic scenario differs most from the other scenarios, with a consistently larger share of older people, and the fastest early decrease in the share of the young population (though in the latter case a convergence takes place towards 2060).

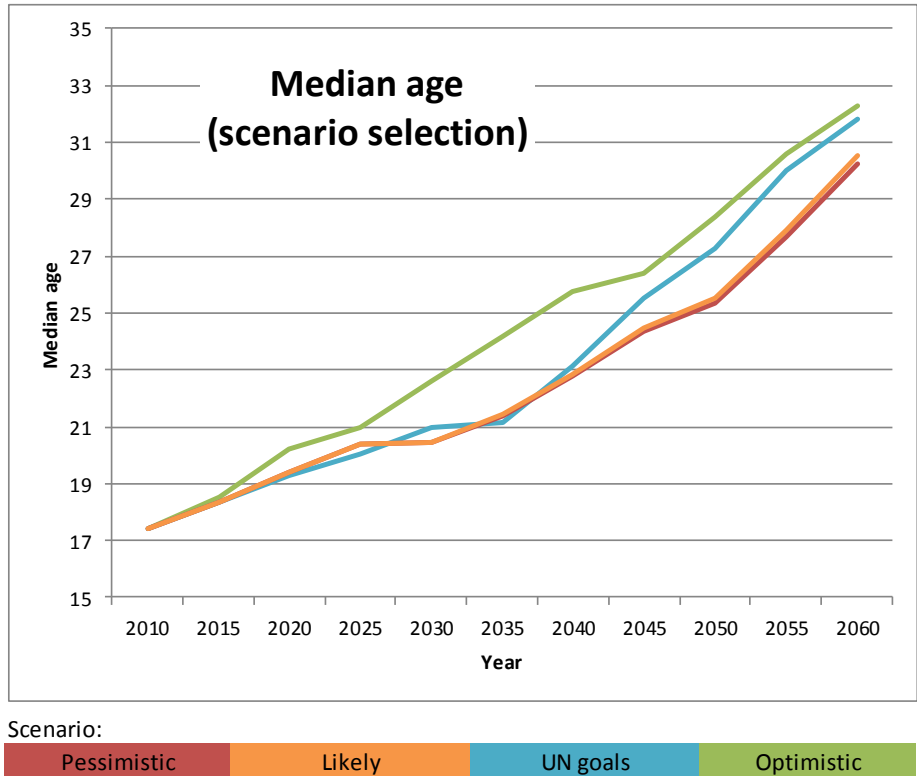


Figure 30: Development of the median age for scenarios 1D, 2C, 3A, 3B.

Figure 30 depicts the trend in median age by scenario and clearly indicates that the median age will increase even in the most pessimistic scenario, from 17.5 years in 2010 to 20 - 22.5 years in 2030 and 30 - 32 years in 2060. It shows that the median age is highest in the optimistic scenario; though the gap between scenarios is widest in the year 2035 and then starts to slightly narrow again.

Figure 31 on the next page compares the different population pyramids for Tanzania in 2060. The population size and shape as well as the educational composition in 2060 vary between scenarios. Even though the difference in total population size may at times not seem very large it has to be emphasized that changes in female educational composition and their effect on fertility work strongly in the long run (after 2060).

- The population size estimations vary between 102 (optimistic) and 121 million (pessimistic) people, whereas the likely scenario estimates the Tanzanian population size in 2060 at 120 million. In case the UN education goals are reached, the projected population size is smaller, with 114 million.

- The shapes of the population pyramids also differ: The more optimistic scenarios (optimistic and UN goals) already have had lower birth rates for a longer period of time. The contraction at the base of the pyramid is most pronounced for the optimistic scenario. For the likely and pessimistic scenario the population pyramid has only recently started to contract (this narrowing of the base is mostly due to assumed declining desired fertility rates after 2030 in scenario 3), and the largest age group is that of persons aged 15-19.

- The educational composition in the SDG scenario is similar to that of the optimistic one, with only people aged 45+ having no or only primary education. In case of the optimistic scenario a larger share of enrollment in tertiary education can also be observed. Whereas in the likely scenario a moderate increase in the shares of secondary and tertiary education can be seen, these shares stay the same in case of constant enrollment rates.

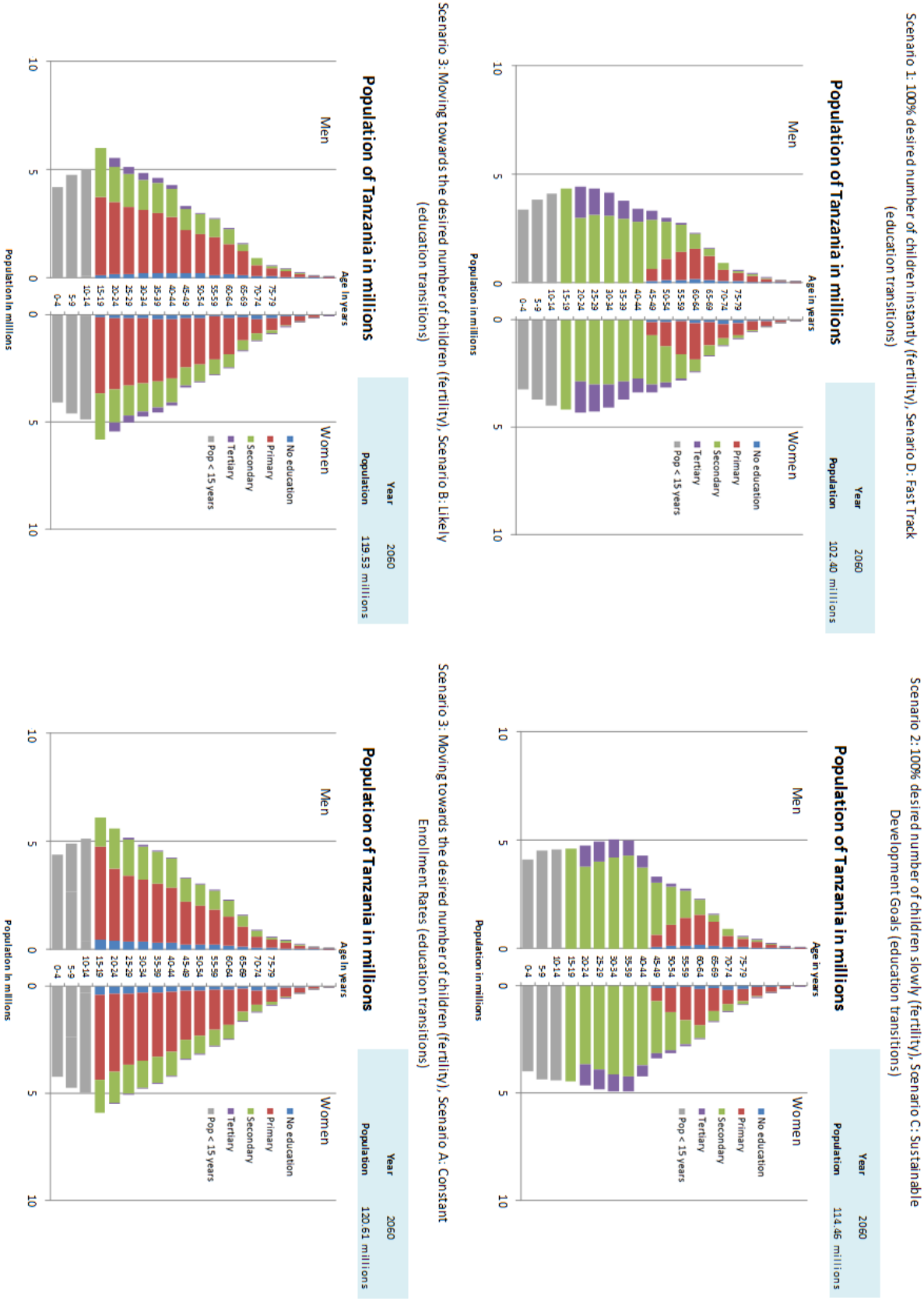


Figure 31: Comparison of population pyramids in 2060 for scenarios 1D, 2C, 3A, 3B.

5.2.3 Results for UN fertility scenarios

As previously discussed, the aim of including these three scenarios is to illustrate how education-specific fertility rates would need to change in order to achieve a certain overall TFR. Figure 32 gives an overview of these changes, with each box depicting a different TFR target. These calculations have assumptions that need to be kept in mind: It is assumed that the age distribution of education-specific fertility stays the same. This might not necessarily be true as women may start to have children at a later age, e.g. due to adaptation to higher life expectancy or a decrease in marriages and pregnancy of teenage women. We also assume that the ratios between the education-specific TFRs stay the same, e.g. that fertility for women with tertiary education equals 78% of the fertility for women with secondary education. Educational differentials, however, have been shown to be largest for countries in the early stages of the demographic transition and seem to narrow down once the overall TFR reaches 4 children (K.C. & Potancokova, 2013).

The influence of the overall target (medium/high/low fertility) is clearly visible in each of the three graphs, with the third graph showing the strongest decline in fertility by women's educational attainment. Whereas women with no formal education had on average 8 children in 2010, in the case of the "Likely" (B) educational development (in blue) their fertility would need to decrease to 4.5 children in the medium fertility scenario in 2060, to slightly above 5 children in the high fertility scenario and to below four children in the low fertility scenario. In the case of the "Constant Enrollment Rates" (A) educational scenario these numbers are even lower, and in the case of the optimistic scenarios "Sustainable Development Goals" and "Fast Track" (C and D) education-specific fertility can be much higher (up to two children!) and still reach UN overall TFR[18]. This is of course because the scenarios differ by the share of women in each education group. If there are more women in groups with a lower education-specific fertility (e.g. secondary and tertiary education), average fertility in all groups can be higher.

What do these results mean for Tanzania? They underline how important an instrument education may be in population policy, and that even a set overall fertility goal may be reached in very different ways: By only targeting fertility, or by combining family planning and (female) education, which is much more effective.

[18] As can be seen in the graphs the results between Scenario C and D hardly differ, as the only difference between them lies with more ambitious enrolment rates in tertiary education.

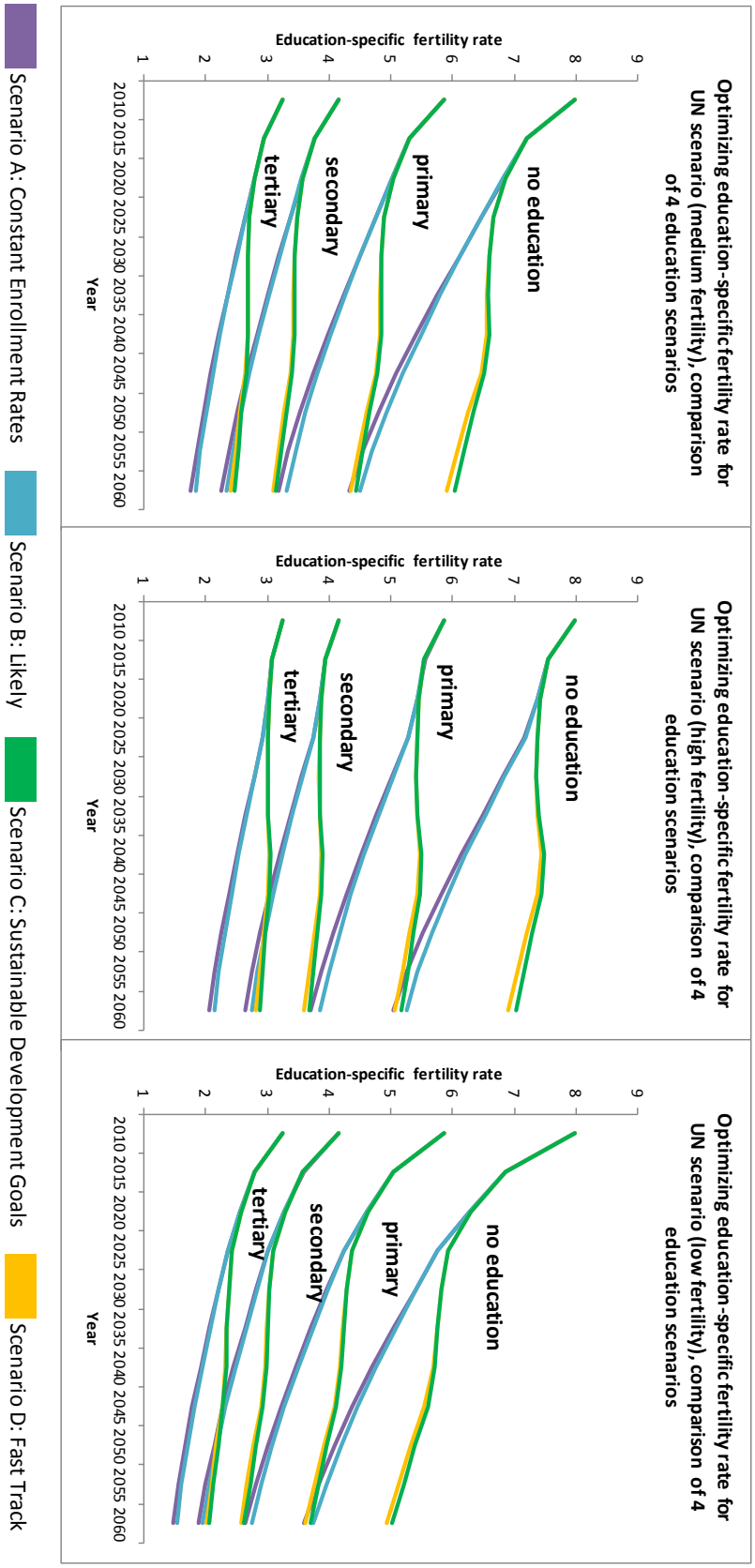


Figure 32: Comparison of fertility optimization for four education scenarios.

