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News from IIASA

The current 10-year research program of IIASA is coming to an end in 2010. In November 2009 IIASA's Council approved a new strategic plan for the period 2011–2020. This new strategy also reflects the fact that IIASA's membership has recently expanded beyond the traditional National Member Organizations (NMOs, typically national academies of science) in Europe, Japan, and the United States and now includes China, Egypt, India, Pakistan, Republic of Korea, and South Africa.

The new strategic plan sees IIASA research structured around three major thematic issues: "Energy and Climate," "Food and Water," and "Poverty and Equity." In addition, activities will cover specific drivers of change that matter for all three themes such as population and technology. As things look now, from 2011 onwards IIASA's World Population Program will primarily cover the specific driver of population which is linked to all three themes as well as engage in collaborative projects with other projects under the "Poverty and Equity" theme.

The program on "Population and Climate Change"—which was led by Brian O'Neill for five years (funded by a predecessor scheme of the current ERC Starting Grants)—is coming to a natural end and Brian has moved on to the National Center for Atmospheric Research in Boulder, Colorado, USA. While this program mostly studied the role of population factors in emissions, the new ERC Advanced Grant to Wolfgang Lutz on "Forecasting Societies' Adaptive Capacities to Climate Change" will, for the coming five years, study the likely effect of climate change on human wellbeing with a special focus on education. In addition, the new ERC Starting Grant to Vegard Skirbekk (see last page of this issue) will address various other social changes that tend to unfold along cohort lines. Together, these two new ERC grants will provide population activities at IIASA with a solid financial basis. And the continuing intensive collaboration with the Vienna Institute of Demography (VID) will assure a critical mass of some 40–50 population experts in the Vienna area. *WL*

International Institute for Applied Systems Analysis
IIASA www.iiasa.ac.at

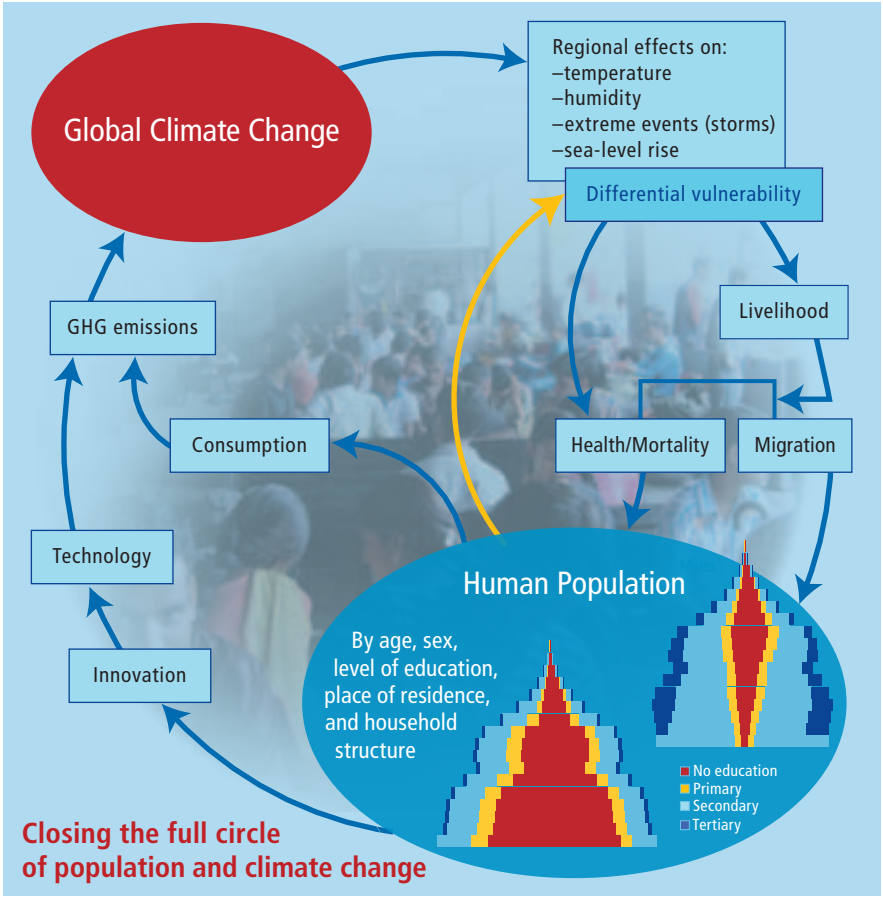
What can demographers contribute to understanding the link between

Population and Climate Change

Human population enters our concerns about climate change at both the beginning and the end of the causal chain: humans have produced the emissions that trigger climate change; consequently the potentially dangerous impact of this change on human wellbeing is our main cause for concern.

