POPULATION NETWORK NEWSLETTER

POPNET

Wolfgang Lutz, Editor

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"It's human capital, stupid!"

"It's the economy, stupid" was a widely used phrase as part of Bill Clinton's campaign for the United State Presidency in 1992. Today, people are facing an even worse economic outlook. Economies are in deep crisis and the values of financial assets are plummeting leaving few safe investments. On a different note, international aid for Africa is going nowhere, and an increasing number of experts is raising the question about what appropriate development priorities could look like. Finally, as it becomes progressively clearer that our planet is bound to experience a dramatic and unavoidable climate change throughout the next century, people are deliberating what can be done to strengthen societies' adaptive capacity in the face of climate change. Amidst all this gloom, is there anything that can make the future look more optimistic? There is one surprisingly simple answer to this question: yes, if we focus on human capital formation.

In this issue of *POPNET*, we will touch upon all the issues addressed above. New reconstructions and projections on education by age, sex, and level of educational attainment highlight the momentum of changes in the human capital of the working age population. Consequently, the past advances in school enrolment rates in most countries of the world will inevitably lead to a significant improvement in human capital of the global adult population. Given the positive consequences related to higher human capital, this is definitely very good news for the future (see page 2).

While there is no doubt that more education generally leads to higher income at the individual level, the evidence is less clear that education also leads to higher economic growth at the aggregate level. Inconclusive statistical findings on this issue resulted from the use of inappropriate empirical data on human capital by age. The *Science* article reprinted here emphasizes that better data also yield better results, and that human capital does indeed greatly matter. Human capital formation may even be the key for societies' adaptive capacity to climate change. This will be the focus of a large new ERC Advanced Grant (see page 8).

Human capital—which I see as the combination of education and health—is not a sufficient answer in all cases, but is arguably a necessary prerequisite and probably the single most important one. *WL*

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The IIASA–VID reconstructions and projections of educational attainment by age and sex for 120 countries, 1970–2050

New Data on Human Capital

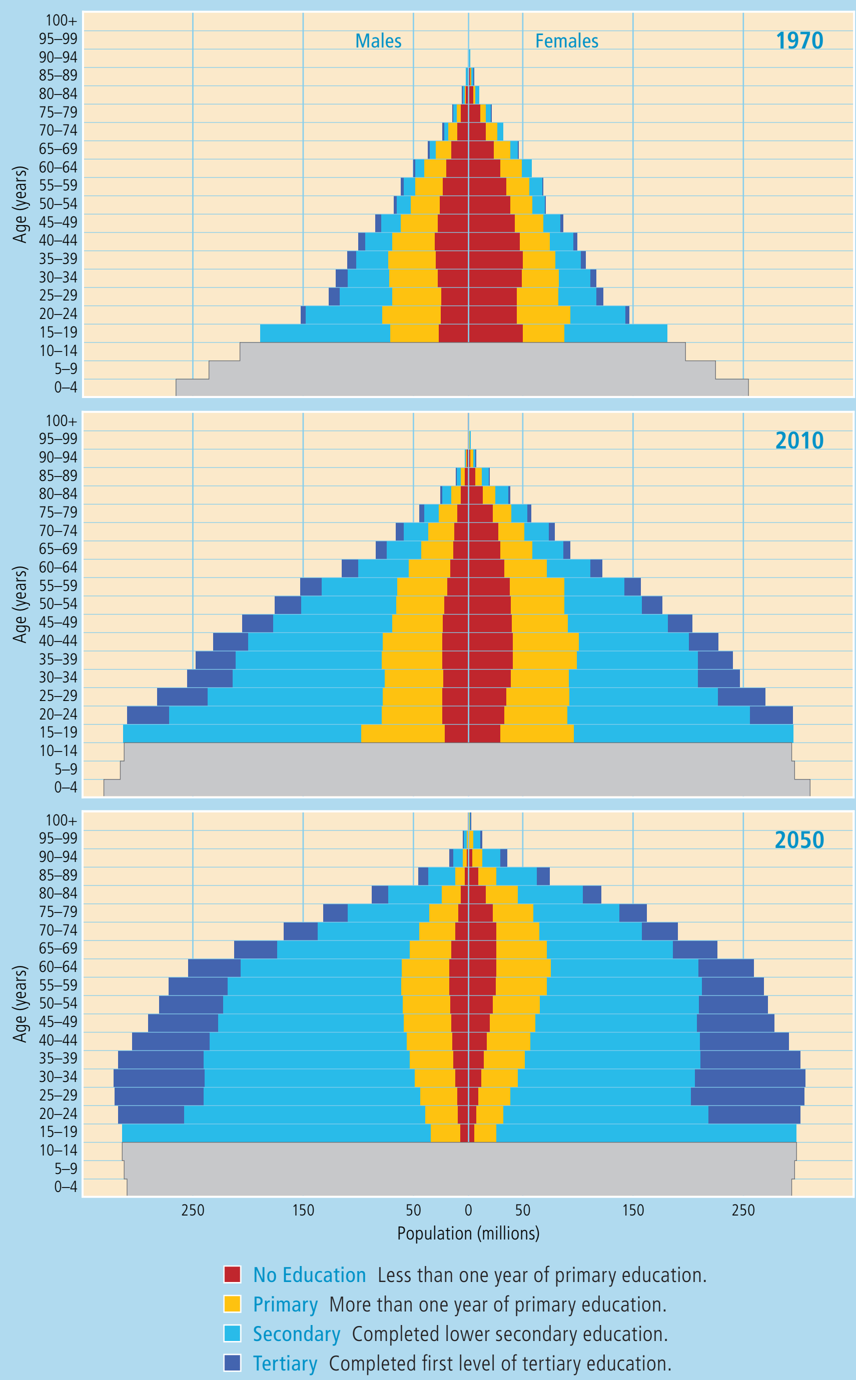

FIGURE 1 The world's growing human capital: World population by age, sex, and educational attainment in 1970 (*top*) and in Global Education Trend (GET) Scenarios for 2010 (*middle*) and 2050 (*bottom*).