6. Summary and discussion

6.1 Summary of outcomes and conclusion

Based on the education and fertility scenarios presented here, Tanzania's total population size in 2060 could vary from 102 to 121 million in 2060, when taking the three UN fertility scenarios as baseline this range is much higher, between 119 and 152 million. The latter range would equal an increase of the country's total population size by 169-244% in only 50 years. A comparison of own projections to estimations by the United Nations shows that our results consistently stay below the UN medium projections, and are mostly consistent with the SSP 2 (medium development) projections by the Wittgenstein Centre. It can thus be argued that **including education into population projections yields significantly different and lower results** from population projections by only sex and age. In addition, important policy recommendations can be derived, which underline the influence of education policy on population development:

- By **aiming at fulfilling the Sustainable Development Goals of universal primary and secondary education** the estimated population size in 2060 is between 1.6% and 8.3% smaller than under a scenario of constant enrollment rates at all educational levels. Investments in secondary education may have an even stronger impact on fertility than primary education (own tabulations and Kravdal, 2001). An additional increase of tertiary education raises the maximum difference estimated to 8.6%[19]. At the same time the median age increases up to two years. These effects would become even more pronounced in the long run after 2060.[20]

- It is also necessary to underline that, even though adding education brings in a "quality" dimension to population projections (Lutz & KC, 2011), the way this dimension has been included into the projections here excludes issues such as e.g. the size of classes, the availability of books and other resources, teachers' qualifications and the course contents taught. **One important future challenge is thus to ensure the quality of the education system besides increasing enrollment rates** (see e.g. Jong-Wha, 2014).

[19] In scenario 3: Moving towards the desired number of children

[20] Even though the inclusion of education into population projection models is crucial it is hard to quantify the extent to which education may affect fertility, as has been done in this study. Thus it is important to underline that the projections presented here outline different scenarios, or potential development paths.

Tanzanian women with higher education have **smaller less children as well as a smaller desired family size** today, **give birth at later ages**, have in general better knowledge of contraception and **better access to family planning**, and thus **less unmet need** for it (10% compared to 24% of women with no education). Even though women's illiteracy and lack of education have long been seen as one of the most important factors behind high fertility, the causal ways through which education may work are hard to measure. **Education and women's status/empowerment are very likely to be closely linked**: "A woman's education is partly a result of women's general status in the community, filtered through parent's views and resources. Conversely, her education is likely to influence her individual status"(Kravdal, 2001:190). Women who are not able to fend for themselves have also been shown to have high boy preferences, which is seen as another factor contributing to high fertility (see e.g. Cain, 1993): While daughters are oftentimes involved in domestic work they are likely to earn a lower income than sons, even if they receive an equal education. As women are oftentimes much younger than their husbands they can expect a rather long widowhood. Kravdal (2001) argues that a woman may be more likely to continue working the land after her husband's death if she has a son, in addition bearing a son is expected to benefiting the whole family and may be a source of respect as well as an insurance against abandonment as well as ill treatment. Increasing education will of course have a larger impact on fertility if it goes hand in hand with other measures to empower women more generally. Women with more education may also be more likely to realize their own fertility desires and stand up to their partners in the case these oppose to contraception.

Regarding fertility and family planning several conclusions can be drawn, with all of them pointing towards the **necessity of comprehensive** (not only focusing on abstinence) **sexuality education in schools and the need for seeing fertility** not only as an issue of contraception, but **connected to health and family planning as a whole**:

- Knowledge of contraception is in general quite high, but despite this high unmet need remains. **Family planning programs**, especially if embedded into a well-functioning health care system, may be more effective than focusing on contraception alone. Even though it is argued that family planning cannot succeed given Africa's cultural bias towards larger families (Caldwell, 1982), **unmet need for contraception exists in Tanzania, and leads to unwanted pregnancies as well as unsafe abortions**. It has also been suggested that **family planning itself may reduce desired family size**, especially when accompanied by

comprehensive information, education and communication programs supported by political and religious leaders (Bongaarts, 2011). These information programs may also be able to reach women who are not attending any formal education.

- In the case of women below the age of 19 knowledge about contraception is especially low: 15% of women aged 15-19 with no formal education report not knowing about any contraceptives, and knowledge about HIV/AIDS and preventive measures has also been shown to be lowest in this age group (Tanzanian Commission for AIDS, 2013). As **Tanzania has one of the highest adolescent pregnancy and birth rates in the world** and more than 44% of adolescent girls have given birth or are pregnant by the age of 19 (Center for Reproductive Rights, 2013, p. 26), a focus on informing young women and men about pregnancy, birth control, HIV/AIDS and related topics seems crucial. The Center for Reproductive Rights (2013, p. 11) argues that **sexual and reproductive health education** should be made a mandatory and robust component of primary and secondary schooling, as well as vocational schooling; that it should be taught as an independent subject, must be scientifically accurate and comprehensive (pregnancy prevention, abortion, spread and prevention of HIV and STDs in general, family planning and contraception as well as emergency contraception). In addition it is important to highlight that **pregnancy or childbirth should not affect a woman's access to education**: In 2013, a report on forced pregnancy tests in Tanzanian schools estimated that more than 55 000 adolescent girls were forced to drop out or were expelled from primary and secondary schools due to pregnancy between 2003 and 2011. These tests were carried out without any legal mandate and girls were expulsed upon pregnancy (Center for Reproductive Rights, 2013, p. 11).

6.2 Potential further improvements in the population projection model

The projection model used here has some characteristics that could be refined in future versions. This was mostly not done due to reasons of time, data, and/or complexity:

- Even though it is of course an issue, also in Tanzania, external migration has not been included. This was mainly because it is hard to estimate fertility/mortality for migrants, and even more difficult to make realistic assumptions about future migration. The Net Migration Rate in 2010-2015 is estimated at -2.5 persons/1000, 12.4% of people living in Tanzania are estimated to be immigrants (United Nations, 2013) and the World Bank calculates that worker's remittances and migrants' transfers in 2013 amounted to 75 million USD (International Organization for Migration, 2014).

- The pattern of fertility (by educational category) has been assumed to stay the same over a woman's lifetime. This might not reflect reality, as fertility timing may change with e.g. an increase in life expectancy. Future work could thus introduce a changing pattern of childbirth over time.

- The extrapolation of women's desired family size may be problematic, as desired family size has been shown to change with age and parity, though it might also as argued be representative of a societal trend. One option would be to evaluate older DHS data sets for Tanzania to see if a trend over time can be found, another one to compare Tanzania to a country already further along the demographic transition. Both of these, however, would need to introduce auxiliary assumptions which again may be difficult to argue.

7. References

28 Too Many. (2013). *Country Profile: FGM in Tanzania*. Retrieved from http://www.28toomany.org/media/uploads/tanzania_final_final_final.pdf

Al-Samarrai, S. M. (2001). *Educational Inequality in Tanzania*. University of Sussex.

Barro, R., & Lee, J.-W. (2010). A New Data Set of Educational Attainment in the World, 1950-2010. *Journal of Development Economics*, *104*, 184–198.

Bongaarts, J. (2003). Completing the Fertility Transition in the Developing World: The Role of Educational Differences and Fertility Preferences. *Population Council Working Paper*, *177*. Retrieved from http://www.popcouncil.org/pdfs/wp/177.pdf

Bongaarts, J. (2010). The Causes of Educational Differences in Fertility in Sub-Saharan Africa. *Vienna Yearbook of Population Research*, *8*, 31–50.

Bongaarts, J. (2011). Can Family Planning Programs Reduce High Desired Family Size in Sub-Saharan Africa? *International Perspectives on Sexual and Reproductive Health*, *37*, 209–216.

Bongaarts, J., & Casterline, J. (2013). Fertility Transition: Is Sub-Saharan Africa Different? *Population and Development Review*, *38*, 153–168.

Bulatao, R. A., & Lee, R. D. (1983). *Determinants of Fertility in Developing Countries*. New York: National Academic Press.

Cain, M. (1993). Patriarchal Structures and Demographic Change. In *Women's Position and Demographic Change* (pp. 43–60). Oxford: Oxford University Press.

Caldwell, J. (1980). Mass Education as a Determinant of the Timing of Fertility Decline. *Population and Development Review*, *6*, 225–255.

Caldwell, J. (1982). *Theory of Fertility Decline*. London: Academic Press.

Caldwell, J., Orubuloye, I. O., & Caldwell, P. (1992). Fertility Decline in Africa: A New Type of Transition? *Population and Development Review*, *18*, 211–242.

Cameron, J., & Dodd, W. (1970). *Schools, Society and Progress in Tanzania*. Oxford: Pergamon Press.

Castro Martin, T., & Juarez, F. (1995). Women's Education and Fertility: Results from 26 Demographic and Health Surveys. *Studies in Family Planning*, *26*, 187–202.

Center for Reproductive Rights. (2013). *Forced Out. Mandatory Pregnancy Testing and the Expulsion of Pregnant Students in Tanzanian Schools*. Retrieved from http://reproductiverights.org/sites/crr.civicactions.net/files/documents/crr_Tanzania_Report_Part1.pdf

Cleland, J. (2002). Education and Future Fertility Trends, with Special Reference to Mid-Transitional Countries. Retrieved from http://www.un.org/esa/population/publications/completingfertility/RevisedCLELANDpaper.PDF

Cleland, J., & Wilson, C. (1987). Demand Theories of the Fertility Transition: An Iconoclastic View. *Population Studies*, *41*, 5–30.

Coale, A. (1973). *The Demographic Transition* (Vol. 1). Liege.

Cochrane, S. (1979). *Fertility and Education: What do We Really Know?*. Baltimore: The Johns Hopkins University Press.

Coulson, A. (2013). *Tanzania. A Political Economy*. Oxford: Oxford University Press.

Dennis, C., & Stahley, K. (2012). Universal Primary Education in Tanzania: The Role of School Expenses and Opportunity Costs. *Evans School Review*, *2*(1), 47–65.

Dyson, T. (2010). *Population and Development: The Demographic Transition*. London, New York: Zed Books.

Fuchs, R., & Goujon, A. (2014). Future Fertility in High Fertility Countries. In *World Population and Human Capital in the Twenty-First Century* (pp. 148–225). Oxford: Oxford University Press.

Goldstein, S. (1983). *Migration and Fertility in Peninsular Malaysia: An Analysis Using Life History Data* (Rand Corporation Report No. N-1860-AID). Santa Monica: Rand Corporation.

International Organization for Migration. (2014). IOM Country Information: Tanzania. Retrieved from https://www.iom.int/cms/tanzania

Jejeebhoy, S. (1995). *Women's Education, Autonomy, Reproductive Behaviour: Experiences From Developing Countries*. Oxford Clarendon Press.

Jong-Wha, L. (2014, September 11). Education and Opportunity. *Project Syndicate*. Retrieved from http://www.project-syndicate.org/commentary/lee-jong-wha-shows-why-improving-academic-access-and-quality-should-be-a-top-priority-for-world-leaders

Kagashe, G., & Honest, G. (2013). Knowledge and Use of Contraceptives Among Secondary School Girls in Dar es Salaam, Tanzania. *Journal of Applied Pharmaceutical Science*, *3*(1), 66–68.

KC, S. (2009). *Multistate Demography with R?*. Retrieved from http://statmath.wu.ac.at/research/talks/resources/Multistate_Demography_short_presentation.pdf

K.C., S., & Potancokova, M. (2013). Differential Fertility by Level of Education in DHS Countries. IUSSP Conference Papers. Retrieved from http://iussp.org/sites/default/files/event_call_for_papers/Differential%20fertility%20by%20level%20of%20Education.pdf

Kravdal, O. (2001). Main and Interaction Effects of Women's Education and Status on Fertility: The Case of Tanzania. *European Journal of Population*, *17*(2), 107–135.

Ledent, J., & Zeng, Y. (2006). *Demography Vol. II*. Retrieved from http://www.eolss.net/sample-chapters/c04/e6-147-16.pdf

Lesthaeghe, R., & Surkyn, J. (1988). Cultural Dynamics and Economic Theories of Fertility Change. *Population and Development Review*, *14*, 1–45.

Lutz, W., & Butz, W. (2014). Introduction. In *World Population and Human Capital in the Twenty-First Century* (pp. 1–13). Oxford University Press.

Lutz, W., Butz, W., & K.C., S. (Eds.). (2014). *World Population and Human Capital in the Twenty-First Century*. Oxford University Press.

Lutz, W., Goujon, A., & Doblhammer-Reiter, G. (1998). Demographic Dimensions in Forecasting: Adding Education to Age and Sex. *Population and Development Review*, *24*(Supplement: Frontiers of Population Forecasting), 42–58.

Lutz, W., & KC, S. (2010). Dimensions of Global Population Projections: What Do We Know About Future Population Trends and Structures? *Philosophical Transactions of the Royal Society B*, *365*, 2779–2791.

