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Toward a 21st Century Population Policy Paradigm

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Contents

Abstract

This paper aims to stimulate a systematic discussion about what should be the goals of aggregate level population policies in the context of population aging and shrinking in some parts of the world and continued rapid growth in others. It starts with a discussion of the shortcomings of three currently dominating assumptions: (a) the desirability of achieving replacement level fertility, (b) a demographic dividend will translate fertility declines into aggregate economic growth, and (c) only addressing the "unmet need" for contraception in developing countries will result in significant fertility declines. The paper then summarizes new empirical evidence on the interactions between changing age and education structures and their impacts on population growth, health, economic growth, democracy, and adaptive capacity to environmental change. It suggests that strengthening the human resource base for sustainable development should become the 21st century population policy paradigm.

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Toward a 21st Century Population Policy Paradigm

Wolfgang Lutz

1 Introduction

While the second half of the 20th century – at least up to 1994 – had a strong and pervasive international population policy paradigm that focused on curbing rapid population growth in developing countries through family planning, the beginning of the new century has seen increasing differentiation, if not confusion, about what should be the goal of population policies and what the appropriate instruments for pursuing them are. The International Conference on Population and Development (ICPD) in Cairo 1994 has seen a paradigm shift away from demographic targets to a focus on individual reproductive and human rights, thus essentially giving up on aggregate population level considerations. Today, governments of an increasing number of countries, whose low fertility levels and rapidly ageing populations cause serious concern, are forcefully returning to aggregate level considerations and search for policy interventions that are both effective at the population level and socially acceptable at the individual level. Meanwhile, governments of a diminishing number of high fertility countries continue to struggle with the consequences of rapid population growth which are reflected in high youth unemployment, difficulties in expanding health and education services and in some instances environmental degradation. While for this second group of countries that is concentrated in Africa and West Asia, conventional 20th century pre- and post-Cairo population policies with an emphasis on family planning programs and reproductive health are still highly relevant, there is significant new evidence indicating that such programs can become much more effective when reproductive health services and the supply of contraceptives are complemented by a strong emphasis on girls' education. But this new scientific evidence does not yet seem to have fully arrived in the population policy community.

The helplessness of conventional population policy approaches to deal with 21st century demographic challenges was bluntly manifest at a recent 20-year review conference of ICPD. This conference for the UN Economic Commission for Europe in Geneva included 56 Northern countries from Vladivostok westward to Vancouver. All these countries are in the process of rapid population ageing, and except for those with significant migration gains many face the prospect of population shrinking. Bulgaria, for instance, has already shrunk rapidly from around 9 million in 1990 to 7.2 million today, heading toward an estimated 6 million by 2030. Japan has also started to shrink and faces the prospect of losing 30 percent of its population over the coming decades, with the median age of the population increasing from 44 years now to above 55 in 2050. Efforts to turn around these trends through policies that directly enhance birth rates have been largely ineffective and are unlikely to change the big picture in the foreseeable future.

The governments of an increasing number of these rapidly ageing and partly shrinking countries, particularly in Eastern Europe and Eastern Asia turn to the international population research community for help and advice. This was very evident at the IUSSP International Population Conference in Busan (South Korea) in August 2013. But the international research community seems to be rather helpless. Except for some fairly unsystematic discussions about the desirability or effectiveness of pro-natalist policies it lacks an explicit and comprehensive discussion about what could and should be the overarching goal of 21st century population policies.

In this paper I will try to prepare the grounds for a systematic discussion about what should be the goal of aggregate level population policies and according to what criteria this discussion should be conducted. There are two important premises for the discussion. The first is that the paper deals with "population" in its genuine meaning, i.e. as an aggregation of human beings whose change over time with respect to size and composition is being addressed. The study of such aggregate level population issues corresponds to the original definition of what constitutes demography and population studies (Keyfitz 1982; Preston et al. 2001). It is epistemologically a completely different topic from addressing the individual human rights issues related to reproductive rights and health, although they are frequently also labeled as "population" topics, mostly by advocacy groups. Whether or not any policy that may affect aggregate population trends is desirable from the perspective of individual human rights, is indeed a politically highly relevant question which can and should be scholarly discussed by the human rights research community but it is not a population issue to be studied in demographic terms. Before studying any possible population related policy with respect to its human rights implications there first needs to be a demographic assessment of what are meaningful policies with respect to their aggregate i.e. population level consequences for society and the economy. This discussion of possibilities to influence trends at the population level is the primary topic of this paper.

The second premise refers to the substantive focus of this aggregate level analysis which addresses the changing composition of the population in addition to total population size. In conventional demography, this composition is usually studied with respect to the changing distribution of individual members of the population by age and sex. But throughout the history of demography, population dynamics in a given territory has also occasionally been studied with respect to additional demographic dimensions. In a review article in *Philosophical Transactions* (Lutz & KC 2010) these different possible demographic dimensions are systematically discussed with respect to their relevance to population dynamics and specific substantive research questions. In another review article in *Science* (Lutz & KC 2011) the authors go one step further and establish educational attainment as the single most important source of observable population heterogeneity after age and sex. This is based on the assessment of clearly specified criteria concerning the effects of heterogeneity on aggregate level population dynamics and its substantive relevance for the study of social and economic development. Following this logic, in this paper I consider education to be a demographic dimension and all discussions of population structure will consistently refer to age, sex and highest level of educational attainment. This approach has also been interpreted as a way of introducing the "quality dimension" into population modeling (Lutz & KC 2011). As will be seen below, this choice has far-reaching consequences for what is viewed as the goal of population policies.

Put in a nutshell, the main proposition of this paper is that the primary goal of 21st century population policies is to strengthen the human resource base for national as well as global sustainable development. Population policies under this paradigm could be viewed as public human resource management – to stress an analogy with the private sector. Under this approach no certain population size, specific growth rate, set fertility rate, or particular age structure is viewed as a goal in its own right. This approach is thus in line with the ICPD decisions that have frequently been praised as doing away with demographic targets. Population policies should rather try to efficiently and flexibly manage human resources with respect to achieving the highest long-term wellbeing of current and future generations while fully respecting all dimensions of human rights. The instruments for pursuing such policies cover a broad range from family and social security policies to education and health policies to migration and labor market policies. A comprehensive view of public human resource management can help to integrate these often separate policy sectors.

This paper will be structured in the following way: First I will discuss the shortcomings of three of the dominating assumptions of current population policy approaches. These are (a) the assumed desirability of achieving replacement level fertility, (b) the assumption that a demographic dividend will translate fertility declines into aggregate economic growth, and (c) the assumption that only addressing the "unmet need" for contraception in developing countries will result in significant fertility declines. I will discuss these three basic assumptions with respect to their empirical relevance and their internal consistencies once education is also considered as an explicit demographic dimension as suggested above.

In the second part of the paper I will briefly summarize some recent scientific evidence about how the interaction between changing age and education structures impact on population health, economic growth, quality of governance and democracy, and adaptive capacity to environmental change. Most of this evidence has already been published elsewhere and the innovation of this paper is only to bring it together in a way that establishes the substantive foundations for the relevance of the newly proposed population policy paradigm.

The paper will conclude with briefly introducing a field of modeling in which this new paradigm has already been effectively implemented. The Shared Socioeconomic Pathways (SSPs) are part of a new generation of global climate change scenarios in which societies' mitagative and adaptive capacities are captured through human capital as described by the age, sex and education structures of populations. I will conclude with more general considerations and suggestions how this new paradigm could inspire national and international policy makers.

2 Shortcomings of Three Key Aspects of the 20th Century Population Policy Paradigm

2.1 Replacement Level Fertility is not a Meaningful Goal to Aim at

The notion that replacement level fertility would somehow be optimal seems to be ubiquitous. When asked about what a desirable fertility level for populations might be, most politicians, journalists and even demographers would spontaneously answer that it is slightly above two children per woman or often even the precise number of a Total

Fertility Rate (TFR) of 2.1. The reasons stated in support of this level of fertility usually refer to some vague notions of stabilizing population size, or the dependency ratio, or maintaining the size of the labor force. But a closer look at the demographic models that underlie this reasoning reveals that this supposedly precise level of 2.1 (actually more like 2.06 under low mortality conditions) is only derived from a highly stylized theoretical model of stationary population. It has little to do with actually maintaining the size of the labor force in contemporary *real* societies. These have an age structure which is often quite irregular and the size of the working age population is influenced by migration and mortality changes in addition to fertility. However, even in the hypothetical absence of migration and under constant mortality conditions, in countries with a high share of young people (positive momentum of population growth) fertility should be well below replacement level if the goal is to keep the absolute size of the working age population constant. Conversely, in countries with relatively few younger people (i.e. that have already entered a phase of negative momentum) fertility should be significantly above replacement level if again, the goal is to maintain the working age population. Lutz et al. (2003) showed that Europe's population entered the phase of negative momentum around the year 2000. Hence in this context of real European populations and their empirically given age structures, a reference to replacement level fertility makes little sense in terms of the stated goal of maintaining the labor force in its current size. On top of this, all real populations in Europe and elsewhere do experience mortality change and migration and hence render the 2.1 goal even less relevant as a way to achieve the supposedly desirable stationary demographic situation.

Recently, there have been two independent strains of research that both come to the conclusion that for most countries in the world long term fertility levels somewhat below replacement level would be preferable to replacement level fertility for economic reasons. One is based on an extension of the National Transfer Accounts (NTA) approach which collected empirical data for over 40 countries for age-specific consumption and income profiles (Lee & Mason 2011). In a recent study this NTA approach is combined with the economic model showing that population decline actually increases the capital/output ratio, and hence a moderate shrinking of the population leads to higher consumption and also welfare. While from a pure fiscal/public finance point of view the model shows that fertility should be significantly above replacement, combining this with the goal to maximize consumption yields a much lower desirable long term TFR: 1.24 for today's low income countries, 1.50 for the middle income group, and 1.79 for the high income group (Lee & Mason 2012).

A different line of research focusing on the heterogeneity of the population with respect to education and the fact that more educated persons cost more due to education investments during the early phases of life but are then more productive later in life arrives at very similar conclusions. Striessnig and Lutz (2013) systematically assess this issue of "optimal fertility" by first defining and discussing a number of optimality criteria and then presenting extensive sets of simulations about the implications of alternative long term fertility levels on education-weighted support ratios, which also factor in the costs and benefits of education. In a subsequent article (2014), the authors go one step further and include further externalities to childbearing such as emissions contributing to global climate change. Below some key aspects of this analysis will be summarized.

In their review of possible arguments in favor of considering two surviving children as optimal Lutz and Striessnig (2013) also address the micro-level argument that there is a supposedly "natural" desire for a man and a woman to have two children together in order to replace themselves, and hence continue living in their children. In this context Lutz and Scherbov (2008) had argued that it is worth distinguishing between population-level replacement and individual-level replacement, and that at the individual level it is sufficient to have one surviving child if the primary goal is to pass on your genes and continue to live on in the next generation. In the absence of cloning it takes a partner of the opposite sex to produce this one offspring. As such, the child is made up of only half each parent's genes. Yet, having two or three children does not make the offspring more similar to you. It would of course spread your genes more widely, but this is a very different goal from replacement and if this were the goal then, of course, one should have as many children as possible. There would be no reason to stop at two. There can be other individual-level reasons for having a second (or further) child, such as providing the first child with a sibling. But this is not related to the question of replacement, and again, there would be nothing magic about two children.

With a view to low fertility countries Striessnig and Lutz (2013) discuss optimality criteria for the fertility level in terms of the economic and social consequences of population ageing and focus on maximizing the projected education-weighted support ratio which is often seen equivalent to, more generally, maximizing the economic wellbeing of the average citizen in the population studied. In a second step (Striessnig & Lutz 2014) they complement this focus on age structure by the possible impacts of different demographic trajectories on future paths of greenhouse gas emissions and hence climate change which is also seen as a relevant factor contributing to future societal wellbeing. The authors further discuss a third, quite powerful criterion relating to strictly national level considerations of changes in population size as compared to that of other nations. Although such considerations of relative national strength that is assumed to be related to population size has been a powerful driver of fertility related policies – ranging at least from 19th century France to Russia today – the authors argue that it cannot be meaningfully operationalized in terms of a globally valid criterion because it is based on the very idea that one nation increases more than the others, a principle that – if followed by every nation – in the end would lead to ever accelerating population growth. One might still be able to define some more reasonable criteria in terms of national/ethnic identity, or the survival of certain languages or cultures which requires a critical minimum population size, but this is beyond the scope of their analysis.

Figure 1 shows the results of extensive simulations as given by Striessnig and Lutz (2014) for the European Union. It shows education-weighted dependency ratios in which the working age population in the denominator is weighted by a set of assumed education-specific productivity weights, and in the numerator children are weighted by education costs and elderly by pension costs. This is done in steps of 0.1 of the TFR (in the TFR range 0.1-6.0 for age- and education-specific population scenarios to 2100 (keeping the 2011 fertility level constant over the entire projection range). As the model cannot be described in detail here I will only focus on explaining the pattern appearing in Figure 1. The legend in the lower right corner lists selected years for which the pattern is shown and the resulting level of fertility that would minimize the education weighted dependency ratio (OLF = Optimal Level of Fertility). Not surprisingly, if the

time horizon is strictly 2030 (and no future considered beyond that point) the dependency ratio would be lowest if there were no births at all because this would lead to radically declining youth dependency. Only by the middle of the century the assumed constant fertility level will start to significantly affect the working age population and then towards the end of the century also the elderly population. By 2100 the age structure will have become close to stable and this curve (solid line) of education-weighted dependency has a minimum at a constant TFR level of 1.78. Thus, under this model the long term optimal fertility level (assumed to minimize the dependency burden) turns out to be well below replacement level fertility. This is for a population assumed to be closed to migration and with life expectancy gradually increasing. If migration gains were to be included in the model the optimal fertility level would fall even lower below replacement.

