POLICY RESEARCH WORKING PAPER   5719

Population, Poverty, and Sustainable Development

A Review of the Evidence

Monica Das Gupta
John Bongaarts
John Cleland

Abstract

There is a very large but scattered literature debating the economic implications of high fertility. This paper reviews the literature on three themes: (a) Does high fertility affect low-income countries' prospects for economic growth and poverty reduction? (b) Does population growth exacerbate pressure on natural resources? and (c) Are family planning programs effective at lowering fertility, and should they be publicly funded?

The literature shows broad consensus that while policy and institutional settings are key in shaping the prospects of economic growth and poverty reduction, the rate of population growth also matters. Recent studies find that low dependency ratios (as fertility declines) create an opportunity for increasing productivity, savings and investment in future growth. They find that lower fertility is associated with better child health and schooling, and better health and greater labor-force participation for women. They also indicate that rapid population growth can constrain economic growth, especially in low-income countries with poor policy environments.

Population growth also exacerbates pressure on environmental common property resources. Studies highlight the deep challenges to aligning divergent interests for managing these resources. However, part of the pressure on these resources can be mitigated by reducing the rate of population growth.

Although family planning programs are only one policy lever to help reduce fertility, studies find them effective. Such programs might help especially in the Sub-Saharan African region, where high fertility and institutional constraints on economic growth combine to slow rises in living standards.

Population, Poverty, and Sustainable Development:
a review of the evidence[1]

Monica Das Gupta[2], John Bongaarts[3], and John Cleland[4]

JEL codes: Demography, Poverty, Economic Growth, Environment & Development, Public Policy

[2] Development Research Group, The World Bank, Washington DC, USA. Email: mdasgupta@worldbank.org, mdasgupta@gmail.com (Corresponding author)

[3] The Population Council, New York, USA. Email: jbongaarts@popcouncil.org

[4] London School of Hygiene & Tropical Medicine, London, UK. Email: John.Cleland@lshtm.ac.uk

1 Introduction

In recent decades, there has been little policy attention to the potential benefits of reducing high fertility in low-income countries. These have not been seen as compelling, despite many careful studies documenting them. This is partly because the studies are scattered across different subjects, such as family health, economic growth, and environmental change. It is also partly because an earlier literature argued that lowering fertility was largely irrelevant (or even counter-productive) to developing countries' prospects for economic growth and poverty reduction.

This paper seeks to bring together the evidence on these issues, by reviewing the literature on three themes: (a) Does high fertility affect low-income countries' prospects of economic growth and poverty reduction? (b) Does population growth exacerbate pressure on natural resources? and (c) Are family planning programs effective at lowering fertility, and should they be publicly funded?

Section 2 reviews the literature on the relationship between population, economic growth, and poverty reduction. Opinions have swung back and forth on these relationships. Yet there has been a broad consensus that while policy and institutional settings are key in shaping the prospects of economic growth, population dynamics also play a role. At the household level, lower fertility has also been found associated with better health and schooling outcomes, and lower poverty.

Section 3 reviews the literature on whether population growth exacerbates pressures on natural resources. Some have argued that human innovation can overcome any resource constraint, and studies confirm this for some types of resources, which are more fully priced. Others find that there are serious challenges to sustainably managing the use of resources that are underpriced or free, such as global common property resources, whose depreciation will affect the sustainability of production possibilities. Pressures on these resources are exacerbated by increased consumption per capita and by population growth.

Section 4 turns to the implications of continuing high fertility for Sub-Saharan Africa. This region has the highest population growth rates in the world today as mortality decline has far outpaced fertility decline. It also experiences institutional and other constraints to economic growth that make it more difficult to accommodate larger populations. We review some of the pressures building up in this region, and suggest that accelerating the demographic transition may help mitigate them.

What then are the best policy levers to encourage lower fertility? Many factors are associated with smaller families. Educating populations is widely perceived to create many positive externalities associated with lower fertility, such as increased wages (Duflo 2001, Schultz 2002), improved child health and schooling, increased female labor force participation, and lower fertility (Schultz 2002) especially by raising the age at first birth.[1] However, these benefits are well-recognized, and much effort has been made to enhance education quality, reduce barriers to access, and incentivize parents to send their children to school with subsidies, school meals, and conditional transfer programs. Improved child survival can also help reduce fertility, but much programmatic effort is also underway on this.

By contrast, there is little consensus on the potential gains from helping lower fertility through family planning programs, and even the effectiveness of these programs has been challenged.[2] Section 5 reviews the evidence on this, which indicates that well-executed family planning programs are effective at lowering fertility. Section 6 concludes.

2 Does High Fertility Affect Low-income Countries' Prospects for Economic Growth and Poverty Reduction? The Debates

Since the 1960s, economists have taken very different positions on the implications of population dynamics for economic growth. Many of these differences, as discussed below, have been driven by different analytical approaches. For example, some studies have focused on the projected trajectory of a single country while others have done cross-country regressions where it is difficult to control for differences in the policy and governance settings. And over the decades analytical techniques have evolved, yielding different results.

At bottom, there is little fundamental disagreement on the issue. There is broad consensus that policy settings that support growth are the key drivers of economic growth, while population size and structure play an important secondary role in facilitating or hindering economic growth.

2.1 Malthus' original idea

Malthus argued that population and resources maintain a homeostatic balance: if living conditions permit, the population will grow until it is restrained either by the "preventive check" of controlling reproduction or by resource shortages resulting in "positive checks" (famine, disease, war). This was based on the assumption that the supply of key factors of production such as land was largely fixed.

While this may sound like an extreme position today, it was not at the time Malthus wrote. Many studies by economic historians and historical demographers show that GDP growth and real wages were indeed stagnant or grew very slowly over centuries and even millennia. They also show that fertility control was exerted through methods such as postponing marriage, never-marrying, infanticide, and abstinence.[3] Galor and Weil (2000: 807) summarize the findings of several studies covering a wide geographical and historical range:

> "…Angus Maddison (1982) estimates that the growth rate of GDP per capita in Europe between 500 and 1500 was zero. Furthermore, Ronald D. Lee (1980) reports that the real wage in England was roughly the same in 1800 as it had been in 1300. According to Kang Chao's (1986) analysis, real wages in China were lower at the end of the eighteenth century than they had been at the beginning of the first century….. Edward A. Wrigley and Roger S. Schofield (1981) find that there was a strong positive correlation between real wages and marriage rates in England over the period 1551-1801. Negative shocks to population, such as the Black Death, were reflected in higher real wages and faster population growth (Livi-Bacci, 1997)….Finally, the prediction of the Malthusian model that differences in technology should be reflected in population density but not in standards of living is also borne out. As argued by Richard Easterlin (1981), Pritchett (1997), and Lucas (1999), prior to 1800 differences in standards of living among countries were quite small by today's standards; yet there did exist wide differences in technology. China's sophisticated agricultural technologies, for example, allowed high per-acre yields, but failed to raise the standard of living above subsistence. Similarly in Ireland a new productive technology—the potato—allowed a large increase in population over the century prior to the Great Famine without any improvement in standards of living (Livi-Bacci, 1997).

Galor and Weil (2000:826) conclude that "In early stages of development—the Malthusian Regime—the economy remains in the proximity of a Malthusian trap, where output per capita is nearly stationary and episodes of technological change bring about proportional increases in output and population".

Since Malthus' time, things have changed dramatically (Demeny 2011). The functioning of the "preventive checks" has been altered by technological advances which are available even in low-income settings. Advances in agricultural and industrial technologies can transform a society's productive capacity and allow it to sustain growing populations.

2.2 Models indicating that rapid population growth constrains economic growth

Mid-twentieth century models of economic growth indicated that increases in population growth constrain growth in income per-capita. The Harrod-Domar model (Harrod 1939, Domar 1948), showed that in the absence of diminishing returns to capital, growth in income-per-capita is affected negatively by population growth and positively by savings as well by increases in the output-capital ratio. Solow (1956, 1957) assumed that both capital and labor had diminishing returns, and illustrated that an exogenous increase in the population growth rate would translate into a growth of labor supply that would outpace the growth of capital formation and ultimately lower per-capita income.

Coale and Hoover (1958) modeled the relationship between population growth and economic development for one low-income country ─ India in the 1950s ─ characterized at the time by low GDP growth, low industrialization, and heavy reliance on subsistence agriculture. They concluded that population growth might adversely affect the prospects for economic development because of the population's (1) increasing size, as well as (2) its structure, with high and rising child dependency ratios. They argued that the combined effect of these two factors divert national resources away from investment in expanding production and increasing the capital/labor ratio — to meet the growing needs for schools, health, housing, and other infrastructure needed to avoid compromising the future population's wellbeing and productivity. Similarly at the household level, they divert resources away from saving for productive investment, to meet current consumption needs.

These models were deeply influential, developing a consensus in development policy circles on the need to reduce the high rates of population growth rates in developing countries.

2.3 Early empirical challenges to these models

The first challenge to the Coale and Hoover model was the lack of any significant correlation between rates of population growth and per-capita output across a sample of developing countries (Kuznets, 1967, reprinted in Kuznets, 1973:43). A spate of studies followed with similar conclusions (Lee 1983).

What seems to have attracted little attention was the fact that Kuznets very explicitly and carefully qualified the conclusions he drew from his work. He was careful to specify that technological improvements can increase production and help avoid the Malthusian "positive checks". He added that the technologically feasible may not be actualized, that there could be serious social and political problems involved in making the needed adjustments (Kuznets 1973:7, 45). He clarified that lower rates of population growth could enable more rapid growth in per capita output (Kuznets 1973:90).

Moreover, Kuznets did not know at the time of his writing that world population was growing much faster than indicated by the UN medium projections he used, which were published in 1966. These projected a doubling of the population in the less-developed areas of the world between 1965 and 2000 (Kuznets 1973:7). In fact, this projection tallies with recent UN estimates[4]─ but only because from the mid 1960s onwards the most populous developing countries undertook energetic and successful efforts to reduce fertility. This hindsight adds yet another qualification to Kuznets' careful qualifications of his conclusions, that:

> "…purely technological and economic factors allow sufficient margins, in most underdeveloped countries, to permit substantial and sustained economic growth, even with a significant rise in population ─ at least for the proximate future of two to three decades." (Kuznets 1973:41)

Those building on Kuznets' work sometimes seem to think that he did not believe that population growth can hinder economic growth. Easterlin[5] summarizes Kuznets' position more accurately : "Kuznets saw

the basic obstacles to economic growth as arising from delays in adjusting social and political institutions, and viewed population growth, though an impediment, as of secondary importance".

A second challenge to the Coale-Hoover model came from studies exploring their prediction that higher dependency ratios would divert resources towards meeting growing needs for outlays in areas such as education. Schultz (1987) tested for this investment-diversion effect. He found that over the period 1969-1980, enrolment rates and number of years of schooling completed rose significantly in low-income countries, and that the relative size of the school-age cohort exerted no independent influence on the share of GNP allocated to education. Costs per pupil dropped, with rising class sizes per teacher, and decline in teachers' salaries. This suggests that the *quantity* of schooling can rise without diverting resources from other forms of investment despite growth in the school-age population. However, Schultz pointed out that reduced expenditures per pupil may have reduced the *quality* of schooling.

A third challenge to the Coale-Hoover model came from empirical studies that failed to confirm that high youth dependency ratios have a negative impact on savings and thereby on economic growth (National Research Council 1986:44-45, Kelley 1988:1707). However, Kelley (1988:1707) cautioned that these studies have serious methodological limitations, deriving not only from the limitations of cross-country analysis, but also from problems with specifying several key variables.