Lutz, W., & KC, S. (2011). Global Human Capital: Integrating Education and Population. *Science*, *333*, 587–592.

Merrick, T. (2001). Population and Poverty: A Review of Reviews. In *Population matters: Demographic change, economic growth, and poverty in the developing world.* (pp. 201–212). New York: Oxford University Press.

Ministry of Finance and Economic Affairs (Ed.). (2010, July). National Strategy for Growth and Reduction of Poverty II. United Republic of Tanzania.

Moultrie, T. A., Sayi, T. S., & Timaeus, I. M. (2012). Birth Intervals, Postponement, and Fertility Decline in Africa: A New Type of Transition? *Population Studies*, *66*, 241–258.

Nabudere, D. (2006). Julius Kambaragwe Nyere. In D. Simon (Ed.), *Fifty Key Thinkers on Development* (pp. 192–211). Routledge.

Open Working Group of the General Assembly on Sustainable Development Goals. (2014). *Open Working Group Proposal for Sustainable Development Goals*. Retrieved from http://undocs.org/A/68/970

Population Planning Section, M. of P., Economy and Empowerment. (2007). Population, Reproductive Health and Development in Tanzania: A Policy Brief.

President's Office. (1992). *National Population Policy*. Dar es Salaam.

President's Office. (1998). *National Population Policy (Draft)*. Dar es Salaam.

Richey, L. A. (2003). Women's Reproductive Health & Population Policy: Tanzania. *Review of African Political Economy*, *96*, 273–292.

Scherbov, S. (2013, Autumn). *Demographic Analysis and Computer Applications. Modeling of Age Patterns of Vital Rates*. Presented at the Lecture in Specialisation Area Demography II, SEEP Master programme, Vienna University of Economics and Business.

Shapiro, D., & Gebreselassie, T. (2008). Fertility Transition in Sub-Saharan Africa: Falling and Stalling. *African Population Studies*, *23*(1), 3–23.

Tanzanian Commission for AIDS. (2013). *Tanzania HIV/AIDS and Malaria Indicator Survey 2011-12*. Dar es Salaam. Retrieved from http://dhsprogram.com/pubs/pdf/AIS11/AIS11.pdf

Tanzanian Ministry of Finance. (2012). *Poverty and Human Development Report 2011*. United Republic of Tanzania.

Tanzanian National Bureau of Statistics. (2011). *Tanzania Demographic and Health Survey*. Retrieved from http://dhsprogram.com/pubs/pdf/FR243/FR243[24June2011].pdf

Tanzanian National Bureau of Statistics. (2014). *Tanzania: Basic Demographic and Socio-Economic Profile*. Retrieved from http://nbs.go.tz/nbs/takwimu/census2012/Basic_Demographic_and_Socio-Economic_Profile_PopularVersion-KeyFindings_2012_PHC_EnglishVersion.pdf

UNESCO Dakar Office. (2012). *Tanzania Education Sector Analysis. Beyond Primary Education, the Quest for Balanced and Efficient Policy Choices for Human Development and Economic Growth* (Education Sector Analysis No. Sn/2012/ED/PI/1). Dakar.

UNICEF. (2013). *Female Genital Cutting/Mutilation, A Statistical Overview and Exploration of the Dynamics of Change*. Retrieved from http://www.childinfo.org/files/FGCM_Lo_res.pdf

United Nations. (1987). *Fertility Behaviour in the Context of Development: Evidence From the World Fertility Survey*. (Population Studies No. 100).

United Nations. (1989). *Case Studies in Population Policy: United Republic of Tanzania* (No. 22).

United Nations. (1995). *Women's Education and Fertility Behaviour: Recent Evidence From the Demographic and Health Surveys* (No. ST/ESA0SER.R/137).

United Nations. (2013). *World Population Prospects, the 2012 Edition. Volume I: Comprehensive Tables.* (No. ST/ESA/SER.A/336). New York.

United Republic of Tanzania. (2014). *Global Aids Response Country Progress Report* (UNAIDS Country Progress Reports). Dar es Salaam. Retrieved from http://www.unaids.org/sites/default/files/country/documents/TZA_narrative_report_2014.pdf

Vann de Walle, E. (1992). Fertility Transition, Conscious Choice, and Numeracy. *Demography*, *29*(4), 487–502.

Vice President's Office, Division of Environment. (2012). *National Climate Change Strategy*. Retrieved from http://tanzania.um.dk/en/~/media/Tanzania/Documents/Environment/TANZANIA%20CLIMATE%20CHANGE%20STRATEGY/TANZANIA%20CLIMATE%20CHANGE%20STRATEGY.pdf

White, M., Muhidin, S., Andrzejewski, C., & Tagoe, E. (2008). Urbanization and Fertility: An Event-History Analysis of Coastal Ghana. *Demography*, *45*(4), 803–816.

Wittgenstein Centre for Demography and Global Human Capital. (2014). *Wittgenstein Centre Data Explorer Version 1.1*. Retrieved from www.wittgensteincentre.org/dataexplorer

Woog, V., & Pembe, A. B. (2013). *Unsafe Abortion in Tanzania: A Review of the Evidence* (No. 1). New York: Guttmacher Institute.

8. Appendix

8.1 The Brass mortality model

The Brass mortality model was used to calculate the probability of dying q(x,n) for five year age groups above the age of 80 based on life tables from the United Nations, which have been estimated for the years 2010-2100. The calculation steps are based on a lecture by Scherbov (Scherbov, 2013).

8.2 The Gamma fertility model

The formulas for calculating the gamma fertility model are taken from a class presentation (Scherbov, 2013). As the model is nonlinear, initial guesses for all beta values need to be entered as starting values. Those were obtained from TDHS data.

Gamma fertility curve:

$$f_x = \frac{1}{\Gamma(\alpha_3)} \alpha_1 \alpha_2^{\alpha_3} (x-\alpha_4)^{\alpha_3-1} e^{-\alpha_2(x-\alpha_4)}$$

$$\Gamma(p) = \int_0^\infty u^{p-1} e^{-u} du$$

With

$$\alpha_1 = \beta_1$$

$$\alpha_2 = \frac{(\beta_2 - \beta_4)}{\beta_3}$$

$$\alpha_3 = \frac{(\beta_2 - \beta_4)^2}{\beta_3}$$

$$\alpha_4 = \beta_4$$

Beta coefficients can be interpreted as follows:

$\beta_1 = \alpha_1$ total fertility

$\beta_2 = \frac{(\alpha_4 - \alpha_3)}{\alpha_2}$ mean age at childbearing

$\beta_3 = \frac{\alpha_3}{{\alpha_2}^2}$ variance in β_2

$\beta_4 = \alpha_4$ minimum age at childbearing

8.3 ASFR comparison

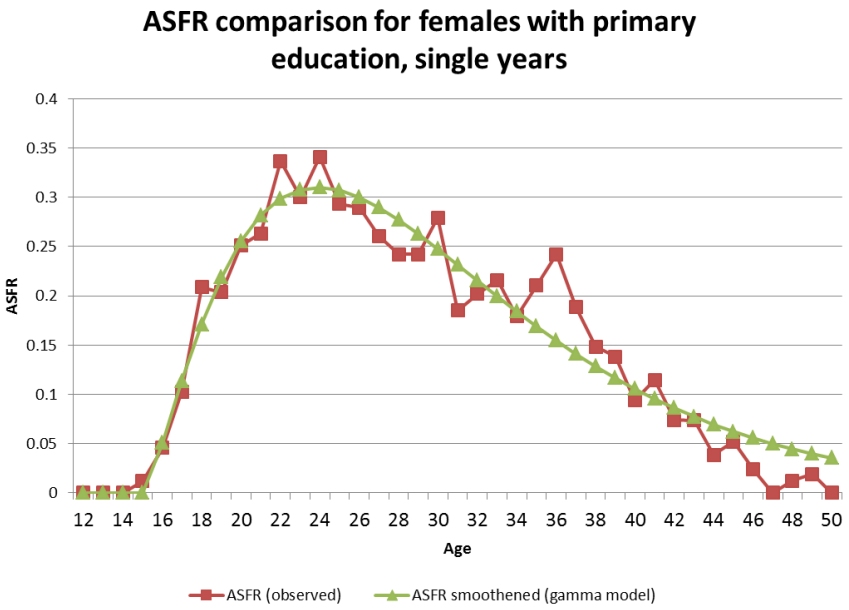


Figure 33: Women with primary education, comparison of single year ASFRs before and after smoothing (Gamma model). Source: TDHS 2010, own calculations and illustration.

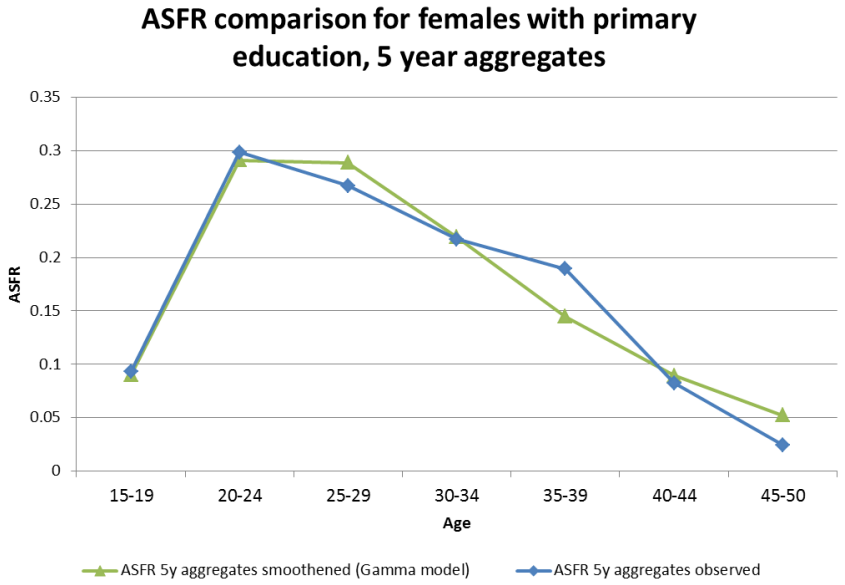


Figure 34: Women with primary education, comparison of five year ASFRs before and after smoothing (Gamma model). Source: TDHS 2010, own calculations and illustration.

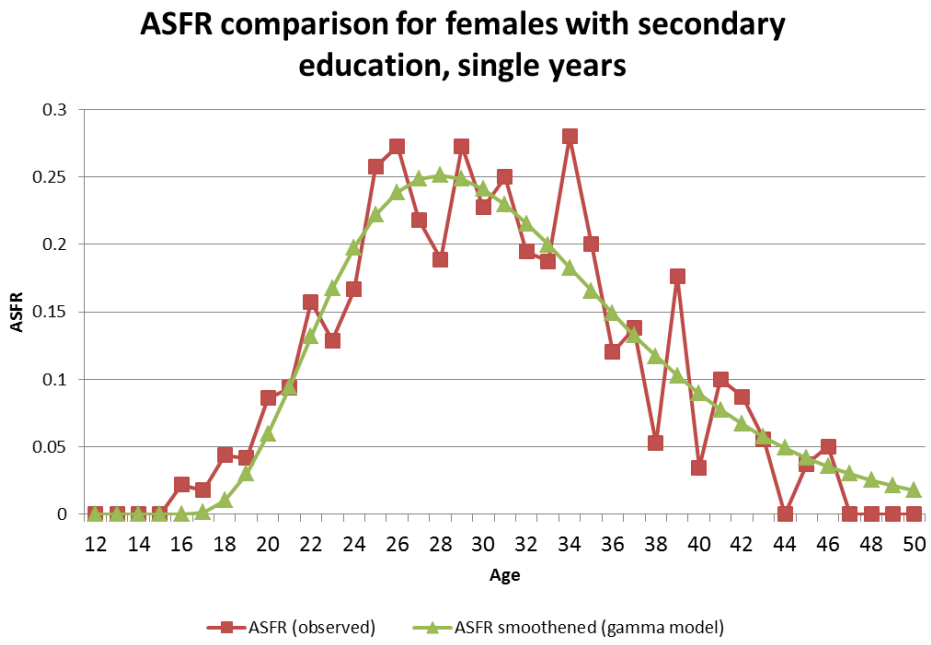


Figure 35: Women with secondary education, comparison of single year ASFRs before and after smoothing (Gamma model). Source: TDHS 2010, own calculations and illustration.

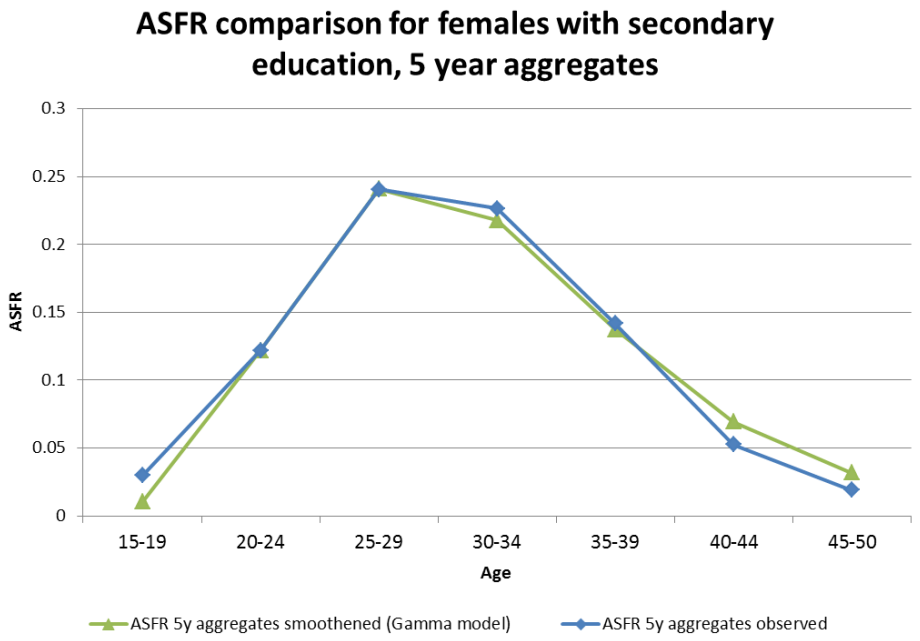


Figure 36: Women with secondary education, comparison of five year ASFRs before and after smoothing (Gamma model). Source: TDHS 2010, own calculations and illustration.

