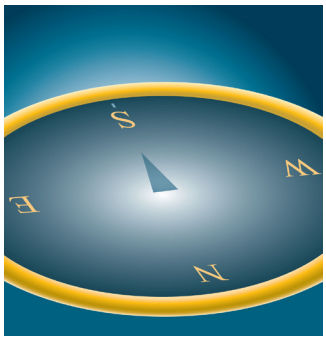
United NationsDevelopment Programme
Human Development Report Office



Demography and Human Development:

Education and Population Projections

by Wolfgang Lutz and Samir KC, International Institute for Applied Systems Analysis (IIASA)

OCCASIONAL PAPER 2013/04

Wolfgang Lutz *is Founding Director of the Wittgenstein Centre for Demography and Global Human Capital and Professorial Research Fellow at the Oxford Martin School for 21st Century Studies. He holds PhDs in Demography from the University of Pennsylvania and in Statistics from the University of Vienna. His work focuses on family demography, fertility analysis, population projections and interactions between population and environment. Dr Lutz is author or editor of 28 books and more than 200 refereed articles. In 2010 he received the highest science award in Austria, the Wittgenstein-Preis.*

Samir K.C. *is leader of the "Modeling Human Capital Formation" project of the World Population Programme at the International Institute for Applied Systems Analysis (IIASA). He joined the programme as a Research Scholar in May 2005. His current research focuses on population projections with various levels of disaggregation, including education and health. Dr. K.C. holds a PhD from the Faculty of Spatial Sciences at the University of Groningen, the Netherlands and a Master's in statistics from Tribhuvan University, Nepal. His major research interest is in developing and applying multi-state population models in demographic analyses and projections.*

UNDP Human Development Report Office
304 E. 45th Street, 12th Floor
New York, NY 10017, USA
Tel: +1 212-906-3661
Fax: +1 212-906-5161
http://hdr.undp.org/

4

Demography and Human Development:

Education and Population Projections

WOLFGANG LUTZ AND SAMIR KC, INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS (IIASA)

ABSTRACT

Changes in the size and structure of human populations are conventionally modeled and projected by stratifying the population by age and sex. Here we present new approaches, which use multidimensional demographic methods to add educational attainment as a third dimension in studying population dynamics. In virtually all societies, better-educated adults have lower mortality rates and their children better chances of survival. Almost universally too, women with higher levels of education have fewer children, through choice and higher access to birth control. Because of these pervasive differentials, scenarios of potential improvements in education have significant implications for future population growth. The projection of future educational attainment distributions is of significant interest in its own right as well, as education has a great influence on almost every aspect of progress in human development.

INTRODUCTION

Human development can best be studied with models that have human beings rather than monetary or other units at the core of their analysis. Demography, which can also be defined as the mathematics of people, specifies all of its models strictly in terms of human beings according to different relevant characteristics. Hence, it offers a most appropriate approach to the study of human development across the world. Traditionally, demographic analysis has mostly focused on the changing composition of populations by age and gender. But human beings have many observable and measurable characteristics that distinguish one individual from another and that can be considered highly relevant for human development; these characteristics can also be assessed in aggregate and used to distinguish one sub-group of a population from another. Here we will focus on the level of highest educational attainment and to a lesser extent also health status in addition to age and gender.

In virtually all societies, better educated men and women have lower mortality rates, and their children have better chances of survival (KC and Lentzner 2010). Almost universally, women with higher levels of education have fewer children, presumably because they want fewer and find better access to birth control. There are, of course, many factors influencing the level of fertility that range from the status of women within the family, to female labour force participation, to general socio-economic development. However, extensive research has shown that among this myriad of factors, the level of female education and the availability of reproductive health services are the two most important ones that are open to policy interventions (Bongaarts and Sinding 2011, and Lutz and KC 2011). The effect of education on fertility is particularly strong in countries that still have relatively high overall fertility levels and hence are in the early phases of their demographic transitions. There are many reasons to assume that these pervasive differentials are directly caused by education, which enhances the level of information, changes the motivations for behaviour, and empowers people to better pursue their own preferences, although strict causality can only be proven for specific cases in which natural experiments occurred. For the following projections by level of education, it is sufficient to assume that systematic associations will continue to persist over the coming decades, as they have for more than a century for all countries for which data exist.

Because of these fertility and mortality differentials by education, future changes in the educational composition of the population will greatly influence the future outlook for overall population trends around the world. In addition, education is not only an important source of population heterogeneity that influences population dynamics, but it is also an important influence on people's capabilities and empowerment, as will be discussed below. Hence there are many reasons for making investments in education in general and in female education in particular in programmes directed at better global health, population stabilization, poverty reduction and sustainable development.

1. MEASURING AND MODELLING EDUCATION[1]

When measuring education, it is important to distinguish conceptually between education flows and stocks.

Flows refer to the process of education – to schooling and, more generally, the production of human capital – and may consist of formal and informal education. The process of education is the central focus of pedagogy and education science, where the usual statistical indicators are school enrolment rates, student-teacher ratios, drop-out rates and repetition rates.

Human capital refers to the stock of educated adults, which is the result of past education flows for younger adults in the more recent past and for older ones some decades ago. This stock is usually measured in terms of the quantity of formal education (highest level of attainment or mean years of schooling) but the quality dimension (the general knowledge and cognitive skills people actually have) and the content or direction of education also matter. For countries with data on the cognitive skills of the adult population, the evidence has shown significant economic impacts of education quality (Hanushek and Woessmann 2008) but the number of these countries is still very limited. The content of education matters more for higher education than for basic education, where the main aim is the acquisition of literacy skills and basic numeracy.

The quantity of formal education is often measured by the mean years of schooling of the adult population above either the age of 15 or 25. This has the advantage of capturing the entire human capital of a population at one point in time in one single number (or two when one distinguishes between men and women). Yet, there is much to be gained from decomposing this highly aggregate indicator into the full distribution of educational attainment categories (and thus capturing the differences in the composition of education stocks across countries and regions) and into different age groups, and hence capturing inter-cohort changes that drive many of the consequences of improving human capital on society and the economy.

There are many ways in which education and the resulting human capital affect human well-being at the individual and society levels. A huge body of literature shows that better educated people tend to have better health, higher income and higher life satisfaction (Lutz 2009); better educated societies tend to have higher economic growth and better institutions (Lutz et al. 2008, 2010). Most of these assessments of the consequences of education only refer to the length and level of formal education, because these elements have the only systematically available data. It is plausible to assume that the quality and content of education also matter for many of these consequences, although little empirical evidence exists to date.

The projections presented here are based on the demographic method of multi-state population projection, which was developed at IIASA during the 1970s, and is now a well accepted method among technical demographers. Our baseline year, providing the empirical starting point, is 2000, the same as in our reconstruction of education distribution in the past. This allows the backward and forward projections to be connected in a gapless time series. We chose 2000 as the base year, since the data for 2005 were not available for a vast majority of countries.

The basic idea of projection is straightforward: Assuming that the educational attainment of a person remains invariant after a certain age, we can derive, e.g., the proportion of women without any formal education aged 50-54 in 2005 directly from the proportion of women without any formal education aged 45-49 in 2000. Continuing to assume that this proportion is constant along cohort lines, the proportion of women without education aged 95-99 in 2050 for the same cohort follows directly. In a similar manner, the proportions for each educational category and each age group of men and women can simply be moved to the next older five-year age group as one moves forward in time in five-year steps.