Kelley (1988:1700) cites a large number of studies that found weak or non-existent empirical support for the thesis that population growth hinders economic growth, based on cross-country correlations. However, he points out that this analytical approach does not reveal causation, and that "institutional variations among countries may mask the relationships".

The methodological problems with these early studies were carefully acknowledged by Johnson and Lee (1987:xi) in their editorial preface to the studies carried out on behalf of the National Research Council's Working Group on Population Growth and Economic Development:

> "The working group concluded that slower population growth would, on balance, benefit most developing countries and that the positive effects of slower population growth on economic development would be clearest in the poorest and most densely populated countries. But the working group also reported that drawing firm conclusions about the overall impact of slower population growth is difficult because the research base is inadequate. Studies completed to date are frequently based on limited samples and data of poor quality, as well as on only partial and occasionally inappropriate conceptual models and statistical techniques. Simply put, the scientific literature contains few adequate studies of the effects of slower population growth in developing countries."

Their conclusion that slower population growth would benefit most developing countries, especially the poorest and most resource-stressed, was much less clearly stated in the NRC's summary report on policy questions (NRC 1986:93). This influential report was widely interpreted as not supporting the view that family planning programs could do much to enhance the prospects for economic growth.

2.4 Recent empirical studies re-affirming the Coale-Hoover model

A spate of recent studies have re-affirmed different aspects of Coale and Hoover's thesis. These use a wide range of analytical methods (macro and micro), including updated approaches to cross-country regressions. [6] Coale and Hoover's youth dependency hypothesis has received the most attention. This is that if a population has a high proportion of children to working-age adults — typical of populations with high fertility — the prospects for economic growth are diminished.

Higgins and Williamson (1997) find that high youth dependency ratios are associated with lower savings and investment. They found that "much of the impressive rise in Asian savings rates since the 1960s can

be explained by the equally impressive decline in youth dependency burdens. Wherever the youth dependency burden has fallen dramatically, Asian countries have relinquished their reliance on foreign capital." They found this effect to be stronger in East Asia than in South Asia, where the fertility transition has been less rapid.

Bloom and Williamson (1998) argued that rapid fertility decline in East Asia facilitated the rapid economic growth in this region by reducing the dependency ratio, "thereby expanding the per capita productive capacity of East Asian economies". They noted that this is a temporary window of opportunity, because continuing fertility and mortality decline will result in high proportions of old people relative to working-age adults. They also pointed out that the East Asia region was able to capitalize heavily on this opportunity because they had built the policy and institutional settings needed to realize the growth potential created by this demographic dividend.

The gains from this demographic window of opportunity may be made permanent if they are invested in physical capital and human capital (Lee 2009). With good planning, this demographic dividend can be used to transform economies such that their growth potential remains high after the window has closed.

Moving to global macro-studies, Kelley and Schmidt (2005) conclude that higher dependency ratios (including both youth and old-age dependency ratios) have a significant impact on growth. They find that "Worldwide, the combined impacts of demographic change have accounted for approximately 20% of per capita output growth impacts, with larger shares in Asia and Europe." Earlier, they had found that dependency ratios impact on savings, from an examination of 65 less developed countries and 23 developed countries over time and cross-sectionally since 1960 (Kelley and Schmidt 1996).

Turning to the question of whether rapid population growth reduces growth in income per capita, Acemoglu and Johnson (2007) examine the data from 47 developed and developing countries over the period 1940-2000 and conclude that

> "Overall, the increases in life expectancy (and the associated increases in population) appear to have reduced income per capita." (Acemoglu and Johnson 2007: 975).

As Galor and Weil (2000: abstract) put it, the relationship between population growth and income growth changes as economies mature:

> "The economy evolves from a Malthusian regime, where technological progress is slow and population growth prevents any sustained rise in income per capita, into a Post-Malthusian regime, where technological progress rises and population growth absorbs only part of output growth. Ultimately…the economy enters a Modem Growth regime with reduced population growth and sustained income growth".

2.5 What of poverty reduction?

Although the debates summarized here have focused more on the potential impact of population dynamics on economic growth rather than explicitly on poverty reduction, it is apparent that they view economic growth as a means to raise living standards and reduce poverty. GDP growth ― whether derived from growth in the agricultural, manufacturing, or service sectors ― typically raises living standards among substantial sections of the population, with ripple effects for others. A possible exception is growth that derives from exploitation of mineral resources (such as oil), where small elites can potentially capture much of the proceeds.

Some micro-studies have focused on fertility and children's wellbeing. They support Coale and Hoover's thesis that at the household level, high fertility reduces investments in children. Some studies use twin births to minimize the potential confounding effect of endogeneity: namely, that parents who have larger numbers of children have different characteristics from those who have few children. Using this method, Rosenzweig and Wolpin (1980:239) found that in India: "exogenous increases in fertility decrease child quality and suggest that a decrease in family size brought about, say, by exogenous improvements in birth

control technology, would increase schooling levels of Indian children". Rosenzweig and Zhang (2009) use the same approach to estimate the net effect of an extra child at parities one and two in China, and find that the extra child "significantly decreases the schooling progress, the expected college enrolment, grades in school and the assessed health of all children in the family".

Other micro-studies find that fertility decline is associated with broader indices of household wellbeing and poverty reduction. In Matlab, Bangladesh, fertility decline was found associated with improvements in women's health, household earnings and assets, use of preventive health inputs, and children's health and schooling (Joshi and Schultz 2007). In Colombia, the family planning program was found to bring substantial socio-economic gains to women, especially if they had access to the program when young. Such women obtained more schooling, and were more likely to work in the formal sector. The study concluded that "(c)omparisons with other well-regarded development interventions suggest that these estimates may place family planning among the most effective (and cost-effective) interventions to foster human capital accumulation" (Miller 2010:711).

3. Does Population Growth Exacerbate Pressure on Natural Resources?

Some economists have argued that more rapid population growth may help drive economic growth, by spurring technological innovation that can potentially stretch resources indefinitely. However, there is reason to believe that human ingenuity may have its limits.

3.1 Can human innovation stretch resources indefinitely?

The first to argue that population growth may have a positive effect on technological innovation was Kuznets (1960), who speculated on *a priori* grounds that if the proportion of geniuses in a population is constant, the larger the population the large the number of geniuses. He acknowledged that this was based on the assumption that the necessary resources would be available for education, training, and other capital investment, to maintain or increase per capita productivity ― and that therefore this argument did not hold for the developing world. Even for the developed world, he warned that there could be severe problems in adjusting to the implications of larger population size.

> "First, few if any of the points made are relevant to the underdeveloped countries. By definition, the latter suffer from an acute shortage of capital, not only for material investment but also for adequate raising and education of their younger generations….Second, even in the advanced and developed economies, population increase means further pressure upon limited natural resources, upon the supply of material capital, and above all, upon the capacity of the social and economic structure to adapt itself to it. All the factors cited in the current (and past) literature that make for the increased burden of larger populations— if higher per capita product is to be attained—are relevant here." (Kuznets (1960: 337-8)

Despite Kuznets' very cautious treatment of his thesis, subsequent studies underplayed his cautions and built on the possibilities he had raised to suggest that population growth was a positive force for economic development.

Boserup (1965) argued that rising population tends to induce agricultural innovation and lead to agricultural intensification, allowing greater productivity per unit of land to feed the larger population. This process of agricultural intensification has been widely observed, but it is less clear how much this raised per capita consumption before the Industrial Revolution brought radical new agricultural technologies. Yet as Galor and Weil (2000) note, many studies indicate that output per capita was nearly stationary for millennia preceding the Industrial Revolution.

Kremer (1993) argued that over the long sweep of history, "larger initial populations have had faster technological change and population growth". Klasen and Nestman (2006: 14-15) argue that SubSaharan Africa's low population density hampered technological change, but that this may change now with rapid population growth. They add, though, that modern technology can be diffused even without high population densities, but that technological uptake is still slow in the region.

Simon (1981, 1996) built on Kuznets' thesis to argue that human innovation assures that population growth has long-term benefits for living standards, in both developing and developed countries. Contrary to the evidence from the wide range of studies summarized by Galor and Weil (2000), Simon (1996: 580) asserts that the "standard of living has risen along with the size of the world's population since the beginning of recorded time…".

Simon argued that people and markets innovate in response to potential resource shortages, and therefore the resource base is effectively infinite. "There is no physical or economic reason why human resourcefulness and enterprise cannot forever continue to respond to impending shortages and existing problems with new expedients that, after an adjustment period, leave us better off than before the problem arose" (Simon 1996:580). He argued further that human activity was not responsible for environmental damage, and that "the trends toward greater cleanliness and less pollution of our air and water are even sharper than before" (Simon 1996:578).

For Simon, population growth helps resolve — not cause — resource scarcities and environmental problems. Simon and Boserup both argued that higher population densities can increase the economies of scale in providing productivity-enhancing infrastructure and services such as transport and extension services (Glover and Simon 1975; Boserup 1981).

Simon's arguments were supported by studies of the costs of some industrial resources. Potter and Christy (1962) for example, showed that mineral prices in the US actually fell by approximately 40 percent between 1870 and 1957, a period during which there was rapid growth in both population and industrial output. Barnett and Morse (1963) showed that the labor and capital inputs needed to produce scarce natural resources that included fuels, metals and non-metal minerals had more than halved over the same time-frame. For such clearly-priced resources, there are strong private incentives to find innovative ways of managing their use to keep prices down.

Certainly the Industrial Revolution and subsequent technological innovation enabled a huge jump in productive capacity, enabling rising levels of per capita GDP and consumption. The manufacturing sector also allows much more scope than the agrarian for absorbing a growing labor force. However, policy and institutional settings shape the scope for benefiting from the new technical possibilities. Much of the developing world lagged behind the developed world in putting policies in place to encourage economic growth, but this has changed in recent decades and their pace of growth has picked up.

The long view taken by some who argue that population growth can be accommodated by technological change discounts the deprivation faced by generations before the benefits of change manifest themselves — even under the most conducive of circumstances. China is a good example, since its political system permits far more radical innovation that most others. From the end of the 1970s, a series of economic reforms were instituted − GDP per capita (in US$ Purchasing Power Parity terms) rose nearly 20-fold between 1980 and 2007 (IMF 2010a), and poverty levels fell sharply. This was helped by rapid fertility decline since 1970, when targets were set for implementation by local authorities.[7] Yet after decades of blistering economic growth and fertility decline, there are still significant levels of poverty in China. Almost a third of the rural population was consumption poor in at least one year between 2001 and 2004, using the dollar-a-day estimate in 1993 PPP dollars which is a low threshold by international standards (World Bank 2009: vi, 18). Using more average thresholds increases the estimated poor population substantially (Chen and Ravallion 2008).

3.2 Limits to innovation – managing environmental common property resources

The concerns raised by early studies[8] forecasting population pressure on resources receded quickly as technological innovation rapidly raised agricultural productivity and kept the prices of some commodities down. More recently, widespread concern over environmental common property resources has again raised issues of sustainable development.

A relentless demand for continuing adaptation and innovation is generated by the world's growing consumption needs, with increases in per capita consumption levels and population growth. Technological progress has certainly increased production, but this has not been without negative ramifications. Common property resources are under pressure from activity to meet rising consumption requirements. For example, fertilizer runoff has increased with agricultural intensification, creating low-oxygen "dead zones" in coastal oceans (Map 1).