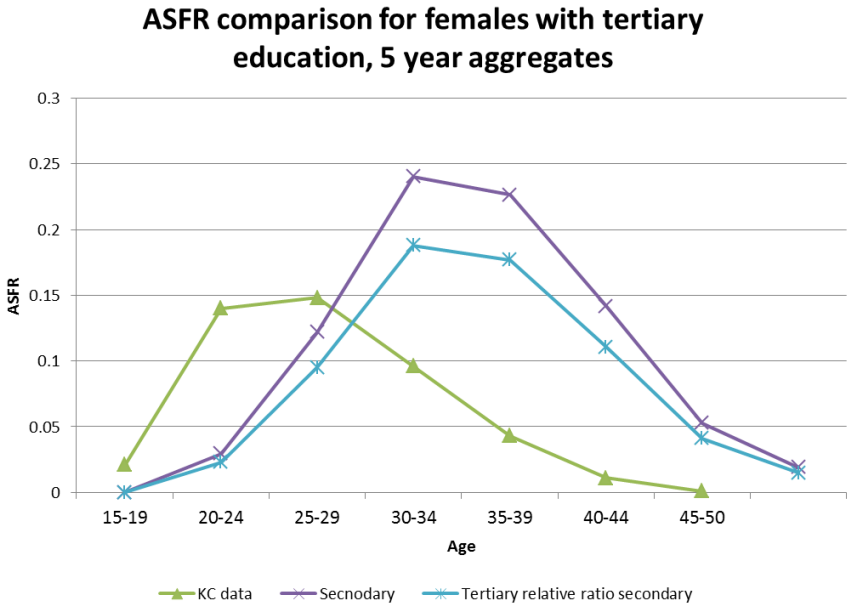


Figure 37: Women with completed tertiary education, comparison of five year ASFRs to secondary education and data supplied by K.C. after scaling (relative ratio of 0.78). Source: TDHS 2010, own calculations and illustration.

8.1 Likely/optimistic/pessimistic scenarios

Scenarios on UN fertility assumptions (category 4) are not depicted here as their design differs from the ones presented below.

LIKELY SCENARIOS (ORANGE)		EDUCATION SCENARIO			
		A: Constant Enrollment Rates	B: Likely	C: Sustainable Development Goals	D: Fast Track
FERTILITY SCENARIO	1: 100% desired number of children instantly	1A	1B	1C	1D
	2: 100% desired number of children slowly	2A	2B	2C	2D
	3: Moving towards the desired number of children	3A	3B	3C	3D

OPTIMISTIC SCENARIOS (GREEN)		EDUCATION SCENARIO			
		A: Constant Enrollment Rates	B: Likely	C: Sustainable Development Goals	D: Fast Track
FERTILITY SCENARIO	1: 100% desired number of children instantly	1A	1B	1C	1D
	2: 100% desired number of children slowly	2A	2B	2C	2D
	3: Moving towards the desired number of children	3A	3B	3C	3D

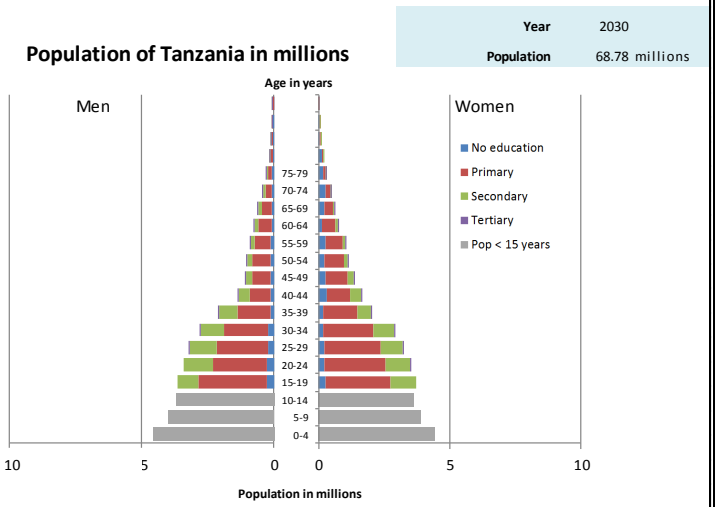
PESSIMISTIC SCENARIOS (RED)		EDUCATION SCENARIO			
		A: Constant Enrollment Rates	B: Likely	C: Sustainable Development Goals	D: Fast Track
FERTILITY SCENARIO	1: 100% desired number of children instantly	1A	1B	1C	1D
	2: 100% desired number of children slowly	2A	2B	2C	2D
	3: Moving towards the desired number of children	3A	3B	3C	3D

Figure 38: Likely, optimistic and pessimistic scenarios.

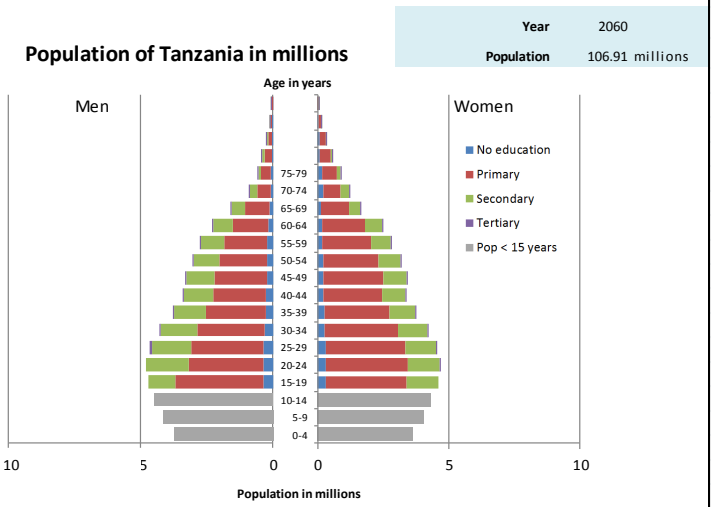
8.2 Population pyramids for all 24 scenarios in 2030 and 2060

Depending on the calculated transition rates behind the scenarios the youngest age groups (up to either the age of 14 or 19) are colored in grey. Scenarios are sorted by fertility and then education scenario (1A, 1B, … 4cC, 4cD).

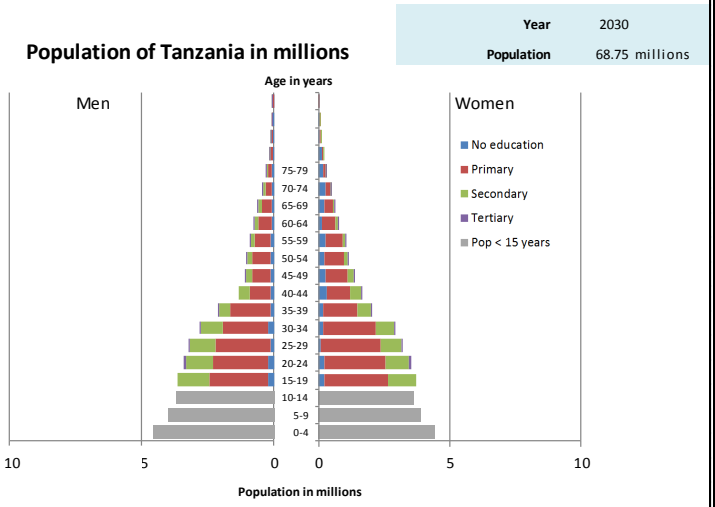
Scenario 1: 100% desired number of children instantly (fertility), Scenario A: Constant Enrollment Rates (education transitions)



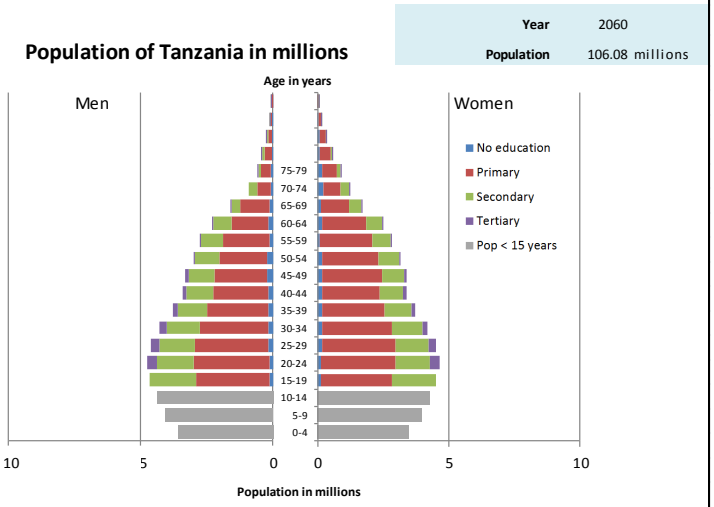
Scenario 1: 100% desired number of children instantly (fertility), Scenario A: Constant Enrollment Rates (education transitions)



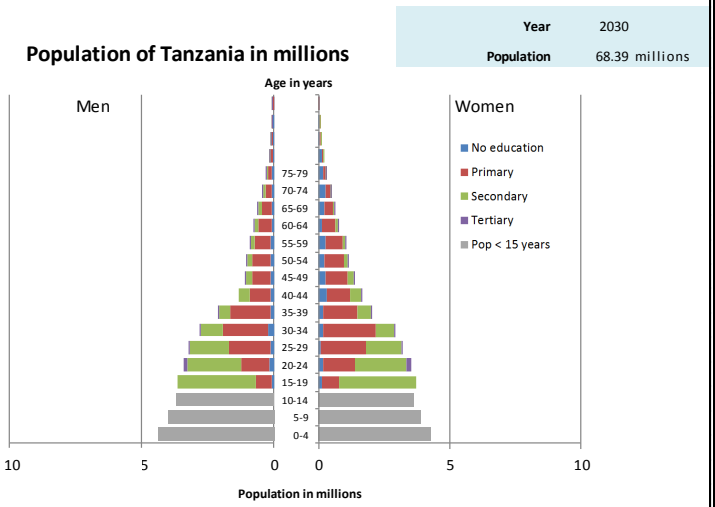
Scenario 1: 100% desired number of children instantly (fertility), Scenario B: Likely (education transitions)



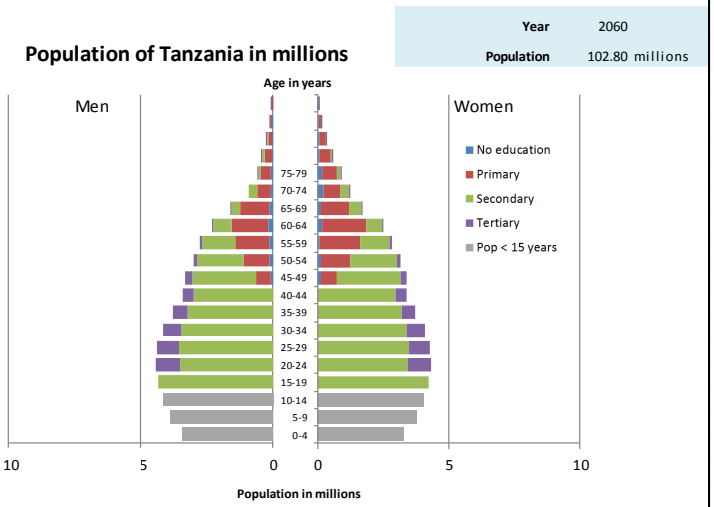
Scenario 1: 100% desired number of children instantly (fertility), Scenario B: Likely (education transitions)



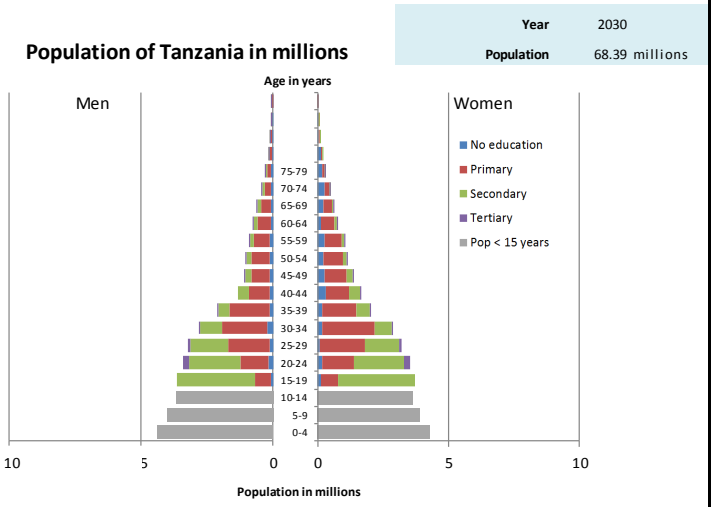
Scenario 1: 100% desired number of children instantly (fertility), Scenario C: Sustainable Development Goals (education transitions)