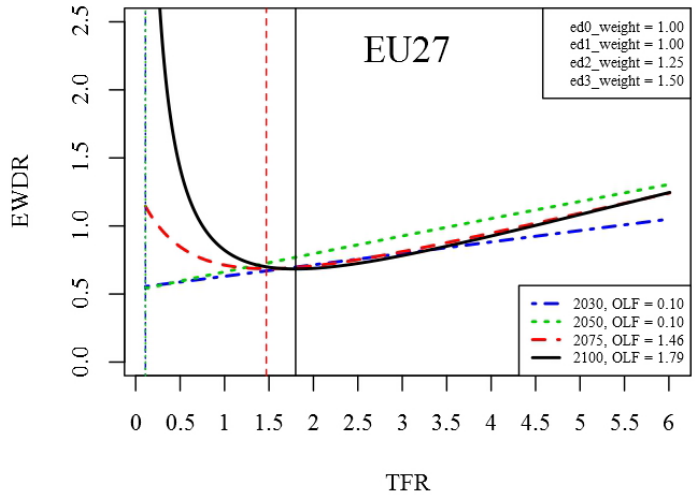

Figure 1. Education Weighted Dependency Ratios for Different TFR Levels and Time Horizons as Simulated for European Union (with 27 Members as of 2011) (Source: Striessnig & Lutz 2014).

In a second part of their analysis, Striessnig and Lutz (2014) include greenhouse gas emissions into their model which changes the results dramatically. Based on the PET (Population-Environment-Technology) model by O'Neill et al (2010) they translate the population trajectories resulting from the different fertility levels into trajectories of carbon emissions. It is important to note that carbon emissions do not decline linearly with lower fertility because the PET model also considers the emissions to depend on changing household size associated with lower fertility. The results of this combined model greatly depend on how much weight is put on the environmental burden as compared to the age-dependency burden. If we only cared about minimizing carbon emission then the optimal fertility rate would be zero. If zero weight is put on carbon emissions then the results are identical to those shown in Figure 1 giving an optimal TFR of 1.79 with the time horizon 2100. When a weight of .2 is given to minimizing carbon emissions and .8 on minimizing the dependency ratio then a TFR of 1.51 comes out as optimal for the EU27. The more the weights are changed in favor of

reducing emissions the lower the resulting optimal level of fertility. Striessnig and Lutz also applied the model to China with rather similar results.

What do these results imply for the question of whether or not current fertility levels in different parts of Europe should be considered as too low? When comparing the results of the Striessnig and Lutz simulations to currently reported TFRs in Europe we have to consider the fact that for many countries the period TFRs are downward distorted by a tempo effect resulting from an ongoing increase in the mean age of childbearing. Hence the long term stable TFRs considered in this model should be compared to the tempo-adjusted TFRs which according to the European Demographic Data Sheet 2012 (VID 2012) is 1.77 for the combined EU27. This happens to be almost exactly the optimal TFR level resulting from the above simulations without considering carbon emissions. When carbon emissions are also taken into account – even with a very low weight – the current average EU fertility level should be considered as being too high.

Viewed together, these calculations suggested that current fertility levels in Europe are probably around their optimum provided that the European society continues to invest in education and this past trend also results in higher productivity. At the country level the calculations lead to politically sensitive conclusions: following this rationale the current German fertility level is about right but that of France is too high to be optimal. These results are obtained even without considering the impacts of immigration and with giving only minimal weight to carbon emissions. If climate change is given a higher weight, then most countries of Europe and in particular the United States can be viewed as having too high fertility even under optimistic assumptions about future transitions to green technologies.

Whether or not the model assumptions made by Striessnig and Lutz are being accepted this analysis together with the above mentioned studies by Lee and Mason (2012) and Bongaarts and Sobotka (2012), who showed that in Europe migration gains compensate in part for the age structural effects of low fertility, make it clear that the ubiquitous view that replacement level fertility should be considered as ideal is far from self-evident and needs to be reconsidered. Furthermore, explicitly factoring in education makes a significant difference in the assessing of this issue.

2.2 The Demographic Dividend is Actually an Education-triggered Dividend

The effect of changes in age structure on economic growth has been widely studied in the demography and population economics literature. The beneficial effect of changes in age structure after a decrease in fertility has become known as the “Demographic Dividend”. The major innovation of this concept was a systematic consideration of age structure and the associated dependency ratios in addition to just focusing at growth rates in total population. A recent paper in *Demography* by Crespo Cuaresma et al. (2013) goes another step forward by systematically considering the changing education structure in addition to the age structure. The paper assesses the empirical evidence with respect to the relative effects of changes in age-structure as compared to those in education structure. The findings shed new light on our understanding of the effects of population change on economic growth by showing that improvements in education rather than fertility decline are the main driver of subsequent economic growth.

It is worth noting that education and the demographic dividend were linked from the beginning of the studies made in this field. Bloom and Williamson (1998) studied the rate of real gross domestic product (GDP) per capita growth in 78 countries between 1965 and 1990. One of their independent variables was the level of human capital in 1965, measured as the log of the average years of post-primary schooling of the population 25+ years old, based on data in Barro and Lee (1993). The results for the education variable were reported only for their ordinary least squares (OLS) regressions and not the instrumental variable ones. In all those regressions, the education variable always had a positive and statistically significant coefficient. Bloom and Williamson (1998), however, did not discuss in depth the importance of education changes to the East Asian economic miracle. Kelley and Schmidt (2005) further developed the demographic dividend model by making a distinction between the demographic determinants of the growth of output per person of working age (the "productivity effect") and the growth of output per capita resulting from changes in the share of the working-age population in the total population (the "translations effect" or "accounting effect"). The productivity effect has been studied in detail in more recent contributions. Bloom et al. (2009) show in a panel of countries, that a reduction in fertility increases female labor force participation and thus increases the proportion of the working age population who are in the labor force. While many of the key papers on this issue did include education in their specifications – typically by treating it as an enabling factor rather than a trigger – the now widely used and popularized concept of the demographic dividend only refers to changes in age-dependency ratios, whose evolution over the course of demographic transition presumably results in a demographic window that first opens and then closes in a predictable way as the old-age dependency ratio starts to increase (UNFPA 2011). Similarly, recent estimates of the effects of meeting the "unmet need" for modern contraception in Africa on economic growth directly translate assumed lower fertility rates in to higher economic growth rates without accounting for education (Bloom et al. 2013).

Improving educational attainment of the adult population can impact economic growth through various channels. Higher skill levels of the labor force can directly translate into higher productivity and into better and faster take up of new technologies. The direct effects of educational attainment on labor productivity constitute the centerpiece of the model developed by Mankiw et al. (1992), which generalizes the Solow model of economic growth by human capital as an extra production factor. Mankiw et al. (1992) show that this human capital-augmented specification can explain income differences across countries better than the standard Solow model. Benhabib and Spiegel (2005; 1994), on the other hand, emphasize the role played by education as a catalyst of innovation and technology adoption to model the effects of education on income growth. Based on the insights provided by Nelson and Phelps (1966), such a theoretical framework implies that economic growth is not only affected by the accumulation of human capital, but also by its stock. The empirical results provided by Benhabib and Spiegel (2005; 1994) indicate that this technology adoption channel appears extremely important to explain income growth experiences across countries.

Following this logic Lutz et al. (2008) extend the demographic dividend model in two ways. First, they distinguish two mechanisms for human capital to influence economic growth through the direct effect of the productivity of workers and indirectly through its effect on the rate of total factor productivity growth. Second, they use the

new IIASA-VID education database (Lutz et al. 2007) to disaggregate education effects by both age and level of educational attainment. These data are more consistent and more detailed than previously existing data sources. Educational attainment distributions for four educational categories have been reconstructed by 5-year age groups and sex using methods of multi-dimensional population dynamics which also incorporate educational mortality differentials. Using data for 101 countries over six five-year time periods from 1970-2000, they find that the direct productivity effect is particularly strong for older workers with secondary education while younger workers with tertiary education have the greatest effect on the speed of total factor productivity growth. For poor countries they also show that it is broad based junior secondary education that results in higher growth than high education of a small elite combined with broad segments remaining uneducated.

The new paper by Crespo Cuaresma et al. (2013) systematically reassess the empirical evidence on the associations among economic growth, changes in age structure, labor force participation and educational attainment. Using a global panel of 105 countries for the period 1980-2005 and several alternative model specifications with Generalized Method of Moments (GMM) methods to overcome the endogeneity problem in state of the art conditional convergence growth equations, it finds that once the effect of human capital dynamics is controlled for there is no evidence that changes in age structure affect labor productivity. In other words, this paper shows that educational attainment expansions are able to account for the sizable "productivity effects" which past authors had claimed to be caused by age structure changes. The pure demographic dividend found in the new analysis is therefore reduced to a modest "accounting effect", whose size is significantly smaller than that of the productivity changes which are caused by the investment in education. If instead of GDP per capita economic growth is measured in terms of total GDP, as is often done in international comparisons, then even the accounting effect disappears.

Since in the context of this paper it would be inappropriate to reprint all the formal and numerical details of the Crespo Cuaresma et al. (2013) analysis, I will instead highlight the differences between the earlier studies on the demographic dividend and our new findings in a schematic form (see Figure 2 below). In this schematization the conventional demographic dividend model views fertility decline as an exogenous trigger of a declining youth dependency ratio which under certain conditions (good governance, investments in education, etc.) leads to higher productivity and thus economic growth (Model A). In contrast, the education-triggered dividend model views the same empirically observed correlation between lower youth dependency and higher productivity as a result of the joint effect of higher educational attainment on fertility decline (which in turn results in lower youth dependency) and independently on higher productivity (Model B). Which of the two alternative models offers the better explanation is a matter of empirical testing, here it clearly came out in favor of Model B.

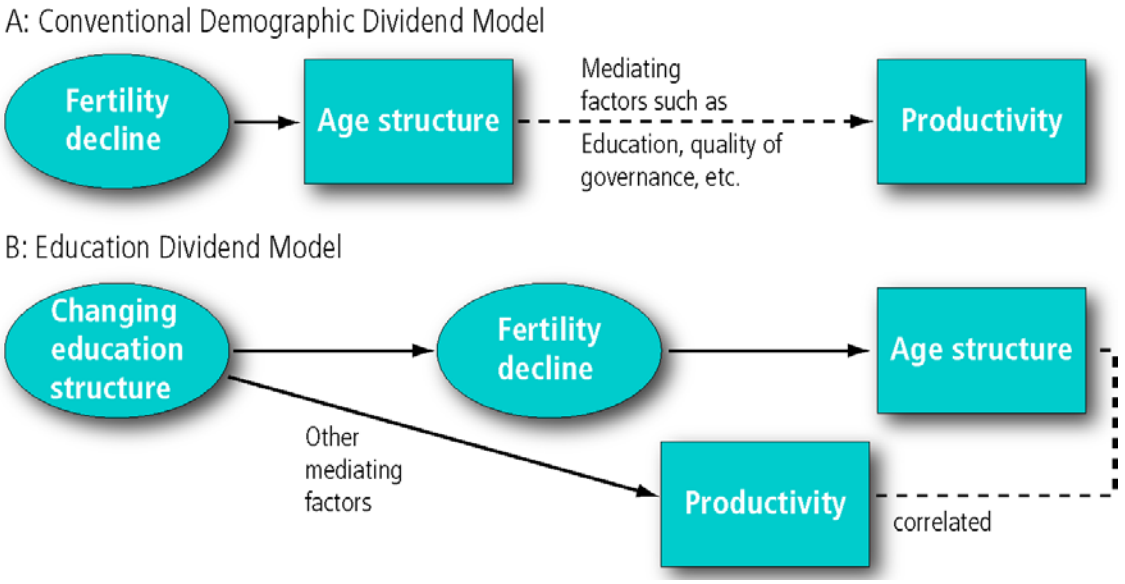

Figure 2. The Conventional and the Education-Triggered Models of the Demographic Dividend

Yet in other words, there is no doubt (and no difference between the two models in this respect) that a decrease in fertility as part of the demographic transition brings about changes in the age structure of populations, which in the short term leads to a lower youth dependency ratio. The conventional demographic dividend model assumes that the falling proportions of children in the total population that is triggered by an exogenous fertility decline (often assumed to be a consequence of family planning programs) and the associated increasing proportions of the population in working ages creates a window of opportunity during which there can be higher growth rates of income per capita. This effect is not seen as automatic, however, but depends on several enabling factors that also include investments in education. The very notion of a "window" also implies that after some time this favorability disappears when as a longer-term consequence of low fertility the old-age dependency ratio starts to increase.

In contrast, the new Crespo Cuaresma et al. (2013) study also demonstrates the empirical validity of the alternative Model B which assigns to education the dual role of helping to bring down fertility and enhancing productivity. Hence, in periods of expanding educational attainment, improvements in education of women of childbearing age contribute to declining birth rates, while at the same time a more productive workforce (due to the increases in human capital) populates the labor market. This Model B also provides a more optimistic outlook for the future because the strong productivity enhancing effect of human capital does not assume the closing of a "window" and even ageing populations can see continued productivity growth as a function of further improving human capital.