These proportions would be precisely correct if no individual moves up to the category with primary education after the age of 15, and if mortality and migration did not differ by level of education. This follows directly from the fact that the size of a birth cohort as it ages over time can only change through mortality and migration. However, strong links do in fact exist between the education level and mortality, fertility and migration behaviour. Accordingly, the above approach is adjusted to correct for these effects. The size of birth cohorts is dependent on the levels of education of women of childbearing age, where a negative relationship is traditionally observed. In projecting these cohorts forward, differential survival rates are applied to the education groups. The differentials are based on a comprehensive literature review as well as on modelling exercises based on past data. The details of these adjustments are provided in later sections of this paper.

The above treats the different education groups essentially as separate sub-populations. In addition, at younger years, transitions between education categories may occur. These are described in detail in later sections. The analysis is simplified

1 This sections draws heavily on Lutz et al. 2007; KC et al. 2010.

by the assumption that changes in educational attainment are uni-directional; in other words, individuals can only move from the 'no education' status to primary, and on to secondary and possibly to tertiary, but never revert to a lower status.

In reality, the likelihood of an individual making the transition from one educational attainment level to the next highest is strongly dependent on the education of the parents. This educational inheritance mechanism is not, however, modeled explicitly here. Instead, the assumptions regarding the transition rates and their future development are statistically derived from the aggregate behaviour of education systems in the past. Since this expansion is partly the result of the inheritance mechanism, i.e., the fact that many parents aspire for their children to reach an education level at least as high as they themselves did, inheritance is implicitly reflected in the projection, even though it is not formally part of the model. Such an approach appears preferable at this time, because data on the aggregate growth patterns of education systems, on which assumptions for the future can be based, are much more readily available than robust data on the micro-process of educational inheritance.

The starting point for the projection is data collected for each country (typically around the year 2000) that gives the total population by sex, five-year age groups, and four attainment categories based on the current International Standard Classification of Education (ISCED 1997): no education, primary, secondary and tertiary (see Table 1).

Table 1: Education categories

Category	Definition
No education (E1)	No formal education or less than one year of primary
Primary (E2)	Uncompleted primary, completed primary (ISCED 1) and uncompleted lower secondary
Secondary (E3)	Completed lower secondary (ISCED 2) uncompleted and completed higher secondary (ISCED 3/4) and uncompleted tertiary education
Tertiary (E4)	Completed tertiary education (ISCED 5/6)

A single set of categories applied to all countries regardless of their state of educational development inevitably requires some compromises. Surveys used exclusively in developing countries have historically provided little differentiation at higher education levels. Conversely, data collected in industrialized countries may not differentiate below completed primary level. For present purposes, the entire spectrum from no education to completed tertiary needs to be covered. At the same time, a large number of detailed categories would be unwieldy and limit the number of countries for which data are available. Consequently, a relatively small number of categories is used to cover the entire spectrum. This means that the categories are relatively broad. Note, for instance, that 'primary' does not refer to completed primary, but to having more than one year of primary schooling. Likewise, for the purposes of this study, 'secondary' refers to lower secondary, not completed upper secondary. As a result, the 'secondary' category is quite broad, encompassing ISCED levels 2-4. The reason for not splitting off ISCED 4, however, is that the distinction between ISCED 3 and 4 is one of the least clear-cut. ISCED 4 programmes "are often not significantly more advanced than programmes at ISCED 3" (UNESCO Institute for Statistics 2009, p. 258). As a result, attempting to distinguish between ISCED 3 and 4 would have undermined the straightforward hierarchical interpretation of our education categories.

Our procedure for each country can be summarized as follows:

- A baseline population distribution by five-year age group, sex and level of educational attainment is derived for the year 2000.
- For each five-year time step, cohorts move to the next highest five-year age group.
- Mortality rates are applied, specific to each age, sex and education group, and to each period.
- Age- and sex-specific educational transition rates are applied.
- Age-, sex- and education-specific net migrants are added to or removed from the population. In the projections presented here, the migration assumptions correspond to those used in UN population projections, with additional assumptions on the education profile of migrants. Since the United Nations assumes an overall decrease in the volume of migration over time, these assumptions are not of critical importance.
- Fertility rates are applied, specific to each age, sex and education group, and to each period, to determine the size of the new 0-4 age group.
- The new population distribution by age, sex and level of educational attainment is noted, and the above steps repeated for the next five-year time step.

The aim of the projection is to obtain a dataset with the population distributed by five-year age groups, starting at age

Figure 1a: Structure by age, sex and level of education for South Africa for the year 2000

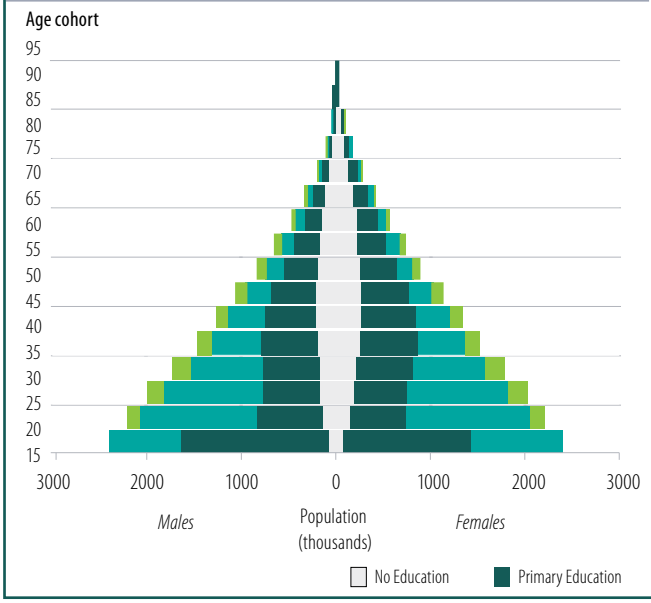
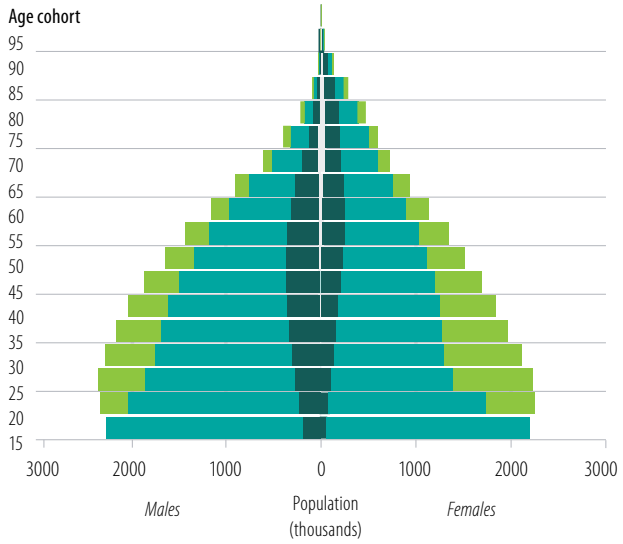


Figure 1b: Projected structure for South Africa for the year 2050



15 and with the highest age group 100+; by sex; and by four levels of educational attainment over a period of 50 years, from 2000 (base year) to 2050, in five-year intervals.