While market forces and ingenuity can find ways to better manage the use of non-renewable resources that are clearly priced, it is proving more difficult to conserve resources that are unpriced or underpriced, such as oceans and the atmosphere. Even to understand the intricacies of environmental change is a challenging task for scientists ─ and organizing collective action to avert negative consequences is a challenging task for political leaders even at local levels, let alone national and global levels.

These factors combine to create a daunting list of needed adaptations and innovations, which are complex to develop as well as to implement. The World Development Report 2010 summarizes some of the measures needed just for sustainable food production (World Bank 2010a). To manage land and water resources to feed 9 billion people and protect natural systems, they point to the need for politically daunting measures, such as:
- building flexible international agreements
- pricing carbon, food and energy
- redirecting agricultural subsidies
- strengthening the policy environment for natural resource management.

As the World Bank (2010a) points out, food demand is rising with growth in incomes as well as in population size. Climate change will make it harder to meet that food demand. A huge increase in productivity will be needed at the same time as huge increase in regulation to protect natural systems. However, the report takes as given the projected rate of population growth, perhaps because it was outside its already enormous scope to discuss policies that might alter its trajectory.

Yet population size *is* amenable to policy, as we discuss below, and makes a big difference to the size of adjustments required on other fronts. Models vary, but the World Bank (2010a) estimates that to meet the growing demand for food between 2005 and 2055, agricultural productivity will need to rise by 64 percent under the assumptions of the "business as usual" scenario and by a further 80 percent under the assumptions of projected stresses arising from climate change (Figure 1). Yet the model indicates that if population remained constant at the 2005 level, agricultural productivity would need to rise only 25% under the "business as usual" scenario ─ i.e., more of the required productivity increase under the "business as usual" scenario is necessitated by population growth, than by increases in per capita consumption.

Conventional estimates of GDP growth are misleading on the sustainability of production possibilities, because they ignore the depreciation of natural capital (Arrow et al 2004, Dasgupta 2010).

> "Since GDP is the total value of the final goods and services an economy produces, it does not deduct the depreciation of capital that accompanies production—in particular, it does not deduct the depreciation of natural capital. In the quantitative models that appear in leading economics journals and textbooks, nature

is taken to be a fixed, indestructible factor of production. The problem with the assumption is that it is wrong: nature consists of degradable resources. Agricultural land, forests, watersheds, fisheries, fresh water sources, river estuaries and the atmosphere are capital assets that are self-regenerative, but suffer from depletion or deterioration when they are over-used. (I am excluding oil and natural gas, which are at the limiting end of self-regenerative resources.) To assume away the physical depreciation of capital assets is to draw a wrong picture of future production and consumption possibilities that are open to a society." (Dasgupta 2010:6)

Moreover, "property rights to natural capital are frequently unprotected or ill-specified....(which) typically leads to their overexploitation, and so to waste and inequity" (Dasgupta 2010: 6).

Arrow et al (2004: Table 2) estimate how much "genuine wealth per capita" (including natural capital, human capital, and manufactured capital) changed during 1970-2000. The estimates are necessarily approximate, but they have been made carefully and the results are instructive. They find that while GDP per capita grew quite rapidly in all regions except in Sub-Saharan Africa, rates of growth in "genuine wealth per capita" were far lower. They *declined* sharply in Sub-Saharan Africa and in the Middle East and North Africa (by -2.6 and -3.8 percent per year respectively). They grew very slowly (well below 1 percent per year) in South Asia and the United States. They grew rapidly only in China, due to its low population growth and heavy investment in productivity. Revising the method to include more information on growth in human capital and institutional change, Dasgupta (2010: 9-10) derives far lower estimates of growth in genuine wealth per capita for China 1970-2000, and for South Asia he estimates a *decline* of between -0.4 percent per year (India) and -1.4 percent (Pakistan).

Rates of internal and international labor migration will rise with the pressures of environmental degradation and climate change (Laczko and Aghazarm 2009, World Bank 2010a: ch2). Even current rates of migration have proved difficult to manage politically in many countries, as local residents resent encroachment on their resources. It is likely to prove very daunting to accommodate accelerated in-migration, especially when receiving areas are under greater pressure themselves. This is just one of the challenges that increasing rates of population growth pose to societies' capacity to adapt their social, political, and economic institutions to respond to the new needs (Kuznets 1973:91, McNicoll 1984).

Human ingenuity has faced an uphill task at devising ways of managing common property resources ─ given the institutional and political challenges posed in aligning divergent interests. Markets are very poor at incentivizing people not to overuse resources that are un-priced or under-priced relative to social cost (Arrow 1969, Dasgupta 2001, Stern 2006), especially in the case of transnational common resources (Dasgupta et al 1997). The consequent negative externalities need to be addressed through collective action, but in the absence of strong mechanisms for mutual coercion it is very difficult to align the interests of different stakeholders to this end. Ostrom (1990) has argued that common property can be successfully managed by user associations in small communities if eight "design principles" are met, including the ability to effectively exclude unentitled parties. Such conditions clearly do not apply to global common resources. As Lee (1990:317) points out "each birth inflicts costs on all others by reducing the value of their environmental birthright".

The juxtaposition of all these daunting scientific, executive, and political challenges suggest that even countries which have so far adapted to growing needs may find it difficult to respond to these new kinds of demands (Demeny 2011). They place high demands on national and global institutional capacity, as evidenced by the slow progress made in decades of efforts to regulate carbon emissions.

Reducing the number of births may be one of the simplest ways of reducing pressure on common property resources. For instance, it is estimated that the effect of a 40% reduction in CO_2 emissions per head in developed countries between 2000 and 2050 would be entirely offset by the increase in emissions attributable to expected population growth in poorer countries over this period, even assuming no change in emissions per head in these countries (Dyson 2005). Moreover, CO_2 emissions per head have risen in

countries such as China, India and Brazil in line with rapid economic growth. O'Neill et al (2010) estimate that slowing population growth could reduce carbon emissions significantly. Indeed it has been argued that the prevention of unwanted births today is likely to be one of the most cost-effective ways to preserve the planet's environment in the longer term (Birdsall 1994).

4. Implications for Sub-Saharan Africa

Sub-Saharan Africa is now the developing region closest to the scenario described by many as that in which rapid population growth is most difficult to accommodate because of slow productivity growth. As Weil and Wilde (2009:259) conclude from their study:

> "The Malthusian channel by which a high level of population reduces income per capita is still relevant in poor developing countries that have large rural populations dependent on agriculture, as well as in countries that are heavily reliant on mineral or energy exports."

Fertility rates remain high in much of Sub-Saharan Africa, with a regional average of 5.1 children per woman in 2008 — matched outside the region only by 4 small war-torn countries[9] (World Bank 2010b: Table 2.19). Although fertility has declined in many countries in this region,[10] only a few have a TFR below 4.[11] High fertility also helps keep maternal mortality high (section 5.1) — Sub-Saharan Africa has an estimated 1:31 lifetime risk of maternal death, which is *four times higher* than that of developing regions as a whole (WHO et al 2010: Table 2).

Between 1970 and 2005, the population aged below 15 years grew by 150 percent in Sub-Saharan Africa as a whole, and by over 200 percent in the high-fertility country of Niger — compared with 30 percent for Asia, and 36 percent for Latin America (Figure 2). As a result, Sub-Saharan Africa has as yet benefited far less than other regions from the impact of reduced dependency ratios on per capita output growth (Kelley and Schmidt 2005, Eastwood and Lipton 2011).

This region is estimated to have depleted "genuine wealth per capita" quite rapidly during 1970-2000 (Arrow et al 2004, Dasgupta 2010):

> "Population growth implies significant differences between the initially estimated growth rate of genuine wealth… and the growth rate on a per capita basis…. At an annual rate of decline of 2.6 percent in genuine wealth per annum, the average person in the sub-Saharan Africa region becomes poorer by a factor of two about every 25 years." (Arrow et al 2004: 164-5)

Although it has an enormous wealth of resources, including land and minerals, policy environments in many countries have not been conducive to rapid growth in average living standards. Growth in real GDP per capita during 1960-2004 was only 24% in the Sub-Saharan African region, compared with 108% on average in low-income countries, and 685% in the East Asian region (Figure 3). The region as a whole showed low growth despite rapid growth in some countries, including Botswana and Mauritius. This is because several populous countries show low growth: population growth rates from 1960-2004 were higher for countries with large- and medium-sized populations than for those with small ones (World Bank 2007a:33-35). More recently the annual percentage growth in GDP has risen (at constant prices) to around 5.6% per year during 2004-07 (IMF 2010a), and similar rates are projected for the region for 2011-12 (IMF 2011: Box 1). Some countries are growing much faster. However, the regional GDP growth is nearly halved on a per capita basis by population growth.

Agricultural production per capita was stagnant during 1960-2005, whether measured in overall food production per capita (Figure 4) or cereal yields per hectare (World Bank 2007b:Fig 2.1) — in sharp contrast to rapid growth in these indices in Asia and Latin America. Agricultural stagnation is an especial

problem because a large proportion of the people depend on it for a livelihood: agriculture in Sub-Saharan Africa employs 65 percent of the labor force and generates 32 percent of GDP growth.[12]

Productivity growth in agriculture has been hampered by policies discouraging innovation by smallholders. In a seminal study, Bates (1981) showed how in many countries, policies have depressed the prices smallholders can obtain for their output, and limited their access to subsidies for agricultural inputs and credit. This reduces smallholders' incentives to invest in their land, and to grow more than they need for subsistence. By contrast, elite farmers with political connections are given access to highly beneficial terms.[13] Djurfeldt et al (2006:10) note that "The result was a dual structure comprising, on the one hand a small group of 'modern' often well-connected and sometimes absent, commercial farmers and estate owners and, on the other hand, a vast majority of low-productivity, semi-subsistence oriented smallholders growing traditional varieties using only small amounts of fertilizers and improved seeds." Added to this are investment disincentives in areas with insecure tenure arising from traditional patterns of communal landownership (Besley 1995, Otsuka and Place 2001).

Rates of technological uptake have been low (World Bank 2007b:52-55). The use of modern inputs such as fertilizers, improved varieties of cereals, and irrigation are far lower in Sub-Saharan Africa than in other developing regions. Soil degradation is widespread. This contrasts with the policies that helped most Asian countries to increase agricultural production by providing credit, support prices, and input subsidies to farmers, as well as by investing in research and development and in infrastructure such as roads and irrigation. The good news is that policies are improving. Djurfeldt et al (2006:10, 62) note policy shifts that will improve incentives for smallholders to invest in their land and enhance productivity. Agricultural taxation has fallen in several countries (World Bank 2007b:100).[14] In recent years, agricultural output has increased in several countries (Badiane 2008). And a study in Machakos, Kenya finds that with improved agricultural policies it is possible to raise productivity and reverse soil degradation (Tiffen et al 1994).

Meanwhile, population pressures are growing on the land. Jayne et al. (2003) found that almost a quarter of rural households in Ethiopia, Kenya, Rwanda, Mozambique and Zambia were virtually landless and had little non-farm income to supplement their livelihood. Aggregate availability of cropland per agricultural person fell by 40 percent between 1960 and 2003 (World Bank 2007b:63). Land quality is another issue ─ although cropland availability was still double that of Asia in 2003, population densities on the land are similar to those of Asia when adjustment is made for land quality (World Bank 2007b:55,63). The land-quality-adjusted population density in Kenya was estimated in the 1980s to be higher than that in Bangladesh (Binswanger and Pingali 1988, cited in World Bank 2007b:55).   In response to population pressure, people are degrading land through over-cropping and over-grazing, and expanding into more fragile lands (World Bank 2007b:55). The FAO (2003) estimates that the demand for food will increase by 2.9% per year, heavily fuelled by population growth of 2.4%.