The results of the new study summarized above have important implications for setting 21st century international development policy priorities. While not questioning the positive effects of family planning services on health and well-being and their independent importance under a human rights perspective, the results described here imply that focusing primarily on fertility reduction to reap the returns of the demographic dividend is erroneous. The change in age structure on its own is not the driving force of economic growth during the demographic transition. Instead, a labor

force that has the required skills that enable productivity improvements appears as the key factor to ensure higher growth rates of income. Under the model supported by the analysis performed in the study, it is education which appears at the root of the beneficial effects of the demographic dividend, affecting the change in age structure and the growth rate of income simultaneously (Model B in Figure 2). In the light of the new analysis, the double dividend of education expansions, by simultaneously reducing fertility and increasing productivity, can create a virtuous circle of economic growth and should put human capital investment in the center of global development strategies aimed at poverty reduction.

2.3 Responding to the "Unmet Need" with Supply of Contraceptives May Have Little Effect on Fertility

The concept of "meeting the unmet need" for reproductive health and family planning has over the past 20 years become one of the most prominent goals of the international "population community". It seemed to be the magic bullet that helped to consolidate the ICPD concern of individual rights and thus respecting individually desired family size with the still tacitly underlying pre-Cairo aggregate level goal of bringing down fertility levels in high fertility countries. This concept has even risen to the highest level of international development policy prominence by being included as one of the six indicators used for Goal 5 (maternal and reproductive health) of the Millennium Development Goals. Today it is widely considered a valuable concept which is frequently used for advocacy of reproductive health and family planning programs. Sometimes quantitative information on the prevalence of unmet need in developing countries is presented together with some hypothetical calculations showing how much lower fertility levels in those countries would be in case the unmet need were met (Bradley et al. 2012). This is based on the strong assumption that somehow programs that improve the supply of contraceptives and lower their cost would lead to a near elimination of unmet need. In the following I will present empirical evidence that casts strong doubts on this assumption, and show that investments in girls' education is likely to be a much more efficient strategy towards lower fertility because it also decreases desired family size and can better help to remove some key obstacles to meeting the unmet need than a focus on the provision of supply of contraceptives.

While the official WHO definition of unmet need restricts it to women who are sexually active the frequently used empirical estimates on the basis of DHS and other survey data define it as the proportion of married women who are not currently using contraception and want to stop or delay childbearing. Furthermore, most scientific studies of unmet need clearly distinguish between unmet need for spacing and unmet need for limiting. Only the latter could meaningfully be related to estimates of how many births could be avoided in the case that the unmet need could be fulfilled. The definition of unmet need on the basis of Demographic and Health Surveys (DHS) has recently been modified slightly and re-estimated for all surveys since 1990 (Bradley et al. 2012). These modifications essentially simplified the classification of unmet need for spacing and limiting by removing calendar data from the calculation and standardizing the calculation of infecundity, but they did not address what – in my view – is one of the most serious shortcomings of the concept, namely, the assumption that every married woman is constantly exposed to the risk of pregnancy no matter whether her husband is

around or working far away for extended periods. Strangely enough, this redefinition has not addressed the issue that marital status can be a bad proxy for sexual activity.

Let me illustrate this issue with the example of Nepal. According to the new DHS definitions Nepal had an unmet need of 32.4 percent in 1996 which was one of the highest among all Asian DHS countries. By 2006 this figure had declined to 24.7 percent but this decline seems to have stalled and the most recent 2011 DHS report show a slight increase to 27 percent (DHS Nepal 2012). This is all the more surprising since other indicators of modernization have been improving and the TFR has declined from 4.1 in 2001 to 3.1 in 2006 and 2.6 in 2011. Large numbers of Nepali men are working abroad, mostly in the Golf states. A majority of them are married men, leaving their wives and young children behind and supporting their life with remittances. Khanal et al. (2013) estimate that nearly one-third of women of reproductive age is separated from their husbands. For these married women whose husbands are away for extended periods (up to several years without a visit) it would indeed be very strange and socially inacceptable to use contraception – yet according to the DHS criteria they are clearly classified of having an "unmet need" if they state in the survey that they do not want to have further children. Hence, this definition significantly inflates the estimated unmet need figure. While Nepal may be an extreme case in terms of husbands being abroad, similar patterns of internal labor migration for working in the mines or in cities for extended periods can also be found in many other higher fertility countries. As the following analysis of the reasons for not using contraception will show "lack of exposure" is stated by almost a quarter of African women which makes it the second most important reason after fear of negative health effects.

A large number of recent DHS surveys included a specific set of questions asking women who had been classified as having an unmet need what were the obstacles or reasons for not using contraception. In the following empirical analysis this information has been tabulated by level of educational attainment of the female respondents. There were different predefined reasons that women could state and Table 1 shows the results for Africa and four sub-regions of Africa. As stated above, the two dominating reasons were fear of negative health effects and lack of exposure. For uneducated women opposition to family planning (mostly by the partner or extended family) was an even more frequently cited reason than lack of exposure.

Table 1. Cited Obstacles to Using Contraception for Women Classified to Have an Unmet Need for Limiting by Level of Education (Recent DHS Surveys in Africa)

WOMAN WITH AN UNMET NEED TO LIMIT			lack of exposure	infecund / ppa	breastfeeding	fatalistic	opposition to family planning	lack of knowledge or source	health concerns	lack of access	cost	other or don't know
	Eastern Africa	no education	17.6	9.8	5.4	3.0	25.3	16.4	28.8	3.3	5.1	10.5
		primary	23.5	11.4	7.1	2.1	21.3	7.8	35.7	1.5	4.3	12.0
		secondary+	23.5	14.7	6.9	1.2	17.3	1.8	40.1	0.4	3.4	10.2
	Middle Africa	no education	21.3	11.8	4.9	8.2	18.8	9.6	30.6	2.6	4.5	11.9
		primary	27.0	8.9	6.4	5.5	15.6	2.5	35.6	1.3	4.9	11.2
		secondary+	32.6	10.5	4.6	7.7	13.6	1.8	36.7	0.1	1.3	9.7
	Southern Africa	no education	19.1	8.7	14.2	1.5	25.5	17.2	37.8	3.3	5.2	3.6
		primary	16.7	7.1	14.3	3.2	22.7	12.0	46.9	2.6	6.6	4.7
		secondary+	22.8	7.5	14.7	2.8	14.4	3.8	55.9	0.3	0.7	6.3
	Western Africa	no education	19.7	10.7	6.4	4.8	20.6	18.7	33.7	2.3	7.2	8.3
		primary	21.4	12.4	7.8	3.7	16.3	7.7	38.8	1.9	5.8	10.8
		secondary+	24.4	10.2	6.4	3.4	18.6	3.2	38.1	1.8	2.8	11.2
	Africa	**no education**	**19.2**	**10.4**	**6.6**	**4.4**	**22.5**	**16.0**	**31.8**	**2.8**	**5.7**	**9.2**
		primary	**22.7**	**10.8**	**8.0**	**3.4**	**18.7**	**7.3**	**38.0**	**1.7**	**5.2**	**10.7**
		secondary+	**25.4**	**11.6**	**7.2**	**3.3**	**16.7**	**2.5**	**40.6**	**0.8**	**2.5**	**10.0**

With respect to the prominence of health concerns about the possible negative effects or side effects of using contraception it is unclear to what degree these answers reflect simply a lack of information and are based on unfounded rumors. The fact that the percentage citing health reasons as an obstacle tends to be higher for the better educated women may also point to this answer possibly being a rationalization because it may sound more like an acceptable reason than other reasons in the list provided. But on the other hand it may indeed reflect real health concerns as a consequence of poor reproductive health service delivery conditions that may result in negative and unpleasant health consequences. The second most frequently cited reason is lack of exposure and seems to be a direct consequence of DHS using marital status as the only indicator of exposure. It is also interesting to see that this reason is more important for the better educated women, which probably reflects a higher education of the husbands and a higher probability of them being away for paid work. Next in line of the obstacles to contraceptive use comes cited opposition to family planning. This includes both the opposition of the woman herself as well as opposition by her husband and extended family.

The most surprising and politically relevant aspect of this analysis is the fact that the obstacles that are most directly addressed by family planning services such as access to contraception and cost of contraception seem to be of only minor importance. This has also been shown by other studies of the data on obstacles to contraception (Bradley et al. 2012). The DHS data show that of all African women who are classified as having an unmet need for contraception only less than 3 percent cite lack of access as an important reason for not using contraception. Among more educated women this percentage even lies below 1 percent. Cost of contraception is cited by between 5 and 6

percent of less educated women and 2.5 percent of more educated women. In other words, for uneducated African women who are classified as having an unmet need for contraception only 8.5 percent say that either lack of access or high costs are an important reason. For women with secondary education only 3.3 percent mention these supply reasons which in the international political and advocacy discussion are often conveyed as representing 100 percent of the reasons for the unmet need.

While the analysis presented above casts serious doubts on the possible direct effects on lowering fertility of programs that primarily aim at improving access to contraception and reducing the cost in the African context there is no doubt that improving the education of girls will directly translate into lower fertility through a combination of lower desired family size, better empowerment of women to pursue their own plans and better ways of finding access to effective contraception. There is massive empirical evidence supporting this view which has been reviewed in Lutz and KC (2011) and Lutz et al. (2014). This evidence is also succinctly summarized in a paper by Bongaarts (2010) entitled "The causes of educational differences in fertility in Sub-Saharan Africa" in which he shows for 30 countries using DHS data that not only is desired family size significantly lower for more educated women but also that "as education rises, fertility is lower at a given level of contraceptive use, contraceptive use is higher at a given level of demand, and demand is higher at a given level of desired family size" (p. 31). To illustrate this pervasive relationship between female education and contraceptive use Figure 3 shows the pattern for DHS countries in West Africa.

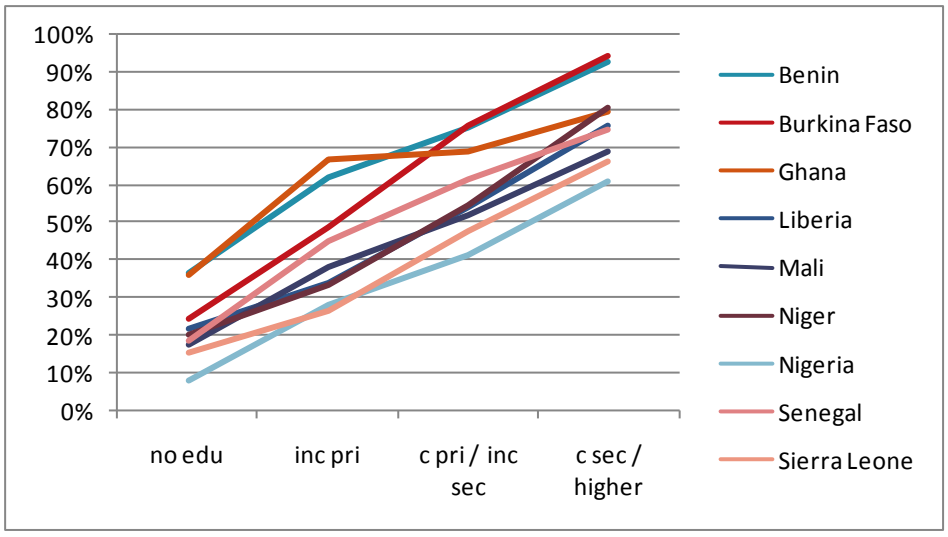

Figure 3. Ever-use of Contraception by Educational Attainment of Women (DHS Data for 9 Countries in West Africa)

For the above described reasons investments in the rapid expansion of female education in the poorest countries can be a very effective policy priority in bringing down overall fertility and hence total population growth. The magnitude of the effects of alternative education scenarios on future population growth will be illustrated in the following sections. When these very strong expected impacts of female education are quantitatively compared to the possible impacts of focusing on the obstacles to meeting the unmet need the effects differ by an order of magnitude. For the above described case of West Africa Bradly et al (2012) calculate that under the very strong assumption that programs can eliminate the entire unmet need, the TFR would be 4.9 instead of 5.4, i.e.

on average 0.5 children lower. But Table 1 above indicates that in West Africa only 6 percent of the women classified as having an unmet need actually cite lack of access as the relevant obstacles and only 2 percent cite cost. From this indication, one can infer that even radically improving on cost and supply without addressing the other obstacles would only bring down the TFR by around 0.04 children (0.5 times 0.08). This compares to a decline in TFR of between 2 and 4 children on average in the case of educating all girls to junior or senior secondary level respectively. Hence the effects of these two alternative strategies on the fertility level differ according to these calculations by a factor of between 50 and 100. To the extent that family planning programs also include counseling and education elements – as many of the programs on the ground do – they are likely to also address some of the other obstacles mentioned. But even if programs are successful in reducing these other obstacles the net effect of fertility would still be an order of magnitude smaller than the likely education effects that also address desired family size.

This is by no means to say that investments in female education should be played against investments in reproductive health services. In fact, there are good reasons to assume that both are strongly synergistic and strong female education programs combined with high quality reproductive health programs are the best way to go. But the analysis described here does imply that the often exclusive focus on reproductive health without even mentioning of female education – as one tends to find it in the discussion of unmet need in the advocacy literature – is misleading and should not be part of a reasonable science based 21st population policy paradigm.