To illustrate the kind of information that this projection method generates for 120 countries in the world, Figure 1 gives an example in terms of age pyramids by level of education for South Africa. The first pyramid (Figure 1a) shows the structure by age, sex and level of education for the year 2000, which is the empirical baseline information used for the reconstruction. The second pyramid (Figure 1b) gives the projected structure for the year 2050, resulting from our method.

2. ALTERNATIVE EDUCATION SCENARIOS[2]

While the fertility, mortality and migration assumptions underlying the projections presented here are discussed extensively elsewhere (Lutz et al. 2004; KC et al. 2010), we will focus on the definition of four different scenarios reflecting different education policies in countries around the world.

While making assumptions about future educational development over the course of several decades is a difficult task, it is not intrinsically more difficult than making assumptions about reproductive behaviour or mortality. Like variant projections of demographic indicators, the education scenarios below are not to be interpreted as predictions or forecasts, but as exercises in 'what if' reasoning. As such they serve the important purpose of illustrating the consequences of different kinds of trends and policy environments on global human capital. 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. The changing educational composition of a population not only matters as a source of heterogeneity in population projections. Information about the likely future educational composition is also very important in its own right for charting progress in human development and drawing inferences in terms of the likely benefits from such different possible trends.

The following four scenarios try to demarcate the broad range of possible future trends in schooling. Since the stock of human capital can only change through changing patterns of school enrolment for the young generation (in addition to minor possible changes through differential mortality and migration, and very rarely adult education), all four scenarios are defined in terms of future trends in school enrolment. They range from the worst case of declining school enrolment rates, to the case of no further improvements in enrolment rates that might result from political inaction, to a medium policy scenario in which it is assumed that the future expansion of enrolment rates follows the collective experience of

2 This section draws heavily on KC et al. 2010.

the countries that are already somewhat more advanced in educational expansion, to the strong policy fast track scenario. This last scenario assumes that the country manages to follow the experience of nations such as the Republic of Korea and Singapore, who experienced some of the most rapid expansions in schooling in human history. While the medium policy global education trend scenario may be considered the most likely trajectory for every country, the range from the fastest possible expansion to the decline of enrolment rates spans all future trends that might be considered plausible (in the sense of not impossible), although they are not necessarily likely trajectories.

CONSTANT ENROLMENT NUMBER (CEN) SCENARIO: WORST CASE SCENARIO

In a sense, this is a worst-case scenario in that it assumes zero expansion of schooling. In the context of population growth, this implies that the proportion of children enrolled in school is actually declining over time. Although some African countries have shown such a trend during the 1980s, here this scenario is not presented as a likely future possibility, but serves reference purposes only. Its technical definition is straightforward.

The assumption is that in each country, the number in each cohort (by gender) making each educational transition at the appropriate age remains constant over time. Accordingly, the relative share of the attainment levels can rise and fall, depending on changes in cohort size.

CONSTANT ENROLMENT RATIO (CER) SCENARIO: NO ACTION SCENARIO

Like the previous scenario, the projection of constant transition rates between attainment levels (and as a result constant proportions in each level within each cohort) serves largely illustrative purposes. It demonstrates the implications of extending the status quo into the future, without regard for contextual change. In its disregard of historical upward trends and of the opportunity for 'no-cost expansion' when cohort size declines, it is a somewhat pessimistic scenario.

The technical definition of the CER scenario is straightforward. In each country, the proportion of each cohort (by gender) making each educational transition at the appropriate age remains constant over time. Note that these constant proportions are applied not to cohorts at birth, but to cohorts of survivors at the relevant age. This ensures that a decrease in infant mortality by itself will not reduce the educational transitions of surviving children under the assumption of constant proportions.

GLOBAL EDUCATION TREND (GET) SCENARIO: MEDIUM POLICY SCENARIO

This is a more complex scenario that is not derived from a single, simple assumption. Informally, the GET scenario assumes that a country's educational expansion will converge on an expansion trajectory based on the historical global trend. The identification of the global trend is based on a data-driven judgemental analysis. This means it is neither derived by mechanistically applying a statistical model, nor a mere 'expert estimate', but based on the application of domain knowledge to the empirical data.

This scenario, which resembles the collective experience of countries already further advanced in education expansion, needs to make some special assumptions for front-runners, including the assumption of a possible maximum of education. From a theoretical perspective, the limiting constraints of educational expansion differ at different stages. Initially, expansion in enrolment is likely to be essentially limited by the available supply of school places. As long as only a small fraction of each cohort is enrolled in primary school, it seems plausible that each additional school that is built can be filled with willing students. At this stage, enrolment is largely supply-limited. Once the vast majority of each cohort is enrolled, say 90% or more, the fact that the remaining 10% are not enrolled is unlikely to be the result of a lack of school places. In fact, by the time 90% are enrolled, cohort growth will typically have fallen considerably, meaning that raising the enrolment ratio further does not require physical expansion. Instead, enrolling the last few percent is typically a matter of accessing hard-to-reach populations, such as children in remote rural areas, working children, those suffering from disabilities and so on. Complete enrolment of these groups in school requires not school expansion, but well-designed and targeted demand-side interventions.

Both accelerating and decelerating phases of attainment expansion can be modeled well by cubic splines at all attainment levels. The placement of the point at which the curve switches from accelerating to decelerating expansion was chosen to ensure the splines connect smoothly. The exact placement is not critical, since the curve is approximately linear for much of the central section. Fitting such bi-cubic models to each country shows good individual fits (in the vast majority of cases with an adjusted R-squared greater than 0.8), and the resulting parameters, indicating the 'pace' with which different countries traverse the cubic curve, turn out to have a unimodal, fairly symmetric and tightly clustered distribution. The parameter means across the individual country models may therefore reasonably be considered to constitute

the 'typical' global trend. Countries that had already achieved 99% or higher participation were excluded in determining the overall mean expansion parameter. The projected trajectories resulting from applying these global trend parameters were examined for their plausibility.

In general, the comparison of the average growth patterns across phases and genders shows that while the schooling of girls may have started later, it has been expanding at a much faster pace. The gender difference is more or less the same at primary and secondary levels, but dramatically greater at the tertiary level. Between 1970 and 2000, female tertiary attainment growth has been closer to the pace of male primary or secondary expansion in the past.

The application of the GET scenario will normally result in more optimistic trajectories of educational attainment than either the CEN or CER scenarios. However, it is important to note that in the case of the latter, this is not by definition. In a context of rapidly falling cohort sizes, the assumption of constant enrolment may in principle translate into increases in the proportions at higher attainment levels that are higher than the increases implied by the GET scenario. In fact, it could be argued that the GET scenario is rather conservative. The above parameters imply, for instance, that it takes a typical country about 40 years to raise female participation in primary schooling from 50% to 90%, and over 30 years after that to reach 99%. The latter in particular may seem discouragingly slow (moreover, female primary participation has been the fastest process over the period studied), but reflects the empirical average. While some countries have expanded access much more quickly, others have stagnated and made even less progress during the final decades of the 20th century, and this is reflected in the average slope.

THE FAST-TRACK (FT) SCENARIO: STRONG POLICY SCENARIO

In addition to the above scenarios that define lower bounds, worst-case or 'no change' environments, an optimistic scenario has been defined. This is based on the GET scenario defined above, but assumes the achievement of certain milestones. If stated targets in attainment are not reached by certain years (both of which are defined below) under the assumptions of the GET scenario, then an accelerated rate of growth is applied that meets these targets.