While in the past much of the focus has been on mitigating greenhouse gas emissions, this presentation mainly focuses on strategies for strengthening adaptive capacities for coping with unavoidable climate change. This shift in the research question also opens up important new areas of analysis for demographers. While efforts to quantify the contribution of population changes in addition to and in interaction with other important factors, such as technology and consumption levels, have been difficult and largely beyond the realm of demography, efforts to address adaptive capacity through studying differential vulnerability and forecasting such differentials into the future are right at the heart of what our powerful demographic toolbox has to offer. Demographers should be better at doing this than scientists from any other discipline. In the following I will try to explain why.

Substantively, the central hypothesis discussed in this presentation* is that strengthening human capacity primarily through education which, in consequence, also reduces population growth and enhances economic growth, is the most promising investment for adaptation in view of uncertain but potentially dangerous climate change impacts.



How dangerous is climate change for human wellbeing?

We worry about climate change because we think it is dangerous. The notion "dangerous" has a specific importance with respect to climate change because the only globally binding agreement, the 1992 Framework Convention on Climate Change, calls in its core sentence for avoidance of "dangerous interference with the climate system." Since then every international effort has made reference to this.

In principle every assessment of the dangers associated with alternative emission trajectories must try to anticipate the consequences of the resulting climate change for human wellbeing. In practice, this is impossible because simply not enough is known about what exactly will happen in terms of changing biophysical conditions and how the populations of the future will be able to cope with these changes.

For this reason the European Union and the Copenhagen Climate Summit have operationalized climate goals in terms of a change of not more than 2 °C in the global mean temperature. This pragmatic definition of dangerous climate change, however, completely leaves out the possible role of adaptation as a way of moderating the impact on human wellbeing. This path of causation is depicted on the right-hand side of the chart at the bottom of page 1.

Population as a driver

On the left side of the chart, population is viewed as a driver of the emissions of greenhouse gases (GHG) which is in line with the more conventional view. The I = PAT model tried to distinguish between the supposedly separate effects of population size (P), consumption associated with affluence (A), and technological efficiency (T). Recent analyses have considered more complex effects and the possibility of interactions. The PCC (Population and Climate Change) Project carried out at IIASA over the past five years under the leadership of Brian O'Neill produced a comprehensive model which includes the effects of changing household size, age structure, and urbanization on energy use. The findings show that population aging and urbanization can have significant effects in addition to population size but that the size of the effect greatly depends on how the question is posed.

In the same chart, the changing structure of the human population by age, sex, education, place of residence, and household size (just to list some of the key properties of people) is also seen as a direct driver of consumption levels and of technological innovation. After all, it is the people with their specific properties who carry out these activities in ways that depend on their properties.

Populations being affected

What are the dangers for human wellbeing that can result from climate change? People will likely be exposed to increasing hazards resulting from more frequent and more intensive extreme events such as storms and floods, sea-level rise, and a changing regional and temporal pattern of temperature and humidity, which may impact agricultural production and the spread of certain diseases. Whether and to what extent these hazards will result in human fatalities depends on the vulnerability of the people affected or, positively put, on their robustness and resiliency. This assessment of likely future vulnerability is very difficult and probably presents the biggest research gap for assessing the dangers associated with climate change.

Many published estimates of likely climate induced fatalities—for instance, calculations of additional malaria deaths due to climate change—assume that future climate conditions (e.g., in 2050) will affect populations that will be at a similar stage of socioeconomic development and hence have similar public health capabilities as societies on the same territory have today. But, as demographers, we know that societies are not stationary and in all likelihood will be quite different. In particular, the fact that in almost all countries the young generations are on average better educated than the older ones will result in improvements in the average education of the future adults which will likely have positive consequences for economic growth and public health governance. The WHO Report on Climate Change and Human Health explicitly states: "In general, countries with more 'human capital' or knowledge have greater adaptive capacity. Illiteracy increases a population's vulnerability to many problems."

In addition to mortality and morbidity directly inflicted by such hazards, many of the assumed dangerous consequences of climate change work through threats to traditional livelihoods. Loss of livelihood may constitute a push factor for migration or, in the worst case, lead to mortality, both of which are demographic factors changing the population structures.

What can demographers contribute?

As demographers we not only know that societies change over time as a function of changing age, sex, education, and other structures, but we also have a unique tool kit (multi-state cohort component methods) to model and project these changing structures with only small uncertainties over several decades.

If we know how many girls aged 15 today have completed primary education, we have a very good basis for estimating how many women aged 55 in 2050 will have at least primary education. The only errors come from future trends in mortality and migration—which should be considered as being education-specific—and from some late transitions to primary education. No other discipline offers better long-term projections of social structure than demography.

Furthermore, demographers have a long tradition of studying all kinds of differentials and, in particular, differential vulnerability to threats such as infant mortality, adult mortality, morbidity, and disability. But we can also study differentials in education and other factors of empowerment that enhance the adaptive capacity of individuals, households, and communities.

