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Role of Family Planning in the Climate Change Response

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Abstract

Outcomes in the IPCC's socioeconomic scenario modelling depend strongly on future population growth. These models treat population growth as dependent on economic and education outcomes. Consequently, population measures are not among their policy options. Historical data show, on the contrary, that population-focused voluntary family planning drove fertility decline in adopting countries, preceding and stimulating economic development and elevating women's status. Support for such measures has waned in the past two decades, resulting in a resurgence of global population growth. Recent UN projections have repeatedly been revised upward, demonstrating over-optimistic modelling of fertility decline. Nevertheless, the IPCC's SSP scenarios assume far lower populations, representing a dramatic divergence from recent trends. Continuing current population path is incompatible with outcomes which contain global warming under 2ºC. Policy-based projections of global population are presented, contrasting BAU with voluntary family planning adoption. With pro-active intervention, global population could yet peak around 9 billion. Current trends are more likely to see a population over 13 billion by 2100, unless calamitous mortality intervenes. Global support for family planning could reduce 2050 population by 15% and 2100 population by 45% compared with the current trend. Each year of delay adds around 100,000 to the (peacefully) achievable peak population.

Key words: Population growth, Greenhouse gas emissions, Shared socioeconomic pathways, Economic development, Family planning

Introduction

Between 2004 and 2009, least developed countries were invited by the United Nations Framework Convention on Climate Change (UNFCCC) to submit "National Adaptation Programmes of Action" (NAPAs), identifying their specific vulnerabilities to climate change and proposing projects for potential funding through the Global Environmental Facility. Of the 41 NAPAs submitted, 37 identified rapid population growth as a factor compounding the effects of climate change or impeding their ability to adapt (Bryant et al., 2009; Mutunga and Hardee, 2010). Despite this concern, none of the funded projects included a family planning component.

The literature on the interactions between population growth and vulnerability to environmental stresses is extensive. From food and water insecurity to exposure to floods, heat stress and infectious diseases, population density and growth are key determinants of vulnerability. Dos Santos et al. (2017) stress that the numbers of people without access to safe water is growing, particularly in informal settlements that dominate urban expansion in least developed countries. Water for crop production is also increasingly limited by population growth (Vörösmarty et al. 2000). It has been estimated that each additional billion people need fresh water equivalent to an extra 20 Nile Rivers (Bigas, 2012). Currently we are adding one billion every 12 years or less. Carter and Parker (2009, p676) evaluated threats to groundwater access in Africa, and observed,

> *"The climate change impacts [on groundwater] are likely to be significant, though uncertain in direction and magnitude, while the direct and indirect impacts of demographic change on both water resources and water demand are not only known with far greater certainty, but are also likely to be much larger. The combined effects of urban population growth, rising food demands and energy costs, and consequent demand for fresh water represent real cause for alarm, and these dwarf the likely impacts of climate change on groundwater resources, at least over the first half of the 21st century."*

Population growth not only increases the number of people exposed to flooding and natural disasters, but also contributes to increasing frequency and intensity of flooding, due to impervious surfaces and watershed alteration (Vidal 2017). Rainfall patterns may also be influenced: Zeng et al. (1999) found strong evidence that the reduction in rainfall in West Africa over recent decades was due in larger part to regional vegetation change (deforestation) than to global climate change. Increasing dependence on food imports (Worldwatch Institute 2015) has increased the urban poor's exposure to weather-related spikes in global food prices, which are closely linked to violent civil unrest (Lagi et al. 2011). The Population Institute's (2015) "Demographic Vulnerability Report" noted,

> "*Population pressures are also contributing to environmental degradation and political instability. In effect, rapid population growth is a challenge multiplier, and for many developing countries the challenges are formidable*."