As a result, the increases over the GET scenario are not in the form of uniformly faster growth, but in the form of lifting up the countries that are furthest behind. This reflects the actual political dynamics through which such acceleration has been attempted in the past. Both the Millennium Development Goals (MDGs) and the Education for All (EFA) goals took a 'milestones' approach, and the EFA Fast Track Initiative (FTI) shows that international support will not be indiscriminate and thinly spread, but focused on those countries lagging furthest behind.

Our FT scenario illustrates the implications of a new round of similar policy initiatives focusing on secondary education (the next logical step after the achievement of universal primary education). Since our category E3 is based on completed lower secondary, it is assumed that the target proportion will eventually be universal attainment of E3 by 2050. Since this target is very far off, however, a more achievable intermediate target is assumed for 2030. While no international policy frameworks have so far recommended specific targets for tertiary participation, the rapid pace of tertiary expansion in many parts of the world displays a great amount of ambition in this regard, both individual and national. As an explicitly optimistic scenario, the achievement of a proportion of 60% at attainment level E4 is assumed to be reached by 2050. While this is as high as some of the very highest levels observed today, it is already exceeded by the aspirations of teenagers in some developing and transitional countries (OECD 2007). Even if the assumptions turn out to be overoptimistic (given that it appears increasingly unlikely that the EFA goals for enrolment will be achieved in 2015), the scenario serves as a useful comparison with actual developments to assess how much human capital has been 'lost' by missing the targets.

For the primary level (E2), the attainment of 99% transition to E2 by 2015 is assumed under the FT scenario, corresponding approximately to the achievement of the EFA goals. Lower secondary schooling (E3) is assumed to reach 50% of each cohort by 2030, and 90% by 2050. Tertiary (E4) is assumed to reach 60% by 2050.

Finally, a word on intergenerational transmission of education in the scenarios. This is implicit in the above assumptions, which have been defined in terms of the proportion of a cohort that reaches a certain level of highest educational attainment. These proportions are comprised of children who come from mothers with that level of education plus children with mothers from lower education groups (upward mobility) and children whose mothers had a higher educational level (downward mobility). Here we only refer to mothers' education, since there are more data available and the effect is better documented. Clearly, fathers' education also matters in this context. Since there is generally very little empirical information on educational upward and downward mobility in most countries of the world, and since those movements

are greatly dependent on government policies with respect to the expansion of the school system, it seemed appropriate to define the scenarios in terms of overall proportions. In the GET scenario, which is based on the continuation of empirically given trends that already include such intergenerational transmission mechanisms, a simple continuation of past transmission and mobility trends is assumed. In the CEN and CER scenarios, upward mobility is assumed to be curtailed, while in the FT, it is assumed to be greatly enhanced. Finally, it is important to stress that child mortality (up to age 15) under all scenarios is derived from the mother's education, and hence different education scenarios will also result in different mortality trajectories, as will be discussed in the last section.

3. RESULTS

Numerical and graphical results for all countries in the world for which data are available (98% of the world population) have been collated for five-year age groups, five-year steps in time up to 2050, four educational categories, and all four education scenarios described above. Due to the enormous amount of data and figures, only trends for selected important countries and scenarios will be presented here.

For highlighting the results, we chose five countries from different continents and at very different stages of socio-economic development. Table 2 gives selected indicators of female educational attainment for these countries in 2010, and as projected to 2050 according to the four alternative scenarios. The four figures show the changing educational compositions over time for each country. Only one scenario per country is depicted for illustration.

The Republic of Korea has seen one of the fastest expansions of education in human history. While in the 1950s it was one of the poorest countries, with a vast majority of the adult population never having been in school, today women there are among the best educated in the world. The table shows that 43% of all women aged 15-44 have completed tertiary education, a value much higher than in most European countries.

Figure 2 shows the dramatically changing educational composition of the Republic of Korea from 1970 to 2050 resulting from the no-action constant enrolment scenario from 2010 onwards. Cohorts that were of school age in the 1950s have to a large proportion received no formal education at all, while today more than half of all young women have completed tertiary education. As a consequence of the great momentum described above, elderly people in the Republic of Korea today still have very low education, but we know with certainty that the elderly of the future will be much better educated and therefore most likely also in better health. In part, because of the high education of young women, the birth rates in the Republic of Korea have also declined to very low levels, and the population is expected to age very rapidly and start declining over the longer run. Because today the younger population is already among the best educated in the world, the different scenarios as shown in Table 2 only differ slightly with respect to the proportion of women with tertiary education in 2050.

Figure 3 shows the trends since 1970 for the world's most populous country, China, according to the medium policy GET scenario. It clearly demonstrates the enormous educational expansion that took place over the past decades, which without doubt was a major engine of economic growth and poverty reduction (Lutz et al. 2008). In the 1970s, more than a third of Chinese adults had no formal education at all, and a significant part had only some primary education. It was during the 1980s and 1990s that rapid expansion of the school system even in remote rural areas resulted in a significant increase in the proportion of people who had completed junior secondary education, which was concentrated among younger adults. With the passage of time, these better educated cohorts will move up to older age groups and result in significant further improvements of the average educational attainment of the adult population. As Table 2 shows, this momentum of improvements in human capital will even under the worst scenarios result in further increases in the education of the female adult population. While today around 10% of Chinese women of reproductive age have completed tertiary education, by 2050 this proportion will have increased to between 14% and 50%. Under the FT scenario and even under the GET scenario, the Chinese population in 2050 will be much better educated than the populations of Europe today.

The picture for India looks very different. Figure 4 shows that up until 2000, more than half the adult population of India had no formal schooling whatsoever; this trend was particularly pronounced among women (Table 2). Given great momentum in improvements in the educational attainment of adults, recent efforts by the Indian Government to greatly increase school enrolment in rural areas (which are already reflected in the GET scenario shown in the graph) will only very slowly reduce the uneducated proportion of the total adult population. Partly due to the lower level of female education, the total population of India is expected to grow more rapidly than in China. At the same time, there is an impressive expansion of the number of better educated people in India, which is undoubtedly a key factor in India's recent economic growth.

Table 2: Results of projections by age, gender and level of education for five selected countries and all four scenarios focusing on the education of women of reproductive age

Country			Population (millions)		Proportion (women aged 15-44)			
			All	Women aged 15-44	No education (%)	Primary (%)	Secondary (%)	Tertiary (%)
Brazil	2010		195	47	3	38	52	7
	2050	FT	223	40	0	9	57	34
		GET	224	41	0	9	71	20
		CER	240	44	1	32	60	7
		CEN	238	44	0	24	68	8
China	2010	GET	1,341	318	3	18	69	10
	2050	FT	1,266	190	0	2	48	50
		GET	1,301	198	0	2	69	29
		CER	1,328	202	1	10	76	14
		CEN	1,294	195	0	0	76	24
India	2010	GET	1,225	284	35	23	35	6
	2050	FT	1,604	323	0	16	45	38
		GET	1,624	328	6	12	61	21
		CER	1,682	339	21	24	46	8
		CEN	1,687	340	21	24	47	7
Kenya	2010	GET	41	9	9	35	53	2
	2050	FT	90	22	0	9	62	29
		GET	90	22	1	8	82	9
		CER	101	24	6	32	60	2
		CEN	119	27	57	15	27	1
Republic of Korea	2010	GET	48	11	0	3	54	43
	2050	FT	47	7	0	0	50	50
		GET	47	7	0	0	50	50
		CER	47	7	0	2	44	53
		CEN	46	7	0	0	45	55

However, even under this rather optimistic GET scenario, India will have highly unequal distribution of education by 2050. Under the two more pessimistic scenarios, more than one out of five young Indian women—more than 70 million women of childbearing age—will still be without any formal education.