Here, demographers can make a unique and crucial contribution to the global discussion on global change. We are better at studying differentials and doing projections than any other social science—and we should use this strength to help the world to assess what is likely to happen in future societies and what are the most effective policies to mitigate GHG emissions and reduce vulnerability to climate change. ■

* This is the summary of a plenary address delivered by Wolfgang Lutz at the XXVI. General Conference of the IUSSP in Marrakech on 1 October 2009 in the context of receiving the 2009 Mattei Dogan Award of the IUSSP.

Reminding ourselves of the findings of

The 2002 Global Science Panel on Population and Environment

Produced on the occasion of the 2002 World Summit for Sustainable Development in Johannesburg, the document *Population in Sustainable Development: Analyses, Goals, Actions, Realities* was widely circulated (and its principal ideas published in the correspondence pages of *Nature* in 2002) and supported by many governments. But it was then dropped from the official agenda, presumably out of fear of yet another controversy with the Bush administration over abortion.

This document was in several respects ahead of its time and is as relevant for the current considerations of population and climate change as it was at the time it was put together.

The Global Science Panel: Background

In 2001 IIASA, the IUSSP (International Union for the Scientific Study of Population), and the UNU (United Nations University) started a joint initiative to prepare a comprehensive scientific assessment of the role of population in sustainable development strategies, to produce a science-based policy statement as input to the 2002 Johannesburg World Summit. The Global Science Panel comprises over 30 distinguished scientists from various disciplines under the joint patronage of Maurice Strong and Nafis Sadik. It received financial support from the government of Austria, UNFPA (United Nations Population Fund), and the MacArthur Foundation. Initial discussions were held at a meeting at NIDI (Netherlands Interdisciplinary Demographic Institute) and at General Conferences organized by the IUSSP and IHDP (International Human Dimensions of Global Environmental Change Program). Drafts were also discussed at two cyber seminars organized by the IUSSP/IHDP Population Environment Research Network (PERN). Full documentation can be found at www.populationenvironmentresearch.org.

The Global Science Panel: Members (2002)

Patrons Maurice F. Strong • Nafis Sadik **Coordinators** Wolfgang Lutz (IIASA; Institute for Demography, Austrian Academy of Sciences) • Mahendra Shah (IIASA) **Ex Officio** Hans J.A. van Ginkel (United Nations Under-Secretary-General, United Nations University, Japan) • Jacques Vallin (International Union for the Scientific Study of Population, Institut National d'Etudes Démographiques, France) • Arne Jernelöv (IIASA) **Members** Alaka M. Basu (Harvard Center for Population and Development Studies, Harvard University, USA) • Richard E. Bilsborrow (Carolina Population Center, University of North Carolina—Chapel Hill, USA) • John Bongaarts (Research Division, The Population Council, USA) • Partha DasGupta (Faculty of Economics, Cambridge University, UK) • Barbara Entwisle (Dept. of Sociology, University of North Carolina—Chapel Hill, USA) • Günther Fischer (IIASA) • Brigida Garcia (El Colegio De Mexico) • Daniel J. Hogan (Cidade Universitaria "Zeferino Vaz" Campinas, Brazil) • Zhenghua Jiang (People's Congress of China) • Robert W. Kates (Independent Scholar, USA) • Sanjaya Lall (Queen Elizabeth House, Oxford University, UK) • Landis MacKellar (IIASA) • P.K. Makinwa-Adebusoye (Nigeria Institute of Social and Economic Research) • Anthony J. McMichael (National Centre for Epidemiology & Population Health, The Australian National University) • Vinod Mishra (East-West Center, University of Hawaii, USA) • Norman Myers (Consultant in Environment & Development, Oxford University, UK) • Nebojsa Nakicenovic (IIASA) • Sten Nilsson (IIASA) • Brian C. O'Neill (IIASA) • Peng Xizhe (Institute of Population Research, Fudan University, People's Republic of China) • Harriet B. Presser (Dept. of Sociology, University of Maryland—College Park, USA) • Warren Sanderson (Depts. of Economics and History, State University of New York—Stony Brook, USA) • Gita Sen (Indian Institute of Management) • Barbara Torrey (Population Reference Bureau, USA) • Dirk van de Kaa (Netherlands) • Meryl Williams (ICLARM—The World Fish Center, Malaysia) • Brenda Yeoh (Asian MetaCentre for Population & Sustainable Development Analysis, Centre for Advanced Studies, Faculty of Arts & Social Sciences, National University of Singapore) • Huda Zurayk (Faculty of Health Sciences, American University of Beirut, Lebanon) ■

Science policy statement of the Global Science Panel

Population in Sustainable Development

If we do not put the human population at the core of the sustainable development agenda, our efforts to improve human well-being and preserve the quality of the environment will fail. The Johannesburg Summit must heed the first principle of the 1992 Rio Declaration—that "human beings are at the centre of concern for sustainable development"—by taking full account of how population and society interact with the natural environment.