It is relatively uncontentious that climate change adaptation in high-fertility countries would benefit from lower population growth. It is also widely recognised that at least 40% of pregnancies are unintended, in both developed and developing countries, and that over 200 million women have an unmet need for contraception. However, ironically the fact that reducing population growth would also help reduce greenhouse gas emissions appears to make population interventions less, rather than more, acceptable means of climate change response. This is an odd anomaly. In contrast, one does not hear biodiversity advocates decrying the protection of forests for the sake of carbon sequestration, on the grounds that biodiversity should be the sole consideration; they are only too pleased that this synergy may be used to advance their goals. Yet advancing the long-neglected goal of universal reproductive rights is more often claimed to be threatened rather than aided by the synergistic goals of reducing emissions and climate change vulnerability through population growth reduction. It is implied that such measures invoke coercive "population control" such as forced sterilisations, and detract from reducing the carbon footprint of the rich. Neither claim is valid.

Even in countries where per capita emissions are lowest, avoiding unwanted births through investments in voluntary family planning and girls' education would avoid greenhouse gas emissions at considerably lower cost than renewable energy initiatives, generally less than $10 per tonne (Wheeler and Hammer, 2010). Beyond being inexpensive in terms of carbon abatement, voluntary family planning programs have been shown to save more money than they cost by reducing demands on health, education, energy and other services. A USAID study of 16 sub-Saharan African countries in 2006 found that fulfilling the unmet need for family planning would not only contribute materially to attaining all other Millennium Development Goals, but each dollar spent on family planning saved between two and six dollars by reducing need for interventions to meet other development goals (Moreland and Talbird, 2006). Even in developed countries, where unwanted pregnancies are common and each avoided birth reduces far more emissions, net costs have been found to be negative. A recent program to reduce teen pregnancies in the USA state of Colorado lowered the teen birth rate and abortion rate by 40 and 42 percent respectively, and saw a similar decline in the number of unintended pregnancies in unmarried women under 25 (Tavernise, 2015). The program saved Medicaid around $5.85 in perinatal care for every $1 invested (Colorado Department of Public Health & Environment, 2015).

Far from reducing efforts in other areas, avoiding unwanted births simultaneously lowers the scale of other efforts needed to meet emissions reduction goals, and frees up resources available to those efforts. Nor is the focus entirely on less developed countries: as calculated by Murtaugh and Schlax (2009) for USA, and Wynes and Nicholas (2017) across OECD countries, having one child fewer has greater impact on a person’s lifetime emissions legacy than any other lifestyle choice. Concern about low fertility may be misplaced in a world with rising demand for migration.

Dependence of future greenhouse gas emissions on population growth

In models of future greenhouse gas emissions, the contribution of population growth is not neglected, but is often buried in model assumptions among the exogenous factors not amenable to policy interventions, and its influence on outcomes is rarely mentioned. For example, in the ‘roadmap’ of Rockström et al. (2017), renewable energy roll-out is expressed only in terms of percentage share of primary energy. The prospect of a doubling or more in energy demand, and the attribution of this demand growth among population growth, economic development or technology change, is thereby avoided altogether. Such population-energy-technology (PET) analyses have found that the sensitivity of emissions to population change is greater than that to change in GDP per capita by a factor of more than two (Jorgenson and Clark, 2010) to almost seven (Casey and Galor, 2017), when considering only carbon dioxide emissions from fossil fuels and industry (FFI).

Given the less flexible relationship between population and demand for land resources, the common omission of emissions from agriculture, biomass use and land use change underestimates the influence of population on emissions. Bajželj et al. (2014) found that greenhouse gas emissions from the food system were sensitive to population outcomes by a factor of 1.9, meaning that 10% higher population would result in 19% more emissions from the food system, assuming the same wealth and dietary preferences.

Using an economic-demographic model taking account of multiple channels of effects of change in fertility and population on economic growth, Casey and Galor (2017) estimated that moving from the medium to the low variant of the United Nations (2015) global population projection could reduce FFI emissions by 10% by 2050, and 35% by 2100, despite increasing income per capita. Similarly comparing the UN medium and low projections, and including emissions from the food system, O'Neill et al. (2010) estimated emissions reduction around 15% by 2050 and 35-42% by 2100. Their careful analysis accounted for changes in urbanisation, age distribution and household size, on a country-by-country basis.