Even under the most optimistic FT scenario, which is depicted in Figure 4, and which assumes education expansions similar to those in the Republic of Korea over the past decades, the slow change in the composition implies that by the middle of the century, there will be a sizable group of uneducated, mostly elderly adults in India. However, the assumed rapid expansion in tertiary education under this scenario will result in a very well educated younger labour force.

The picture for Brazil lies between those for China and India. Brazil has not seen as rapid an education expansion as China, but also has a significantly lower proportion of people without any formal education than India. As in the Asian Tiger states and many other countries, in Brazil, the current economic boom together with effective anti-poverty programmes linked to education are closely associated with a rapid expansion of the better educated, younger work force. The data by five-year age groups demonstrate this clearly. Frequently given interpretations of the recent economic boom as due mostly to the export of raw materials tend to disregard this important human capital factor. Today, more than half of reproductive age women have completed junior secondary

Figure 2: Population trends by level of education according to the constant enrollment ratio (CER) scenario for the Republic of Korea (1970-2050)

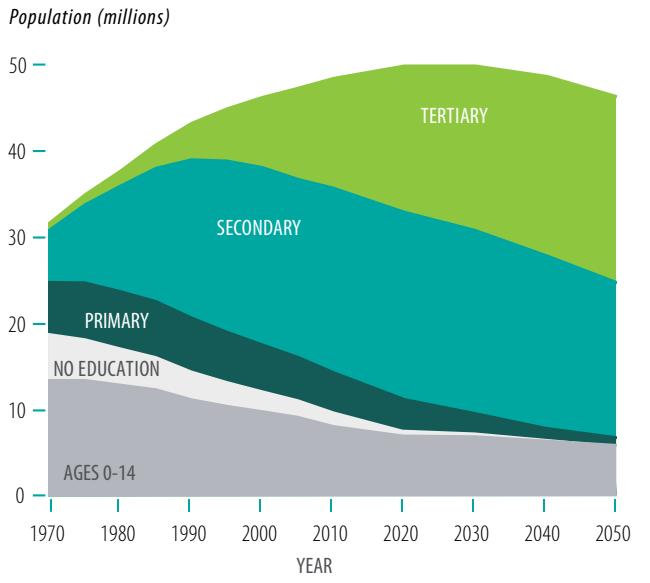
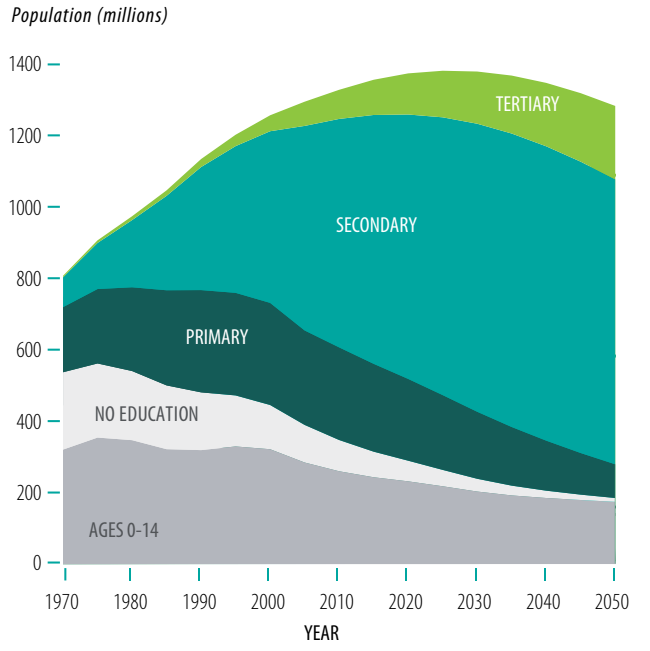


Figure 3: Population trends by level of education according to the global education trend (GET) scenario for China (1970-2050)



education, and only 3% of them have no formal schooling. If Brazil chooses to pursue the strong policy FT trajectory, its proportion of young women with completed tertiary education would increase from the current 7% to 34%, similar to what the Asian Tiger states recently experienced. Even the medium policy GET scenario (depicted in Figure 5) shows an improvement by a factor of three in the proportion of highly educated women.

Some developing countries have not yet gained enough educational momentum to assure continued further increases in the average education of the population. Kenya has recently seen significant expansion of primary and junior secondary education even among women. Although there are some doubts about the quality of this education, it needs to be acknowledged as an achievement that already more than 90% of young women (a greater share than in India) have at least had some schooling. However, fertility rates in Kenya are still very high by any standard, with Kenyan women having on average 4-5 children.

While the FT scenario shows how Kenya could accelerate its development, Figure 6 gives the most pessimistic CEN scenario, which assumes that essentially no new schools are being built and the number of students does not further increase, despite rapid population growth due to rather high birth rates. For this reason, it will be a major challenge for the school system to keep pace with the rapidly expanding number of children of school age. In the CEN scenario, the country's Government (for whatever reason) is assumed not to keep pace with population growth. Since women with low education have particularly high fertility, this will result in even more births with a still lower prospect for education. As a consequence, there will be a decline in the average educational attainment of the population, and an even more rapid pace of population increase, which would make all efforts towards social and economic development an even more difficult uphill battle.

Figure 7 finally shows the global impact of alternative education trends on population growth paths until the middle of the century. It is based on identical education-specific fertility rates; hence, all the differences are a function of the changing proportion of women in different education categories as a consequence of the different education scenarios described above. Population size in the FT scenario will be over 1 billion people, lower than under the CEN scenario by 2050. This implies that alternative education trajectories alone over the next 40 years will make a difference to global population size that is bigger than the entire population of Africa today or three times the current US population. This effect is strongest

Figure 4. Population trends by level of education according to the fast track (FT) scenario for India (1970-2050)