Sustainable development aims at improving human well-being, particularly by alleviating poverty, increasing gender equality, and improving health, human resources, and stewardship of the natural environment. Because demographic factors are closely linked to these goals, strategies that consider population have a better chance of success.

The International Conference on Population and Development in Cairo in 1994 recognized that population policy should be oriented toward improving social conditions and expanding choices for individuals. The key recognition was that focusing on people—their rights, capabilities, and opportunities—would have multiple benefits for individuals, for society, and for their sustainable relationship with the environment.

Hence in Johannesburg, consideration of sustainable development policies must include population growth and distribution, mobility, differential vulnerability, and the empowerment of the people, especially women.

A demographically diverse world

We live in a world of unprecedented demographic change. Global population increased by 2 billion during the last quarter of the 20th century, reaching 6 billion in 2000. Despite declining fertility rates, population is expected to increase by another 2 billion during the first decades of the 21st century. Nearly all of this growth will occur in developing countries and will be concentrated among the poorest communities and in urban areas. ▶

Reprinted from: O'Neill BC (ed.) (2002). *Population in Sustainable Development. Analyses, Goals, Actions, Realities*. Report of the Global Science Panel on Population & Environment, an initiative of IIASA, IUSSP, and UNU. Available at www.iiasa.ac.at/gsp.

We also live in a world of unprecedented demographic diversity. Traditional demographic groupings of countries are breaking down. Over the next 25 years increases in population in sub-Saharan Africa, South Asia, and the Middle East are expected to be larger than in the past quarter century, and growth in North America will be substantial as well. In contrast, in most European countries and in East Asia, population growth has slowed or stopped, and rapid population aging has become a serious concern. Mortality also varies widely across regions, with the burden of infectious disease, including HIV/AIDS, being particularly heavy in Africa. In addition, levels of mobility, urbanization, and education differ substantially among and within regions, affecting economic and health outlooks.

This diversity presents different challenges requiring differentiated responses. The most urgent of these occur where rapid population growth, high levels of poverty, and environmental degradation coincide.

Population matters to development and environment

Research has shown that changes in population growth, age structure, and spatial distribution interact closely with the environment and with development. Rapid population growth has exacerbated freshwater depletion, climate change, biodiversity loss, depletion of fisheries and other coastal resources, and degradation of agricultural lands. Fertility decline in high-fertility countries, by slowing population growth, can make many environmental problems easier to solve. It can also have important economic benefits by reducing the number of children relative to the working-age population, and creating a unique opportunity to increase investments in health, education, infrastructure, and environmental protection.

In high-income countries, the environmental impact of population growth and distribution must be considered jointly with high consumption rates. Even in countries where little growth is envisioned, unsustainable patterns of consumption have global implications for the environment and human well-being, and must be addressed with appropriate policies.

Before the end of this decade, the majority of the world's population will live in urban areas. Urbanization can improve people's access to education, health, and other services. But it also creates environmental health hazards, such as water and air pollution, and by increasing consumption levels, it can have environmental impacts in distant rural areas as well.

The mobility and spatial distribution of populations, especially at local and regional scales, are a significant determinant of sustainability. Where the population lives and works relative to the location of natural resources affects environmental quality. The expansion of the agricultural frontier and other human activity is encroaching on fragile ecosystems in many parts of the world.

Policy must account for differential vulnerability within populations

Deteriorating environmental conditions and extreme events do not affect all countries, populations, or households in the same way. Even within a household, the effects may differ by age and gender. Consideration of vulnerability must therefore focus not only on countries but also on the most vulnerable segments of the population within countries.

Many factors contribute to vulnerability, including poverty, poor health, low levels of education, gender inequality, lack of access to resources and services, and unfavorable geographic location. Populations that are socially disadvantaged or lack political voice are also at greater risk. Particularly vulnerable populations include the poorest, least empowered segments, especially women and children. Vulnerable populations have limited capacity to protect themselves from current and future environmental hazards, such as polluted air and water and catastrophes, and the adverse consequences of large-scale environmental change, such as land degradation, biodiversity loss, and climate change.

Vulnerability can be reduced by promoting empowerment, investing in human resources, and fostering participation in public affairs and decision-making.

Empowerment through education and reproductive health benefits people and the environment

Two policies have multiple benefits for individual welfare, for social and economic development, and for the environment. One is investment in voluntary family planning and reproductive health programs. Since research has shown that many women in high-fertility countries have more children than they actually want, these programs allow couples to have the number of children they desire, thus reducing unwanted childbearing and lowering fertility rates. Lower fertility leads to slower population growth, allowing more time for coping with the adverse effects of that growth, and easing stress on the environment.