These studies applied alternative population projections as exogenous factors, without identifying to what extent specific measures would achieve lower population outcomes. In this analysis, historical evidence for the effect of both economic advancement and voluntary family planning programs on population outcomes is examined, and future projections are based on whether or not remaining high-fertility countries adopt voluntary family planning programs, assuming they achieve the average outcome achieved by such programs in the past. It therefore more directly addresses the value of including population measures in the climate change response.

Population assumptions in climate change scenarios

Predicting future greenhouse gas emissions, and the effect of mitigation measures, involves many assumptions about future trends in economic, social and technological change and international relations. To help make such assumptions explicit and consistent between modelling exercises, and to explore the likely range of outcomes, scenario narratives are built describing alternate possible futures.

The socioeconomic scenarios developed by the IPCC have formed the basis of many attempts by independent research groups to model the impact of policy options on outcomes. The "shared socioeconomic pathways" (SSPs) described in the IPCC's Fifth Assessment Report (AR5) (IPCC, 2014) replace the previous SRES scenarios, named from the Special Report on Emissions Scenarios (IPCC, 2000). The SSPs are likely to remain the dominant framework for modelling for some years. The SSPs comprise five scenario "families" (O'Neill et al., 2013). In the base case, the scenario describes a future without policies to address climate change, setting assumptions about trends in key drivers and the interactions between them. Against this, modellers may vary policy, technology and other assumptions to generate mitigation scenarios.

Each of the SSPs has a different global population trajectory (van Vuuren et al., 2014). These projections depend primarily on the assumed timing, rate and extent of the fall in family size in remaining high-fertility countries, and to a lesser extent on assumptions about change in mortality rates, migration and family size in low-fertility countries (i.e. those below the "replacement rate", around 2.1 children per woman, at which children just replace their parents' generation in the absence of migration). However, the SSPs do not differ with respect to actions to influence fertility – none are included in any of the scenarios. This is because family size outcomes are assumed to be a product of economic and educational outcomes (KC and Lutz, 2014).

Figure 1 indicates the relative challenges posed for climate change adaptation and mitigation by each SSP baseline scenario, and the approximate trends in population and emissions per person among the SSPs (their actual population projections are given in Figure 7 below).

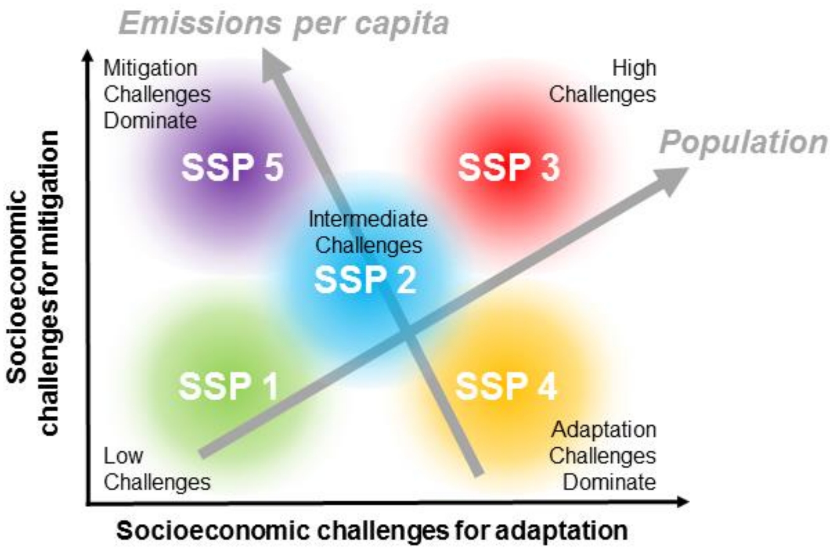

Figure 1. A conceptual map of the five families of IPCC Shared Socioeconomic Pathways (SSPs), in relation to the strength of mitigation and adaptation challenges posed by each scenario (after van Vuuren et al., 2014). Approximate trends in population outcomes and emissions per capita outcomes are superimposed. Population growth is most strongly related to adaptation challenges.