Other pressures are also building up. Africa is one of the regions projected to be most severely affected by drought and temperature rises due to global warming. Water availability will shrink significantly, especially in the South, West, and North of the continent (World Bank 2010a:137). Land degradation and drought have already caused much movement of people seeking livelihoods elsewhere, and the Sahel is especially at risk.

Demographic, economic and political pressures ─ population growth, land degradation, government crises ─ generate conflict, which in turn can create further economic and political pressures. Conflicts over land and livelihoods are intensifying in many countries (Peters 2004, Green 2010). Mamdani (2001: ch 6,7) points out that rapid population growth was one of the factors underlying the Rwanda genocide, generating resentment among locals who experienced heavy in-migration of people seeking areas with richer land. Large flows of refugees and other migrants create pressures for the receiving areas: Hatton

and Williamson (2003:474) estimate that for every two refugees, one local is pushed out of the home labor market.

These pressures generate much migration in the region (Hatton and Williamson 2003). Most of this migration is within the region, within-country and between-country. People migrate to other rural areas where sometimes competition for land generates conflict, and to cities where slow growth in infrastructure and jobs make urban poverty a serious issue. And the pressures for international out-migration are projected to continue to mount (Hatton and Williamson 2003).

Yet things could really change. As the case of Botswana shows, with good management the region's enormous mineral wealth and other natural resources can be tapped to create social and physical infrastructure and generate employment for the large cohorts of young people. Some of the wealth could be invested in expanding the manufacturing sector, which can absorb large amounts of labor. Such measures could offset demographic pressures and enhance living standards. In many settings though, this wealth has been viewed as having been turned into a "resource curse", facilitating elite capture and reducing the need for the political leadership to maintain their legitimacy by building institutions for a developmental state (Collier and Goderis 2007, Unsworth and Moore 2010).

Despite many successes, most countries in this region face challenges to growth arising from institutional constraints of various kinds. Tackling these constraints to growth is urgently required. In addition, most countries would benefit from strengthening family planning programs, to ease the currently high momentum of population growth that further constrains the prospects for improving standards of living.

5. Do Family Planning Programs Help Lower Fertility?

Family planning programs seek to expand the availability of contraceptives and reduce barriers to their use.[15] They are especially important for the poor, who typically have higher numbers of unwanted children than the rich except in settings with very effective programs, such as Indonesia (Figure 5). Family planning programs also typically disseminate information on contraception, and on how lower fertility can help parents invest in their children and avail new opportunities for raising living standards.[16] Parents – especially poorer parents – have imperfect information on these issues. Households also appear to face difficulties in making optimal choices that involve long-term planning horizons (see for example Cronqvist and Thaler 2004 on pension decisions). Offering simple information on contraception — or more complex messages through media such as soap operas that portray the lives of people with small families and how they access new opportunities — helps reduce imperfect information. Many studies using cross-sectional survey data have found access to media significantly associated with increased contraceptive use and reduced fertility.[17] The few quasi-randomized evaluations of media effect have found it effective at altering fertility and contraceptive use in Tanzania (Rogers et al 1999) and reducing fertility in Brazil and India (La Ferrara et al 2008; Jensen and Oster 2009).[18]

In a highly influential paper, Pritchett (1994a) argued that family planning programs have little impact on fertility:

> "Ninety percent of the differences across countries in total fertility rates are accounted for solely by differences in women's reported desired fertility…. The results contradict theories that assert a large causal role for expansion of contraceptive use in the reductions of fertility." Pritchett (1994: abstract)

Many have taken Pritchett's study as indicating that effort on family planning programs is ill-spent, but he later concludes that his estimates imply that strengthening a family planning program substantially (by 50 points out of a scale of 0-100) would reduce fertility by one birth (Pritchett 1994b: 626). Bongaarts

(1997) estimates the corresponding fertility reduction at 1.4 births, but even Pritchett's lower estimate amounts to a very large difference in population momentum and size ─ if one birth less per woman was sustained in Sub-Saharan Africa over the projection period 2010-2050, the UN (2009) estimates that there would be half a billion fewer people in that region (Figure 6).[19]

The crucial gap in Pritchett's argument is that he assumes that family planning programs work only on the supply side, and overlooks their important role in reducing desired family size. He conducts cross-country regressions of the Total Fertility Rate against contraceptive prevalence and against family planning effort, but in both cases he *controls for desired fertility* (Pritchett 1994: Table 3). As he says (1994:41-42), he does not focus on the determinants of desired fertility, and concludes that reducing fertility has little to do with manipulating contraceptive supply. This is missing much of the point, as mass media outreach to reduce desired family size is a major component of family planning programs. Studies have shown that the mass media is very effective at increasing contraceptive use and reducing fertility (see above).

Evaluating the impact of family-planning programs is challenging, because they are rarely randomly placed and uniformly executed. However, many studies indicate that family planning programs affect fertility. Schultz (2009: 4) notes that several careful evaluations of family planning programs (including in Taiwan, Colombia, and Indonesia) find a negative association between "the regional intensity of program treatment and the regional level of fertility" in a country.[20] While some studies are simple cross-sectional analyses, others have gone further to analyze panel data and include fixed effects for regions and time. However, the estimated program impact may be biased by nonrandom placement ─ for example it could be over-estimated if program effort is directed more towards areas with greatest demand, and under-estimated if effort is directed more towards areas with the greatest need.[21] In Indonesia, the program was found to have helped reduce fertility, and this effect was if anything under-estimated because the authors found that "the government targets resources to areas of low contraceptive use and dynamically updates those allocations on the basis of program performance" (Molyneaux and Gertler 2000:82-83).

Rigorous randomized experiments of family planning programs are not available. The Matlab program in Bangladesh approximates a randomized trial, since half the villages studied for the period 1974-96 received more intensive family planning and maternal and child health program inputs, while the other half received regular government program inputs. Note that the country was poor and largely illiterate for much of the study period. The first set of villages showed more rapid fertility decline after the program began, and maintained 15 percent lower fertility 1982-96 (Joshi and Schultz 2007:30). This difference is especially striking given that fertility was falling rapidly across the country. Similar results emerge from an evaluation of Colombia's family planning program, which exploits differences in timing of the introduction of the family planning program to estimate the impact of contraceptive availability on fertility (Miller 2010:717).[22] The program is found to have lowered fertility by about 10 percent ─ again, despite the fact that fertility was declining rapidly across the country. As described above, households with lower fertility also showed improvements in schooling, health, and earnings.

These evaluations may tend to under-estimate the impact of family planning programs, insofar as their measures of program effort are more likely to pick up variation on the supply side. Mass communication efforts to reduce desired family size are likely to reach people regardless of whether they live in areas with higher or lower supply-side program effort. However, as mentioned above, without randomized trials it is difficult to assess whether on balance evaluations tend to over-estimate or under-estimate program effect.

Fertility and maternal mortality

Reducing fertility also helps lower maternal mortality (NRC 1989). Abortions following unplanned pregnancies are a significant cause of maternal death. Secondly, the risk of maternal death varies widely with maternal age and birth order ─ it is high for younger teenage mothers, and rises sharply again at higher birth orders and higher ages. Avoiding teen childbearing and having smaller families reduces maternal mortality risks, as does longer spacing between births. And women's mortality risk remains elevated for long after childbirth: a study in Bangladesh found that it is nearly twice as high as normal for up to two years after childbirth (Menken et al 2003).

That fertility reduction can help improve women's health is suggested by Figure 7, which shows how much female adult mortality improved (relative to male) in India concomitant with fertility decline. The comparison with men provides a rough control for overall health improvements. In the early 1970s, female mortality plummeted relative to males in the early childbearing years, picking up gradually over the lifecycle. By 1990, adult women's mortality relative to men's had improved sharply, not only in the childbearing years but also up to age 50, suggestive of reductions not only in maternal mortality but also in lagged mortality arising from maternal depletion and maternal morbidity from repeated childbearing. Improved maternal health care is another major factor in maternal mortality decline. Note, however, that these data predate the big donor thrust from the mid-1990s, aimed at improving reducing maternal mortality.

6. Conclusions

The argument that has raged for half a century over the relationship between population and economic development has distracted people from recognizing that there is in fact little disagreement over the bottom line. There is wide consensus that appropriate policy environments and technological advances are key to improving standards of living ─ and that population dynamics play an important secondary role in this process.[23] A combination of policies is in order, as the World Bank put it:

> In short, policies to reduce population growth can make an important contribution to development (especially in the long run), but their beneficial effects will be greatly diminished if they are not supported by the right macroeconomic and sectoral policies. At the same time, failure to address the population problem will itself reduce the set of macroeconomic and sectoral policies that are possible, and permanently foreclose some long-run development options. (World Bank 1984:105)

Recent studies conclude that reducing fertility facilitates economic growth in low-income countries. Low dependency ratios (resulting from fertility decline) create a window of opportunity for savings, increased productivity, and investment ─ which if properly managed can transform living standards permanently. The more rapid the fertility decline in a region, the wider the window of opportunity, though its duration will be shorter because the population will age more rapidly. They also indicate that rapid population growth can be a constraint on economic growth, especially in poor countries with policies that do not encourage rapid rise in productivity. Micro-studies also find that lower fertility is also associated with better child health and schooling, reduced maternal mortality and morbidity, increased women's labor force participation, and higher household earnings. This is quite aside from the intrinsic human right of being able to control one's own fertility.

Hopefully these recent studies will put this debate to rest. Meanwhile, the debate has helped discourage donors from investing in family planning programs. While these are by no means the only policy lever to help reduce fertility, they are an effective but neglected lever with a clear rationale for public funding. This has been a missed opportunity, especially for the Sub-Saharan African region, where fertility

remains high and pressures on resources have been increasing. Much of the growth achieved by countries in this region is diluted by population growth. Through careful effort, Tanzania has achieved 6-7 percent real GDP growth over the past decade, but the effect of this on a per capita basis is almost halved by population growth (IMF 2010b:5).

Family planning programs are intrinsic to anti-poverty efforts by facilitating increases in living standards. They also form part of a package of measures addressing basic government failures that help sustain poverty and high fertility ─ including efforts to improve health and schooling, and to expand income-earning opportunities. Family planning programs help by increasing access to contraception, and by providing informational outreach to enhance perception of the benefits of shifting to a more secure equilibrium in which people have fewer children and are able to invest more in them.

The developing world offers sharply contrasting models. At one end of the spectrum is the East Asian region, where policies highly conducive to rapid economic growth were boosted by low dependency ratios resulting from rapid fertility decline. These countries are using these favorable conditions to build up human and physical assets, thus transforming their economies and locking in high growth potential even after the demographic "window of opportunity" closes and the population starts aging. At the other end of the spectrum is Sub-Saharan Africa, characterized by high fertility and low growth in income per capita. The fact that many countries in this region have shown some fertility decline suggests a decline in desired family size, and family planning programs can build on this and accelerate fertility decline.

Rapid population growth exacerbates an even less tractable problem ─ environmental change and the management of global common property resources, whose depreciation will affect the sustainability of production possibilities. While changing consumption patterns with rising incomes is a strong driver of pressure on these resources, population growth is also key (Figure 1). Managing global common property resources has proven to be politically very challenging and ridden with difficulties. Family planning programs are far simpler to design and implement. The most feasible way to reduce mankind's ecological footprint may be to further reduce the number of feet being born.

References

Acemoglu, Daron, and Simon Johnson. 2007. "Disease and Development: The Effect of Life Expectancy on Economic Growth", *Journal of Political Economy*, 115(6): 925-85.