3 Reasons for Including Education in 21st Century Population Policies

The ultimate goal of any population policy in both high and low fertility settings must be the enhancement of long term human wellbeing, including health, wealth and resiliency to unavoidable environmental change. Hence, the question of how certain changes in population size and structure impact on human wellbeing must lie at the heart of any such policy. This is primarily a scientific question. Only once research has assessed with reasonable confidence the likely consequences of specific kinds of population changes on selected outcome variables that can be taken as indicators or determinants of human wellbeing, the question about the desirability of certain policy interventions can be posed.

In this second part of the paper I will focus on summarizing new scientific evidence that suggests that indeed education deserves to be given central attention in any 21st century population policy paradigm. This review of recent analysis on the returns to investments in education based on an integration of population and education will provide little new empirical analysis but rather bring together the essential findings and policy implications for seven selected areas in which explicit attention to education can have significant consequences for future human wellbeing. I will highlight studies on the effect of female education on the future trajectory of world population growth, on the number of avoidable child deaths as well as on the reduction of adult mortality and disability. I will also demonstrate how education can help to reduce unemployment, enhance democracy and stimulate productivity and economic growth. Finally, I will summarize a recent body of research that shows how education can help to reduce disaster vulnerability and hence should be seen as a prime candidate for enhancing the adaptive capacity to already unavoidable climate change.

Before illustrating how the future looks different when education is explicitly factored into population dynamics and summarizing the scientific evidence on the various specific beneficial effects of education, I will directly address the frequently raised skepticism about the causal nature of these effects. While there is massive empirical evidence from all parts of the world and different points in time on strong associations between more and better education on the one hand and lower mortality, better health, lower fertility, lower unemployment, higher productivity and lower vulnerability on the other hand it could of course be the case that some of these associations are due to selectivity or reverse causality. If there were indeed good reasons to assume that the observed associations are spurious then the case for population policies focusing on education would clearly be weaker. This is why the causality issue needs to be addressed head-on.

3.1 On the Causality of Education Effects

In a "Demographic Debate" contribution entitled "Education will be at the heart of 21st century demography", Lutz (2010) expands on the arguments of an earlier *Population and Development Review* paper on "Adding education to age and sex" (Lutz et al. 1998) stating that educational attainment should be explicitly and routinely included in demographic analysis in addition to age and sex if three criteria were met: (1) "To the users the dimension is interesting in its own right and therefore desirable as an explicit output parameter"; (2) "The dimension is a relevant source of demographic heterogeneity with an impact on the dynamics of the whole system and therefore on the resulting population size"; and (3) "It is feasible (in terms of data and methodology) to consider the dimensions explicitly" (Lutz et al. 1998, p.42). In their analysis the authors discuss each of the criteria in-depth and come to the conclusion that they are indeed met. Lutz (2010) updates the argument in light of more recent discussions about elements of social construction with respect to the presumably "biological " demographic dimensions age and sex. Under the heading "Age is not what it used to be, nor is sex" he discusses recent work on redefining age and aging through indicators other than chronological age which consider increasing life expectancy and better health status at a given age (see Lutz, Sanderson, et al. 2008; Sanderson & Scherbov 2010) as well as recent changes in legislation in some countries that allow people to state their sex as "indeterminate" in departing from the strict male/female dichotomy. He also points at the physiological nature of the new synapses that are built in our brains as a consequence of every repeated learning experience and in particular through acquiring literacy and other skills through formal education. He concludes that "…we no longer face a situation in which there are presumably natural factors (age and sex) on an ontologically different level from other factors that are assumed to be merely social construction (such as educational attainment). We now understand that all three factors have elements of social construction as well as elements of underlying determinism." (Lutz 2010, p.12).

Social scientists typically express less doubts about the causal nature of age and sex effects in their models because they presumably take them for granted. But they repeatedly express doubts about assumed education effects, presumably because education is mostly viewed as just a specific aspect of Socio-economic Status (SES) or some elusive social construction. For this reason Lutz and Skirbekk (2014) dedicated a full chapter at the beginning of a major new volume on "World Population and Human

Capital in the 21st Century" (Lutz et al. 2014) to a broad based review of the scientific evidence with respect to the causal nature of the effects of education on better health and survival and other demographic outcomes. They summarize a lot of existing evidence from so-called natural experiments mostly due to education reforms that exposed different parts of the population to different lengths of education without self-selection. While many such pieces of evidence exist and they clearly strengthen the case for assuming a causal relationship, the authors also stress that any such evidence must fall short of establishing a strong causal relationship for all societies at all points in time. When such experiments demonstrate causality for one specific population group in one country at one point in time, it is far from clear that this proven relationship also holds in very different cultures at different stages of social and economic development. Such strong causality may never be proven in the social sciences.

Instead Lutz and Skirbekk (2014) introduce the concept of functional causality. It starts from the premise that in order to use such relationships in a policy context and as a basis for projections of the future effects of education in all countries in the world, we should focus on establishing functional causality through assessing the following three criteria:

> There must be **strong empirically observed associations** between the two factors studied and these associations should hold across different societies and for different sub-groups of the population as well as for different points in time (considering the appropriate lag structures). The case for the assumption of a causal relationship is significantly strengthened if this association is observed both at the individual level (across people and households) and the aggregate level (across societies).
>
> There must be a **plausible narrative about the mechanisms,** by which one force influences the other. This explanation must also give specific attention to the sequence and timing of events according to the general principle that the cause must always transpire before the consequence. In the social sciences it is important to consider that the expectation of a coming event also qualifies as a cause of behavior and not only the event itself.
>
> **Other obvious competing explanations** for the observed associations should be explicitly and systematically studied and ruled out as explaining the overall pattern of the observed associations. This does not rule out that such other forces play a minor and non-dominant role. The two main alternative explanations of observed associations are self-selection and reverse causality.

Lutz and Skirbekk demonstrate that these three criteria are being met in the case of education effects on health, mortality, and fertility. The foundations of the effects of education on human behavior refer to modern brain research, which leaves no doubt that every learning experience and in particular repeated experiences physiologically changes our brains by building new synapses that not only store the information content of our experiences but also become an integral part of what forms our sense of personality (Kandel 2007). While neuroscience still seems to be far away from a full understanding of the process of learning, neurological studies have confirmed beyond doubt that brain volumes, cortical thickness and neurological structures can be affected by more education. Hence, it seems reasonable to assume that cognitive functions that relate to our perception of the environment around us, our view of the future, and our

degree of rationality are related to our previous education experiences. In particular, empirical studies show that better educated individuals tend to have a longer investment horizon and are more risk adverse (van der Pol 2011).

It seems plausible to extend the reasoning of education as a generally empowering factor to the association with other outcome variables studied in this paper, namely contraception and fertility, economic productivity, the probability of finding a job, and general resilience to natural disasters. In addition to the many useful and empowering skills that undoubtedly come with education at a deeper level, education is also associated with a higher degree of abstraction and counterfactual thinking that is necessary to prepare for risks that the person has not yet experienced but that can be reasonably assumed to pose a potential danger. (LeVine et al. 2012)

Several other recent reviews (Baker et al. 2011; LeVine et al. 2012) of the global level evidence have come to similar conclusions. While in a few specific cases there may be reason to assume reverse causality such as a teenage pregnancy forcing a girl out of school, there are often ways to address such issues e.g. through limiting the sample to girls before menarche. Possible selectivity with respect to education and health is not likely to play a major role when it comes to the aggregate patterns. Otherwise countries that experienced massive education expansions – from a privileged elite to the general population being educated – should see diminishing positive health effects. But no such evidence could be found. Hence, given the current state of global level evidence it seems safe to assume that the strong positive effects of education that will be summarized in this section are indeed functionally causal, i.e. they can be assumed to hold in the foreseeable future.

3.2 Female Education is Key to Future Global Population Stabilization

The observed educational differentials are particularly pronounced in countries that have just entered the fertility transition. In Ethiopia the 2005 DHS for instance finds that the TFR of women without any formal education is 6.1 whereas it is 2.0 for women with secondary and higher education. (DHS Ethiopia 2006) While in low fertility countries the absolute differences between education levels are clearly smaller the relative differences show some regional variations with the lowest in Northern Europe and the highest in Latin America and Asia. A comprehensive global analysis of fertility trends by level of education in 195 countries is provided by KC et al. (2014) which also specifies assumptions for future trends in educational fertility differentials to be used in education specific population projections (Lutz et al. 2014).

Child mortality also systematically varies by level of mothers' education as will be discussed in the following section. The same is true for adult mortality by the person's own level of education. This implies that under a scenario of improving female education there will be viewer children born but more of them will survive to higher age. Combining these two effects under a high education scenario the lower fertility by far outweighs the lower mortality in terms of total population growth. A review article in *Science* under the title "Global Human Capital: Integrating Education and Population" (Lutz & KC 2011) illustrates the global level implications of four different education scenarios by applying identical sets of education-specific fertility trajectories. These calculations isolate the "pure" effect of education from other reasons of possibly higher or lower future fertility. The authors define four different education scenarios for

the coming decades and present results to 2050 based on a starting year 2000. Already by the middle of the century the difference between total world population size resulting from the most optimistic Fast Track scenario (FT: 8.9 billion) and the most pessimistic Constant Enrolment Numbers scenario (CEN: 10.0 billion) was more than one billion people only due to differences in education policies.

More recently, new calculations were conducted based on 2010 data as the starting date, a larger number of countries (195) and seven instead of four education categories (Lutz et al. 2014). The data and figures presented here are derived from this new assessment. The different education scenarios were again combined with identical sets of education-specific fertility trajectories: Under the most optimistic Fast Track (FT) education scenario, all countries in the world are assumed to start following the pattern of education expansion of the best performer which was South Korea. Although for any given country, for example in Africa, it may be unlikely that over the coming five years the school enrollment rates will expand at a rate similar to the unprecedented expansion in South Korea in the 1960s, it is at least theoretically possible because it has actually occurred in the historical experience of at least one country. Under this scenario the world's population will not only be much better educated than in the medium scenario but also significantly smaller (8.85 billion in 2060) due to the fact that more educated women in developing countries want and have fewer children.

The GET (Global Education Trend) scenario is a middle-of-the-road scenario which is considered to be the most likely one. Its rate of education expansion is derived from a Bayesian model that takes the experience of more advanced countries as well as country-specific properties into account (Barakat & Durham 2013). According to the GET scenario the world population in 2060 will be quite a bit better educated than today and increase to 9.36 billion. The global age structure will be close to rectangular up to age 50 although the younger cohorts already start to become somewhat less numerous (see Figure 4).

As to the low education scenarios, Figure 4 presents the Constant Enrolment Rates (CER) scenario. The CER is a useful benchmark scenario which allows us to understand how much of the expected future increase in human capital is a consequence of the momentum already embedded in today's cross-cohort improvements in education. When assuming constant future enrollment rates we essentially freeze the transitions from lower to higher levels of education at their current levels, which results in a constant distribution of the members of younger cohorts over the educational attainment categories. But since older cohorts still have different (and typically lower) levels of education, the process of demographic metabolism (see Lutz 2013) – in which the less educated older cohorts are successively replaced by the better educated younger ones – means that even under this CER scenario, the average educational attainment of the entire adult population will continue to improve for decades. This is the momentum of educational improvement that can be quantified with reference to this CER scenario. By 2060 the CER scenario results in a world population of 9.8 billion which is almost one billion higher than that resulting from the optimistic FT scenario. The most pessimistic CEN (constant absolute enrollment numbers) scenario, which assumes that school expansion cannot even keep pace with population growth and hence results in lower enrolment rates, was only calculated for selected developing countries and leads to yet higher population growth (see Table 2).

The comparison between the results of the FT and CER scenarios by 2060 (see Figure 4) shows two very different worlds. The only thing these two pictures have in common is that in both cases the world population will be bigger and older than it is today. Otherwise, at the global level, the assumption of constant school enrollment rates in each country leads to an actual increase in the number of people with no education, particularly among the younger cohorts (compare to pyramid for 2010 in Figure 4). This is because in the least educated countries fertility rates remain much higher than in the better educated countries, and therefore these less educated segments of the world population are increasing more rapidly. This increase causes a higher proportion of younger persons in the world to remain without any education. Under the FT scenario the above described educational momentum – due to demographic metabolism – is significantly augmented by much better education of the younger cohorts. As a result, the global proportion of women without any education would decline from 22 percent to only two percent by 2060. Correspondingly, among adult women in the world the mean years of schooling would increase from 7.4 years to 13.3 years between 2010 and 2060. As Figure 4 illustrates large majorities of both young men and women at the global level would have post-secondary education by 2060 under the FT scenario.