The other top policy priority is education. Education enhances individual choice, fosters women's empowerment, and improves gender equality. Better-educated people are in better health, and often contribute to greater environmental awareness. The increased economic productivity and technological advance that education induces can lead to less pollution-intensive production. It may also reduce vulnerability to environmental change by facilitating access to information and the means to protect oneself. Furthermore, in countries with rapid population growth, the fertility-depressing effect of education contributes to reducing the scale of human impact on the environment.

These two policies—education and reproductive health programs—are in high demand by individuals almost universally because their multiple benefits are clear. They also empower individuals to make informed choices. Efforts to achieve sustainable development should give them the highest priority.

Strengthening interdisciplinary training and research

To facilitate the joint consideration of population, development, and environment, more interdisciplinary research and education addressing these topics is necessary at all levels. The different disciplines should also conduct their studies in ways that make the results mutually accessible. Training about the nature of these interactions is a priority issue for the policy-making community, media, and scientists. ■

Note This statement on Population in Sustainable Development reflects the views of the Global Science Panel and does not necessarily reflect those of the institutions that have co-sponsored the process leading to this statement.

Reprinted from *Journal of the Royal Statistical Society*: Editorial

Towards a world of 2–6 billion well-educated and therefore healthy and wealthy people

In times of economic crisis and increasing food insecurity coupled with continued rapid population growth in the poor countries, as well as the prospect of dramatic consequences of climate change around the globe, the future looks rather bleak to many people. Hence the title of this editorial may sound oddly optimistic. But there is very good news hidden in the statistics of recent education trends around the world which imply significant future improvements in human capital and, as a consequence, likely improvements in global health and material well-being. In what follows I shall try to summarize what new statistical and demographic models applied to the long-term trends of population imply for our common future.

Demographic trends can be forecast into the longer-term future with lower uncertainty than many other social and economic trends, but they are less predictable than most geobiophysical trends. The reason lies in the length of the human lifespan of currently around 70 years on the global average. If we know how many 10-year-old girls are alive today, we have a very good basis for projecting how many 60-year-old women will be alive 50 years from now. On the global level the only uncertainty lies in unexpected future changes in mortality. For national and regional projections, uncertainties about future migration matter. The same is true for projecting certain stable properties of people: knowing how many 30-year-old men have been to college today is a good basis for projecting how many 60-year-old men will have a college education in 2040. In doing so we also must consider the fact that generally more highly educated people have lower mortality rates. Whereas the 'stocks' are inert and rather easy to project, the projection uncertainties come from assumptions on the 'flows'. For population projections it is the uncertainty about future trends in the birth rates that has the greatest effect on long-term population size. In the case of human capital projections, the future transition rates from lower to higher educational status are the main source of uncertainty.

Fig. 1 shows the evolution of the world population for ages 15 years and above by level of educational attainment since 1970 and projected to 2050. It shows that the past decades have seen great progress in education. Whereas over the past 40 years the number of people without education or only primary education has remained roughly constant, those with secondary or higher education have increased almost fourfold. And, since throughout the world—and particularly in developing countries—the young have much higher levels of education than the old, further significant increases in the average education of the adult population is virtually preprogrammed. Even if school enrolment rates do not further increase, such improvements in average adult education would take place as a consequence of the past education expansion. But countries with high population growth will have to make very significant efforts not to see enrolment rates decline as increasingly larger cohorts enter school age. Recently, enrolment rates in some African countries have actually declined which, as the following discussion will show, is probably the worst thing that can happen to a country's future.

These data are based on new projections and reconstructions of populations by age, sex and four levels of educational attainment that were recently produced by using the demographic method of multistate populations (Lutz *et al.*, 2007; KC *et al.*, 2008), which is essentially based on Markov chain models with different fertility and mortality rates for people with different educational status. These new data on human capital since 1970 for 120 countries have also recently been used to resolve an old statistical puzzle concerning the importance of human capital for economic growth. Although at the individual level it has been established beyond any doubt that more years of schooling on average bring higher income, the analysis of country level panel data so far has not resulted in consistently positive and significant coefficients for human capital. This is due to the fact that they only considered the entire adult population aged 25 years and older as one age group and therefore rapid improvements in education of the young adult population—an important driver of economic growth—did not produce enough statistical signals in this very broad age group, which also includes elderly, poorly educated