Arrow, Kenneth J. 1969. "The Organization of Economic Activity: Issues Pertinent to the Choice of Market versus Non-market Allocations", Washington, D.C.: Joint Economic Committee of Congress.

Arrow, Kenneth, Partha Dasgupta, Lawrence Goulder, Gretchen Daily, Paul Ehrlich, Geoffrey Heal, Simon Levin, Karl-Göran Mäler, Stephen Schneider, David Starrett, and Brian Walker. 2004. "Are We Consuming Too Much?" *Journal of Economic Perspectives*, 18(3): 147–172.

Ashraf, Quamrul H., David N. Weil, and Joshua Wilde.2010. "The Effect of Interventions to Reduce Fertility on Economic Growth" Providence RI: Brown University

Badiane , Ousmane. 2008. "Sustaining and Accelerating Africa's Agricultural Growth Recovery in the Context of Changing Global Food Prices", Washington DC: IFPRI Policy Brief

Barnett Harold J. and Chandler Morse. 1963. *Scarcity and growth: the economics of natural resource availability*, Baltimore: Johns Hopkins Press.

Bates, Robert H. 1981. *Markets and States in Tropical Africa: the political basis of agricultural policies*, Berkeley: University of California Press.

Behrman, Jere R., Alexis Murphy, Agnes Quisumbing, Usha Ramakrishnan, and Kathryn Yount. 2006. "What is the real impact of schooling on age of first union and age of first parenting? New evidence from Guatemala", Washington DC: The World Bank Policy Research Working Paper 4023.

Besley, Tim. 1995. "Property Rights and Investment Incentives: Theory and Evidence from Ghana." *Journal of Political Economy*, 103(5): 903-937.

Bhat, P.N. Mari. 1996. "Contours of fertility decline in India: A district level study based on the 1991Census", in K. Srinivasan (ed) *Population Policy and Reproductive Health,* New Delhi: Hindustan Publishing Corporation.

Binswanger, Hans P. and Prabhu L. Pingali. 1988. "Technological Priorities for Farming in SubSaharan Africa", *The World Bank Research Observer* 3(1):81-98.

Birdsall, Nancy. 1994. "Another look at population and global warming". *Proceedings of the UN expert group meeting on population, environment and development*. New York, United Nations: 39-54.

Birdsall, Nancy, Allen C Kelley, and Steve W. Sinding (eds). 2001. *Population Matters: Demographic Change, Economic Growth, and Poverty in the Developing World,* Oxford: Oxford University Press.

Bloom, David E. and Jeffrey G. Williamson. 1998. "Demographic Transitions and Economic Miracles in Emerging Asia" *World Bank Economic Review* 12(3): 419-455.

Bongaarts, John. 1997. "The role of family planning programmes in contemporary fertility transitions," in Gavin W. Jones, Robert M. Douglas, John C. Caldwell, and Rennie M. D'Souza (eds.), *The Continuing Demographic Transition*. Oxford: Clarendon Press, pp. 422–444.

Boserup, Ester. 1965. *The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure,* Chicago: Aldine.

Boserup, Ester. 1981. *Population and Technological Change: A Study of Long-Term Trends,* Chicago: University of Chicago Press.

Breierova, Lucia, and Esther Duflo. 2004. "The Impact of Education on Fertility and Child Mortality: Do Fathers Really Matter Less Than Mothers? Cambridge, MA: NBER Working Paper 10513.

CPDRC (China Population Development Research Center, and National Population and Family Planning Commission) 2009. *Population and Family Planning Data Handbook*, Beijing: China Population Press.

Chen, Shaohua, and Martin Ravallion. 2008. "China is poorer than we thought, but no less successful in the fight against poverty." World Bank Policy Research Paper No. 4621.

Coale, Ansley J. and Edgar M. Hoover. 1958. *Population Growth and Economic Development in Low Income Countries: a case study of India's prospects,* Princeton: Princeton University Press.

Collier, Paul, and Benedikt Goderis. 2007. "Commodity Prices, Growth, and the Natural Resource Curse: Reconciling a Conundrum", Oxford University: Centre for the Study of African Economies Working Paper 274.

Cronqvist, Henrik and Richard Thaler. 2004. "Design choices in privatized social-security systems: Learning from the Swedish experience." *American Economic Review* 94 (2): 424-428.

Dasgupta, Partha. 2001. *Human Well-Being and the Natural Environment*, Oxford: Oxford University Press.

Dasgupta, Partha. 2010. "Nature's role in sustaining economic development", *Philosophical Transactions of the Royal Society* 365(1537):5-11.

Dasgupta, Partha, Karl-Göran Mäler, and Alessandro Vercelli (eds). 1997. *The Economics of Transnational Commons*, Oxford: Clarendon Press.

Das Gupta, Monica. 1995. "Fertility decline in Punjab, India: parallels with historical Europe", *Population Studies* 49(3): 481-500.

DellaVigna, Stefano, and Ethan Kaplan. 2007. "The Fox News Effect: Media Bias and Voting," *Quarterly Journal of Economics,* 122: 1187–1234.

Demeny, Paul. 2011. "Population Policy and the Demographic Transition: Performance, Prospects, and Options" *Population and Development Review* 37 (Supplement): 249–274.

Diaz, Robert J. and Rutger Rosenberg. 2008. "Spreading Dead Zones and Consequences for Marine Ecosystems" *Science* 321:926-928.

Djurfeldt, Göran, Hans Homén, Magnus Jirström and Rolf Larsson. 2006. *Addressing food crisis in Africa: What can sub-saharan Africa learn from Asian experiences in addressing its food crisis?* Stockhom: Swedish International Development Cooperation Agency (SIDA).

Domar, Evsey D. 1946. "Capital Expansion, Rate of Growth, and Employment", *Econometrica* 14(2):137-47.

Duflo, Esther. 2001. "Schooling and Labor Market Consequences of School Construction in Indonesia: Evidence from an Unusual Policy Experiment." *American Economic Review*, 91(4): 795–813.

Dyson, Tim. 2005. "On development, demography and climate change: the end of the world as we know it?" *Population and Environment* 27 (2): 117-149.

Eastwood, Robert, and Michael Lipton. 1999. "The impact of changes in human fertility on poverty, *Journal of Development Studies* 36(1): 1-30.

Eastwood, Robert, and Michael Lipton. 2011. "Demographic Transition in Sub-Saharan Africa: How Big Will the Economic Dividend Be?" *Population Studies* 65 (1): 9-35

Ehrlich, Paul R. 1968. *The Population Bomb.*. Ballantine Books

FAO (Food and Agriculture Organisation) 2003. *World Agriculture: Towards 2015/2030: An FAO Perspective.* London: Earthscan.

Foster, Andrew D. and Mark.R. Rosenzweig. 1995. "Learning by Doing and Learning from Others: Human Capital and Technical Change in Agriculture", *Journal of Political Economy*, 103 (6):1176-1209.

Galor, Oded, and David Weil. 2000. "Population, Technology, and Growth: From Malthusian Stagnation to the Demographic Transition and Beyond", *American Economic Review*, 90(4):806-828.

Garenne, Michel and Veronique Joseph. 2002. "The Timing of the Fertility Transition in Sub-Saharan Africa." *World Development* 30(10): 1835-1843.

Garenne, Michel. 2008. *Fertility Changes in Sub-Saharan Africa*, Calverton MD, USA: Macro International Inc. DHS Comparative Reports 18.

Gillespie, Duff, Saifuddin Ahmed, Amy Tsui, and Scott Radloff. 2007. "Unwanted fertility among the poor: an inequity?" Bulletin of the World Health Organization 85 (2): 100-107

Glover, Donald R., and Julian L. Simon. 1975. "The Effect of Population Density Upon Infrastructure: The Case of Road Building", *Economic Development and Cultural Change* 23(3): 453-468.

Green, Elliott D. 2010. "The Political Demography of Conflict in Modern Africa", London: London School of Economics, Development Studies Institute (DESTIN) Working Paper No.10-111.

Harrod, Roy. 1939. "An Essay in Dynamic Theory", *The Economic Journal* 49(193): 14–33.

Hatton, Timothy J., and Jeffrey G. Williamson. 2003. "Demographic and Economic Pressure on Emigration out of Africa", *Scandinavian Journal of Economics* 105(3): 465–486.

Higgins, Matthew, and Jeffrey Williamson.1997. "Age Structure Dynamics in Asia and Dependence on Foreign Capital", *Population and Development Review* 23 (2): 261-293.

(IMF) International Monetary Fund. 2010a. *World Economic Outlook Database April 2006* (accessed 15 December 2010) http://www.imf.org/external/pubs/ft/weo/2006/01/data/dbcselm.cfm?G=2001.

(IMF) International Monetary Fund. 2010b. Tanzania: Seventh Review Under the Policy Support Instrument, Second Review Under the Exogenous Shocks Facility, and Request for a New Three-Year Policy Support Instrument—Staff Report; Staff Supplement; Press Release on the Executive Board Discussion; and Statement by the Executive Director for Tanzania. Washington DC: IMF Country Report No. 10/173 (http://www.imf.org/external/pubs/ft/scr/2010/cr10173.pdf).

(IMF) International Monetary Fund. 2011. *World Economic Ouput Update*, Washington DC: IMF http://www.imf.org/external/pubs/ft/weo/2011/update/01/pdf/0111.pdf

Jayne, Thomas S., Takashi Yamano, Michael T. Weber, David Tschirley, Rui Benfica, Antony Chapoto, and Ballard Zulu. 2003. "Smallholder Income and Land Distribution in Africa: Implications for Poverty Reduction Strategies", *Food Policy 28*(3), 253-275.

Jensen, Robert, and Emily Oster. 2009. "The Power of TV: Cable Television and Women's Status in India", *Quarterly Journal of Economics* 124(3):1057-94.

Johnson, D. Gale, and Ronald D. Lee (eds). 1987. *Population Growth and Economic Development: Issues and Evidence*, (US National Research Council Committee on Population, Working Group on Population Growth and Economic Development), Madison WI and London England: The University of Wisconsin Press.

Joshi, Shareen and T. P. Schultz, 2007, "Family Planning an Investment in Development: Evaluation of a Program's Consequences in Matlab, Bangladesh", *Economic Growth Center Discussion Paper* No. 951, Yale University, New Haven CT.

Kane, Penny, and and Ching Y. Choi. 1999. "China's one child family policy", *British Medical Journal* 319(7215): 992–994.

Kelley, Allen C. 1988. "Economic Consequences of Population Change in the Third World," *Journal of Economic Literature* 26 (4):1685-1728.

Kelley Allen C. and Robert M. Schmidt. 1996. "Saving, Dependency and Development", *Journal of Population Economics* 9(4):365–386.

Kelley, Allen C., Robert M. Schmidt. 2005. "Evolution of recent economic-demographic modeling: A synthesis" *Journal of Population Economics* 18:275–300.

Klasen, Stephan, and Thorsten Nestmann. 2006. "Population, population density and technological change," *Journal of Population Economics*, 19(3): 611-626.

Kremer, Michael. 1993. "Population Growth and Technological Change: One Million B.C. to 1990", *The Quarterly Journal of Economics* 108(3): 681-716.

Kuznets, Simon, 1960. "Population Change and Aggregate Output," in *Demographic and Economic Change in Developed Countries*. Special Conference series, no.11. Universities – National Bureau Committee for Economic Research. Princeton, NJ: Princeton University Press, 324-40.