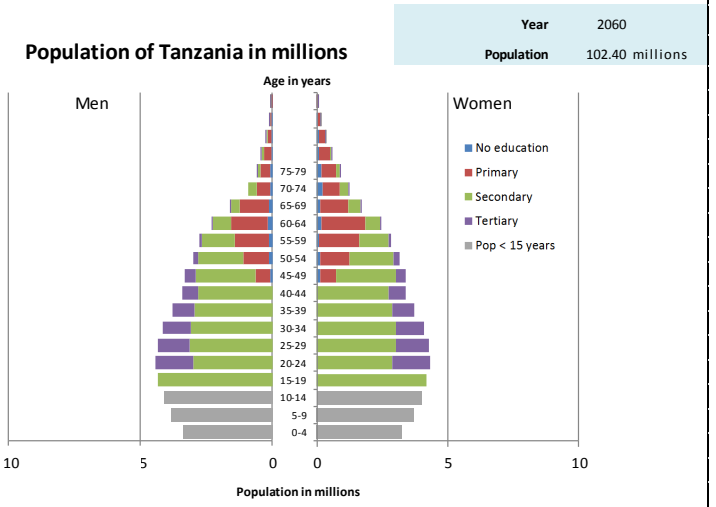
Scenario 1: 100% desired number of children instantly (fertility), Scenario C: Sustainable Development Goals (education transitions)



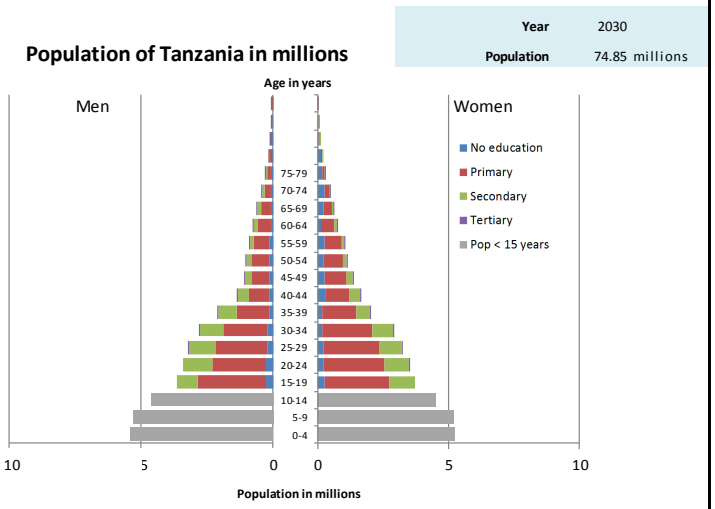
Scenario 1: 100% desired number of children instantly (fertility), Senario D: Fast Track (education transitions)



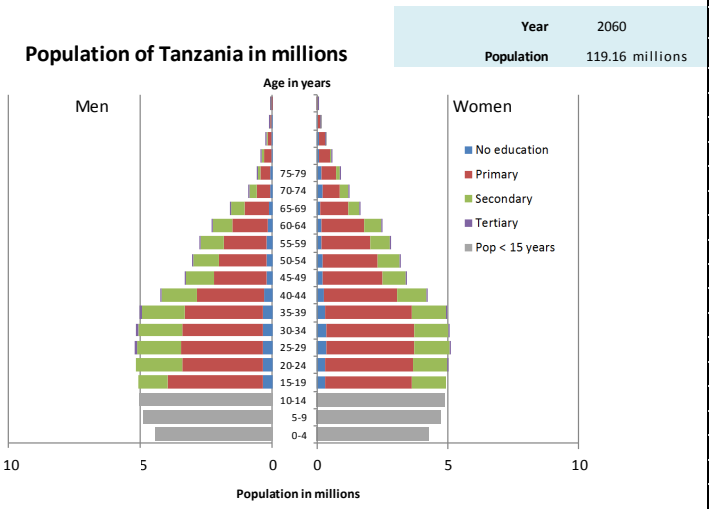
Scenario 1: 100% desired number of children instantly (fertility), Senario D: Fast Track (education transitions)



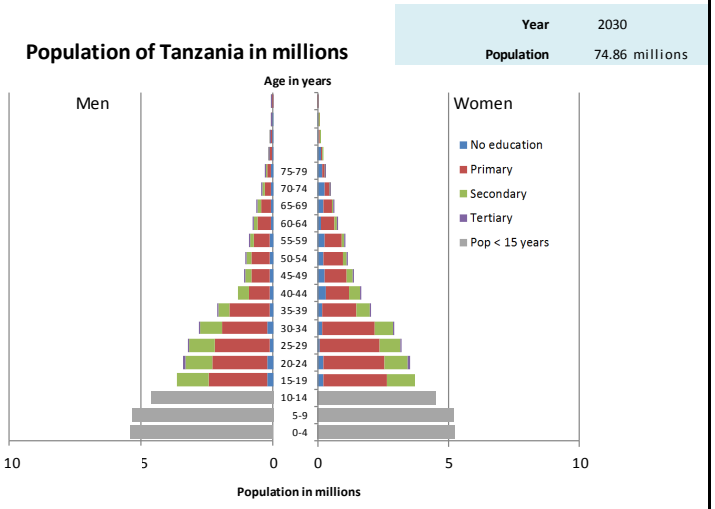
Scenario 2: 100% desired number of children slowly (fertility), Scenario A: Constant Enrollment Rates (education transitions)



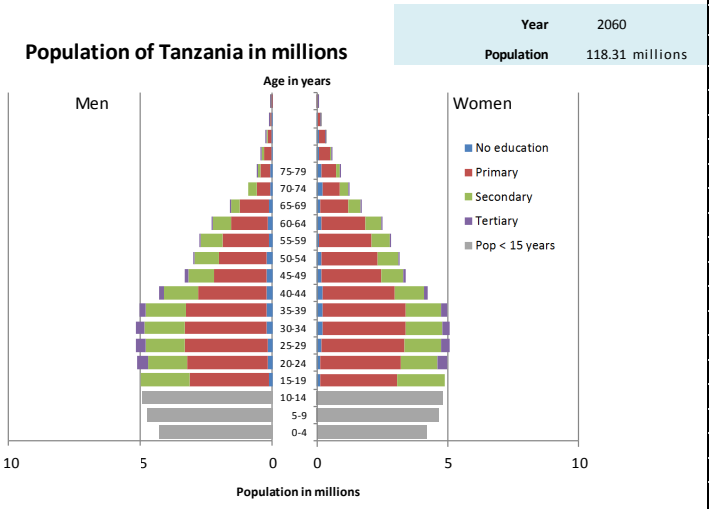
Scenario 2: 100% desired number of children slowly (fertility), Scenario A: Constant Enrollment Rates (education transitions)



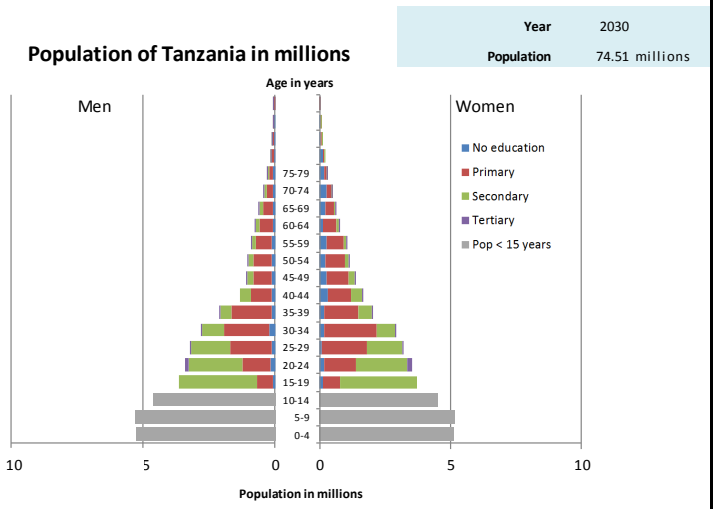
Scenario 2: 100% desired number of children slowly (fertility), Scenario B: Likely (education transitions)



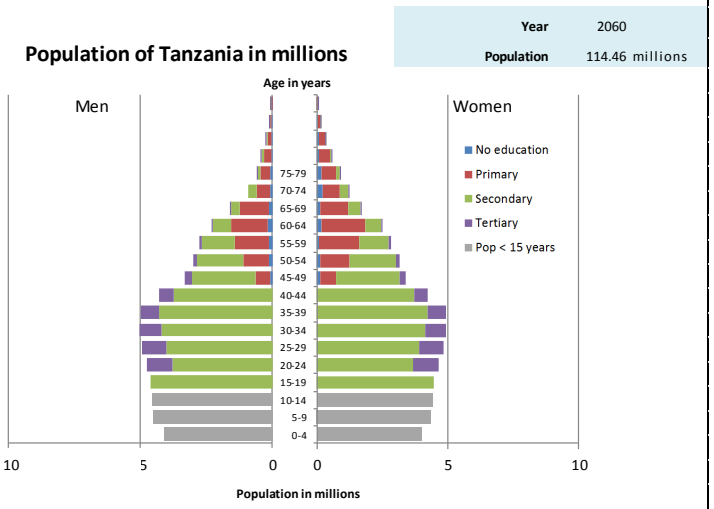
Scenario 2: 100% desired number of children slowly (fertility), Scenario B: Likely (education transitions)



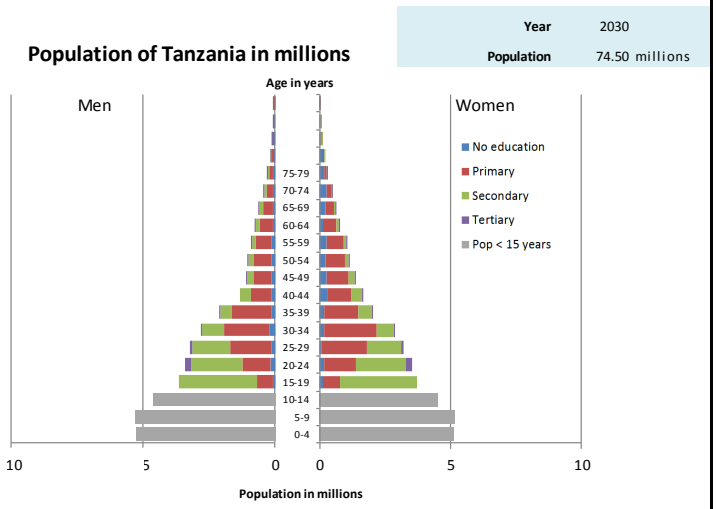
Scenario 2: 100% desired number of children slowly (fertility), Scenario C: Sustainable Development Goals (education transitions)



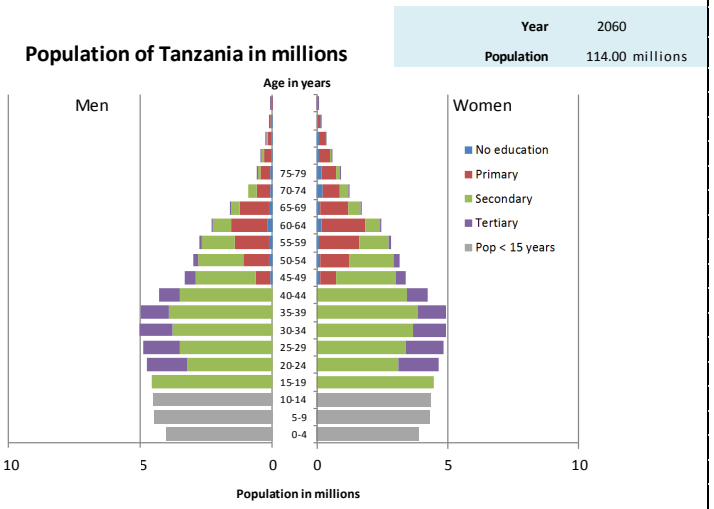
Scenario 2: 100% desired number of children slowly (fertility), Scenario C: Sustainable Development Goals (education transitions)



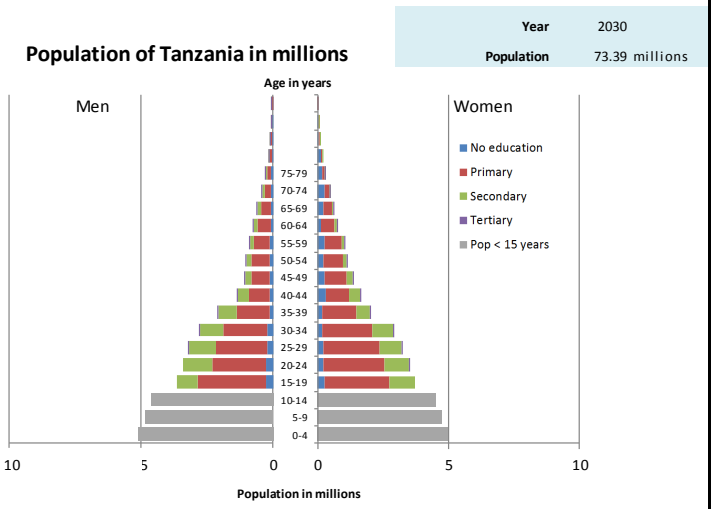
Scenario 2: 100% desired number of children slowly (fertility), Senario D: Fast Track (education transitions)