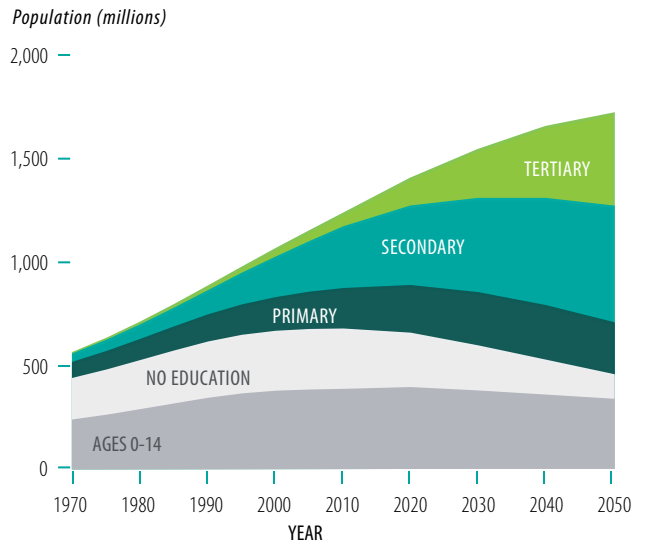
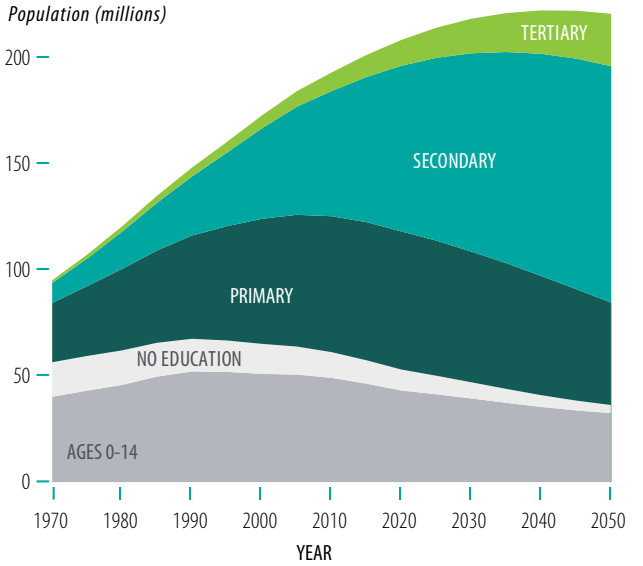
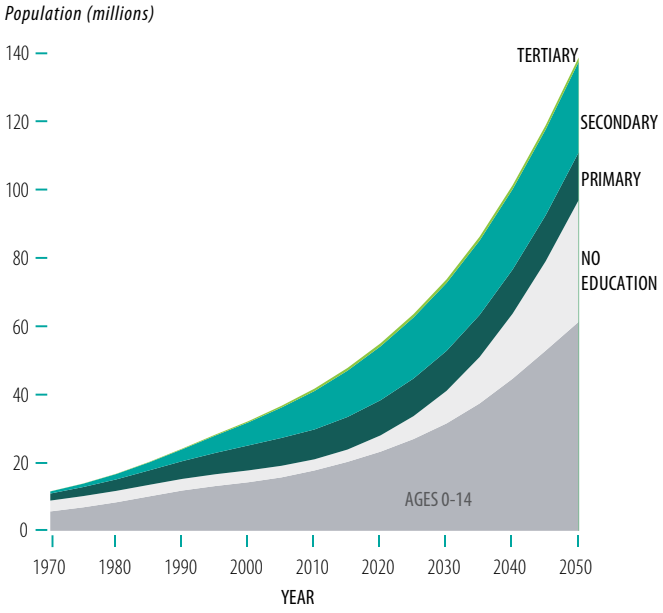


Figure 5: Population trends by level of education according to the global education trend (GET) scenario for Brazil (1970-2050)



for countries with currently high fertility rates and high education differentials. In Kenya, as discussed above, the population would increase from 31 million in 2000 to 84-85 million in 2050 under the optimistic scenarios (FT, GET), but increase to an incredible 114 million if no new schools are built (CEN). The difference between these extreme scenarios is 30 million—about the size of Kenya's total population in 2000.

Figure 6: Population trends by level of education (1970-2050) according to the CEN scenario for Kenya

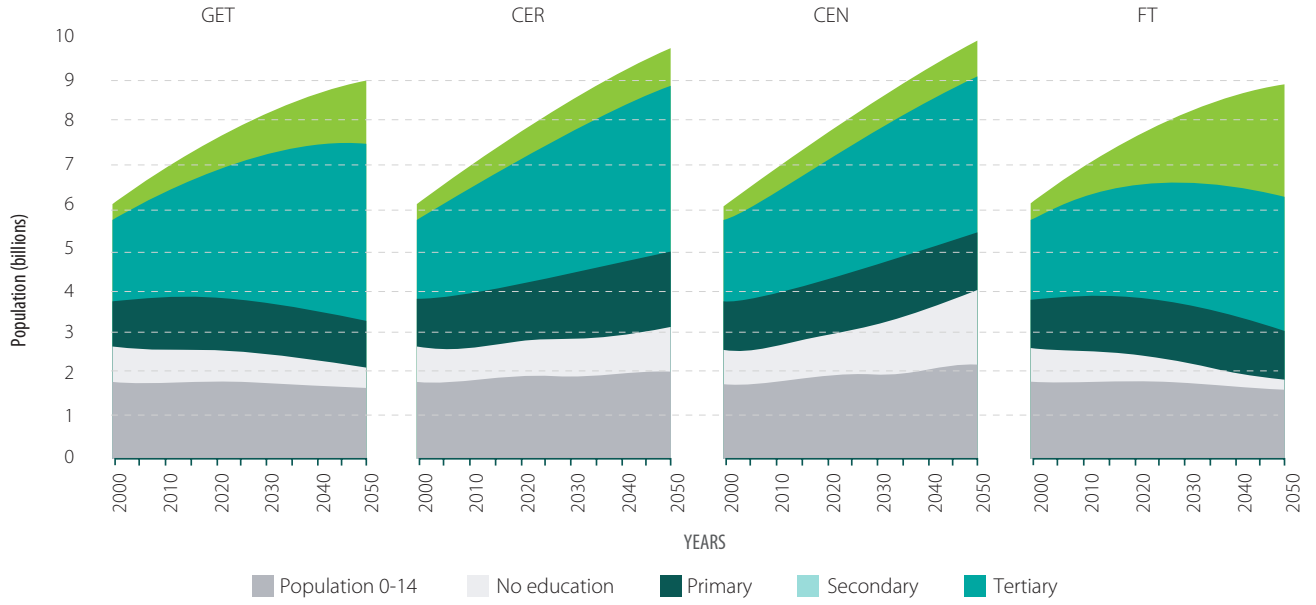


4. EDUCATION, HEALTH AND MORTALITY[3]

Education has long been considered a key covariate of health and mortality in both industrialized and developing countries; recently, more research has substantiated the causal nature of this relationship. In particular, a great deal of research has focused on substantiating the independent and causal relationship between maternal schooling and child health (Caldwell 1979; Fuchs et al. 2010). Reviews of surveys and census data from developing countries (Hobcraft et al. 1984; Mensch et al. 1985) and econometric analyses of cross-country macro-data have confirmed women's education as the most significant determinant of child mortality, where estimates show that each additional year of schooling is associated with a 5-7% reduction in child death (Mensch et al. 1985; Schultz 1993).

3 This section heavily draws on Lutz and KC 2011.

Figure 7: Alternative projections of total world population size by level of education according to the four different education scenarios (with otherwise identical education-specific fertility and mortality rates)



A systematic assessment for a large number of developing countries using recent Demographic and Health Survey (DHS) micro-level data finds that almost universally, a mother's education is more important for child survival than household income and wealth. This finding has significant implications for setting policy priorities, because it makes a big difference whether the emphasis is put primarily on girls' education or on household income generation.

Table 3 shows the magnitude of empirically measured child mortality differentials in a selection of developing countries. The indicators for the under-five mortality rate and the total fertility rate are compiled from DHS for the most recent surveys (after 2004). The under-five mortality rate is high in many African countries, especially among the children of uneducated mothers. The worst situation among the countries listed in the table is in Mali and Niger. In every country, the mortality rates are lower for better educated mothers. In some countries, primary education is already associated with much lower child mortality (e.g., in Bolivia and Nigeria); in others, the decisive difference only comes with secondary education (e.g., in Liberia and Uganda).