Kuznets, Simon, 1967. "Population and Economic Growth," in *Population Problems.Proceedings of the American Philosophical Society* 3, 170-93. Reprinted in Simon Kuznets *Population, Capital and Growth: Selected Essays*. New York: W.W. Norton & Co., 1973, 1-48.

Laczko, Frank and Christine Aghazarm (eds). 2009. *Migration, Environment and Climate Change: assessing the evidence*, Geneva: International Organization for Migration.

La Ferrara, Eliana, Alberto Chong, and Suzanne Duryea. 2008. "Soap Operas and Fertility: Evidence from Brazil", Duke University: Bureau for Research and Economic Analysis of Development (BREAD) Working Paper No. 172.

Lee, Ronald D. 1983. *Determinants of Fertility Change in Developing Countries*, Academic Press.

Lee, Ronald D. 1990. "Comment: The Second Tragedy of the Commons", *Population and Development Review* 16(Supplement):315-322.

Lee, Ronald. 2009. "New Perspectives on Population Growth and Economic Development", paper presented at the International Union for the Scientific Study of Population Conference, Marrakech.

Lee, Ronald D., and Tim Miller. 1990. "Population Policy and Externalities to Childbearing", *Annals of the American Academy of Political and Social Science* 510 (July):17-32.

Lotze-Campen, Hermann, Alexander Popp, Jan Philipp Dietrich, and Michael Krause, 2009. "Competition for land between food, bioenergy and conservation", Washington DC: The World Bank, Background Note to the World Development Report 2010.

Mamdani, M. 2001. *When Victims Become Killers: Colonialism, Nativism, and the Genocide in Rwanda*. Princeton, N.J.: Princeton University Press.

McNicoll, Geoffrey. 1984. "Consequences of rapid population growth: overview and assessment", *Population and Development Review* 10(2):177-240.

McNicoll, Geoffrey , 2011. "Achievers and Laggards in Demographic Transition: A Comparison of Indonesia and Nigeria", *Population and Development Review* 37 (Supplement): 191–214

Meadows, Donella H., Dennis L. Meadows, Jørgen Randers, and William W. Behrens III. 1972. *The Limits to Growth*, New York: Universe Books

Menken, Jane, Linda Duffy, and Randall Kuhn. 2003. "Childbearing and Women's Survival: New Evidence from Rural Bangladesh." *Population and Development Review* 29(3):405–26.

Miller, Grant. 2010. Contraception as Development? New Evidence from Family Planning in Colombia", *Economic Journal* 120(545):709-736.

Molyneaux, John W. and Paul J. Gertler. 2000. "The Impact of Targeted Family Planning Programs in Indonesia" *Population and Development Review* (26 Supplement: Population and Economic Change in East Asia): 61-85.

NRC (National Research Council). 1986. *Population Growth and Economic Development: Policy Questions* Washington D.C.: National Academy Press.

NRC (National Research Council). 1989. *Contraception and Reproduction: Health Consequences for Women and Children in the Developing World,* Washington DC: National Academy Press.

Osili, Una Okonkwo and B. T. Long. 2008. "Does Female Schooling Reduce Fertility? Evidence from Nigeria" *Journal of Development Economics* 87(1): 57-75

O'Neill, Brian C., Michael Dalton, Regina Fuchs, Leiwen Jiang, Shonali Pachauri, and Katarina Zigova. 2010. "Global demographic trends and future carbon emissions", *Proceedings of the National Academy of Sciences* 107(41): 17521-6.

Ostrom, Elinor. 1990. *Governing the commons: The evolution of institutions for collective action*. Cambridge: Cambridge University Press.

Otsuka, Keijiro, and Frank Place (eds). 2001. *Land Tenure and Natural Resource Management: A comparative study of agrarian communities in Asia and Africa,* Baltimore: Johns Hopkins Press.

Page, Hilary J., and Ron Lesthaeghe (eds).1981.Child-Spacing in Tropical Africa*: Traditions and Change*, London: Academic Press.

Peters, Pauline. 2004. "Inequality and Social Conflict Over Land in Africa", *Journal of Agrarian Change* 4(3): 269-314.

Potter, Neal and Francis T. Christy, Jr. 1962. *Trends in Natural Resource Commodities,* Baltimore: Johns Hopkins University Press.

Pritchett, Lant H. 1994a. "Desired Fertility and the Impact of Population Policies", *Population and Development Review*, 20(1): 1-55.

Pritchett, Lant H. 1994b. "The Impact of Population Policies: Reply", *Population and Development Review*, 20(3): 621-30.

Rogers, Everett M., Peter W. Vaughan, Ramadhan M.A. Swalehe, Nagesh Rao, Peer Svenkerud, and Suruchi Sood. 1999. "Effects of an Entertainment-education Radio Soap Opera on Family Planning Behavior in Tanzania", *Studies in Family Planning* 30 (3): 193–211.

Rosenzweig, Mark and Kenneth I. Wolpin. 1980. "Testing the Quantity-Quality Fertility Model: The Use of Twins as a Natural Experiment" *Econometrica* 48(1): 227-240.

Rosenzweig, Mark and T. Paul Schultz. 1982. "Child Mortality and Fertility in Colombia", *Health Policy and Education* 2: 305-348.

Rosenzweig, Mark R. and Junsen Zhang. 2009. "Do Population Control Policies Induce More Human Capital Investment? Twins, Birth Weight and China's 'One-Child' Policy", *Review of Economic Studies* Vol. 76(3):1149-74.

Royal Society, The. 2009. *Reaping the Benefits: science and the sustainable intensification of global agriculture*, London: The Royal Society.

Schultz, T. Paul, 1973, "Explanations of Birth Rate Changes over Space and Time: a Study of Taiwan", *Journal of Political Economy* 81(2): S238-S274.

Schultz, T. Paul. 1987. "School Expenditures and Enrolments, 1960-80: The Effects of Income, Prices, and Population Growth", Chapter 11 in D. Gale Johnson and Ronald D. Lee (eds). 1987. *Population Growth and Economic Development: Issues and Evidence*, (US National Research Council Committee on Population, Working Group on Population Growth and Economic Development) Madison WI and London England: The University of Wisconsin Press, pages 413-476.

Schultz, T. Paul. 1992. "Assessing Family Planning Cost-Effectiveness", in *Family Planning Programmes and Fertility*, J.F. Phillips and J.A. Press, New York: Oxford University Press, pp. 78-105.

Schultz, T. Paul. 2002. "Why governments should invest more to educate girls", *World Development* 30(2):207–25.

Schultz, T. Paul. 2009. "How Does Family Planning Promote Development?: Evidence from a Social Experiment in Matlab, Bangladesh, 1977 – 1996" (http://www.econ.yale.edu/~pschultz/TPS_10_30_QJE.pdf).

Scrimshaw, Susan C.M. 1984. "Infanticide in Human Populations: Societal and Individual Concerns". In Glenn Hausfater and Sarah B. Hrdy (eds.) *Infanticide: Comparative and Evolutionary*. New York: Aldine.

Simon, Julian L. 1981. *The Ultimate Resource* Princeton: Princeton University Press.

Simon, Julian L. 1996. *The Ultimate Resource 2* Princeton: Princeton University Press.

Solow, Robert M. 1956. "A Contribution to the Theory of Economic Growth," *Quarterly Journal of Economics* 70 (1): 65–94.

Solow, Robert M. 1957. "Technical Change and the Aggregate Production Function," *Review of Economics and Statistics* 3(3): 312–320.

Stern, Nicholas. 2006. "Introduction", *The Economics of Climate Change The Stern Review*. Cambridge UK, New York USA: Cambridge University Press.

Tiffen, Mary, Michael Mortimore, and Francis Gichuki. 1994. *More People, Less Erosion: environmental recovery in Kenya,* Chichester: John Wiley & Sons.

Tsuya, Noriko O., Wang Feng, George Alter and James Z. Lee (eds.) 2010. *Prudence and Pressure Reproduction and Human Agency in Europe and Asia, 1700-1900,* Cambridge MA: MIT Press.

United Nations. 2009. *World Population Prospects: The 2008 Revision,* New York: United Nations.

Unsworth, Sue, and Mick Moore. 2010. *An Upside-down View of Governance*, University of Sussex UK, Institute of Development Studies.

Weil, David N. and Joshua Wilde. 2009. "How Relevant Is Malthus for Economic Development Today?" *American Economic Review* 99(2): 255–260.

World Bank.1984. *World Development Report 1984,* New York: Oxford University Press.

World Bank 2007a. *Challenges of African Growth: Opportunities, Constraints, and Strategic Directions,* Washington DC: The World Bank.

World Bank. 2007b. *World Development Report 2008: Agriculture for Development,* Washington DC: The World Bank.

World Bank. 2009a. *From poor areas to poor people: China's evolving poverty reduction agenda*, Washington DC: The World Bank.

World Bank. 2010a. *World Development Report 2010: Development and Climate Change,* Washington DC: The World Bank.

World Bank. 2010b. *World Development Indicators (WDI) 2010,* Washington DC: The World Bank.

World Health Organization, UNICEF, UNFPA, and The World Bank. 2010. *Trends in Maternal Mortality 1990-2008*, Geneva: World Health Organization.

Figure 1: Required growth in agricultural productivity
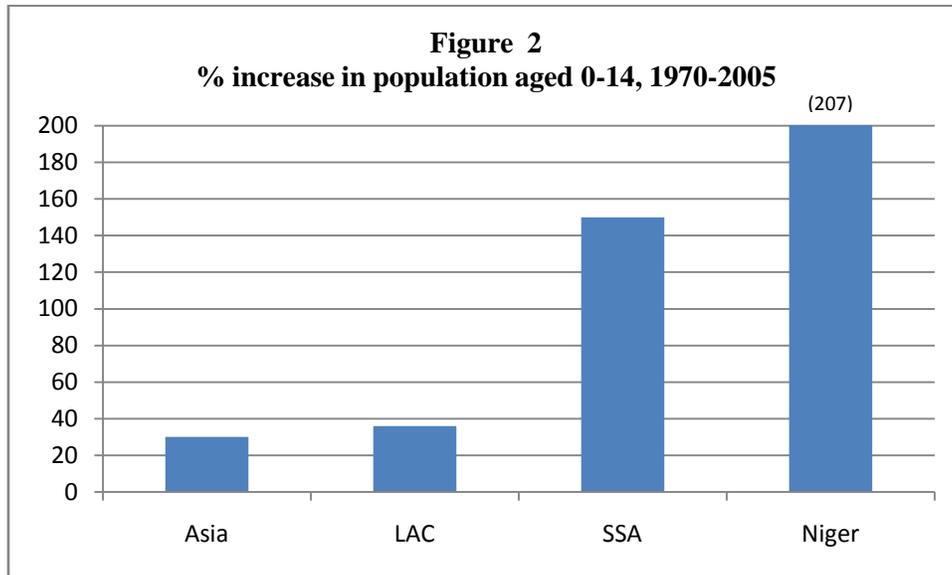## under different assumptions of climate change and population growth