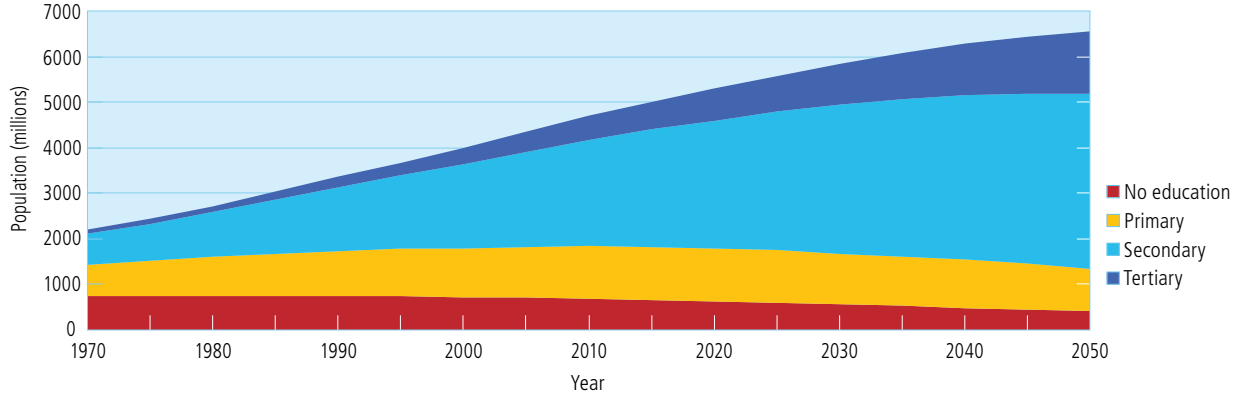


Fig. 1. The world's growing human capital: world population aged 15 years and above by level of educational attainment in 1970–2050, according to the mildly optimistic global education trend scenario (source, KC *et al.* (2008))

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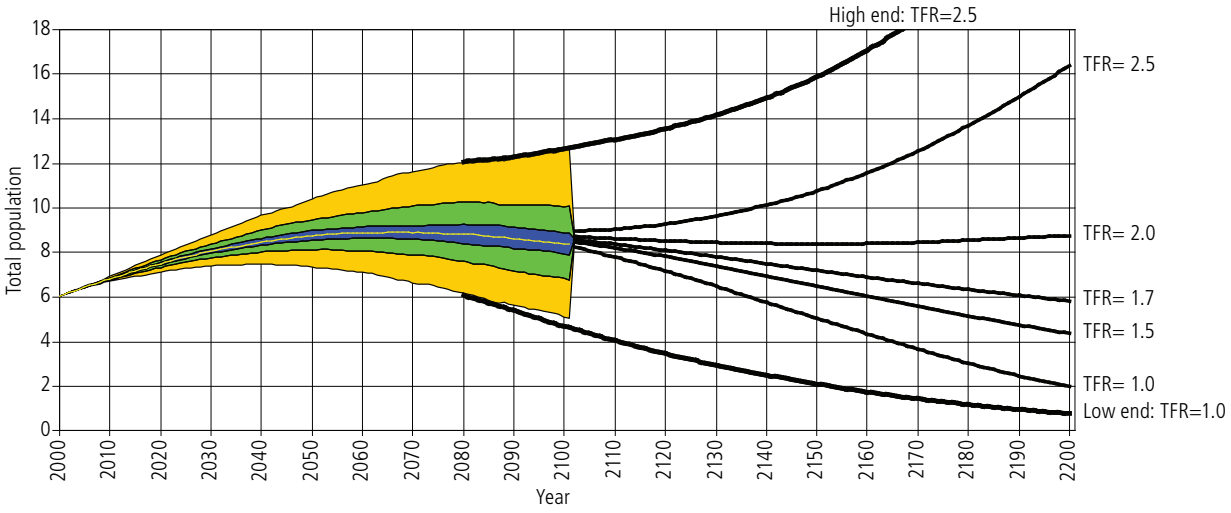

Fig. 2. Total world population in billions (for the scenario labels, see the text; source, Lutz and Scherbov (2008)): probabilistic projections until 2100 (■, 90% interval; ■, 60% interval; ■, 20% interval) and extensions to 2200 (for all: LEMAX = 120)

people. On the basis of the new data by 5-year age groups, Lutz, Crespo Cuaresma and Sanderson (2008) could conclusively show that indeed educational attainment is the key driver of economic growth. Moreover, their results indicate that universal primary education is not enough, and only when combined with broadly based secondary education will the poorest countries be able to come out of their poverty traps. Not surprisingly, the results also show that, for industrialized countries, tertiary education matters most. As to the positive implications of education on longevity and health, the literature has been less ambiguous and, almost universally, more highly educated people have better health and live longer. In Europe the differences in life expectancies at birth between the highest and lowest education groups are 5–10 years depending on the country.

Hence, again, the good news is that the population with secondary and tertiary education is likely to double over the coming four decades (increasing by a factor of 7 compared with 1970) whereas a further doubling of world population is highly unlikely (Lutz *et al.*, 1997). But education and population growth are not independent: the higher the education of women, the lower the fertility rate. These educational differentials, which are due to lower desired family size (a move from 'quantity' to 'quality') as well as better access to family planning, are particularly pronounced in countries in the early phases of demographic transition. In Ethiopia women without education have on average six children, whereas those with at least junior secondary education have only two. Hence, it is fair to say that progress in female education together with access to family planning services are the key determinants of future population growth in the less developed countries.