Notably, all but one (the worst-case scenario, SSP3) of the SSP scenario families anticipate a global population well below the UN's current medium projection – indeed, below the 95% probability range of the UN's 2015 probabilistic projections (UNDESA, 2015). The preferred scenario, SSP1, combines a very low global population with low per capita footprint in a world of more integrated and equitable governance. SSP5 combines a similarly low population path with high energy demands per person. For these two scenarios, population path is lower than the UN's "low fertility projection", which is not intended as a realistic scenario but as a sensitivity analysis: it merely applies a fertility rate (the average number of children per woman) 0.5 units lower than the medium projection, in all countries with immediate effect. Fertility is expected to fall steadily under the UN's medium projection, but no faster or slower in the low and high projection, after the initial adjustment of 0.5 units. However, a path similar to the SSP1 and UN low projection is achievable if fertility were reduced in remaining high-fertility countries faster and further than assumed in the UN projections.

The population outcome has a dominant influence on prospects for both mitigation and adaptation, as Young et al. (2009) also demonstrated with respect to the earlier SRES scenarios. Riahi et al. (2017) reported that, across six independent integrated assessment models running a total of 105 mitigation scenarios, outcomes as low as 2.6 W/m^2 climate forcing (consistent with below-2^{o}C warming) were found to be infeasible when applying SSP3. This was despite SSP3 assuming considerably less economic development than other scenarios. SSP3 also had no feasibility of increasing forest cover, and only SSP1 projected forest expansion as likely in the base scenario.

Current trends and future uncertainty in global population

It is vital to note that each of the UN's revisions in the past decade has increased the expected population, because fertility decline is not happening as fast as its medium scenario expects.

The UN's estimate for the year 2100 has increased by more than two billion in just 11 years (Figure 2). This suggests that the feasibility of more favourable climate change outcomes is being eroded over time, as global population growth is exceeding the expectations of lower-emissions models.

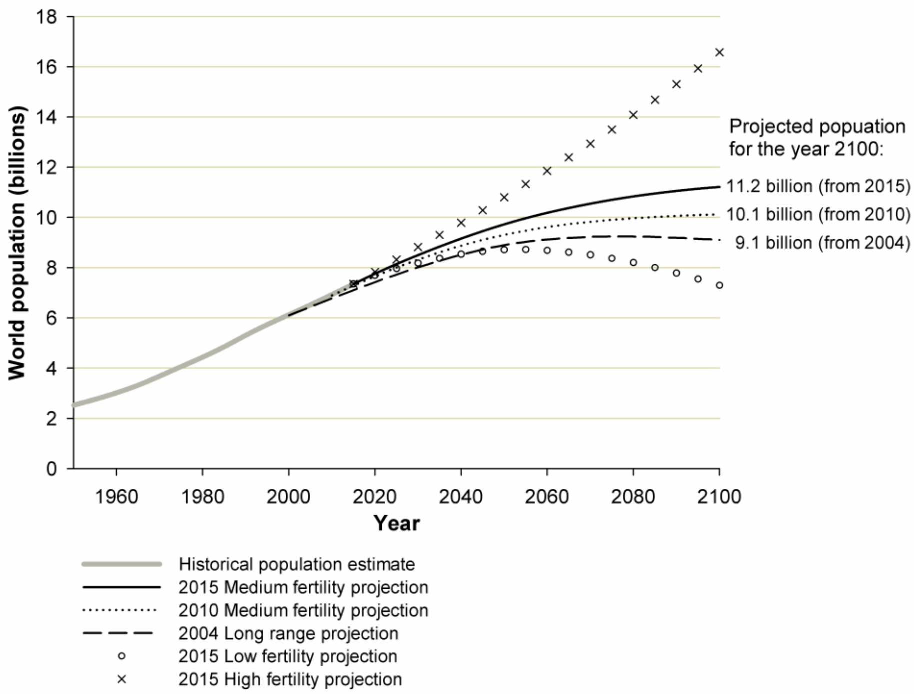

Figure 2. Population projections from the United Nations, showing the dramatic rise in expected outcomes since 2004. (Data sources: UNDESA 2004, 2011, 2015)