Population growth and climate change mean that increases in agricultural productivity must accelerate to meet the growing food demands as incomes rise
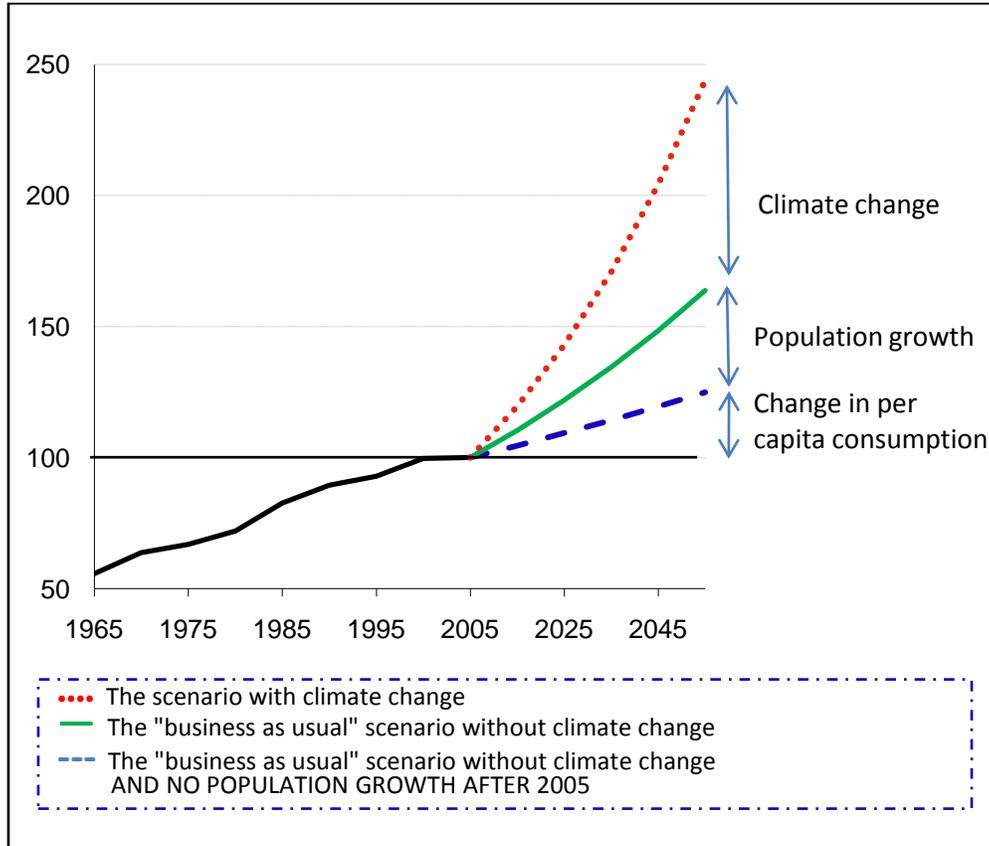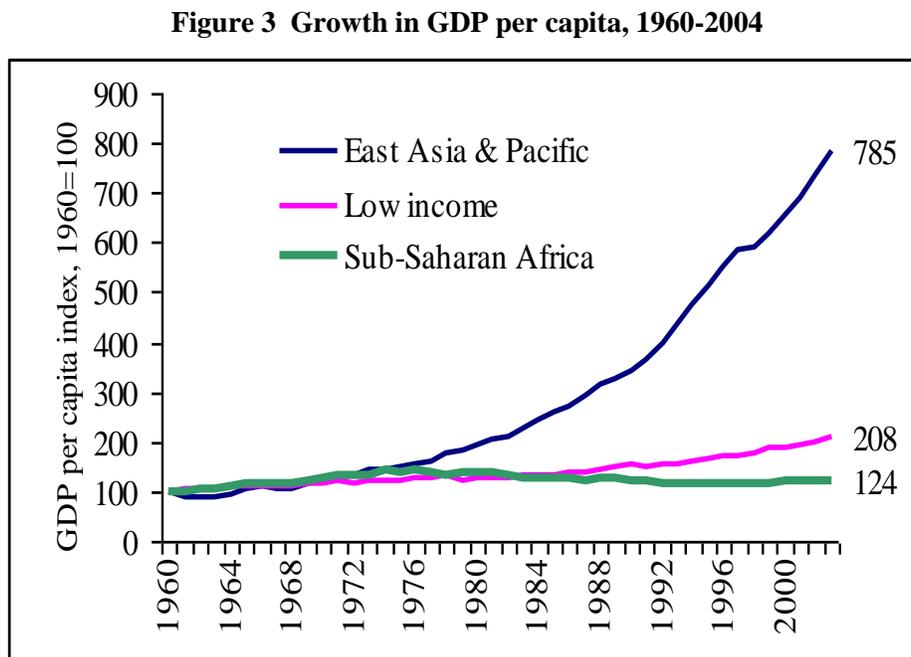

Source: World Bank (2010a) *World Development Report 2010*: Figure 3.5 (derived from Lotze-Campen et al 2009). We thank Dr Lotze-Campen for disaggregating the "business as usual" scenario into two estimates: (1) with population held constant at the 2005 level, and (2) the WDR 2010's "business as usual" scenario, which includes anticipated population increase to 9 billion by 2055.

Explanatory note from the original figure in the WDR 2010:
"The figure shows the required growth[24] in an agricultural productivity index under two scenarios. In this index, 100 indicates productivity in 2005. The projections include all major food and feed crops. The green line represents a scenario without climate change of global population increasing to 9 billion in 2055; total calorie consumption per capita and the dietary share of animal calories increasing in proportion to rising per capita income from economic growth; further trade liberalization (doubling the share of agricultural trade in total production over the next 50 years); cropland continuing to grow at historical rates of 0.8 percent a year; and no climate change impacts. The orange line represents a scenario of climate change impacts and associated societal responses (IPCC SRES A2): no CO_2 fertilization, and agricultural trade reduced to 1995 levels (about 7 percent of total production) on the assumption that climate change-related price volatility triggers protectionism and that mitigation policy curbs the expansion of cropland (because of forest conservation activities) and increases demand for bioenergy (reaching 100 EJ [10^{18} joules] globally in 2055)."
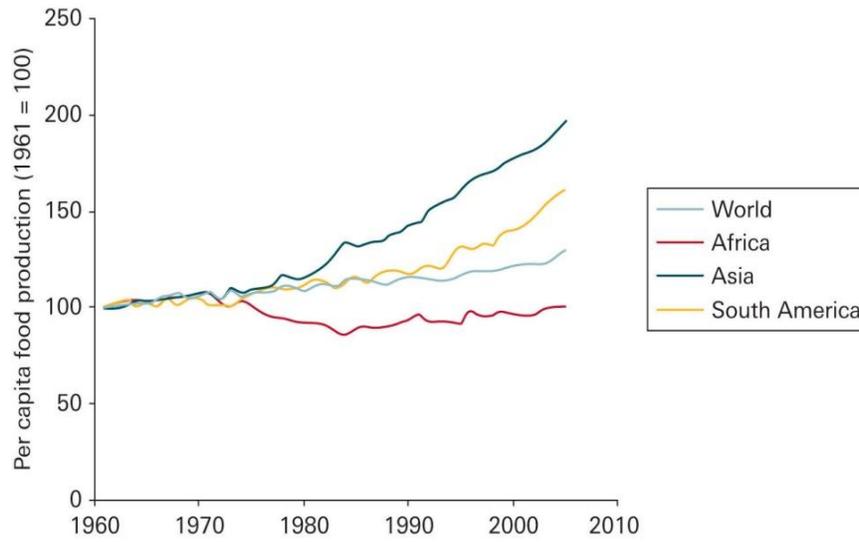
**Figure 2
% increase in population aged 0-14, 1970-2005**

(207)

| Asia | LAC | SSA | Niger |

Figure 3 Growth in GDP per capita, 1960-2004

GDP per capita index, 1960=100

- East Asia & Pacific
- Low income
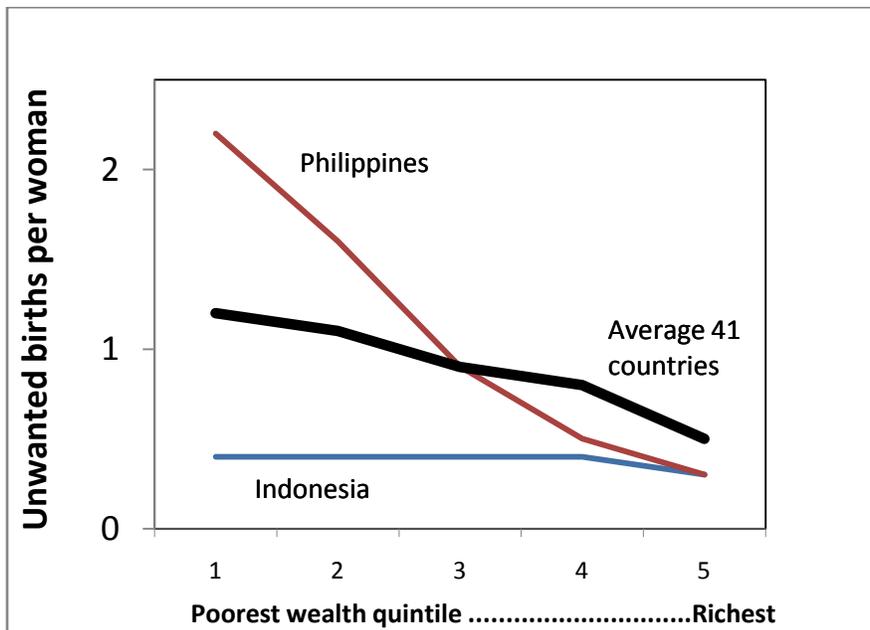- Sub-Saharan Africa

785

208

124

Note: GDP per capita index 1960=100.

23

Figure 4: Changes in per capita food production, 1961-2005

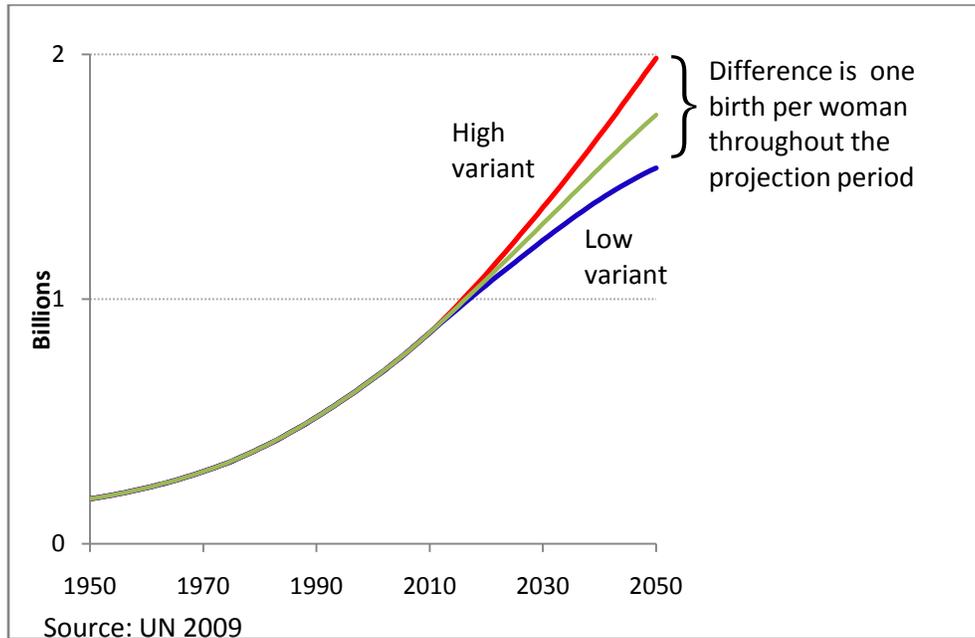*Source:* The Royal Society 2009: Figure 1.4

**Figure 5: Unwanted fertility is higher among the poor,
and effective family planning programs can reduce this gap**

Source: Gillespie et al (2007): Table 1

**Figure 6: Population projections for sub-Saharan Africa**

Maintaining one less birth per woman reduces projected population size in 2050 by half a billion