Measuring Human Capital

The human capabilities approach to development, proposed by Amartya Sen, has become popular among scholars concerned with human well-being and humans' contribution to improving the well-being of others, not just in developing countries, but for all humans in general. This approach also lies behind the widely used Human Development Index (HDI) which is regularly published by the United Nations Development Program (UNDP). Based on three elements (empowerment through education, health and survival, and material standard of living), the approach's first two elements directly address what we refer to here as "human capital" or "human resources" (for those who dislike the economic connotation of "capital"). These two elements cover the properties of an individual that are (at least theoretically) directly observable and measurable (e.g. whether a person can read and write or has disabilities). The third element of the HDI—material standard of living—is only indirectly derived from systems of national accounting and not measured directly to include individuals. Consequently, the third element is not considered part of the human capital but rather describes economic conditions that to some extent result from specific levels of human capital.

Ideally, indicators of human capital should comprehensively measure the capabilities and potentials of humans, including their physical and mental health, as well as skills, particularly those acquired through education with reference to length, quality, and content. The reality of measurement practices lag far behind these aspirations. The HDI, for example, uses life expectancy at birth as a proxy for health and self-defined literacy (a stock variable) combined with current school enrolment rates (a flow variable) as an indicator for level of education. Most economic studies on the returns to education use the population's mean years of schooling above the age of 25 (MYS 25+) as their most sophisticated human capital indicator. The distribution by level of highest educational attainment is very rarely used and is hardly ever stratified by age groups. For a limited number of countries (mostly only OECD countries) such self-reported education measures are complemented by tests on actual abilities, mostly for school age children (such as the PISA tests), but also for the general adult population. Currently, UNESCO is trying to expand such studies to developing countries, but only few results have been achieved so far. Except for the indicator Literate Life Expectancy (introduced by Lutz *et al.*), no systematic attempts have—to our knowledge—yet been undertaken to combine education indicators with heath and disability indicators to arrive at a more comprehensive human capital indicator.

Within this context, the new data set developed jointly by IIASA's World Population Program and the Vienna Institute of Demography (VID) of the Austrian Academy of Sciences attempts to move beyond the state-of-the-art by estimating consistent data by age, sex, and four levels of educational attainment for 120 countries for the period 1970–2050. Here, we summarize the results of the reconstruction and projection efforts made over the past three years. This is only the beginning of a larger project in which we will further validate the reconstructed data, define a larger number of scenarios that consider alternative fertility and mortality trends as well, in addition to alternative education trends. Finally, we also aim to incorporate elements of quality of education and health/disability status into the human capital indicators used. ■

The Need for New Age-Specific Data

Many of the studies attempting to estimate the returns to education have been hampered by a lack of appropriate age details in the available human capital data. In particular, economists interested in the determinants of economic growth have been puzzled by the fact that indicators of human capital do not consistently reveal significant and positive effects in economic growth regressions, despite strong theory-based expectations and unambiguous evidence at the micro level, where more years of schooling generally translates into a higher income. As the reprint of the *Science* Policy Forum on pages 6 and 7 in this issue of *POPNET* shows, this problem disappears when more detailed age-stratified data are used.

This point can further be illustrated when looking at the education pyramid for Singapore for 2000 (*right*). Educational expansion over the past three decades has been so rapid that the younger working age cohorts (aged 20–34 in 2000) belong to the best-educated in the world, while more than half of the women in their parents' generation (aged 55–69) never attended school, because Singapore was then a very poor developing country. This particularly strong educational improvement among younger employees, which was evidently an important driver of economic growth in Singapore, is inadequately reflected in the traditional human capital indicator MYS 25+, because this indicator is very static and still includes the less educated older cohorts. Table 1 provides a sample (for the case of India) of what the detailed information

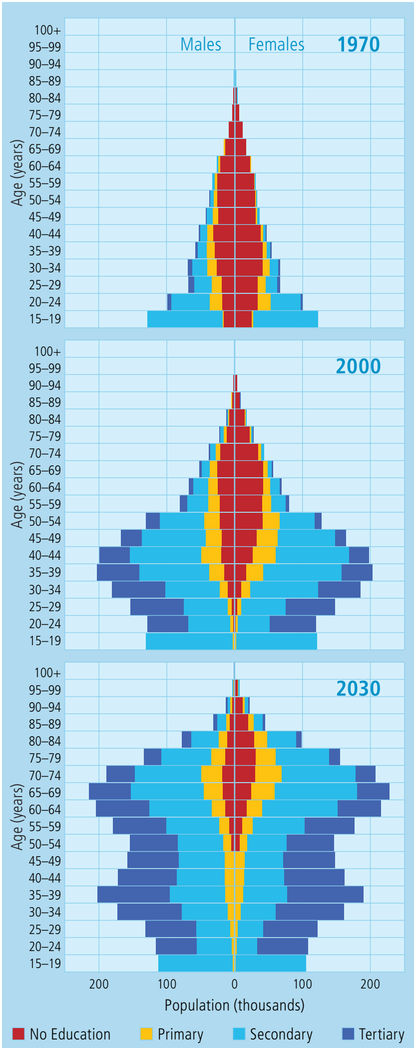

FIGURE 2 Singapore: Population by age, sex, and educational attainment in 1970 (*top*), in 2000 (*middle*), and in 2030 according to the Global Education Trend (GET) Scenario (*bottom*).