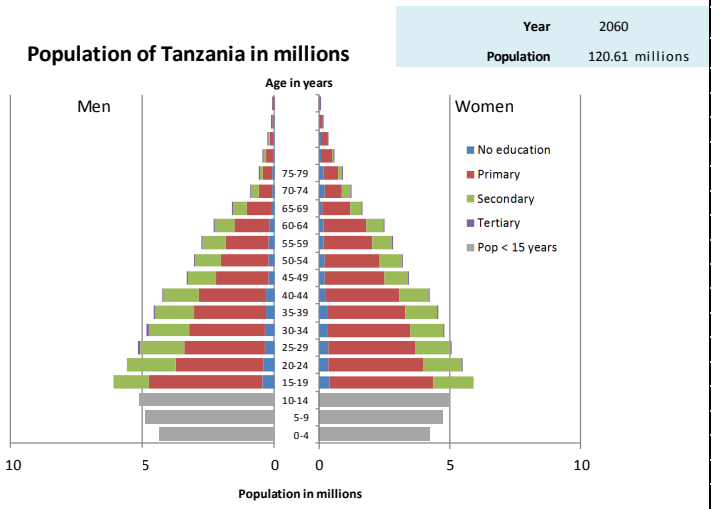
Scenario 2: 100% desired number of children slowly (fertility), Senario D: Fast Track (education transitions)



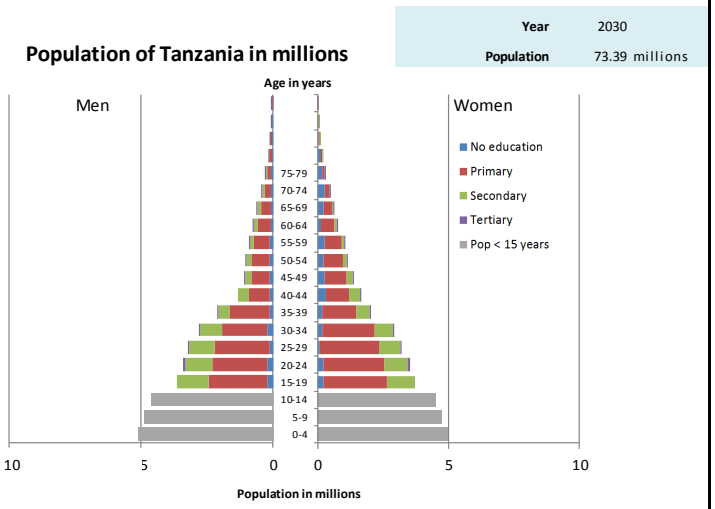
Scenario 3: Moving towards the desired number of children (fertility), Scenario A: Constant Enrollment Rates (education transitions)



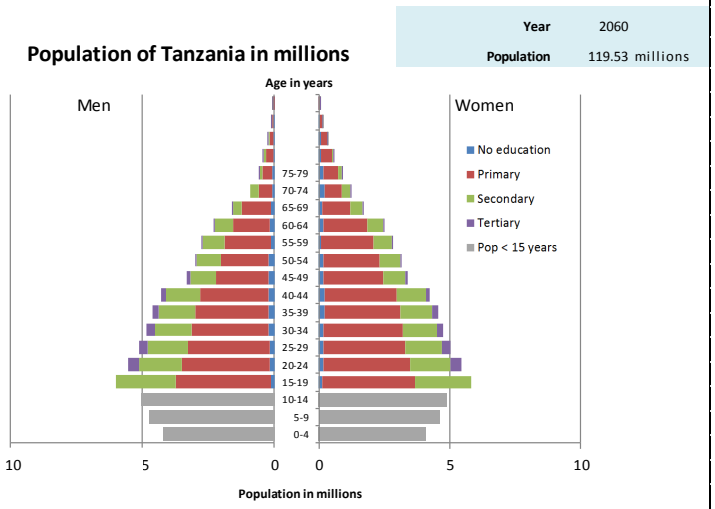
Scenario 3: Moving towards the desired number of children (fertility), Scenario A: Constant Enrollment Rates (education transitions)



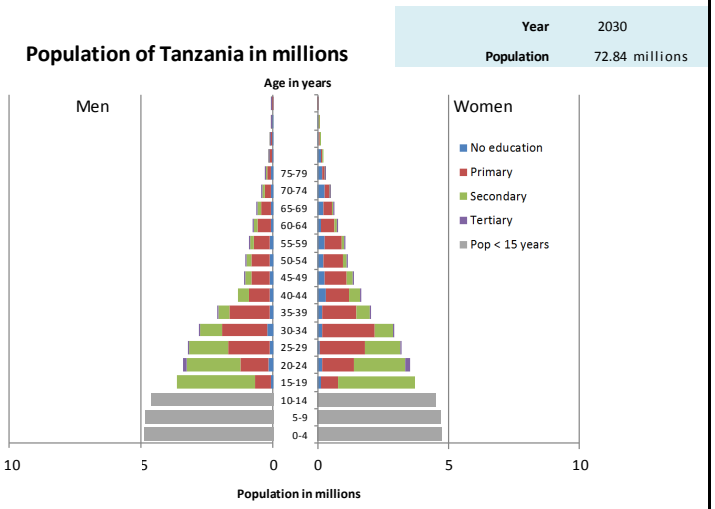
Scenario 3: Moving towards the desired number of children (fertility), Scenario B: Likely (education transitions)



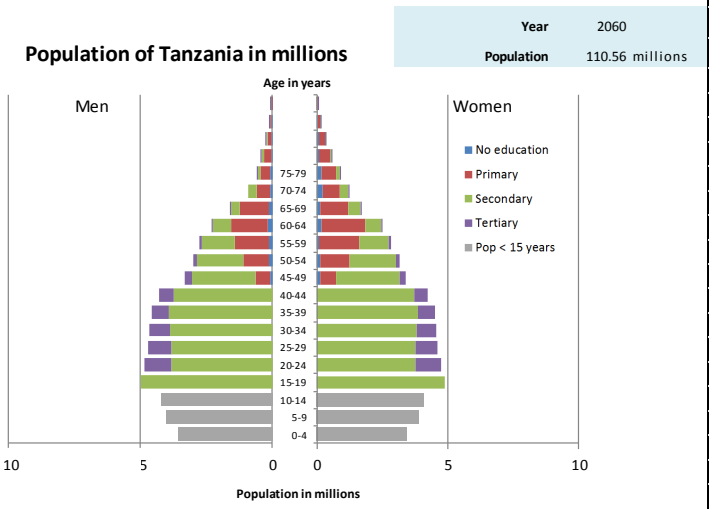
Scenario 3: Moving towards the desired number of children (fertility), Scenario B: Likely (education transitions)



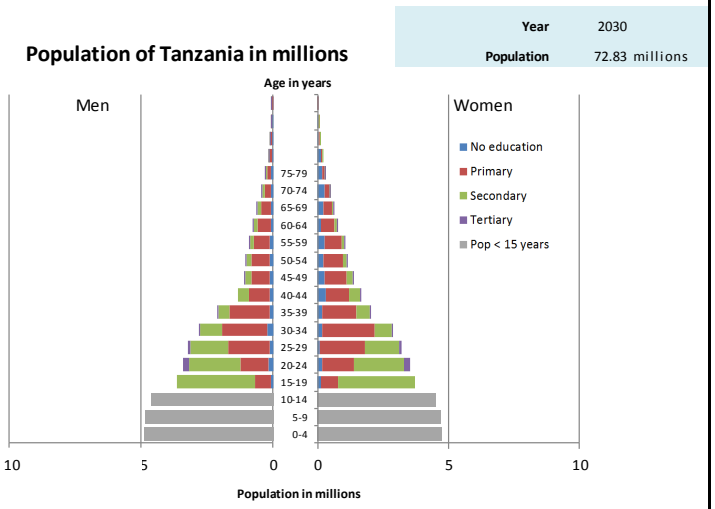
Scenario 3: Moving towards the desired number of children (fertility), Scenario C: Sustainable Development Goals (education transitions)



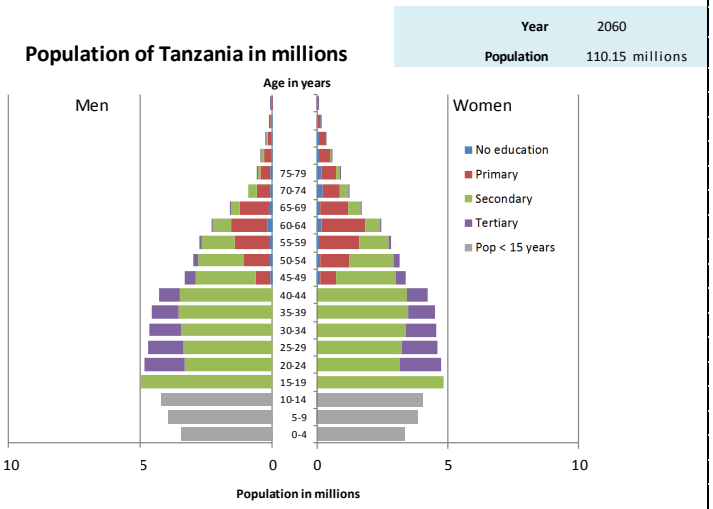
Scenario 3: Moving towards the desired number of children (fertility), Scenario C: Sustainable Development Goals (education transitions)



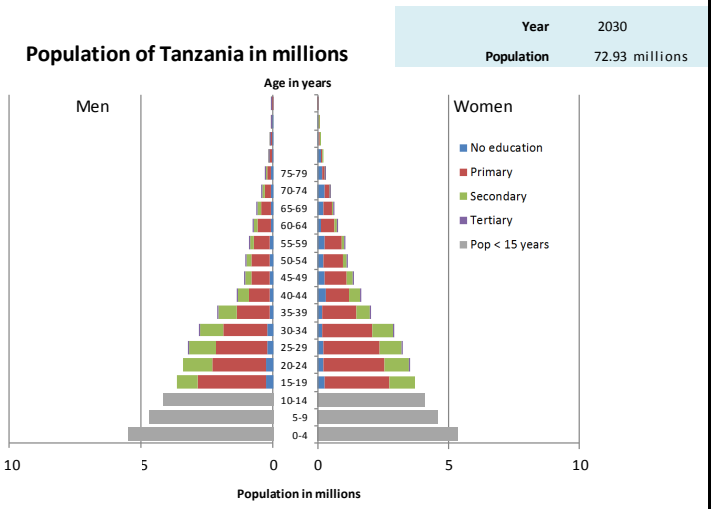
Scenario 3: Moving towards the desired number of children (fertility), Senario D: Fast Track (education transitions)



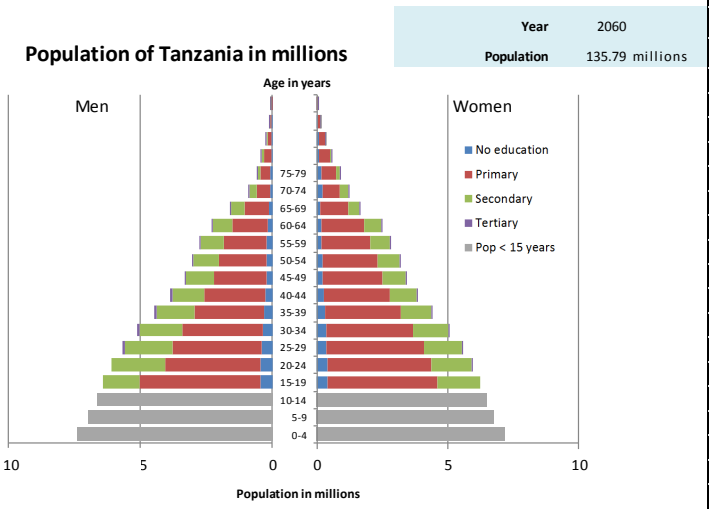
Scenario 3: Moving towards the desired number of children (fertility), Senario D: Fast Track (education transitions)



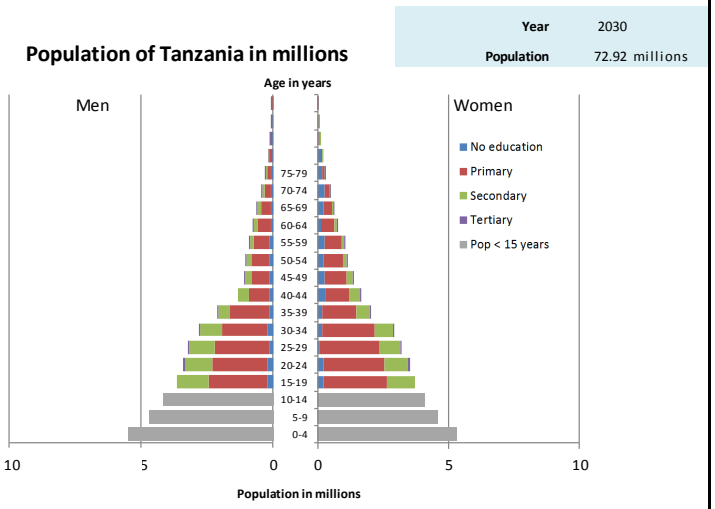
Scenario 4: Solver UN medium fertility (fertility), Scenario A: Constant Enrollment Rates (education)