Source: UN 2009

Note: The UN creates the high and low variants by keeping the TFR 0.5 births higher or lower than the median variant throughout the projection period. Hence the total difference between the high and low variants is 1 birth per woman
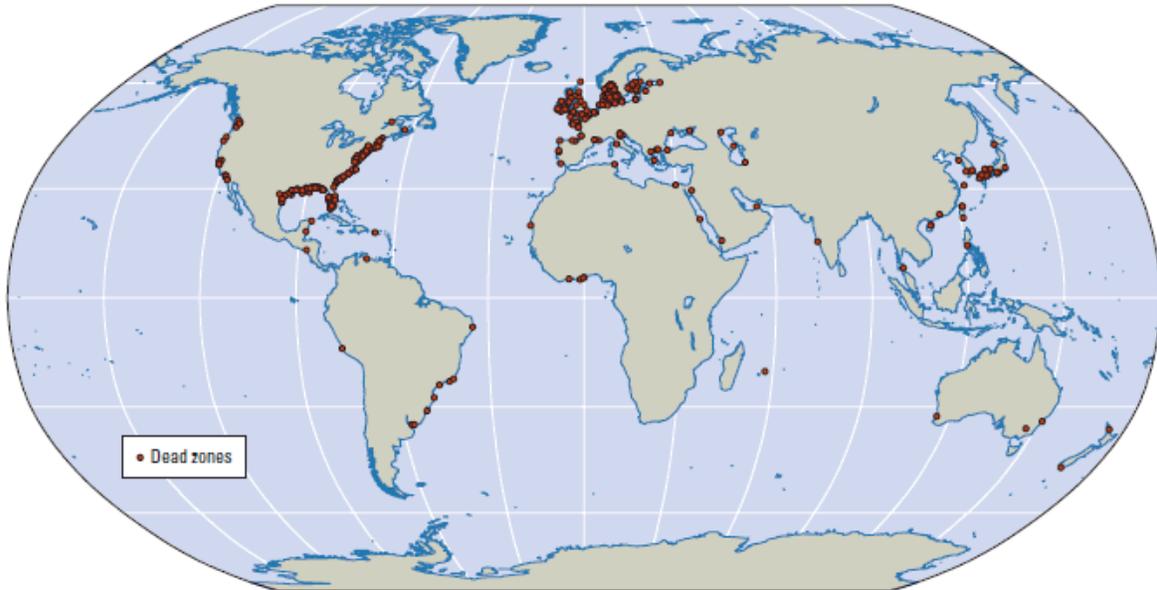
Figure 7

Fertility Decline Helps Improve Women's Health: adult women's mortality fell faster than men's

Trends in the Ratio of Male to Female Mortality, India, 1970-1990
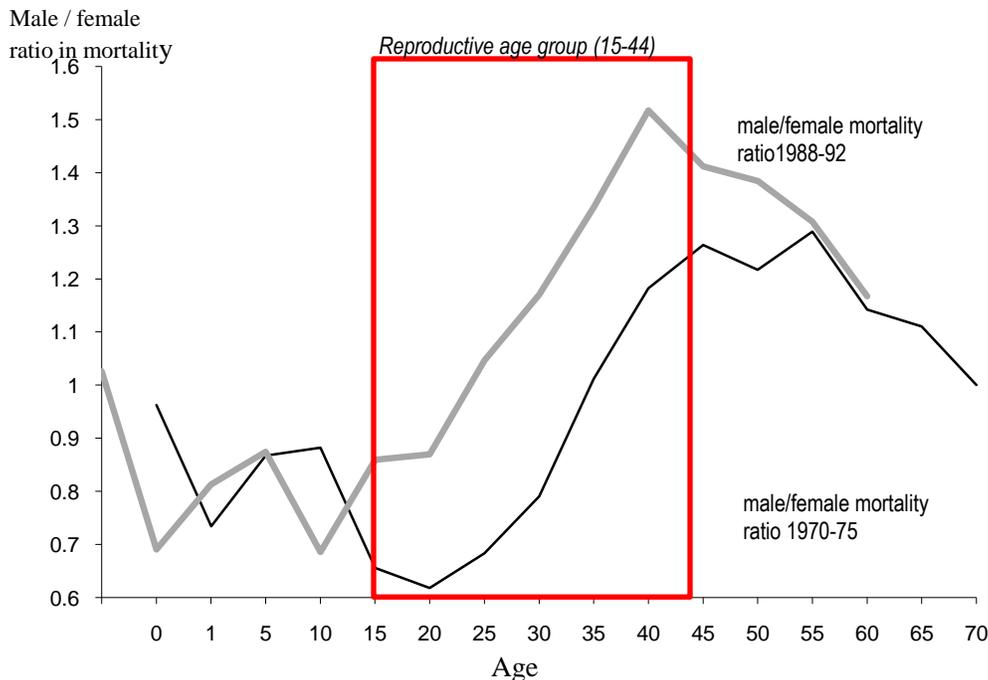
Source: Government of India, Sample Registration Bulletin 16(1), June 1982, and SRS Based Abridged Life Tables 1988-92, New Delhi: Registrar-General of India.

Map 1: Intensive agriculture in the developed world has contributed to the proliferation of dead zones

Source: Diaz and Rosenberg 2008.

Source: World Bank (2010a) *World Development Report 2010*: Map 3.4 (derived from Diaz and Rosenberg 2008).

Explanatory note from the original figure in the WDR 2010: "In the developed world intensive agriculture has often come at high environmental cost, including runoff of excess fertilizers leading to dead zones in coastal areas. Dead zones are defined as extreme hypoxic zones, that is, areas where oxygen concentrations are lower than 0.5 milliliters of oxygen per liter of water. These conditions normally lead to mass mortality of sea organisms, although in some of these zones organisms have been found that can survive at oxygen levels of 0.1 milliliter per liter of water."

Endnotes

[1] It is associated with later entry into union and higher age at first birth in settings as varied as Guatemala, Indonesia, and Nigeria (Behrman et al 2006; Breierova and Duflo 2004; Osili and Long 2008).

[2] For example, expanding access to family planning services was introduced into the Millenium Development Goals many years after these goals were initially adopted.

[3] This is indicated by many studies across Europe, Asia, and Africa. See for example Scrimshaw (1984), Das Gupta (1995), and the papers in Page and Lesthaeghe (eds) 1981 and Tsuya et al (eds) 2010.

[4] *Source*: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, *World Population Prospects: The 2008 Revision*, http://esa.un.org/unpp, Tuesday, August 24, 2010; 4:37:08 PM

[5] http://www-bcf.usc.edu/~easterl/papers/SimonKuznets.pdf

[6] In ongoing research, Ashraf, Weil and Wilde (2010) simulate the effect on Nigeria's per capita output, if its Total Fertility Rate were to decline by 1.0 immediately and exogenously. Their model "allows for effects that run through schooling, the size and age structure of the population, capital accumulation, parental time input into child-rearing, and crowding of fixed natural resources". They estimate that this fertility decline (of one child per woman) would raise output per capita "by approximately 13.2% at a horizon of 20 years, and by 25.4% at a horizon of 50 years", and that the dependency effect is the dominant channel whereby this impact takes place.

Eastwood and Lipton (1999) did cross-national regressions that found that "higher fertility increases poverty both by retarding economic growth and by skewing distribution against the poor".

[7] Contraceptive and abortion services were extended to the rural areas. "At local level, collective incomes and allocation of funds—for health care, welfare, and schools, for example—made it possible for couples to understand the effect of their personal family choices on the community. They also made it possible for the community to exercise pressure on those who wished to have children outside the agreed plans." (Kane and Choi 1999:992). The Total Fertility Rate fell from 6.4 1968 to 2.7 in 1978, and 2.0 by 1992 (CPDRC 2009: Table 3-3).

[8] See for example Ehrlich 1968, Meadows et al 1972

[9] These are Afghanistan, Timor-Leste, West Bank & Gaza, and Yemen.

[10] The decline began in the late 1960s and 1970s in urban areas, and about 10 years later in rural areas (Garenne and Joseph 2002). Some cities are at or below replacement levels (Garenne 2008). However, the fertility decline stalled in many countries, even in Ghana and Kenya which had shown significant decline (Garenne 2008:26).

[11] McNicoll (2011) argues that the slow pace of fertility decline in Nigeria (and perhaps also other countries in the region), as compared with Indonesia, is partly attributable to differences in institutional legacies from the past.

[12] WDR 2008 press release (http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:21517663~pagePK:64257043~piPK:437376~theSitePK:4607,00.html)

[13] Bates (1981:59):"Using political connections to secure land, publicly subsidized credit and forgiveness of debts, publicly subsidized and allocated fertilizer, and highly favorable terms for the importation and financing of capital equipment, influential members of the urban elite with close ties to the managers of the public bureaucracies have thus entered into food production in the northern savannah areas. . . . A major consequence of government efforts to promote food production in this area has been the development of disparities of wealth, social status, and political power within the savannah region. When similar policies have been adopted elsewhere in Africa, the consequences have been much the same."

[14] There may be a small uptick in GDP per agricultural person (World Bank 2007b:54), though this is barely detectable when the overall population is included --- so it may be partly an artifact of rural out-migration.

[15] Studies of the adoption of cost-effective new technologies show substantial evidence of learning spillovers—once one household accesses a successful technology others are quick to follow (see for example Foster and Rosenzweig 1995 on agricultural technologies). Because individual households do not appear to fully capture the benefits to their neighbors of their experimentation with these new technologies, spillovers create a classic case for public subsidy of experimentation with possibly beneficial technologies.

[16] Seeking to alter childbearing decisions may seem paternalistic. Yet it is largely accepted that the public sector has a responsibility to influence the set of opportunities and constraints faced by households when this affects the wellbeing of the collectivity. Subsidies and financial incentives are offered, for example, to encourage parents to

send their children to school and use health services. These measures are generally justified in terms of the social benefits of schooling. Safety net transfers are offered to those facing poverty, not only on humanitarian grounds but also because deep social inequalities can be socially corrosive. In other cases action is mandated for the public good, for example immunization or elementary schooling in many countries, and contributing to pension schemes to provide for old age. Mandating lower fertility is clearly unethical, but that is a long way from seeking to alter fertility desires and lowering barriers to contraceptive use.

[17] See for example Bhat (1996).

[18] DellaVigna and Kaplan (2007) show that mass media shape voter behavior. They examined the effect of Fox News, which was introduced between 1996-2000 in about 20 percent of US towns. It was found to significantly increase the Republican share of the vote in these towns between the 1996 and 2000 Presidential elections.

[19] This is the difference between the high and the low variant of the UN population projections.

[20] These include Schultz, 1973, 1992; Rosenzweig and Schultz, 1982; and Molyneaux and Gertler, 1994.

[21] Government programs may prioritize high-demand areas if their primary objective is to meet voter preferences. They may prioritize low-demand areas if their primary objective is to reduce population growth.

[22] Miller (2010:711-5) argues that program placement did not prioritize areas with either higher or lower demand. Schultz (personal communication) observed that the program prioritized high demand populations, and that therefore Miller may have over-estimated the impact of the program. In an earlier study, Rosenzweig and Schultz (1982) found evidence of the Colombian program's effectiveness in a cross sectional association between the regional intensity of program treatment and the regional level of fertility in Colombia (cited in Schultz 2009:4).

[23] Of course, countries with fertility levels far below replacement have the opposite problem of a shrinking laborforce, and shrinking tax base to support the aged.

[24] The original explanatory note said it was the required annual growth, Dr Lotze-Campen corrected this by deleting the word "annual".