included in the new data set for each country and each point in time would look like. While MYS 25+ is only the summarized measure in the lower right corner (see red circle), the new data provide the full matrix by age, sex, and level of attainment.

While several economists have tried to improve the available data sources by using methods such as the "perpetual inventory method" (designed for modeling the accumulation of physical capital) *only the genuinely demographic methods of multi-state population dynamics, which were developed at IIASA during the 1970s and 80s, can adequately model the dynamics of changing educational attainment by age and sex*, and consider differential fertility, mortality, and migration by level of education. The reconstruction and projection results presented here are both based on this methodology.

Reconstruction from 2000 back to 1970 The measurements are based on empirically derived data by age, sex, and the four levels of educational attainment for every country around the year 2000. These data were mostly collected from censuses, Demographic and Health Surveys (DHS), or other nationally representative surveys. We then retraced history along cohort lines, i.e. identifying the male population aged 45–49 without any education in 1995 on the basis of those aged 50–54 in 2000, and so on. Since we use historical distributions by age and sex as provided by the UN's estimates, we can only reconstruct the age- and sex-specific proportions in each category of education. For the reconstruction, we have to consider the fact that men and women with different levels of education also have different survival chances (see discussion, page 4). We also have to make adjustments for individuals who move to higher education categories after the age of 15 (the cut-off age in our reconstructions), make distributional assumptions about the highest open-ended age interval, and consider differential migration, where necessary. All these steps are carefully argued in the article cited below (Lutz *et al.*, 2007). It is important to note that given accurate primary data and assumptions on differential mortality and migration, as well as on recent transitions and the open-ended age interval, the laws of population dynamics divulge that these reconstructions must be correct. There is no possible source of error. Moreover, unlike many empirical time series, these reconstructions are not affected by constantly changing definitions over time, because they are based on the same definition of education used in 2000. The data as presented here have, furthermore, been subjected to a careful validation exercise in which the reconstructions were compared against all available historical educational attainment distributions (in the UNESCO data base) which confirmed or, where necessary, corrected the specific assumptions mentioned above at the individual country level.

Projections to 2050 For the projections by level of educational attainment the same primary data for 2000 as described above were used. Four alternative education scenarios were defined with respect to anticipated future trends in the age- and sex-specific transition probabilities to higher educational levels. They range from the most rapid educational expansion based on ambitious targets (the Fast Track Scenario) to the assumption of constant absolute school enrolment which, under conditions of population growth, actually results in declining school enrolment rates. All projections presented on the first three pages of *POPNET* are based on the Global Education Trend (GET) Scenario, which assumes that countries follow the general trend of improvement that more advanced countries have—in terms of education—experienced over the past decades. While this can be considered a plausible medium-term scenario, it must be noted that it might be a little too optimistic because the "global trend" over the past decades has been strongly influenced by the rapid educational improvements in Asia, and it is not clear whether the majority of African countries will be able to match that trend.

Because fertility and mortality are presumed to differ by level of education (see page 4), the overall population trend in terms of population size and age structure will also be influenced by future education trends (see Figure 4 and Table 2, page 4). In this regard, education can also be seen as a "population policy." While current population and reproductive health policies only focus on the so-called "unmet needs" of family planning, i.e. the gap between the actual and the desired family size, female education in high fertility settings also tends to lower the desired family size among women. In addition to facilitating better access to reproductive health services, female education can effectively foster a strictly voluntary fertility decline. ■

TABLE 1 Sample output table of reconstruction for the case of India: Distribution of female population in 2000 (in thousands) by age and level of education, plus mean years of schooling (MYS).

Age	No Education	Primary	Secondary	Tertiary	MYS
Females					
15–19	14388 (29%)	12058 (24%)	22819 (46%)	–	5.5
20–24	17138 (40%)	8804 (21%)	14025 (33%)	2813 (7%)	5.1
25–29	19288 (48%)	8471 (21%)	9810 (24%)	2893 (7%)	4.4
30–34	19787 (54%)	7470 (21%)	7115 (20%)	2013 (6%)	3.6
35–39	18600 (58%)	6753 (21%)	5346 (17%)	1387 (4%)	3.2
40–44	16975 (61%)	5579 (20%)	4153 (15%)	1104 (4%)	2.9
45–49	14878 (64%)	4504 (19%)	2971 (13%)	751 (3%)	2.6
50–54	13297 (69%)	3362 (18%)	1982 (10%)	508 (3%)	2.1
55–59	12067 (75%)	2639 (16%)	1210 (7%)	262 (2%)	1.6
60–64	10930 (81%)	1819 (13%)	680 (5%)	132 (1%)	1.2
65+	21509 (82%)	3534 (13%)	1022 (4%)	161 (1%)	1.0
15+	178859 (55%)	64993 (20%)	71133 (22%)	12025 (4%)	3.5
25+	147332 (63%)	44131 (19%)	34289 (15%)	9212 (4%)	2.8