Given these strong differentials in child mortality by the level of education of mothers, it is not surprising that over time, alternative possible education trends will result in quite significant differences in child mortality. Table 4 gives some numerical illustrations of this fact for selected countries and world regions. The numbers provided are the absolute numbers of child deaths (ages zero to four) resulting from projections that assume identical education-specific fertility and mortality rates, and only differ by the assumed future paths of education expansion in the form of the scenarios described above.

Looking at India, the country with the highest absolute number of child deaths in the world, the number of deaths occurring in 2010-2015 of children born in this period is estimated to be around 7.9 million. Under the most optimistic FT education scenario, this number will decline to almost half its level by 2025-2030, and to as low as 3.1 million by 2045-2050. Even under the more likely GET scenario, it would decline to 5.4 million and 3.5 million, respectively. Under the pessimistic CEN and CER scenarios that assume no or only very limited future education expansion, some further decline is likely to happen due to the momentum of educational expansion (the already better educated youth cohorts will move up in the age pyramid) and the number of child deaths would slowly decline to around 5.6-6.1 million by the middle of the century.

In China, although it currently still has a greater population than India, the absolute number of child deaths is estimated to be only around 1.7 million, i.e., less than a quarter of those in India. Over time, further declines in the numbers of child deaths according to the different education scenarios are much steeper in China. Under the FT scenario—which

Table 3: Under-five mortality rates and total fertility rates for selected countries for recent years, by level of education of mothers

		Under-five child mortality* (per 1,000 live births)				Total fertility rate (number of live births per woman)			
	Period*	No education	Primary	Secondary or higher	Overall	No education	Primary	Secondary or higher	Overall
Bangladesh	2007	93	73	52	74	3.0	2.9	2.5	2.7
Benin	2006	143	121	78	136	6.4	5.2	3.7	5.7
Bolivia	2008	134	87	44	76	6.1	4.7	2.6	3.5
Cambodia	2005	136	107	53	106	4.3	3.5	2.6	3.4
Congo (Brazzaville)	2005	202	134	101	123	6.2	6.3	4.0	4.8
Democratic Republic of Congo	2007	209	158	112	155	7.1	7.1	5.0	6.3
Egypt	2008	44	38	26	33	3.4	3.2	3.0	3.0
Ethiopia	2005	139	111	54	132	6.1	5.1	2.0	5.4
Ghana	2008	103	88	67	85	6.0	4.9	3.0	4.0
Guatemala	2008	65	40	20	45	5.2	3.8	2.3	3.6
Guinea	2005	194	172	92	188	6.2	5.1	3.3	5.7
Haiti	2005-06	123	97	65	102	5.9	4.3	2.4	3.9
Honduras	2005-06	55	40	20	37	4.9	3.8	2.2	3.3
India	2005-06	106	78	49	85	3.6	2.6	2.1	2.7
Indonesia	2007	94	60	38	51	2.4	2.8	2.6	2.6
Liberia	2009	164	162	131	158	7.1	6.2	3.9	5.9
Mali	2006	223	176	102	215	7.0	6.3	3.8	6.6
Nepal	2006	93	67	32	79	3.9	2.8	2.2	3.1
Nicaragua	2006	67	40	26	41	4.4	3.2	2.0	2.7
Niger	2006	222	209	92	218	7.2	7.0	4.8	7.0
Nigeria	2008	210	159	107	171	7.3	6.5	4.2	5.7
Pakistan	2006-07	102	85	62	93	4.8	4.0	2.8	4.1
Philippines	2008	136	47	30	37	4.5	4.5	3.0	3.3
Rwanda	2007-08	174	127	43	135	6.1	5.7	3.8	5.5
Senegal	2008-09	112	74	33	100	5.6	4.5	3.1	4.9
Sierra Leone	2008	170	187	130	168	5.8	5.1	3.1	5.1
Swaziland	2006-07	150	106	95	106	4.9	4.5	3.4	3.9
Uganda	2006	164	145	91	144	7.7	7.2	4.4	6.7
Zambia	2007	144	146	105	137	8.2	7.1	3.9	6.2

Note: * Under-five child mortality refers to the period of 10 years prior. *Source*: DHS.

actually is relatively close to the path China has recently embarked on—the number of child deaths will decline to only around 0.5 million by mid-century, less than a third its current level. Even under the most pessimistic scenarios, it would only be slightly higher at 0.6-0.8 million. Here it is interesting to note that the CEN scenario results in fewer deaths than the CER scenario because under conditions of declining absolute numbers of children, as will be the case in China, the assumption of constant absolute numbers of students implies a further expansion of the proportion of people who are educated. By the middle of the century, under the CEN scenario, the number of child deaths in India will be almost 10 times higher

than in China, despite the fact that China today still has a significantly higher total population size.

In Kenya, the child mortality differentials due to education are particularly impressive. Currently, it is estimated that there are 0.58 million child deaths, as defined above. Under the most optimistic FT scenario, which is rather unlikely given Kenya's current school system, this number would only slightly decline by the middle of the century to 0.37 million. In contrast, the CER scenario, assuming constant enrolment rates, would see an increase in the number of child deaths to 0.69 million, and the most pessimistic CEN scenario would even see an explosion to 1.5 million. These significant difference are only due to different future education trends. Otherwise, education-specific fertility and mortality trends are identical, showing assumed secular declines over time corresponding to the fertility and mortality assumptions made in the UN population projections.

When interpreting these numbers, it is important to understand that the projected decline in the absolute numbers of child deaths reflects the combined effects of more educated women having fewer children, and fewer of these children dying due to lower child mortality rates. One can, of course, also separately study these two trends and give relative measures of child mortality, but under the view that every death of a child is one too many, it is appropriate to actually compare the absolute numbers of child deaths.

CONCLUSION

The countries of the world are currently at different stages of their demographic transition processes. It confuses many people that in some countries the concern is already with population shrinking (such as in Eastern Europe), while in others (mostly in Africa) it is still primarily with population growth. This pattern is primarily the consequence of the different timing of the phases of demographic transition in different parts of the world. In Europe, death rates started to decline in the late 19th century due to better nutrition and hygiene. Population growth was high during this period due to continued high birth rates, which only started to fall (with the exception of an earlier fertility decline in France) after World War I. Since all traditional societies had cultures and normative systems that were in favour of high fertility, in order to assure the survival of the population under high-mortality conditions, it typically takes societies several decades to adjust to the new lower child mortality conditions and change the normative system. In much of East and South-East Asia, a massive mortality decline after World War II was followed by an equally rapid fertility decline during the last two decades of the past century. It can be argued that the time lag between the mortality and fertility declines (also interpreted as a perception lag) was shortened due to rapidly increasing education in those countries. In Africa, the mortality decline

Table 4: Estimated and projected numbers of child deaths among children born in the stated period according to the different education scenarios (thousands of deaths)

	2010-15	2025-30	2045-50						
	GET	CEN	CER	FT	GET	CEN	CER	FT	GET
Brazil	328	224	232	177	182	161	185	102	106
China	1,716	897	1,067	871	969	625	809	526	633
India	7,872	6,707	6,479	4,806	5,393	6,096	5,566	3,064	3,510
Kenya	582	920	644	482	495	1,552	693	371	392
Republic of Korea	9	8	9	9	9	7	7	7	7
Mali	488	519	497	318	448	541	490	150	337
Pakistan	1,927	1,641	1,610	1,225	1,398	1,676	1,517	773	976
South Africa	288	198	204	165	171	134	137	93	102
Africa	16,552	18,964	16,381	12,095	13,803	24,185	16,807	7,495	10,380
Asia	15,029	11,715	11,544	8,924	9,845	10,561	9,780	5,681	6,493
Europe	276	209	218	204	207	196	207	187	186
Latin America and the Caribbean	1,192	963	911	704	724	950	774	413	435
Northern America	162	160	162	155	154	165	164	152	151
Oceania	11	11	12	11	11	12	12	10	10

has started still later and has been more gradual—in some countries even interrupted by HIV/AIDS. The perception lag seems to be particularly long for various reasons that range from exceptionally strong pro-natalist traditional values to little progress in terms of education. Although in most African societies the fertility transition has already started, the gap between low death rates and high birth rates is still great, resulting in very rapid population growth.