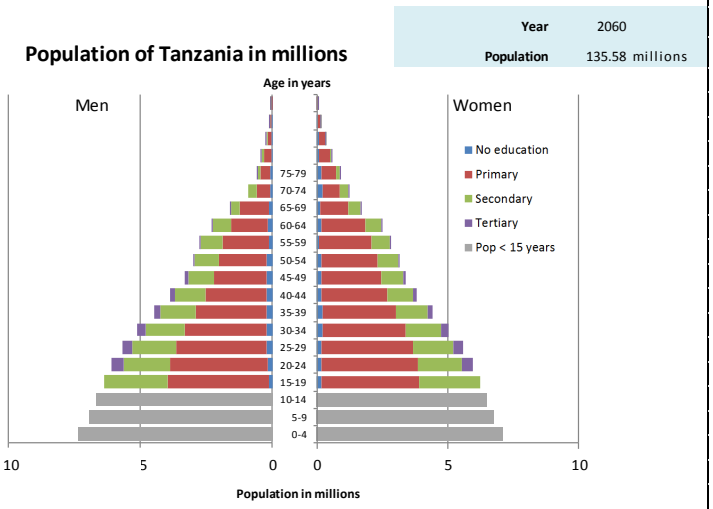
Scenario 4: Solver UN medium fertility (fertility), Scenario A: Constant Enrollment Rates (education)



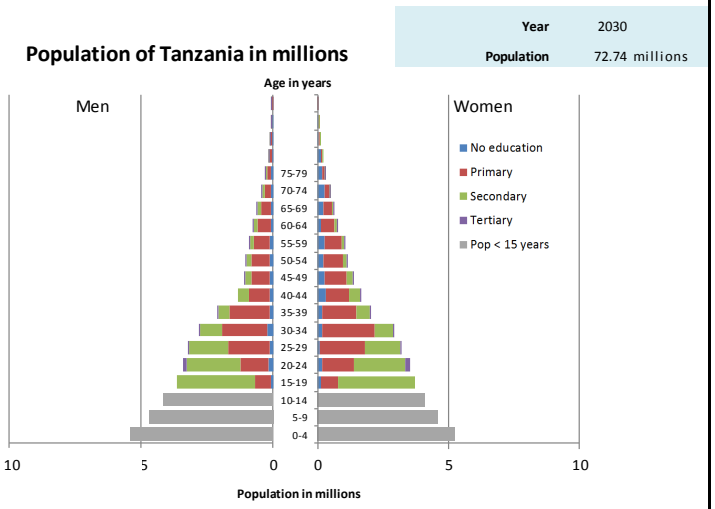
Scenario 4: Solver UN medium fertility (fertility), Scenario B: Likely (education)



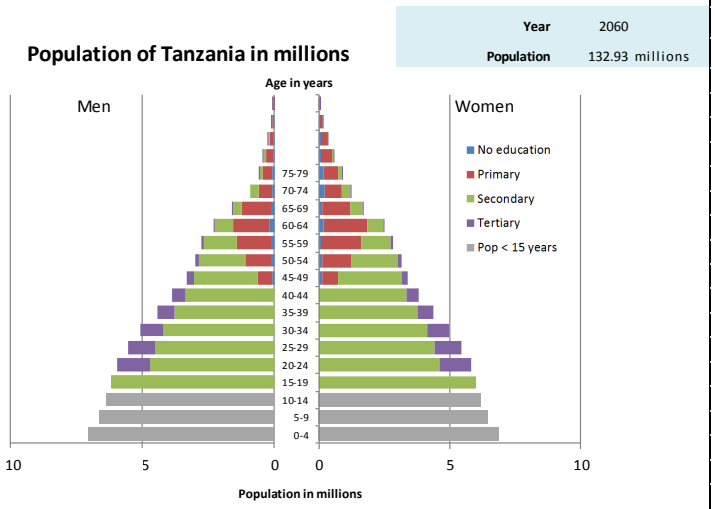
Scenario 4: Solver UN medium fertility (fertility), Scenario B: Likely (education)



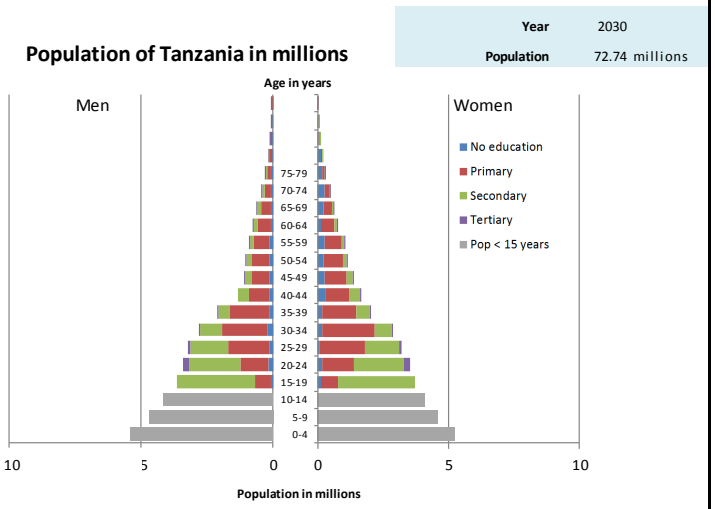
Scenario 4: Solver UN medium fertility (fertility), Scenario C: Sustainable Development Goals (education)



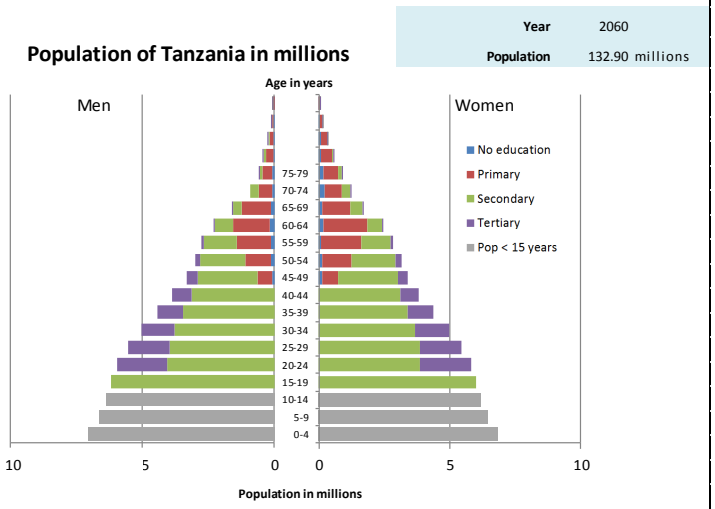
Scenario 4: Solver UN medium fertility (fertility), Scenario C: Sustainable Development Goals (education)



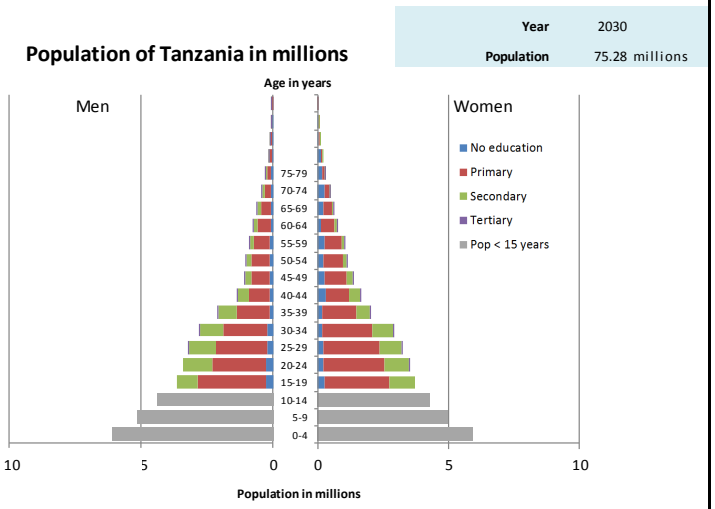
Scenario 4: Solver UN medium fertility (fertility), Senario D: Fast Track (education)



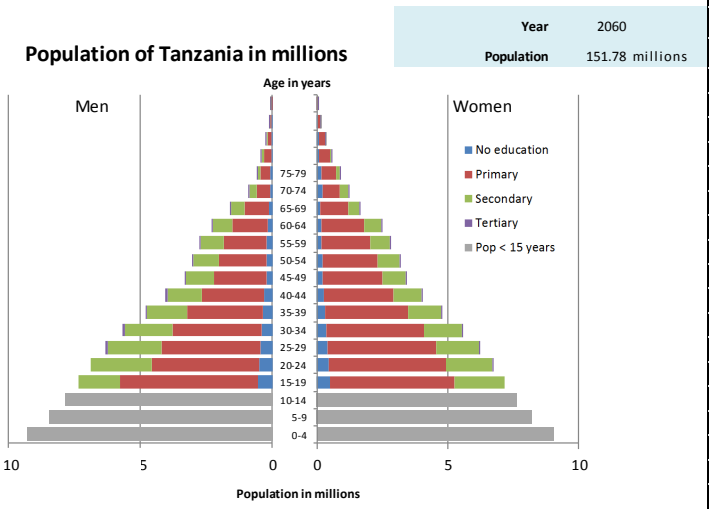
Scenario 4: Solver UN medium fertility (fertility), Senario D: Fast Track (education)



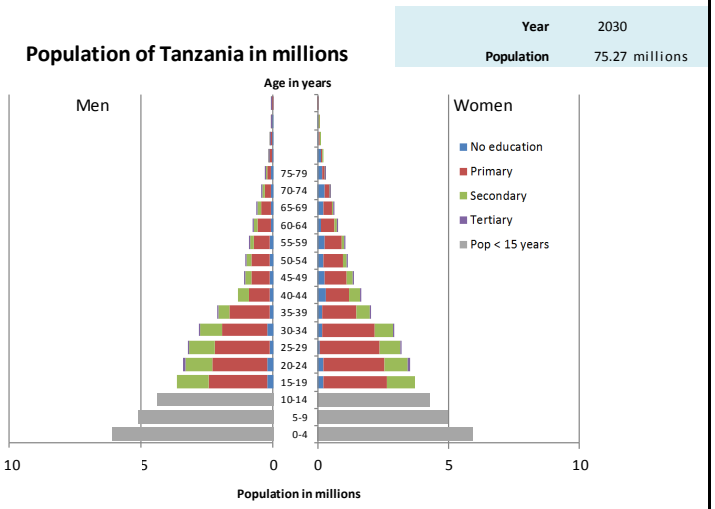
Scenario 4: Solver UN high fertility (fertility), Scenario A: Constant Enrollment Rates (education)



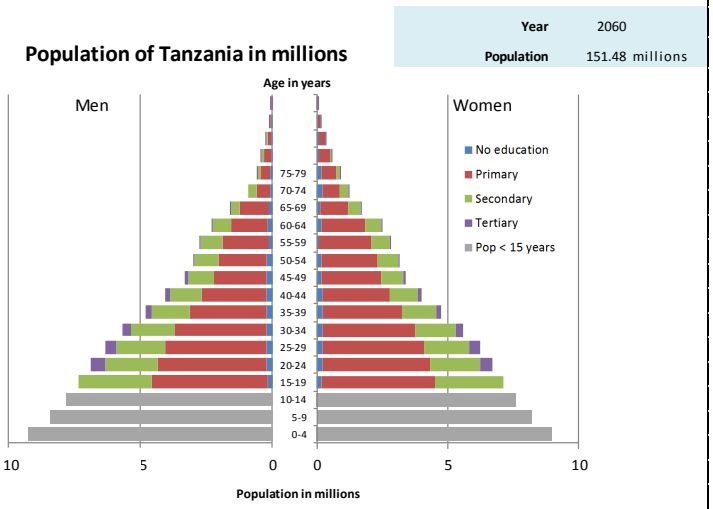
Scenario 4: Solver UN high fertility (fertility), Scenario A: Constant Enrollment Rates (education)



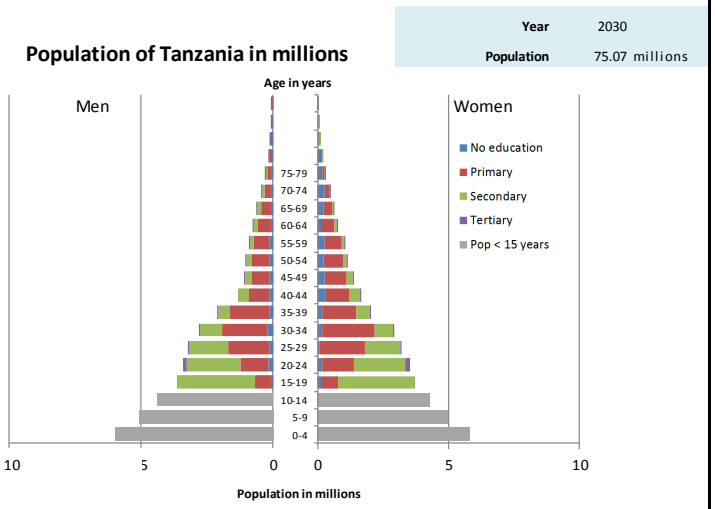
Scenario 4: Solver UN high fertility (fertility), Scenario B: Likely (education)