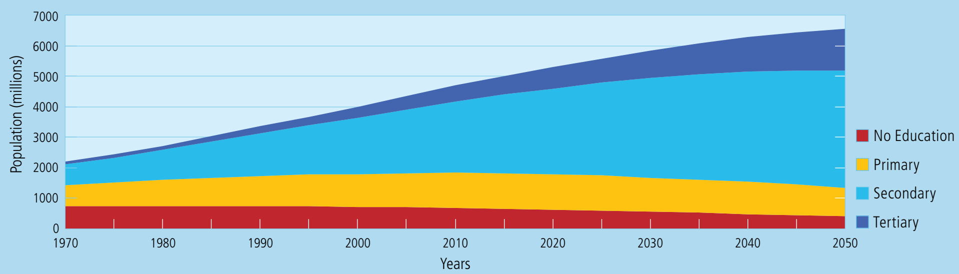

FIGURE 3 The world's growing human capital: World population aged 15 and above by level of educational attainment in 1970–2050, Global Education Trend (GET) Scenario.

The New Motto for Demographers: "Breaking Down by Age and Sex…and Education"

Differential Fertility and Mortality by Level of Education

People with a higher education generally have lower mortality and fertility rates compared to people with lower levels of education. Rare exceptions have been observed at certain stages of development and in specific settings where the more educated population segments act as forerunners in the initial phase when new causes of death, such as those related to smoking or AIDS, are identified. Such exceptions, however, hardly affect the universal picture of a strong negative association between education and mortality/fertility. While the precise causal mechanisms of the links between education–fertility and education–mortality require further research and may differ considerably in different settings, there is a strong case for explicitly modeling the resulting education differentials as outcomes. Educational attainment seems to be the third most important source of observable population heterogeneity next to age and sex and, therefore, deserves explicit consideration.

Modeling Fertility Differentials

In the projections, fertility differentials were modeled by assuming fixed relative differences between the total fertility rates (TFRs) of different education groups over time based on the relative differences in TFRs as observed during the initial period. The values of these relative differences range from around 10% between the highest and the lowest education groups in some Nordic countries to around 50% or more in many developing countries. Focusing on relative rather than on absolute differences in TFRs accommodates for the fact that absolute differences typically diminish as the level of overall fertility declines. Relative differences are more culture-specific and also explain the great dispersion among low fertility countries.

Education- and age-specific fertility rates for each country and at different points in time were determined through a fairly complex iterative procedure which is described in detail in the paper cited below. A parametric model was used to derive the schedules of education- and age-specific fertility rates (see Figure 4 for an example) from a set of education-specific TFRs. These TFRs were derived iteratively from an assumed overall TFR for each point in time, taking the given relative differentials and the educational composition of the female population into account. For the Global Education Trend (GET) Scenario the overall TFRs were defined to match the UN's medium variant projections for most developing countries, Eurostat's projections for the EU, and IIASA/VID's projections for Eastern Europe and low fertility Asian countries. For the other education scenarios, identical sets of age- and education-specific fertility rates were used for each country and point in time, meaning that alternative overall TFRs only result from different educational compositions of the female population.

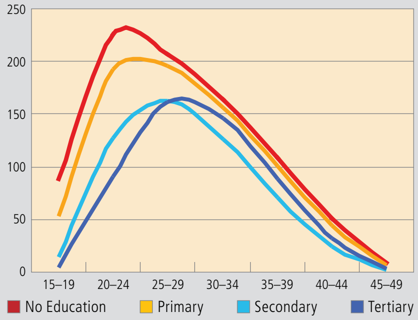

FIGURE 4 Education- and age-specific fertility rates: example of Cambodia 2000–2005.

Modeling Mortality Differentials

Mortality differentials by level of educational attainment may be quantitatively less significant than fertility differentials for projecting the working age population, but they are particularly relevant for differential depletion along cohort lines. Therefore, mortality differentials had to explicitly be considered for both the reconstruction exercise going back to 1970 (when fertility differentials were irrelevant due to the given age distributions taken from the UN's population estimates) and the projections to 2050.

While abundant information exists on child mortality in relation to the mother's education, it is much more difficult to find empirical data on education differentials in adult mortality. In order to derive the required set of adult mortality differentials, an extensive comparative exercise was carried out (documented in the publications mentioned below), which was largely based on education-specific cohort survival data throughout subsequent decennial censuses for several sample countries (mostly based on IPUMS data) from different world regions and different development stages. The results reveal a surprisingly uniform pattern: Measured in terms of differences in life expectancy at age 15, we found that the differentials between the lower educational categories were always smaller than those between the higher educational categories. In specific numerical terms, we assumed a general pattern in which life expectancy at age 15 differs by one year between individuals with no education and those with a primary education, and by two years between the others, resulting in a five year difference between the highest and the lowest educational categories considered. The age-specific mortality rates for the different educational categories were derived using a technique very similar to the one described above for education-specific fertility rates, to ensure that overall age-specific mortality is consistent with the rates provided by the UN (2006). This was obtained by iteration using a Brass–Gompertz Relational Model. Hence, for every country and every point in time the age- and sex-specific mortality schedules correspond to those of the UN estimates and (medium variant) projections. ■

This issue of **POPNET** *is based on the following scientific publications:*

Lutz W, Goujon A, KC Samir, Sanderson W (2007). Reconstruction of populations by age, sex and level of educational attainment for 120 countries for 1970–2000. In: *Vienna Yearbook of Population Research 2007*, pp. 193–235. Verlag der Österreichischen Akademie der Wissenschaften, Vienna, Austria. Available at www.oeaw.ac.at/vid/publications/VYPR2007/Yearbook2007_Lutz-at-al-Education_pp193-235.pdf.