Cohen (2008) has recently argued that universal secondary education should be a policy priority for many reasons but in particular for limiting world population growth to a more sustainable level. KC *et al.* (2008) have illustrated this numerically by showing that, when assuming otherwise identical education-specific fertility rates, the difference between the most optimistic and most pessimistic education scenarios for Africa is that of a population size of 1.8 billion compared with 2.4 billion by 2050. For the world as a whole, the difference due to education is about 1 billion by 2050. The further we go into the future, the greater will be the long-term effect of near-term education efforts.

The very-long-term future of population size will also crucially depend on the future fertility levels at the low end of today's distribution. Currently, already more than half of the world population is below the so-called replacement level of two surviving children per woman (Wilson, 2004) and what will be the future level of human reproduction is still a very poorly understood question. Whereas the UK, France and the Nordic European countries have quite stable fertility levels only slightly below replacement, central, eastern and southern Europe have much lower levels. And East Asia has what has recently been labelled 'ultra low fertility' with fertility levels often around half of replacement. New data for Shanghai (with 20 million representing a bigger population than Sweden, Norway and Finland together) show a total fertility rate of only 0.6. Even after adjusting for possible distortions caused by the postponement of childbearing (the 'tempo' effect) this (now voluntarily) very low level is still hardly above a third of replacement. Will the long-term future of global reproduction follow the pattern of Scandinavia or that of Shanghai? We simply do not know yet and this topic has not been given enough research attention. It deserves a serious interdisciplinary research effort because of its significant long-term consequences.

Another important uncertainty is the future of life expectancy. The current discussion is dominated by the conflict between two opposing schools of thinking: one argues that we shall not see much further increase in maximum life expectancy, whereas the other paints a picture of ever increasing life expectancy virtually without limit. Faced with such uncertainties about the future of longevity and post-demographic transition fertility levels, statisticians in their projections can only try to provide fair numerical representations of these uncertainties and illustrate the consequences in terms of distributions of possible outcomes. Fig. 2 (on its left-hand side) depicts the uncertainty distribution resulting from the stochastic projections of world population

as published by the International Institute for Applied Systems Analysis (Lutz, Sanderson and Scherbov, 2008). They show an 80% range for the world population in 2100 going from a low 6.2 to a high 11.1 billion with the median lying at 8.4. These projections also confirm earlier results that there is an 80–85% chance that the world population will peak and start to decline during this century (Lutz *et al.*, 2001).

The right-hand side of Fig. 2 shows selected scenarios that extend the time horizon to the end of the 22nd century (Lutz and Scherbov, 2008). In the International Institute for Applied Systems Analysis probabilistic long-range projections, uncertainty ranges for fertility and mortality were defined only until 2080, so the additional lines start in 2080 at different points of the distribution and keep fertility and mortality constant at the indicated levels. Unlike the United Nations world population projections to 2300 (United Nations, 2004) where a long-term fertility rate of 1.85 is the lowest fertility level considered, Lutz and Scherbov (2008) presented a much broader range of scenarios with long-run fertility ranging from 1.0 to 2.5 combined with life expectancy trends that either reach a maximum (LEMAX in Fig. 2) at 90 or 120 years. Whereas most of the scenarios start from the median of the distribution in 2080, others depart from the upper and lower ends of the 95% interval in that year.

These scenarios into the 22nd century must be viewed as hypothetical 'if–then' calculations. We simply know too little about the long-term trends to judge which are more likely. But we can conclude from these calculations that a world of (3–4) billion—which is sometimes stated as a sustainable global population size by prominent ecologists—can be reached not only through a Malthusian 'positive check' operating through increased mortality but also in the benign way through voluntarily low fertility. If global fertility after 2080 stayed roughly constant at the level of 1.7, then the world population size would decline to (4.9–5.8) billion in 2200 (and (2.4–3.5) billion in 2300) depending on the life expectancy chosen. A fertility of 1.7 is higher than has been observed in Europe over the past decades (Lutz *et al.*, 2003). If we choose the current average European fertility of 1.5 as the long-term level, then the world population would decline to (3.5–4.4) billion in 2200 (and (1.1–1.7) billion in 2300).

These exploratory scenarios teach us that a substantial long-term decline in world population size is entirely feasible and can happen at the same time with significant further improvements in health and life expectancy. Although under such scenarios the world population would clearly continue to age (actually under a total fertility rate of 1.7 the speed of ageing would be relatively slow), the future elderly can be expected to have a much better health status than today's elderly, in particular because they will be better educated than today's elderly and, almost universally, better educated people have lower levels of disability at any given age. This, finally, brings us back to the overriding importance of education. A global fertility level of 1.5–1.7 in 2080 is only likely to materialize if the world population will be about as educated as Europe is today.