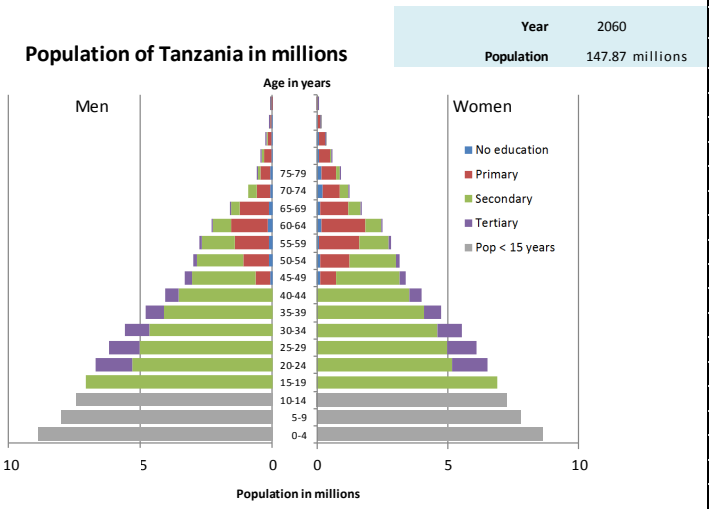
Scenario 4: Solver UN high fertility (fertility), Scenario B: Likely (education)



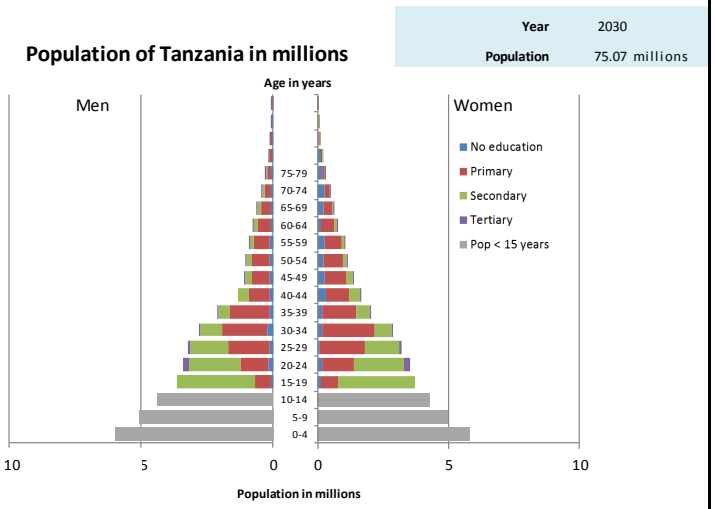
Scenario 4: Solver UN high fertility (fertility), Scenario C: Sustainable Development Goals (education)



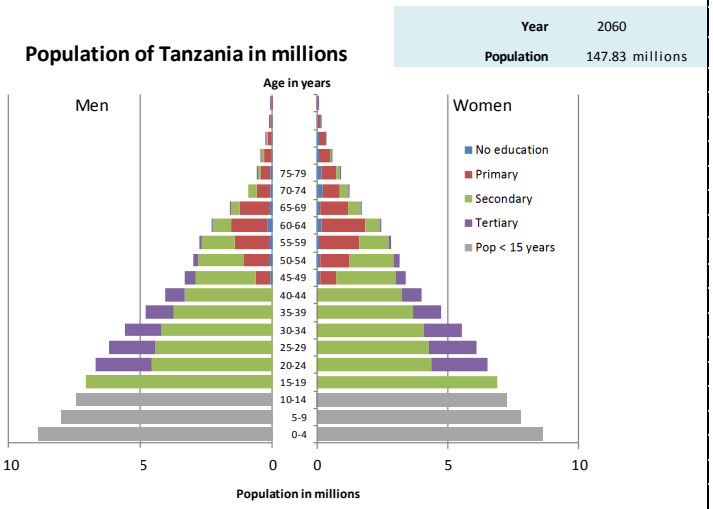
Scenario 4: Solver UN high fertility (fertility), Scenario C: Sustainable Development Goals (education)



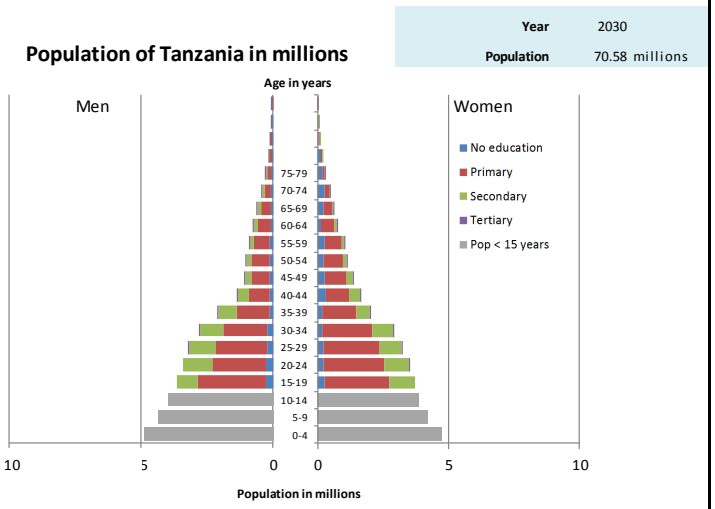
Scenario 4: Solver UN high fertility (fertility), Senario D: Fast Track (education)



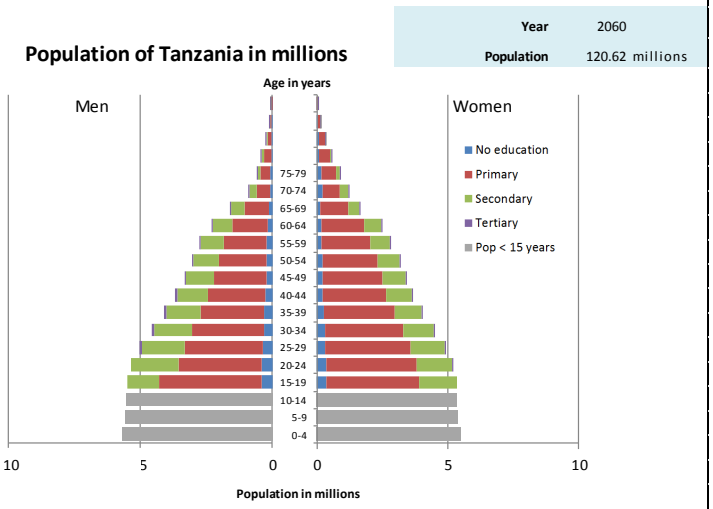
Scenario 4: Solver UN high fertility (fertility), Senario D: Fast Track (education)



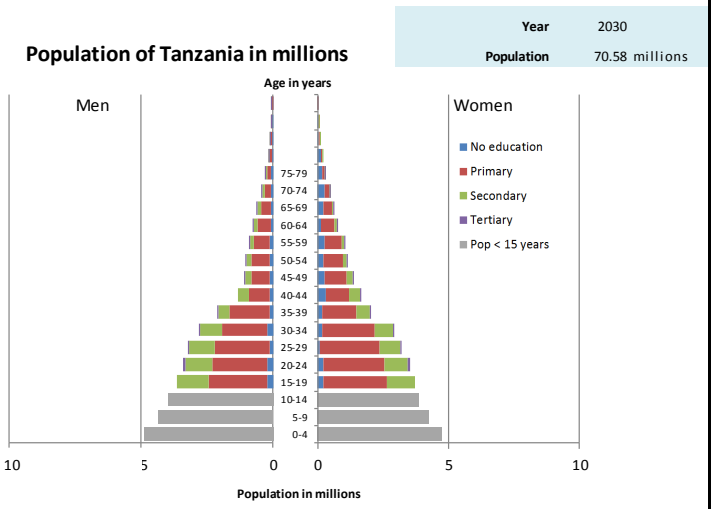
Scenario 4: Solver UN low fertility (fertility), Scenario A: Constant Enrollment Rates (education)



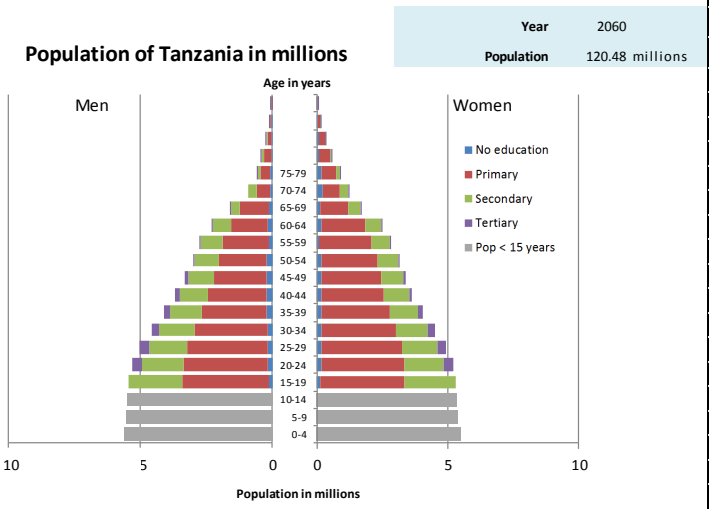
Scenario 4: Solver UN low fertility (fertility), Scenario A: Constant Enrollment Rates (education)



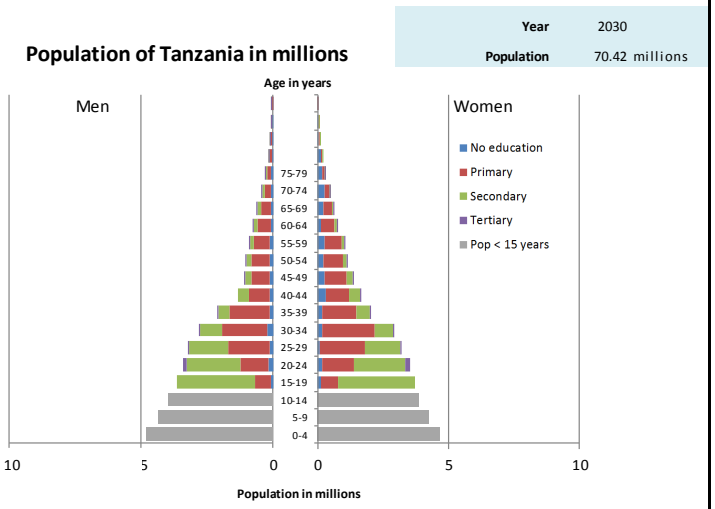
Scenario 4: Solver UN low fertility (fertility), Scenario B: Likely (education)



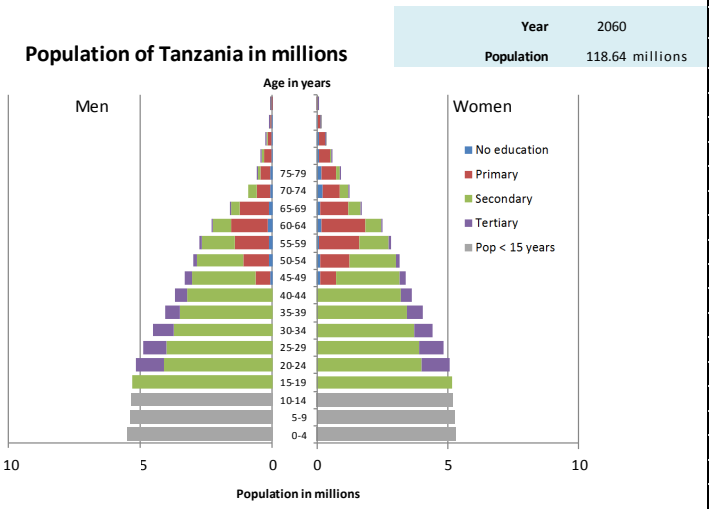
Scenario 4: Solver UN low fertility (fertility), Scenario B: Likely (education)



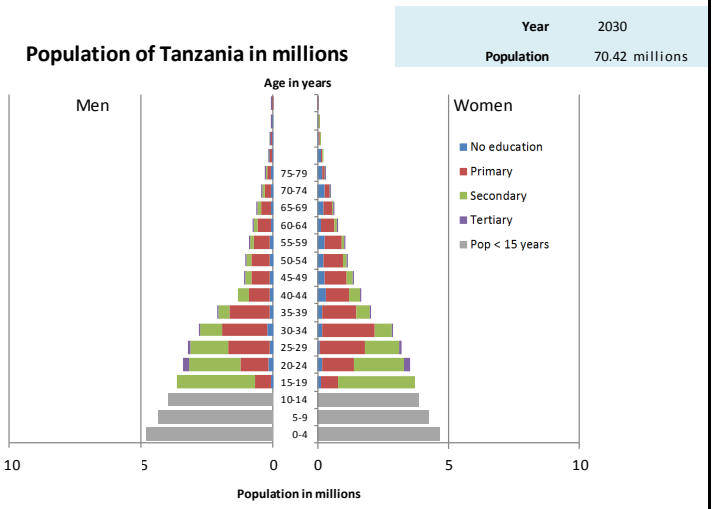
Scenario 4: Solver UN low fertility (fertility), Scenario C: Sustainable Development Goals (education)



Scenario 4: Solver UN low fertility (fertility), Scenario C: Sustainable Development Goals (education)



Scenario 4: Solver UN low fertility (fertility), Senario D: Fast Track (education)



Scenario 4: Solver UN low fertility (fertility), Senario D: Fast Track (education)