KC Samir, Barakat B, Goujon A, Skirbekk V, Lutz W (2008). Projection of Populations by Level of Educational Attainment, Age and Sex for 120 Countries for 2005–2050. IIASA Interim Report IR-08-038. Available at www.iiasa.ac.at/Admin/PUB/Documents/IR-08-038.pdf.

TABLE 2 Total population by region in 2000 and in 2050 according to the four education scenarios: Fast Track (FT), Global Education Trend (GET), Constant Enrolment Rate (CER), and Constant Absolute Enrolment Numbers (CEN) (see definitions, page 5). Percentages represent proportion of women aged 15–49 with at least secondary education.

Region	2000 (Base year)	2050			
		FT	GET	CER	CEN
World	6111987 (61%)	8580789 (88%)	8792671 (85%)	9362686 (61%)	9684384 (53%)
Africa	820873 (34%)	1827412 (81%)	1935794 (70%)	2201127 (37%)	2399278 (20%)
Asia	3704839 (57%)	4908126 (88%)	5009946 (87%)	5276054 (64%)	5420722 (60%)
Europe	695898 (89%)	623548 (97%)	628668 (97%)	621040 (88%)	598000 (94%)
Latin America & The Caribbean	522568 (57%)	761876 (90%)	765948 (89%)	854987 (63%)	908422 (55%)
Northern America	315546 (95%)	456032 (96%)	458446 (96%)	457886 (89%)	402989 (82%)
Pakistan	144360 (37%)	285806 (83%)	292205 (81%)	316698 (45%)	334833 (30%)

The Example of Pakistan

IIASA's member country Pakistan currently faces several challenges in terms of its population and education. Here, we will illustrate what the four alternative education scenarios entail for Pakistan, namely how, on the one hand, broad-based education efforts in coming years could still bring a decisive push to transform Pakistan into a modern country with a well educated society, or how, on the other hand, the absence of such programs could throw the country back by decades in terms of human capital, with the crucial difference that 335 million people will have to be fed (and employed) by 2050 compared to the 60 million in 1970 with a similarly poor education structure.

Figure 5a illustrates the age pyramid by our four education categories for 2005. This pyramid represents a comprehensive reflection of recent demographic and education trends in Pakistan. It reveals a very young population age structure with the bulk of the population being under the age of 20 (49% in 2005). It also shows that the younger generations are more educated than the older ones relative to their cohort size. 50% of individuals in the 20–24 year age group have as a minimum completed a lower secondary education compared to only 26% of those aged 45–49, and 12% in the 65+ age group. However, these improvements have not yet reached all segments of the population, since the majority of the adult population still lacks any formal schooling: Nearly 50% of the working age population (20–64 years) in 2005 had never attended school. In addition, a significant gender gap in education is evident in both the pyramid (Figure 5a), as well as in Figure 5b which depicts the proportion of men and women without any formal education by age. It basically reveals that the proportion of those without any formal education has been consistently declining among boys, but is significantly lagging behind among girls, visible even among the more recent cohorts.

The recent perceptible improvements in education, however, have not yet gained sufficient momentum to ensure continuous improvements in the future. As the application of the four alternative education scenarios indicates, Pakistan currently seems to be at a tipping point where the country's future could tilt either way.

Figure 6a shows the best case, Fast Track Scenario in which Pakistan would essentially in coming years replicate the most rapid education developments experienced by countries such as Singapore and South Korea in the recent past. This would result in a modern education structure in 2050 resembling that of Singapore or Korea today. Under such conditions, 45% of the working age population in Pakistan will have some tertiary education while the majority will at least have a secondary education. Under this scenario, only a few elderly men and in particular women would in 2050 still be without formal education.

Figure 6b provides a more realistic, but still relatively optimistic Global Education Trend Scenario. By 2050, Pakistan's educational profile will have greatly improved, although some men and women at working age would still be without formal education.

Figures 6c and 6d give more pessimistic scenarios in which educational expansion stalls. In Figure 6c, current school enrolment rates remain constant which will, nonetheless, result in some improvement in the education of the adult population, considering that today's younger cohorts are already receiving a better education than before. Figure 6d assumes that the absolute number of students in school remains constant (i.e. no new schools) which on account of population growth implies declining rates of enrolment. As a result, the educational composition will deteriorate significantly.