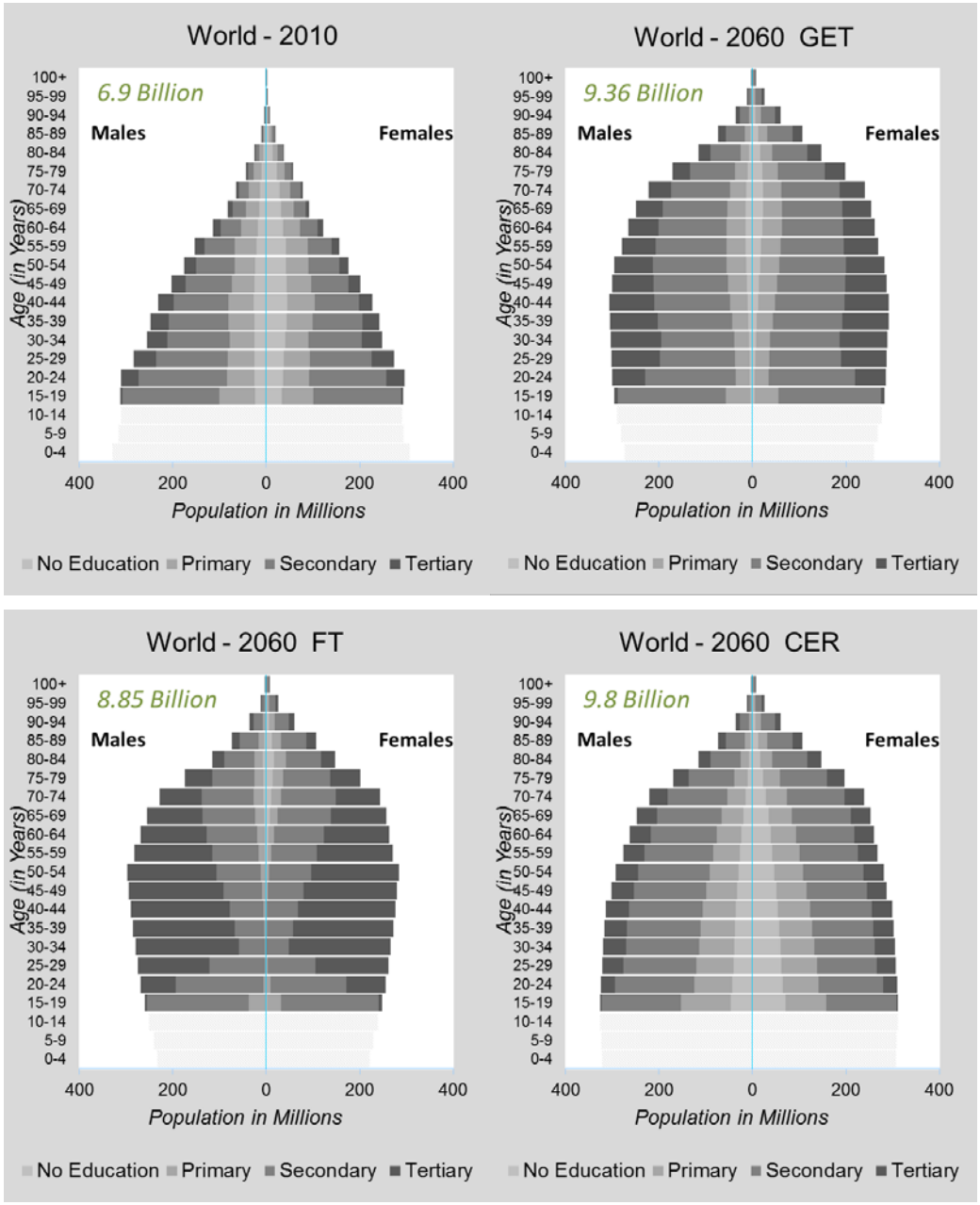

Figure 4. Age and Education Pyramids for the World in 2010 and as Projected to 2060 under Three Different Education Scenarios while Assuming Identical Sets of Education-Specific Fertility, Mortality and Migration Rates (Source: Lutz et al. 2014)

In conclusion, the above presented findings clearly illustrate that female education is a key driver for helping to moderate rapid population growth in today's high fertility countries. This is due to the fact that in virtually all countries of the world more educated women have fewer children. As discussed in the previous section on "unmet need", this in turn is due to the fact that better educated women want significantly fewer children, are better able to defend their own family size ideals against frequent opposition from husbands and grandparents, and are better empowered to actually get access to contraception. Of course, good availability of modern contraception makes this easier. This is why female education should not be seen as an

alternative to providing reproductive health services; rather both approaches should be viewed as synergistically reinforcing each other.

3.3 Female Education Helps to Avoid Millions of Child Deaths

When new citizens of the world are born, the first months of their life are also the most dangerous months of their entire life. A strong negative association between the level of mothers' education and child mortality is well established in the literature. A recent systematic review of the empirical evidence from DHS countries using multi-level models (Pamuk et al. 2011) shows that mothers' education is the most important determinant of child mortality and in particular is more important than household income and wealth. The above described causal mechanisms from empowerment through education to better health and longevity apply particularly well to the determinants of child mortality. In addition Levine et al. (2012) point at the importance of literacy for being able to more rationally address the child's health status and in particular to communicate the child condition to relevant health personnel.

Given this clear relationship between female education and child mortality, we should expect that alternative scenarios about future education trends of women will result not only in different levels of fertility – as discussed in the previous section – but also of child mortality. In a recent study KC et al. (2014) have numerically calculated these effects of alternative education scenarios on the future numbers of child deaths. This relationship is shown in Table 2 for a number of least-developed countries by comparing different demographic outcomes across the different education scenarios which were defined in the previous section. Under the most likely GET scenario, for Ethiopia the table shows that population will increase from 83 million in 2010 to 172 million by 2060, which is more than a doubling of the population due the current high fertility rates and a very young age structure. Under the FT scenario, the population in 2060 would only be 151 million, i.e. more than 20 million less, even when assuming identical education-specific fertility rates. Under the most pessimistic CEN scenario, however, the population would increase to 194 million. This implies that by 2060 the difference between the highest and the lowest education scenarios would be 43 million people, which is more than half of the current population of Ethiopia.

Table 2 also lists the absolute numbers of births and child deaths under the different education scenarios for the 5-year intervals starting in the indicated year. In Ethiopia in 2060-65, the number of births would be more than twice as high under the CEN scenario (17.7 million) than under the FT scenario (8.8 million). As discussed above, the effect of different numbers of births on total population growth is moderated by the differences in mortality that result from different levels of education. The last columns of the table show that the number of child deaths under the age of five would be 120,000 under the FT scenario as compared to 363,000 under CER, and 403,000 under CEN. Hence, the difference due to education is by a factor of three. In other words in this 5-year period alone in Ethiopia around a quarter million premature child deaths could be avoided if a rapid education expansion policy roughly resembling the FT scenarios would be pursued.

Table 2. Different Demographic Outcomes as a Consequence of Different Education Scenarios for a Number of Least-Developed Countries (Medium Fertility Assumptions). Absolute numbers of birth and child deaths are given for the 5-year intervals starting in the indicated year.

		Population (in million)				Births (in'00,000)				Child Deaths under 5 (in '000)			
	Year	GET	CER	FT	CEN	GET	CER	FT	CEN	GET	CER	FT	CEN
Burkina Faso	2010	16	16	16	16	36	37	35	36	270	275	262	272
Burkina Faso	2030	27	28	26	28	43	48	35	48	220	252	160	251
Burkina Faso	2060	43	47	37	47	40	49	28	49	98	142	54	143
DR Congo	2010	66	66	66	66	151	154	148	154	1444	1473	1396	1469
DR Congo	2030	107	109	104	109	170	186	151	191	1301	1561	1007	1642
DR Congo	2060	160	169	149	171	145	174	118	181	671	1000	444	1113
Ethiopia	2010	83	83	83	83	140	142	139	143	722	727	710	731
Ethiopia	2030	124	127	120	128	149	166	121	172	526	608	391	633
Ethiopia	2060	172	188	151	194	129	166	88	177	234	363	120	403

Even under the CER scenario that assumes that school expansion can just keep pace with population growth, the absolute number of child deaths is estimated to be three times higher as compared to the fastest education expansion scenario. This shows that the expansion of female education does not only have significant consequences on population growth and development in general, it also has massive direct effects on child mortality.

These results dramatically illustrate how important progress in female education is for reducing the future number of child deaths. It can even be argued that these given numbers are likely to underestimate the effect of education on child mortality because they only consider the individual level effects and not the community-level impacts of education. The literature has shown (Fuchs et al. 2010; Pamuk et al. 2011) that there are typically spillover effects – normative changes and improvement in health infrastructure that result from an increasing proportion of educated women and benefit all women and their children.

In conclusion, the analysis presented and discussed in this section has clearly demonstrated that improving maternal education can be is a key strategy in reducing future child vulnerability to (by definition) premature death. With reduction in child mortality being one of the major international development goals, a population policy paradigm that explicitly includes this education effect on child mortality has a much more convincing rationale than conventional aggregate level population policies that only address population size and age structure or have a limited individual level focus on mothers' reproductive health.

3.4 Education Reduces Mortality and Disability in Later Life

There are many factors influencing the health/disability status of an adult person. They range from genetic factors to factors associated with individual life style to quality of preventive health care and the curative health care systems of a country. But when it comes to observable differentials in terms of individual characteristics of people there is overwhelming empirical evidence from virtually all countries for which data exist that

the risk of mortality and disability varies greatly by level of education for both men and women (KC & Lentzner 2010). This difference is best documented for the case of mortality where in terms of male life expectancies, the differences between the highest and lowest educational groups in various countries range from as high as 12 years (in Eastern Europe) to 3-4 years (in Mediterranean countries) (Caselli et al. 2013). What is less well known and documented is that the prevalence of disabilities also tends to vary greatly with the level of education. In this section I will try to summarize the evidence with respect to disability rates of adults in the age span 30-74, for which fairly good data has become available as presented in a recent study by KC et al (2014).

Data for this analysis comes from the World Health Survey (WHO 2013), a collection of sample surveys of the adult population of 18 years of age and older in 70 countries across the globe with data collected in 2002/2003 by personal interviews in the local language using standardized survey instruments. 14 percent of the sample population in Eastern Europe turned out to be ADL (activities of daily life) disabled. In the other four classified regions the proportion of disabled ranged from 9 percent in Africa to 5 percent in Latin America. These differences are greatly influenced by the fact that the population in Europe is on average much older than that of Africa. But in addition to age there are also important differentials with respect to level of education. Table 3 shows the percentage of ADL disability in each education group and region for the sample before standardizing by age. As for regional differences, Eastern Europe appears to have the highest level of disability followed by Africa and Asia, with Latin America and Western Europe showing the lowest levels. Eastern Europe also has the highest levels of disability across all levels of education.

Table 3. Proportion of Disabled in Population by Education Level for World Regions, Men and Women Aged 30-74 (Source: KC, Lutz, et al. 2014)

Education	Africa	Asia	Western Europe	Latin America	Eastern Europe
None	0.12	0.16	0.20	0.13	0.37
Primary	0.07	0.08	0.10	0.07	0.29
Secondary	0.04	0.04	0.05	0.04	0.12
Tertiary	0.04	0.03	0.03	0.02	0.09
Total	0.09	0.08	0.06	0.05	0.14

These significant differentials by level of education also have important implications for our expectations of future increases in overall disability rates in the context of population aging. In particular, when these differentials are combined with the fact that we know for sure that in all countries where today the young are better educated than the older adults, the elderly of the future will be better educated than the elderly of today, our projections of future disability rates will be much lower. Under the title “With education the future looks different” Lutz (2014a) presents calculations that combine the above described educational attainment scenarios with the age- and sex-specific disability rates currently observed in different world regions. In doing so first a constant age/sex profile of ADL disability without considering our observed educational differentials was applied to the projection of the future age and sex structure of the

population. This is the conventional way of projecting disability which dominates the current discussion of the health consequences of population ageing.

In a second set of calculation the education/disability relationships obtained from the WHS analysis were factored in KC et al (2014).This was done for three different education scenarios and for more than 100 countries. The results of these alternative projections of disability are shown in Figure 5 for women aged 30-74 for Asia and Western Europe. Without factoring in education and only considering the age pattern of disability (labeled as NES – No Education Scenario) the forecast appears that show significant increases in future disability rates simply as a function of significant population ageing combined with the fact that older ages have a higher prevalence of ADL. This projected increase is particularly strong in Asia where due to the rapid speed of fertility decline population ageing over the coming decades will be even faster than in most other continents but it is also very pronounced in the figure for Western Europe.

Once education is explicitly factored into the model the picture looks completely different. With education taken into account, under all three scenarios there will actually be reductions in disability by 2050 for adult women aged 30-74. Again, the gap between the two kinds of projections is most pronounced for Asia. The reason for this lies in the fact that in Asia in parallel to rapid population ageing the elderly population will also be much better educated than today's elderly. This in turn is a result of the very rapid expansion of schooling among young Asians over the past decades. In some countries (including e.g. South Korea and China) in the 1960s a majority of the adult population still had no formal schooling at all. Today the young cohorts are very well educated and even among the best educated in the world. As a consequence today's elderly still have a very low level of education and we know for sure that the future elderly will be much better educated. This finding holds for all three future education scenarios. As shown by the CEN scenario even no further improvements in schooling result in a much lower level of overall disability than when education is simply not factored into the model, i.e. when the apparent heterogeneity by level of education is disregarded. The most rapid improvement in disability is clearly shown under the very optimistic FT scenario.