Given the strong causal effect that education has on health and wealth, such a well-educated world population of (2–6) billion is very likely to be better off than the average world citizen today. And most ecologists would see fewer people as a highly welcome relief of environmental pressures, although what matters more is *per capita* consumption. As to the expected negative consequences of unavoidable climate change, it seems plausible to assume that, with a large world population, more people will suffer than in a lower population density world. And, again, education is probably the single most important determinant of empowerment for coping with and adapting to the dangerous consequences of climate change.

Whether or not this benign transition to a much smaller, better educated and therefore healthier and wealthier world population in the 22nd century can be achieved will largely depend on actions that are taken over the coming decades. In a number of African countries educational improvements and with them declines in fertility rates have stalled and child mortality increased. Meanwhile, international development policies seem to be in disarray and without clear orientation. The considerations that are summarized in this short note suggest very clearly that continued efforts for universal primary and secondary education around the world should become the overriding priority in international development and climate change adaptation policies. ■

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Age and Cohort Change

A major new IIASA project will carry out demographically based projections of productivity, values, and beliefs in Europe up to 2050

ERC Starting Grant to Vegard Skirbekk

For more information, visit
www.iiasa.ac.at/Research/POP/ACC
or e-mail Dr. Vegard Skirbekk: skirbekk@iiasa.ac.at

European demographic change poses challenges to productivity and social cohesion. The Age and Cohort Change (ACC) project will develop new projection methodology to anticipate such changes and optimize policies for the future. Unlike projections of long-term economic growth or energy use, demographic forecasts tend to have comparatively low error margins, even for forecasts half a century ahead. Traits that change systematically along age or cohort lines can therefore be projected with some degree of accuracy. The ACC project will focus on skills and work performance in addition to beliefs and attitudes in Europe in the coming decades.

With funding of €1 million from a European Research Council Starting Grant, IIASA's Dr. Vegard Skirbekk will lead the five-year research project. If you are interested in collaborating with the project, please contact Dr. Skirbekk at: skirbekk@iiasa.ac.at

Projections of productivity

Part of the project will be devoted to understanding the impact of age and cohort variation on productivity. Many European countries are raising, or planning to raise, the retirement age. However, the ability to increase the number of older people in employment depends to a large extent on older workers' work performance, as determined by their cognitive performance and education. If later-born cohorts perform increasingly better in these areas, this will imply that older individuals can remain productive in the workforce to a higher age. Cohort effects are therefore paramount for understanding the future work performance of senior workers, and how well societies will cope with aging.

The last few decades have seen improvements in mental ability levels among individuals aged 60 and above, their educational attainment, and their work capacities. However, changes in these productivity determinants—education, cognitive skills, and productivity—are yet to be integrated into a common framework that allows us to project the composition of skills by age, sex, and birth cohort.

This research project aims to produce age- and sex-specific projections of key determinants of productivity, such as educational performance, cognitive abilities, and literacy. These important components of productivity will provide insights into future employment capacities, particularly in older people; combined, the components will present crucial information about prospective work capacities.

Evidence on age trajectories of cognitive abilities suggests that these tend to follow relatively similar patterns in different cultures and for both genders. These documented lifecycle changes could be the basis for projections regarding future development in these important productivity determinants—which will shed light on which nations will cope best with population aging.

Values and beliefs

The ACC project will also use multistate population projections to project how demographic change will affect values, attitudes, and religious composition. The projections will be based on empirically estimated cohort changes, age-transition schedules, fertility differentials, migration, and intergenerational transmission of attitudes.

The project will model the demographic dynamics of attitudes and values (e.g., acceptance of marriage dissolution) and religiousness (e.g., affiliation and practice). Older individuals tend to be more religious and hold more conservative values, and population aging could increase the prevalence of those values. However, cohort effects may disrupt such trends; for instance, later-born cohorts in Spain are increasingly secular, which is likely to have implications for the future composition of the population.

The project will also take into account fertility differentials; childbearing patterns affect the composition of values and attitudes in the population as such values are at least partially transferred across generations. Additionally, migration could be a major driver of attitudinal and religious change which can substantially change the prevalence of values within a society over the longer term. ■

Announcement VID—IIASA Seminar on

Optimal Fertility in Aging Societies

8–9 December 2010, Vienna (Austria)

It is often assumed that replacement fertility is the optimal fertility level. Any optimum, however, depends crucially on the criteria used and the factors considered. If, for instance, education (its cost at young ages and higher productivity at adult age) or global environmental change are taken into account, the optimum may turn out to lie well below replacement. The seminar will deal systematically with this highly relevant but rarely discussed topic.

For further information contact: Alexia Fürnkranz-Prskawetz (afp@econ.tuwien.ac.at)

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