The four pyramids for 2050 differ not only in their educational composition, but also in their shape. Although all four are based on the same set of education-specific fertility rates, the various educational compositions result in different rates of population growth. While the Constant Absolute Enrolment Scenario (Figure 6d) results in a total population of 335 million, the Fast Track Scenario estimates a total population of only 285 million, a difference of 50 million which is solely attributable to a higher level of education among females. ■

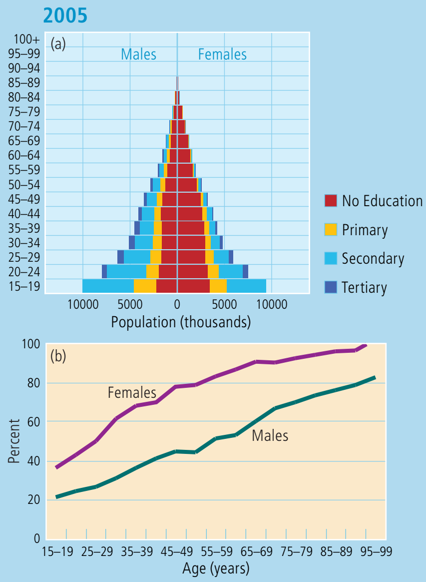

FIGURE 5 Pakistan 2005: (a) Population by age, sex, and educational attainment; (b) Proportion of men and women with no education.

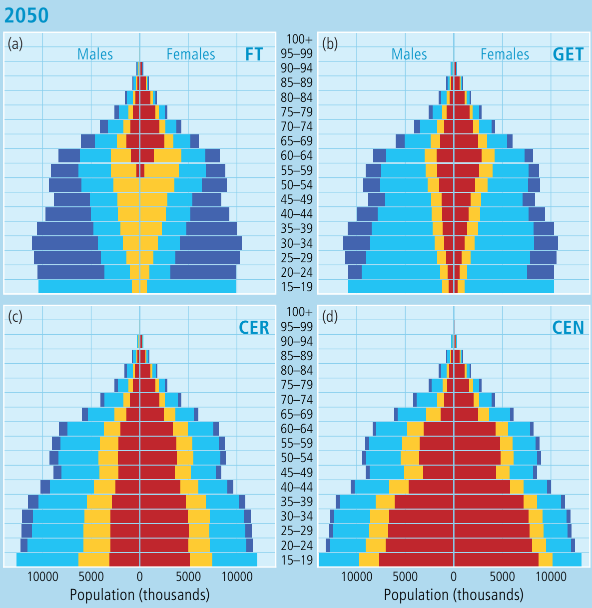

FIGURE 6 Pakistan 2050, according to the four education scenarios (see definitions in box, *right*).

Definitions of the Four Education Scenarios

Fast Track (FT)
The most optimistic scenario; assumes that all countries will achieve certain ambitious milestones (99% primary by 2015, 50% secondary by 2030 and 90% by 2050, 60% tertiary by 2050)

Global Education Trend (GET)
Assumes that a country's future educational expansion will follow an expansion trajectory based on the historical global trend

Constant Enrolment Rates (CER)
Assumes that educational transition rates remain frozen at the 2000 level.

Constant Absolute Enrolment Numbers (CEN)
Assumes that the absolute number of students in each country remains frozen at the 2000 level.

Reprint from *Science**

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ECONOMICS

The Demography of Educational Attainment and Economic Growth

Complementing primary education with secondary education in broad segments of the population is likely to give a strong boost to economic growth.

Wolfgang Lutz,[1]* Jesus Crespo Cuaresma,[2] Warren Sanderson[3]

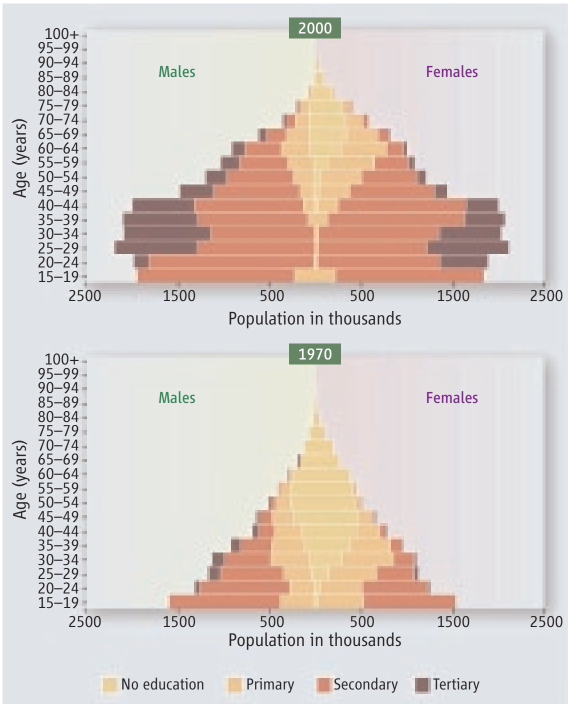
When the world leaders convened in New York in 2000 and solemnly announced the United Nations (U.N.) Millennium Development Goals (MDGs), the goal of universal primary education by 2015 figured prominently, second only to the reduction of extreme poverty and hunger. Although the diminution of poverty and hunger is a self-evident end in itself, putting all children into school is a goal primarily because it is believed to be the vehicle through which the level of adult human capital is improved, in turn enhancing individual well-being, health, and economic growth. The empirical basis for assuming an important positive effect of education on economic growth is, however, surprisingly weak. Although it is well established that, at the individual level, more years of schooling lead to higher income, at the macroeconomic level, the empirical evidence, so far, relating changes in education measures to economic growth has been ambiguous.