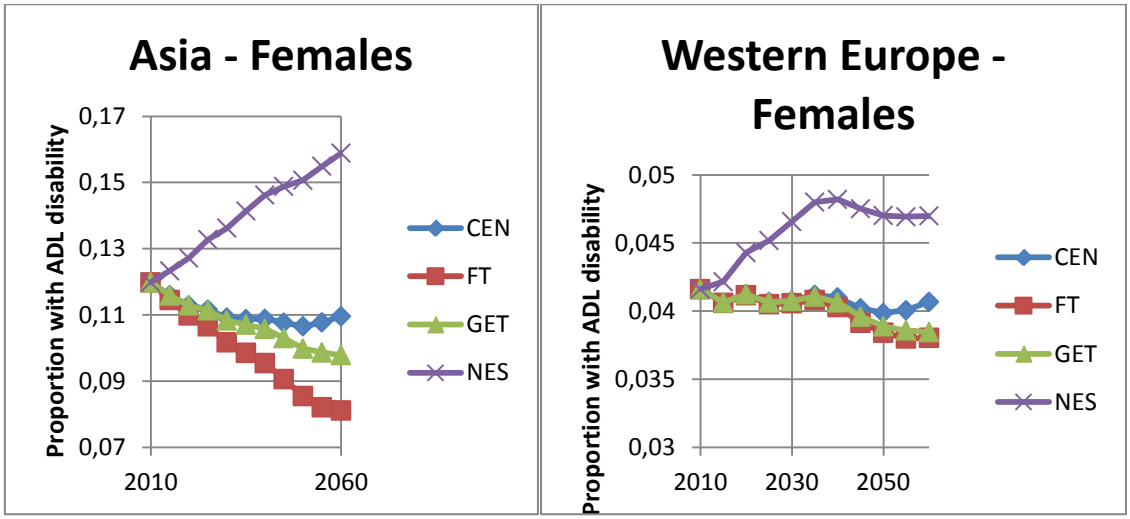

Figure 5. Projected Prevalence of ADL Disability for Women Aged 30-74 in Asia and Western Europe

In conclusion, this section on adult mortality and disability has demonstrated that the prevalence of disability not only varies greatly among countries and across age groups but there are also significant and consistent differences with respect to the level of education. The scenarios presented above also show that once education is explicitly factored in the future looks very different. Instead of the ubiquitous projections that show massive increases of future disability rates as a consequence of population ageing, this analysis shows that we can actually expect declining adult disability for women aged 30-74 even in the rapidly ageing populations of Asia and Western Europe. This also has important consequences beyond individual health and well-being in so far as it may allow people to stay longer in the labor force and increase the productive potential of ageing societies.

3.5 Education Reduces Unemployment

An OECD report entitled "Education at a glance" (OECD 2013) makes the strong point that education is important, since it makes (young) people less vulnerable to the risk of unemployment:

> "The distribution of unemployment within the younger generation sheds light on some of the factors that may increase the risk of joblessness, which, in turn, offers insights for policy responses. Most notably, educational attainment has a huge impact on employability, and the crisis has strengthened this impact even further. On average across OECD countries, 4.8% of individuals with a tertiary degree were unemployed in 2011, while 12.6% of those lacking a secondary education were. Between 2008 and 2011 the unemployment gap between those with low levels of education and those with high levels of education widened: across all age groups, the unemployment rate for low-educated individuals increased by almost 3.8 percentage points, while it increased by only 1.5 percentage points for highly educated individuals. Without the foundation skills provided by a minimum level of education, people find themselves particularly vulnerable in an insecure labor market." (p. 13)

There are several mechanism that result in this pattern of generally lower unemployment for more highly educated younger people (KC, Lutz, et al. 2014). First, structural change in the economies of many countries leads to new job creation in sectors such as Information and Communication Technology (ICT) that typically require higher skills. Secondly, when employers have a choice between a better and lower skilled person for any given job it is a rational decision to offer the job to the better skilled person in the expectation that he/she will be more productive for a given salary level. But on top of this effect of higher skills it has also been argued that there is a "signaling effect" which leads to the recruitment of people with better education on paper even when the actual skills have not been tested. This can also lead to a crowding out effect in which under conditions of a tight labor market more jobs are given to people with better education thus resulting in relatively higher unemployment for those with lower levels of formal education. All these factors are contributing to the described education differentials in unemployment.

But the pattern can also differ by the stage of economic development of a country. While there is ample evidence that higher education increases the chances of employment in advanced economies, for developing countries several studies suggest that "the nature of educational enrollment, attainment, and employment may be very different in rapidly changing societies, and these relationships are likely to change across historical time" (Yabiku & Schlabach 2009, p.537). In transitioning societies, meaning those that are moving out of being predominantly agrarian, education systems

often produce graduates faster than the economy can adjust, leading to a shortage of job opportunities in the formal sector for individuals with higher education. Two factors that contribute to this phenomenon in a number of developing countries are the high aspirations for finding a prestigious job, that often are associated with higher formal education, and that the chosen field of studies does not match the demand by the labor market. It is not unusual that graduates in one field have serious difficulties finding an appropriate job while in other fields there is a lack of qualified graduates.

Adult unemployment is significantly lower than youth unemployment in virtually all European countries for which the data is available. This clearly shows that the period of transition from education to entering the labor market is a particularly critical phase in the life cycle of all people. Typically the burden of finding a job is entirely on the young people themselves. At the same time older people in existing employment contracts are typically rather well protected by labor laws and hence the first reaction in times of economic difficulties for companies is to stop recruiting young people before considering sacking people that are already employed. In addition, in times of crises when it comes to terminating employment contracts, younger employees are often the ones that are more likely to lose their jobs, since they are often less protected by labor laws and cheaper to lay off than older workers.

Unfortunately, reliable statistics on unemployment by level of education are mostly limited to industrialized countries. Eurostat provides consistent annual time series for youth unemployment by level of education which is plotted in Figure 6 (using International Standard Classification of Education (ISCED) categories with 5 and 6 referring to post-secondary education). The education differentials in unemployment vary over time, but at any point between 2000 and 2012, higher levels of education are associated with lower levels of unemployment. The Figure also clearly shows the effect of the economic crisis after the boom years until 2008. While youth unemployment rates increased for all education groups from 2009 onwards the sharp differences by level of education remain unaffected by the crisis, in fact, the differentials still widened a bit as a consequence of the crisis. At the level of the EU-27 the unemployment rate of young men and women in 2012 was 30 percent for the lowest education groups, 20-23 percent for the intermediate education groups and only 18 percent for the highest education categories.

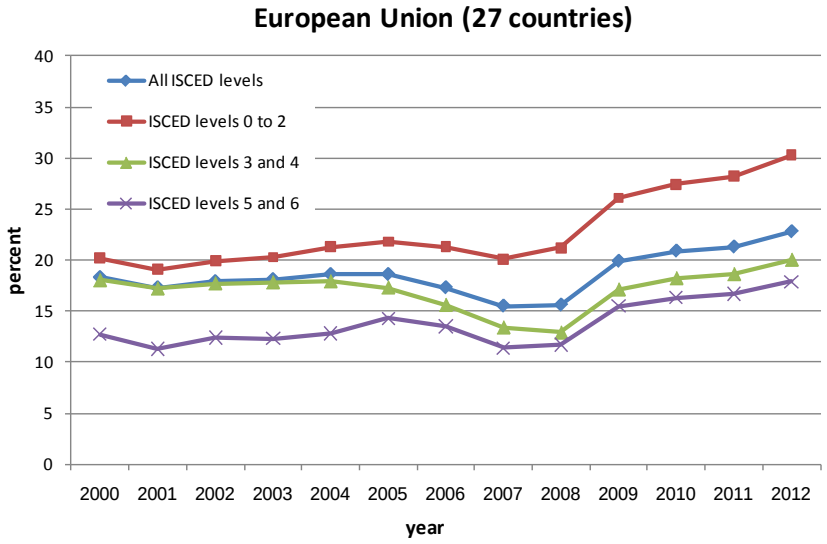

Figure 6. Youth Unemployment Rate (Ages 15 to 24) for All EU27 Countries Combined and Selected Individual Countries, by Highest Level of Educational Attainment, 2000 to 2012 (Source: EUROSTAT Database). ISCED levels 0 to 2 = pre-primary, primary and lower secondary education; ISCED levels 3 and 4 = upper secondary and post-secondary non-tertiary education; ISCED levels 5 and 6 = first and second stage of tertiary education.

In conclusion, this brief section has demonstrated that with respect to the risk of unemployment, young people aged 15-24 tend to be significantly more vulnerable than older ones. But this higher vulnerability does not apply equally to all younger people. For all countries for which reliable and comparable statistics could be found, by far the highest risk of unemployment exists for young men and women with low levels of education. The data also indicates that, almost universally, the risk of unemployment monotonically decreases with higher levels of education. Hence, particularly in the context of technological advance and further automation of production processes, high quality education is widely considered a policy priority for assuring future employment of individuals and economic competitiveness of populations. It should be considered an integral and important part of national human resource management policies.

3.6 Education is Key to Poverty Reduction

It is commonly assumed in economic theory that education has an important positive effect on economic growth, but until recently the statistical evidence for this assumption has been surprisingly weak. Evidence shows beyond any reasonable doubt that, at the individual level, more years of schooling generally lead to higher income. But at the macroeconomic level, empirical evidence relating changes in education measures to economic growth has until recently been ambiguous. Many authors suggest that this may be due to problems with the global empirical data on human capital (Barro & Lee 1996; Benhabib & Spiegel 1994; Cohen & Soto 2007; de la Fuente & Doménech 2006; Pritchett 2001).

The literature on the effects of education on economic growth has already been discussed in the previous section on the demographic dividend. Here I will only

highlight two other relevant dimensions of education – namely the age/cohort pattern of human capital and the distribution across attainment categories that matter for strategies of poverty reduction.

Based on time-series of age-specific educational attainment distributions a study published in *Science*, Lutz et al. (2008) provide for the first time the unambiguous statistical evidence (based on econometric models) that education is a consistently significant determinant of a country's aggregate level of economic growth. The key to these new results lies in the more detailed and more consistent nature of the new IIASA-VID dataset on educational attainment by age and sex for 120 countries back to 1970 (Lutz et al. 2007). In most previous studies (e.g., Barro & Lee 1996) the educational attainment of the entire population above the age of 25 was considered as the human capital variable which is relatively insensitive to rapid improvements in the education of the younger working-age population. The new data provide information by five-year age groups and the full attainment distribution which much better describes the inter-cohort improvements in education in countries that have seen rapid expansions of schooling. In addition to greater detail, the consideration of differential mortality by level of education and the strict consistency over time of the definition of educational categories evidently turned out to be decisive advantages of the new dataset over previous ones.

While the new study and the specific models estimated cannot be described in any detail here, I want to point out one important finding of great policy importance: For poor countries with low human capital, only the combination of universal primary education with broadly-based secondary education results in the kind of rapid economic growth that has the potential to push countries out of poverty. This additional investment in secondary education provides a huge boost to economic growth, much greater than universal primary education alone. In these simulations the effect of secondary education works primarily through the adoption of new technologies. From this we can conclude that the current Millennium Development Goals' 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 or even better, universal secondary education.

3.7 Education Enhances Democracy

Another study by Lutz et al. (2010) in the pages of *Population and Development Review* applies the IIASA-VID education reconstructions by age and sex for 120 countries to reassess the relationship between improving educational attainment of the population, education differentials between men and women, and indicators of civil liberties and the quality of democratic institutions. The results are highly statistically significant and reaffirm on a broader and more consistent basis the findings from earlier studies in the field.

The theoretical arguments relating education to democracy are manifold. At the individual level, education is a determinant of political participation. As the educational level increases, individuals tend to develop a stronger sense of civic duty and a greater interest in politics. However, to the extent that education causes economic growth, it is also an indirect determinant of democracy through the link between wealth at the macroeconomic level and democracy. Recent contributions to the theoretical literature

on the link between educational attainment and democracy emphasize the increase in the benefits of political participation caused by education as the catalytic link relating changes in educational measures to changes in democracy. Glaeser et al. (2007) present a theoretical model where the effect of education, on the (otherwise weak) incentives faced by individuals to support democratic regimes, leads to higher stability of democratic regimes in more educated societies. The empirical evidence on the effect of education on democracy lends support to a positive relationship between these two variables when differences across countries are exploited. Barro (1996) and Glaeser et al. (2007) find a positive effect of education on the level of democracy by exploiting differences across countries from panel data.

The positive relationship also appears when the focus is on variations within countries over time. While the previous empirical evidence on the effect of changes in education on democracy within countries is more mixed (Arellano & Bond 1991; Blundell & Bond 1998; Bobba & Coviello 2007), the richer information of the IIASA-VID dataset allows evaluation of the differential effect of educational attainment depending on its distribution across age groups and genders. The multivariate econometric studies by Lutz et al. (2010) are based on educational attainment for age groups of men and women in five-year steps for 120 countries in the period 1970-2000. These studies also control for GDP per capita, the investment rate, life expectancy, the urbanization rate, the share of agricultural output on total output, and the change in the young-age dependency ratio. Among the interesting findings: Societies with high proportions of young people tend to have a lower probability of achieving democratic regimes; increases in urbanization and investment tend to lead to political changes in the direction of democratization; and education turns out to be a significant and robust determinant of democracy. This was tested for mean years of schooling as well as the full educational attainment distribution. With respect to gender differentials the findings also show that an increase in female relative to male education is a robust predictor of changes towards more democratic rights. Lutz et al. (2010) also apply these global level findings to the specific case of Iran where the significant increases in female education and the most rapid decline in fertility over the past decades suggest a high probability for moving into the direction of more democracy over the coming years.

This study showed that increases in human capital and in particular the improvement of female education relative to male education turned out to be the most important systematic social change associated with the move towards more democracy and higher levels of civil rights and liberties. Since these dimensions together with the overall quality and efficiency of governance are often considered key elements of sustainable development this is yet another case where a broad understanding of population policies including education policies can make it much more relevant than the conventional more narrow focus of population policies.