The demographic transition not only affects the pace of population growth, but also comes with an age-structural transition. When birth rates start to decline, the proportion of children to adults also falls, which results in a decreasing young-age dependency ratio. A given number of adults need to support a smaller number of children, which is a force that can drive economic growth and improvements in infrastructure and education, and is hence called the demographic dividend or demographic bonus. While much of the literature in this field only points to the changing age dependency pattern, it is also worth giving more attention to the improving education profile and the age structure as factors enhancing economic growth. It has been argued that investments in education actually have a double effect on economic growth and poverty reduction: They tend to bring down birth rates and trigger the demographic dividend, and at the same time increase the economic productivity of the young adult population, which has an independent and possibly even stronger direct effect on economic growth (Lutz 2009).

Education matters greatly for almost every aspect of progress in human development. The empowering function of education is considered a major goal in its own right. In particular, universal basic education is a significant factor for enhancing the health and empowerment of men and women alike; this is also why it figures prominently among the MDGs. The Human Development Index, one of the most widely used indicators of desirable social and economic progress, consists of three components, one measuring progress in education itself and the two others capturing progress in health and material well-being (UNDP). As discussed above, there is reason to assume that these latter two aspects are to some extent driven by progress in the education of the population, and that indeed human capital may be viewed as the root cause of human development (Lutz 2009). Human capital data differentiated by age and gender help to shed some light on this assertion. They can open the door to many further studies that go beyond the cruder previous indicators of education, which lacked age or distributional detail, to provide a richer understanding of the many longer term returns to investments in education.

REFERENCES

Bongaarts, J., and S. Sinding. 2011. "Population policy in transition in the developing world." *Science* 333(6042), pp. 574-576.

Caldwell, J. 1979. "Education as a factor in mortality decline: An examination of Nigerian data." *Population Studies 33*, pp. 395-413.

DHS (Demographic and Health Surveys). www.measuredhs.com.

Fuchs, R., E. Pamuk and W. Lutz. 2010. "Education or wealth: Which matters more for reducing child mortality in developing countries?" *Vienna Yearbook of Population Research 2010,* pp. 175-199. Verlag der Österreichischen Akademie der Wissenschaften, Vienna.

Hanushek, E. A., and L. Woessmann. 2008. "The role of cognitive skills in economic development." *Journal of Economic Literature* 46, pp. 607-668.

Hobcraft, J. N., J. W. McDonald and S. O. Rutstein. 1984. "Socio-economic factors in infant and child mortality: A cross-national comparison." *Population Studies* 38(2), pp. 193-223.

KC, S., B. Barakat, A. Goujon, V. Skirbekk, W. Sanderson and W. Lutz. 2010. "Projection of populations by level of educational attainment, age and sex for 120 countries for 2005-2050." *Demographic Research* 22, article 15, pp. 383-472. www.demographic-research.org/Volumes/Vol22/15/, DOI: 10.4054/DemRes.2010.22.15.

KC, S., and H. Lentzner. 2010. "The effect of education on adult mortality and disability: A global perspective." *Vienna Yearbook of Population Research* 2010(8), pp. 201-235.

Lutz, W. 2009. "*Sola schola et sanitate*: Human capital as the root cause and priority for international development?" *Philosophical Transactions of the Royal Society B: Biological Sciences* 364(1532), pp. 3,031-3,047.

Lutz, W., J. Crespo Cuaresma and M. J. Abbasi-Shavazi. 2010. "Demography, education, and democracy: Global trends and the case of Iran." *Population and Development Review* 36(2), pp. 253-281.

Lutz, W., J. Crespo Cuaresma and W. Sanderson. 2008. "The demography of educational attainment and economic growth." *Science* 319, pp. 1,047-1,048.

Lutz, W., A. Goujon, S. KC and W. Sanderson. 2007. "Reconstruction of populations by age, sex and level of educational attainment for 120 countries for 1970-2000." *Vienna Yearbook of Population Research 2007,* pp. 193-235. Verlag der Österreichischen Akademie der Wissenschaften, Vienna.

Lutz, W., and S. KC. 2011. "Global human capital: Integrating education and population." *Science* 333, pp. 587-592.

Lutz, W., W. C. Sanderson and S. Scherbov, eds. 2004. *The End of World Population Growth in the 21st Century: New Challenges for Human Capital Formation and Sustainable Development*. Earthscan, London.

Mensch, B., H. Lentzner and S. Preston. 1985. "Socio-economic differentials in child mortality in developing countries." ST/ESA/SER.A/97. United Nations, New York.

OECD (Organisation for Economic Co-operation and Development). 2007. *Education at a Glance*. Paris.

Schultz, T. P. 1993. "Mortality decline in the low-income world: Causes and consequences." *American Economic Review* 83(2), pp. 337-42.

UNESCO Institute for Statistics. 2009. *Global Education Digest 2009: Comparing Education Statistics Across the World*. Montreal, Canada.

UNDP, United Nations Development Program. Human Development Index. http://hdr.undp.org/en/statistics/hdi/.

Human Development Report 2013

The Rise of the South:
Human Progress in a Diverse World

The Human Development Report is an independent publication commissioned by the United Nations Development Programme (UNDP). Its editorial autonomy is guaranteed by a special resolution of the General Assembly (A/RES/57/264), which recognizes the Human Development Report as "an independent intellectual exercise" and "an important tool for raising awareness about human development around the world."

From the beginning, the Report has been a pioneer of methodological innovation and development thinking. Often provocative, the Report was launched in 1990 with the goal of putting people at the center of development, going beyond income to assess people's long-term well-being. The Reports' messages — and the tools to implement them — have been embraced by people around the world, as shown by the publication of autonomous National Human Development Reports by more than 140 countries over the past two decades. The Human Development Report is translated into more than a dozen languages and launched in more than 100 countries annually.

Contributors to the Report include leading development scholars and practitioners, working under the coordination of UNDP's Human Development Report Office

Human Development Report 2013:
The Rise of the South – Human Progress in a Diverse World

The 2013 Human Development Report examines the causes and consequences of the "Rise of the South," and identifies policies emerging from this new reality that can promote greater sustainability, social cohesion and human development progress throughout the world in the decades to come.

The report may be downloaded at http://hdr.undp.org/
Printed copies may be ordered at https://unp.un.org/hdr/

United Nations Development Programme
Human Development Report Office
304 E 45th Street, FF-1204
New York, NY, 10017 USA