The MDG's focus on universal primary education has to be seen in the context of the evolution of international concerns about eradicating illiteracy with a series of well-intended but "demographically illiterate" and therefore unrealistic goals, which ultimately failed. In 1990 at a historical conference in Jomtien (Thailand), 155 governments and 150 organizations issued a World Declaration on Education for All that included the prominent goal of reducing the adult illiteracy rate to one-half of its 1990 level by the year 2000. From a demographic perspective, it is clear that this goal is impossible to achieve in poorly educated countries if education is primarily concentrated in young people, because it would take many decades for the better-educated youngsters to replace the illiterate adult population. Ten years later in Dakar, the international community, confronted with the failure of the previous goals, chose to use an even more unfortunate formulation of their goal, namely, "increase the literacy rate by 50%," which, for countries that already had more than 66.7% literacy, implied a goal of more than 100%. To correct this evident political innumeracy, the U.N. Educational, Scientific, and Cultural Organization (UNESCO) later modified the goal to imply a goal of 100% for countries that already had 66.7% literacy or more. Leaving aside the fact that 100% literacy may be impossible to reach for any society, even this revised goal focuses on the stock of adult literacy without considering the cohorts involved.

The MDG's focus on enrollment in formal primary education is related but somewhat different from the earlier focus on literacy: Literacy is a skill that, in principle, can also be acquired outside the regular education system and that can be lost again (secondary illiteracy). In contrast, once a certain level of educational attainment is reached, it cannot be lost again throughout the rest of our lives. We will be able to keep our doctorates even if our skills seriously degrade; this property actually makes educational attainment distributions easier to model because movements can only go in one direction, toward higher education.

Using the demographic method of multistate back projection, a group of researchers at the International Institute for Applied Systems Analysis (IIASA) and the Vienna Institute of Demography (VID) has recently completed a full reconstruction of educational attainment distributions by age and sex for 120 countries for the years 1970–2000 (*1*). This improvement in human capital is illustrated (see figure, below) along cohort lines in the case of South Korea. The advantages of this data set relative to others (*2*–*4*) are its detail (four educational categories for 5-year age groups of men and women), its consideration of differential mortality, and its strict consistency of the definition of educational categories over time. The age and education composition detail in our new data allow us to perform more detailed statistical analyses of the relation between education and economic growth than can be performed using preexisting data.

Previous cross-country economic growth regressions tended to show that changes in educational attainment are largely unrelated to economic growth [for example, (*5*, *6*)], which contradicts theory and microeconometric evidence. Most of the literature in this field attributes the existence of this puzzle to



Reconstructing educational attainment. (**Top**) Age pyramid of South Korea in 2000 with colors indicating different educational attainment categories. (**Bottom**) Reconstructed age pyramid of South Korea in 1970 with colors indicating different educational attainment categories.

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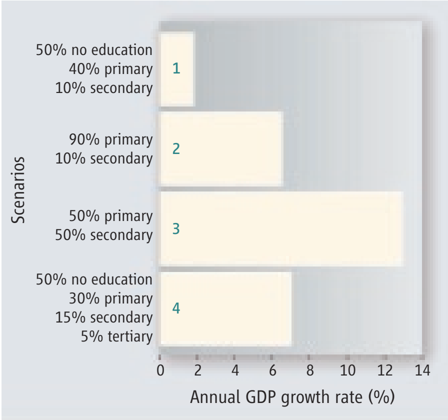
deficiencies in the series of education data (*3*, *4*, *7*). Also, averaging education attainment data over longer horizons has led to more consistent patterns (*8*), which highlights the importance of measurement problems in the previous data.

Using our new educational attainment data by age groups, we estimated simple growth regressions based on 5-year periods for a panel of 101 countries for which all the necessary economic and education data exist over the period 1970–2000. It has a fair representation of all continents (*9*). These new data allow us to use the education levels of different age groups as potential determinants of economic growth. The results show consistently positive, statistically significant education effects on economic growth for some age and education groups (*9*) and, hence, make the puzzle disappear.

In our model, human capital by broad age groups enters production both as differentiated labor force inputs and through the absorption rate of new technologies, which, in turn, depends on the interaction between human capital and distance to the technological frontier [see (*5*) for a similar approach]. The effect of education on labor force participation is assumed to be specific to each age and education group and constant over time. The model is described, related to the literature, and justified in detail (*9*).

The implications of the results and the value added by the new data set are illustrated by simulating four scenarios based on estimated coefficients (see figure below, table S1, and the discussion in the supporting online text). These four roughly resemble alternative hypothetical education policy strategies for a poor African country. In these simulations, we focus on the fact that economic growth is determined by the adoption of new technologies, and that the size of the effect depends on the income level of the country under study, because countries that are further away from the technology frontier are able to profit more [in terms of Gross Domestic Product (GDP) growth] from this channel of the education-growth link.

The figure above presents the average annual GDP growth rates corresponding to different education level distributions. Scenario 1 presents the reference case of a country with a young age structure (70% of the population in the 15- to 40-year-old group and 30% in the 40- to 65-year-old group), a low starting level of income and investment rate and the following educational structure: half of the population without any formal schooling, 40% with some primary and 10% with at least completed junior secondary school (but no tertiary education). The education groups used in the analysis (no education, primary, secondary, and tertiary) are nonoverlapping. This roughly fits the demographic structure of some Latin American and African countries in our sample, e.g., Guatemala, Honduras, Kenya, Rwanda or Uganda. On the basis of the estimated model, such a country would have rather slow economic growth. Scenario 2 considers the otherwise identical country under the hypothetical assumptions that it has for long met MDG goal 2 and that the previously uneducated half of the adult population now has primary education. This case would lead to somewhat higher average growth of GDP. Scenario 3 considers a possible new MDG effort that adds widespread secondary education (we assume here 50% of the population achieving at least some secondary schooling) to universal primary. The model simulations indicate that this additional investment in secondary education provides a huge boost to economic growth, over five times the level of the baseline scenario and also much more than in the scenario of universal primary education alone.