3.8 Education Enhances the Adaptive Capacity to Already Unavoidable Climate Change

The Intergovernmental Panel on Climate Change has recently finished its Fifth Assessment Report (IPCC-AR5) which demonstrates with high certainty that global climate change is an ongoing reality. While there are some uncertainties remaining about what factors contribute to what degree to this ongoing change, almost nobody

denies any more that such change is actually ongoing. Hence, no matter how successful the world community will be in reducing future greenhouse gas emissions a certain degree of climate change is already unavoidable and we have to prepare to cope with it. As one of the IPCC-AR5 lead authors for the section on sustainable development I also got the strong sense that for this reason the attention is now not only focused on mitigating climate change but is also moving increasingly to aspects of adaptation and strengthening the future adaptive capacity to already unavoidable climate change. The international community has already pledged the significant sum of 100 Billion US Dollar per year to be spent on climate change adaptation in developing countries from 2020 onwards. But it seems to be still quite unclear what precisely should happen with this money. Recent work conducted at IIASA suggests that investments in universal primary and secondary education would be a good and efficient way to strengthen adaptive capacity through enhancing general resilience, particularly in a situation in which the precise consequences of climate change in specific areas are still quite uncertain.

But what is the empirical evidence base for claiming that education enhances adaptive capacity and reduces vulnerability to climate change? The problem is that climate change is just starting to show its first consequences so that it is hard to already find solid empirical evidence about what factors are best to reduce the vulnerabilities to this kind of change. One possible strategy is to study differential vulnerability to natural disaster such as flooding, droughts and storms that have occurred over long periods and for which abundant empirical data exist. In this sense, vulnerability to natural disasters is not only of significant interest in its own right as a source of premature death in developing countries but it can also be seen as isomorphic to the likely future risks associated with unavoidable climate change. In other words, if we have a better understanding of the risk factors associated with currently observed vulnerabilities to natural disasters, we can draw conclusions about the risk factors associated with future climate change, in particular with respect to the likely higher frequency and intensity of tropical storms, extreme flooding events and severe droughts.

An international scientific Panel on Population and the Environment recently produced a statement that was published in *Science* (Lutz et al. 2012). It summarizes: “The evidence is clear that demographic differences fundamentally affect people’s contributions to environmental burdens, their ability to participate in sustainable development, and their adaptability to a changing environment” (p. 918). But the empirical basis for assessing the role of educational differences has been very scant until recently, mostly because the hypothesis has not been on the table and therefore no data have been collected to test it. The theoretical argument is quite clear: Education is an important way through which individuals acquire knowledge, skills, and competencies that can directly or indirectly influence their adaptive capacity. Most directly, literacy and numerical skills obtained through formal education imply better access to relevant information, such as early warnings for tropical storms or seasonal prediction of drought (Patt et al. 2007; Moser & Ekstrom 2010). Second, there is evidence that education also enhances cognitive skills and the willingness to change risky behavior while at the same time extending the personal planning horizon (Behrman & Stacey 1997; Neisser et al. 1996; Nisbett 2009). Education also enhances the acquisition of knowledge, influencing values and priorities as well as the capacity to plan for the future and improve allocation of resources (Glewwe 1999; Thomas et al.

1991). Besides that, as described extensively in this volume, education leads to better health and physical wellbeing. Consequently, it is reasonable to assume that when facing natural hazards or climate risks, educated individuals are more empowered and hence more adaptive in their response to, preparation for, and recovery from disasters. At the aggregate level it can be argued that better educated societies have greater social, economic, and institutional capabilities necessary for successful adaptation to climatic change (KC & Lutz 2013).

Taking the above described approach of seeing disaster vulnerability as proxy for climate change vulnerability a recent series of studies has focused on identifying the relative role of education in reducing such vulnerabilities and hence provides the basis for recommending strategies for reducing vulnerability and enhancing the adaptive capacities of populations to unavoidable climate change. A special issue of the journal *Ecology and Society* (2014) is entirely dedicated to studying the empirical evidence on this issue with data from different parts of the world. We summarize several of the findings following Muttarak and Lutz (2014): Muttarak and Pothisiri (2013) present an individual-level study of disaster preparedness of 557 households located along the Andaman coast in Phang Nga province during the 2012 Indian Ocean earthquakes. They find that formal education – measured at the individual, household and community levels – increases the likelihood of preparedness actions being taken. Having been affected by the 2004 tsunami clearly increases emergency preparedness but for the group of persons without such disaster experience, education turned out to be a relevant factor in anticipating the risk and taking preparedness actions. Another tsunami-related study by Frankenberg et al (2013) uses individual level data from the Indonesian Household Panel to examine the extent to which education serves as a means of protection against natural disaster, using longitudinal survey data collected in two provinces on the island of Sumatra, before and after the 2004 Indian Ocean tsunami. They find that education clearly plays a role in coping with the disaster over the longer term, with the better educated being of better psycho-social health five years after the tsunami. They are less likely than others to live under precarious living conditions and appear to be better at compensating for loss of income following the tsunami.

Similar evidence on the association between education and vulnerability has been reported at the community level by KC (2013). Using comprehensive village-level data in Nepal (a microsample of the 2001 census covering 2.5 million individuals together with disaster data for 2000-2009) on damages due to floods and landslides in terms of human lives lost, animals lost and other damage to households, he finds strong effects of education. Comparing the effect of education with those of income and wealth, the author concludes that education has stronger and more consistent impacts in reducing damage due to floods and landslides in Nepal.

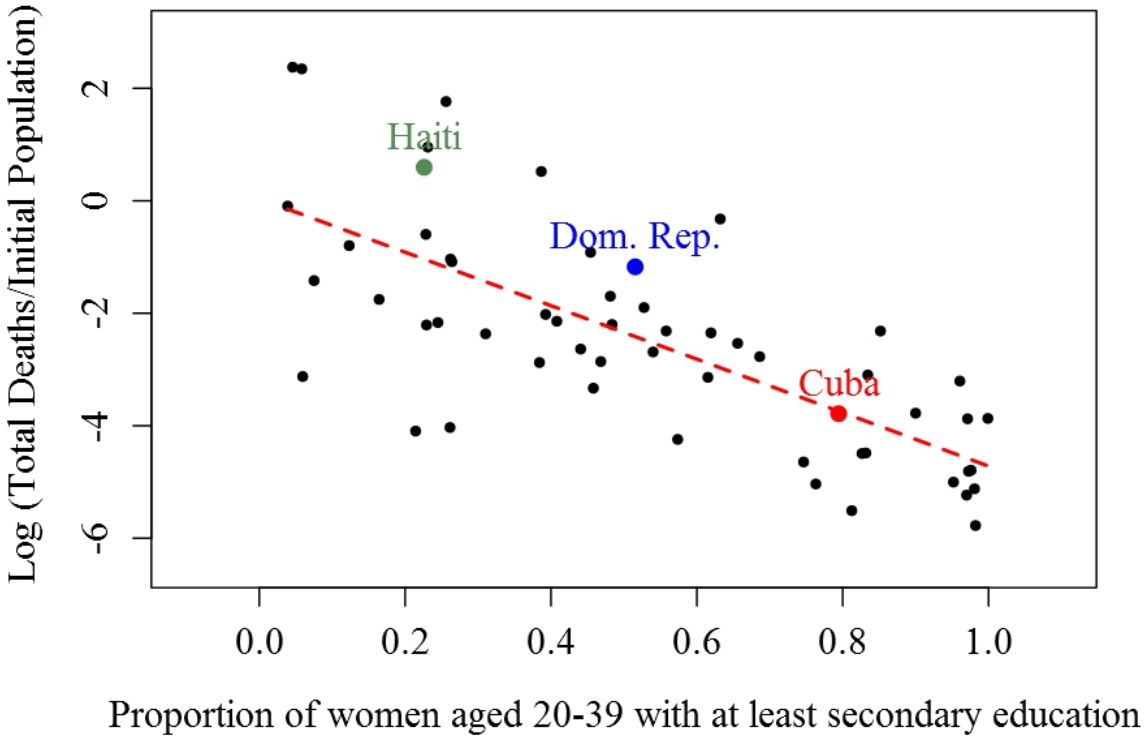

Figure 7. Global Level Association between Level of Education and Disaster Fatalities with Cuba, Dom Rep and Haiti Marked in the Pattern

In addition to further studies based on individual level data that essentially show the same picture, the special issue also includes some country comparisons. Pichler and Striessnig (2013) use data from qualitative interviews conducted in Cuba and the Dominican Republic to compare these two island states with regard to disaster vulnerability. Even though they usually experience the same hurricanes passing with similar strength over Cuba and Hispaniola, the outcomes vary greatly between the two countries. While effective disaster response is strongly embedded in the entire Cuban population, which is one of the most educated in the developing world, the interviews strongly confirm that lack of education and literacy in the Dominican Republic makes people more vulnerable and prevents them from even understanding warnings about upcoming danger (see Figure 7)

At a highly aggregate level Striessnig and Lutz (2013) use national-level time series of disaster fatalities around the world, regressing them against a number of socio-economic variables, including also the three components of the Human Development Index (HDI). Different models with alternative specifications all find significant effects of education – particularly female education – in reducing disaster fatalities, while there is no support for the widely assumed role of income per capita in reducing vulnerability. These findings suggest that education is the more relevant dimension of socio-economic development as compared to income when it comes to enhancing adaptive capacity to natural disasters and hence by implication to future unavoidable climate change. This

makes an emphasis on human resource development an important part of strengthening the adaptive capacity of societies and hence for sustainable development more broadly.

4 Outlook for the 21st Century: Human Resources at the Heart of Sustainable Development Scenarios

The human resources based population and development policy paradigm described in this paper has already been implemented and operationalized in the context of new global climate change scenarios which will likely inspire global change analysis for the coming decade and beyond. The Intergovernmental Panel on Climate Change (IPCC) has recently finalized its Fifth Assessment Report (AR5). In this context the global modeling community on Integrated Assessment (IA) and Vulnerability, Risk and Adaptation (VRA) has agreed to refer to a new common set of Shared Socioeconomic Pathways (SSPs) that describe alternative future worlds with respect to social and economic mitigation and adaptation challenges. Unlike the previous generation of SRES scenarios (Nakicenovic et al. 2000) that only considered total population size and total GDP as relevant socio-economic factors – and this essentially reduced population to a scaling factor for the denominator of different variables – this new set of scenarios provides a much richer socio-economic content including alternative population scenarios by age, sex, and six levels of educational attainment for all countries in the world. The main reason for moving to much more detailed characterizations of the socio-economic aspects of global change is that the SSPs are not any more designed primarily for the description of the factors contributing to CO2 emissions (the challenges for mitigation) but should equally well describe the capabilities of societies in terms of differential vulnerability and adaptive capacity to climate change. In this respect demographic dimensions such as age, sex, level of education and urbanization where considered key factors to be explicitly included in the scenarios.

This approach is also in line with the recommendations of an interdisciplinary global scientific panel which prepared a statement on "Demography's role in Sustainable Development" as input to the 2012 Rio+20 Conference on Sustainable Development. (Lutz et al. 2012) Among others this panel urges to "(i) Recognize that that the numbers, characteristics, and behaviors of people are at the heart of sustainable development challenges and their solutions. (ii) Identify subpopulations that contribute most to environmental degradation and those that are most vulnerable to its consequences" (p. 918). In this spirit the more differentiated demographic part of the SSPs much more comprehensively covers the "human core" of future global change than any previous set of global development scenarios (KC & Lutz 2014).

The SSPs were designed in a lengthy process involving most leading global change modeling teams in a process that was guided by the objective to comprehensively describe alternative possible future global trends with respect to socio-economic challenges associated with climate change mitigation and adaptation. In addition to population, education and urbanization the scenarios also covered several dimensions of the economy and in particular energy consumption and the carbon intensity of possible alternative future technologies. While the five scenarios shown in Figure 8 are only to be considered as stylized pathways that can have many more specific expressions emphasis was put on consistency of the different components of the pathways. The definition was guided by a set of five narratives that are listed here

whereby I primarily focus on the population and socio-economic dimensions and not on the energy and technology aspects of the SSPs:

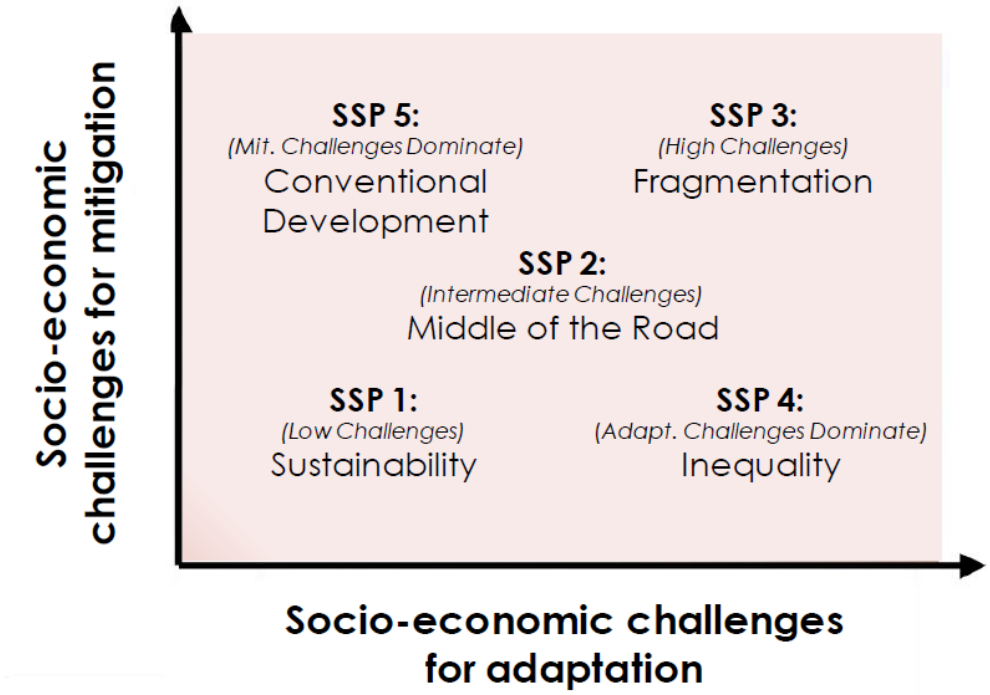

Figure 8. Location of Five SSPs in Space Spanned by Differing Degrees of Socio-Economic Challenges for Adaptation and Mitigation (Source: O'Neill et al. 2013)

SSP1 (Sustainability): This scenario assumes a future that is moving toward a more sustainable path, with educational and health investments accelerating the demographic transition, leading to a relatively low world population. There are major improvements in human capital and fertility in OECD countries is moderately high.