Annual GDP growth rates according to the four alternative educational attainment distributions (see text).

Scenario 4 finally presents another possible direction of improvement from the baseline (which somewhat resembles the case of India), in which half of the population remains without education although 5% have tertiary education, 15% secondary, and 30% primary. This case of elitist education in a context with half of the population being without any schooling does clearly better than the baseline and even better than the universal primary education (combined with 10% secondary and no tertiary), but falls far short of the economic growth implied by universal primary combined with 50% secondary and no tertiary education.

We compared these results with an age-aggregated version of the IIASA-VID data and the widely used Barro-Lee (*2*) data set, which has no age detail (see table S2). The comparison with the full age-structured model gives evidence of differences across age groups in the effects of education on GDP growth (table S1). These results point to the importance of the demographic structure of human capital when assessing the effect of education on economic growth. The IIASA-VID data set is, as of today, the only comprehensive data set offering such demographic detail in education figures.

These new findings have political consequences for the next round of defining international education goals (*10*): The current MDG's focus on universal primary education is important but insufficient. It needs to be complemented with the goal of giving broad segments of the population at least a completed junior secondary education. Only this is likely to give initially poor countries the human capital boost that is necessary to bring large segments of the population out of poverty. For more industrialized countries, tertiary education of younger adults also is an important determinant of economic growth.

In conclusion, better education does not only lead to higher individual income but also is a necessary (although not always sufficient) precondition for long-term economic growth. The fruits of investments in education need a long time to ripen, to translate the education of children into better human capital of the adult labor force. Education is a long-term investment associated with near-term costs, but, in the long run, it is one of the best investments societies can make in their futures.

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11. The input of A. Fürnkranz-Prskawetz, A. Goujon, Samir K.C., and S. Scherbov is gratefully acknowledged.

Supporting Online Material
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Announcing a major new IIASA project for the period 2009–2014

Based on the new European Research Council (ERC) Advanced Investigator Grant won by Wolfgang Lutz and focusing on

Forecasting Societies' Adaptive Capacities to Climate Change ("Future Societies")

In accordance with the requirements of the ERC's Advanced Grant competition, this €2.5 million project addresses an issue with a "high risk—high potential impact." The project aims at nothing less than to fill the most significant gap that remains in our understanding of how dangerous climate change is for our future well-being. While the international scientific community has gained a reasonably detailed understanding of the factors that contribute to greenhouse gas emissions, and the precision of global circulation models in depicting likely future climate conditions in different parts of the world by the end of this century is improving, virtually nothing is known about the abilities of future societies to cope with these changes.

Because of this lack of knowledge about future social and economic conditions, most assessments on e.g., the possible health consequences linked to climate change, contrast the climate conditions of, say, 2080 with the current public health conditions and capabilities in individual countries. Estimates of additional malaria deaths owing to climate change assume that, for instance, Nairobi, which presently has only few malaria cases due to its altitude, will in the future be plagued by endemic malaria. Singapore also faced endemic malaria less than four decades ago, which, however, was quickly eradicated. Why should Nairobi not be capable of eradicating malaria in the next 80 years? The key to answering such questions lies in anticipating societies' future public health or adaptive capacities more generally. Consequently, this project will focus on the hypothesis that the key to anticipating such future capacities lies in projecting societies' future population and education trends as described in this issue of *POPNET*. No other dimensions of social and economic change can be forecast with similarly narrow margins of uncertainty over several decades, because many of the changes occur along cohort lines, and cohorts will increasingly live for 80 years and more.

Theoretical and Empirical Components of the Project

- Development of a new "demographic theory of social change with predictive power." While many sociologists believe that different classifications and definitions constitute a theory, our approach will follow Karl Popper's criterion that theories must be able to predict in order to be falsifiable. The main tool for achieving this will be age-period-cohort analyses and associated multi-state projections of key social characteristics.
- Empirical assessments of differential vulnerability (by level of education and other indicators) in past incidents that may resemble future climate-related threats: The Sahelian draught, Hurricane Mitch, and the Asian Tsunami.
- Forward-looking in-depth case studies of possible vulnerabilities: Mauritius and Thailand's Phuket–Phangna regions.
- New long-term population and education projections for all countries in the world using the new approach of argument-based assumption-making (and the definition of uncertainty ranges) on future fertility, mortality, migration, and education trends involving hundreds of experts in each world region. This will be carried out in collaboration with Oxford University and partner institutions in all continents.
- Assessment of policy implications: Should the billions of dollars that are increasingly being spent on adaptation to climate change (for example, by improving agricultural practices that might be untenable under changed climate conditions) instead be spent on educating girls? Only a truly multisectoral analysis of the kind proposed here can answer such questions. ■

Call for Papers International VID/IIASA Conference on

Education and Demography

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This meeting will address the many interactions of educational and demographic processes. Sessions will focus among others on education and fertility, education and mortality, modeling student and teacher populations, and the demography of human capital formation along cohort lines.

Organizing team Bilal Barakat, Anne Goujon, Samir KC, Frank Landler, and Wolfgang Lutz

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