SSP2 (Continuation): This is the middle-of-the-road scenario in which trends typical of recent decades continue, with some progress toward achieving development goals, reductions in resource and energy intensity, and slowly decreasing fossil fuel dependency. In demographic terms it is identical to the medium scenario in the new global human capital projections produced by the Wittgenstein Centre for Demography and Global Human Capital (Lutz et al. 2014).

SSP3 (Fragmentation): The scenario portrays a world separated into regions characterized by extreme poverty, pockets of moderate wealth, and many countries struggling to maintain living standards for rapidly growing populations. In demographic terms this is a low education and stalled demographic transition scenario for the countries that still have high fertility.

SSP4 (Inequality): This is a world of high inequalities both among and within countries. There is increasing stratification between a well-educated, internationally connected society and a poorly educated society that works in labor-intensive industries. Demographic assumptions reflect the divisions and inequalities.

SSP5 (Conventional Development): In this world conventional development oriented toward economic growth is viewed as the solution to social and economic problems.

Rapid development leads to energy systems dominated by fossil fuels, resulting in high greenhouse gas emissions. Demographic assumptions are rather similar to SSP1.

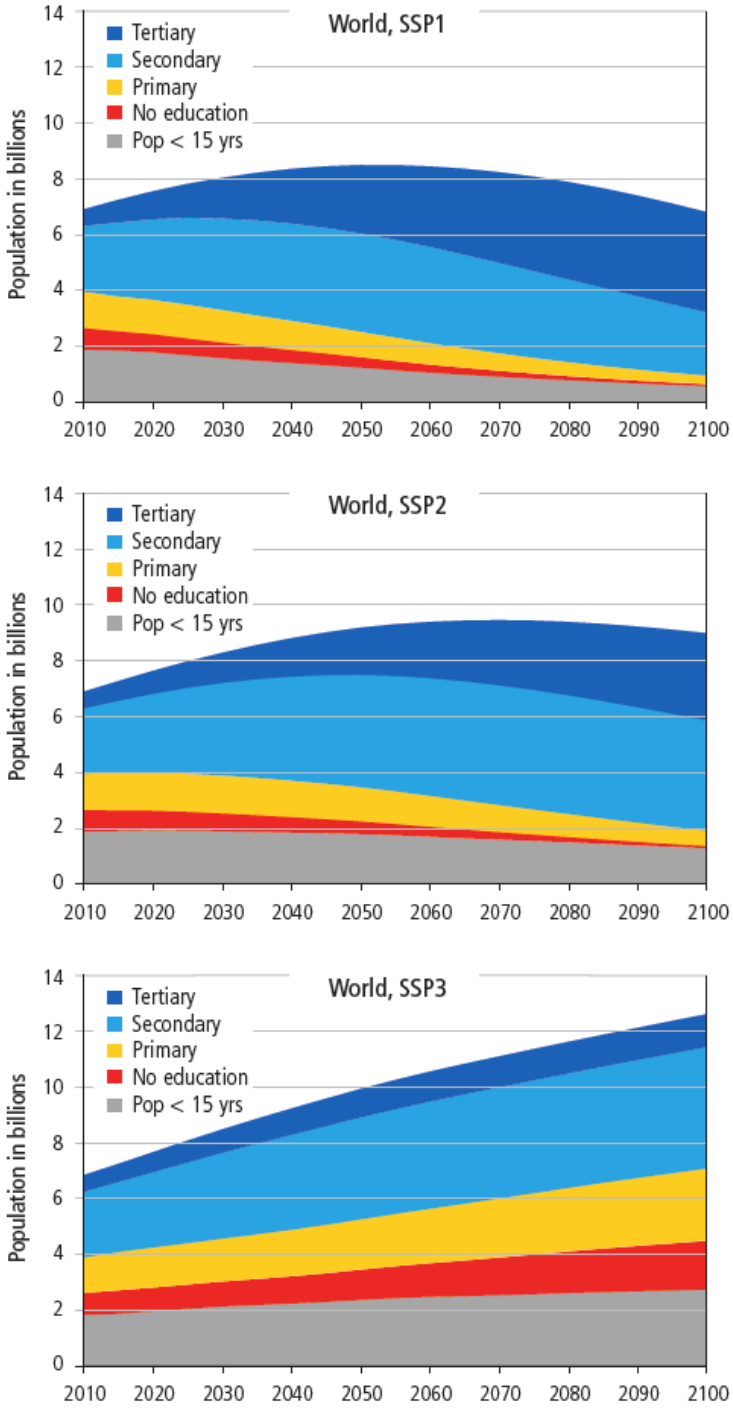

Figure 9. World Population Trends by Level of Education According to the SSP1-3 Scenarios as Discussed above

Figure 9 above depicts the global level results for the main scenarios SSP1-SSP3 in terms of total population size and the level of education of the adult population (collapsed into four education categories). The “sustainability” scenario SSP1 that is associated with rapid social development and green economic growth will result in a

significant increase of the more educated population with world population size peaking by mid-century and reaching about the same level as today by 2100. In sharp contrast the "fragmentation" scenario SSP3 will see continued rapid population growth reaching 10 billion by mid-century and more than 12 billion by 2100. This will be associated with stagnation of the education expansion in the least developed countries and in consequence even some increase of the uneducated and low-educated population segments. These populations will not be able to realize the many benefits of education described in Part 2 of this paper.

In the context of the population policy paradigm discussed in this paper the "sustainability" scenario SSP1 clearly is the most desirable in many respects. More education and better health together with all the other social and economic benefits of education and the resiliency to unavoidable environmental change in the context of a world population that will peak around mid-century and then enters a moderated decline is likely to be associated with the enhancement of long term human well-being that has been identified as the ultimate goal of 21st century population and development policies.

5 Conclusions

In this paper I first brought together new scientific evidence that puts into question some of the dominant assumptions of population policy priorities of the 20th century. It is worth reiterating here that I use the term "population" in its genuine meaning referring to an aggregate of human beings. And I certainly do not want to play down the very important focus on individual human rights that had developed around IPCD which I consider as being primarily a human rights issue rather than a population issue. I then presented a brief summary of new scientific studies on the multiple beneficial effects of education that provide the substantive basis for the new 21st century population policy paradigm proposed. This scientific evidence from diverse geographic regions and methodological approaches points toward the acquired capabilities of human beings—human capital or human resources—as the key to sustainable development in both rich and poor countries. This suggests that **strengthening the human resource base of societies** should be the priority focus of this new paradigm.

At this point in the conclusions of a paper that repeatedly stressed the "new" aspects, it is also worth noting that this focus on human capital is certainly not entirely new in the history of demographic thinking. There is no space here for a review of writings on this topic and I only want to cite as an example a rather unexpected testimony. In 1958 Alfred Sauvy wrote in the context of the miracle of Germany's economic rise after total destruction in 1945 and the fact that it had to absorb five million refugees: "Why this success, contrary to the forecasts of all doctrines…? Because these men without capital came with their knowledge, their qualifications. They worked and they recreated the capital that was lacking, because they included a sufficient number of engineers, mechanics, chemists, doctors, sociologists, etc. If five million manual workers had entered Western Germany instead there would be five million unemployed today" (Sauvy 1958, p.169). But despite the demographic prominence of Sauvy, mainstream demography has not really incorporated this important line of thinking. Instead such "quality dimensions" were considered too difficult to measure and largely left to economists. Only the more advanced demographic tools of multi-state population dynamics, pioneered at and around IIASA

in the 1970s, now allow us to fully and quantitatively integrate the educational attainment dimension into formal demography.

This focus on human resources as an integral part of population policies is slowly gaining momentum in the international discussions. Independently from the above described SSP approach in the climate change community, the UNDP 2013 Human Development Report makes extensive reference to the need for integrated approaches incorporating education, health and population trends in international development strategies (UNDP 2013). And the already mentioned global interdisciplinary scientific panel on "Population and Sustainable Development" concluded the publication of its statement in *Science* with the sentence: "Invest in human capital – people's education and health, including reproductive health – to slow population growth, accelerate the transition to green technologies, and improve people's adaptive capacity to environmental change" (Lutz et al. 2012). While the focus of this panel was mostly on developing countries its recommendations were designed to be of relevance for all countries of the world.

What does this new population policy paradigm then have to offer to the governments in countries in Eastern Europe which are not only rapidly aging but also shrinking? In the introduction to this paper Bulgaria was singled out as a country that has officially declared its demographic trends a national security crisis of the first order because its population had declined from around 9 million in 1990 to about 7.2 million today and is expected to fall to around 6 million in 2030. In this context the following statement suggesting a different perspective was made to the prime minister of Bulgaria by an international visiting expert:

> "'People are the wealth of nations. But it is not only the number of people that counts; it is also the skills, abilities and health status of the people that matter. All these aspects viewed together can be called the human resource base - or human capital in more economic language. This broadened view of population also implies that political goals should not be defined in terms of population size but rather in terms of human resources available for producing the best possible quality of life for all citizens." (Lutz 2008)

This new approach to population policy was then prominently included in the Bulgarian population policy strategy which translated it also into specific health, education, family support and migration policies. More recently, this approach was also received well by many government delegations from Eastern Europe and Central Asia during the ongoing Cairo+20 population policy review process. It is also reflected in the recent White Paper on Population by the government of Singapore. (http://population.sg/)

Human capital and human resource management were also hot topics at the recent 2014 annual meeting of the World Economic Forum in Davos. Among others it was suggested that in analogy to private sector strategies governments should develop a more integrated "Public Human Resource Management". This view was also captured in a piece recently published in the *Harvard Business Review*:

> "Viewing the quality of human capital as resting on a collection of elements, many of the manageable, is something that the private sector has been doing for a long time. Every sizable business pays attention to human resource management. For governments the equivalent would be a form of national human resource management that considered education, migration, family, labor, health, and retirement as components that interact richly – and together drive the richness of the future." (Lutz 2014b)

One decisive difference between public and private sector human resource management is, however, that states cannot fire people (at least not their own citizens). This is why states have social policies in addition to economic policies. But increasingly the goals of social policies also go into the direction of trying to empower people to help themselves, if at all possible. Or as the German education minister put it on the occasion of the 2012 annual assembly of the Max-Planck Society: "Education policy is the social and economic policy of the 21st century" (Ministerium für Schule und Weiterbildung 2012).

Much more still needs to be done in terms of developing specific policy programs that translate these goals into practice in both high and low fertility settings. But before the specific policy programs are worked out in detail it is important to be clear about the overriding objective is to be pursued. To propose such an objective that can guide population policy making for the coming decades was the main objective of this paper. This is also the reason for talking about a "population policy paradigm" rather than just population policies.

The ICPD Programme of Action agreed in Cairo in 1994 supposedly did away with quantitative demographic targets and in a widely agreed move directed the focus to human rights, gender equity and reproductive health – but it did not set any other meaningful aggregate level objective that might take the place of the dismantled demographic targets. A priority focus on human capital development, beginning with and concentrating on education and health, should be the new global population and development policy paradigm, based on sound scientific evidence and equally valid for all societies around the world. Such a new paradigm will certainly not be accepted over night – but the currently ongoing review process associated with Cairo+20 may be a good time to start serious discussions about the deeper and longer term goals of population policies in the context of sustainable development.

6 List of Abbreviations

ADL - activities of daily life

AR5 - Fifth Assessment Report

CEN - Constant Enrollment Numbers

CER - Constant Enrolment Rates

DHS - Demographic and Health Surveys

FT - Fast Track

GDP - gross domestic product

GET - Global Education Trend

GMM - Generalized Method of Moments

HDI - Human Development Index

IA - Integrated Assessment

ICT - Information and Communication Technology

ISCED - International Standard Classification of Education

IIASA - International Institute for Applied Systems Analysis

IPCC - Panel on Climate Change

NES - No Education Scenario

NTA - National Transfer Accounts

OLF - Optimal Level of Fertility

OLS - ordinary least squares

SES - Socio-economic Status

SSPs - Shared Socioeconomic Pathways

TFR - Total Fertility Rate

VID - Vienna Institute for Demography

VRA - Vulnerability, Risk and Adaptation

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