The reason for these regular upward revisions is obvious when we look at annual increments of global population growth (Figure 3). In many countries, rapid falls in fertility were occurring from the 1970s to 1990s, which had enabled the global population increment to peak in 1988 and to decline throughout the 1990s. However, since 2000, the increment has increased again. This is the result of fertility decline slowing, stalling or reversing since the mid-1990s, due to withdrawal of funding and political support for family planning programs (Bongaarts, 2008). Countries such as Indonesia, Algeria and Egypt, which achieved considerable fertility decline under family planning programs prior to the mid-1990s, have seen fertility increase again before reaching replacement rate. This reversal occurred despite accelerated progress on girls' education, child mortality and poverty reduction (factors popularly claimed to drive fertility decline) as these were high priority targets of the Millennium Development Goals (MDGs). The dramatic fall in international support for family planning (Figure 3, right-hand axis) was the factor most consistent with this reversal (Sinding, 2009), providing evidence that its influence on population growth has been stronger than is commonly recognised. The goal of achieving universal access to sexual and reproductive health services was belatedly added to the MDGs in 2007, but remained the least addressed in its agenda.

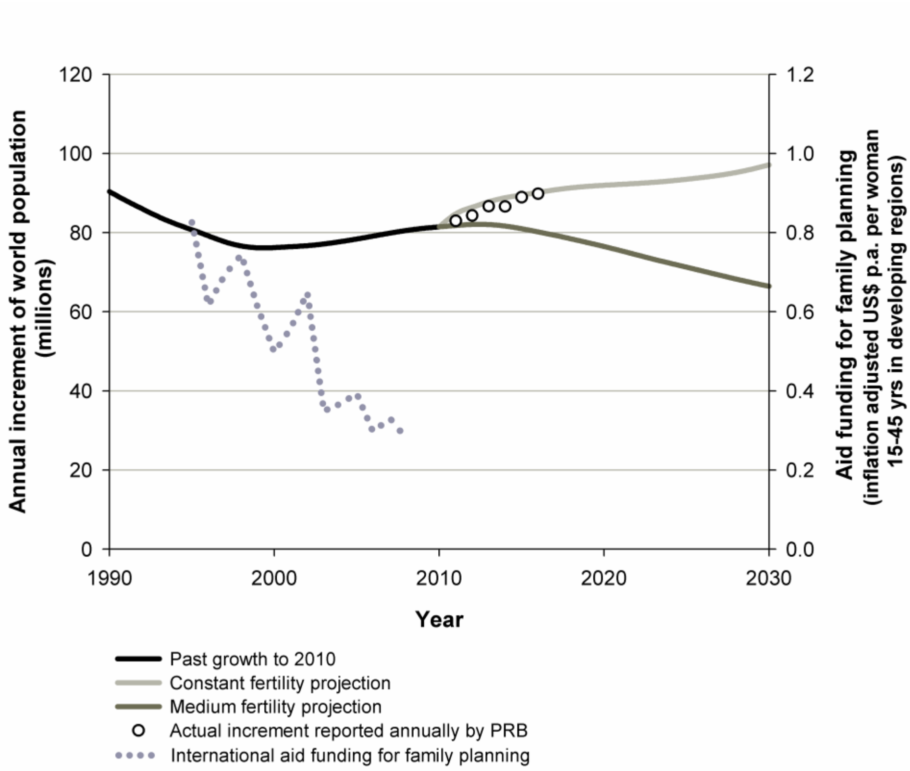

Figure 3. The annual increment of global population 1990-2010, and that projected under the UN's medium fertility and constant fertility projections (2012 revision, UNDESA, 2013). Black circles give estimates of actual increment reported annually in the Population Reference Bureau's "World Population Datasheets" (PRB, 2011-2016). International aid spending on family planning is plotted against the right axis (data source: UN Economic and Social Council 2010).

Interruptions or reversals of the fertility transition, such as those in Egypt and Indonesia, are not accommodated in the UN's population model (O'Sullivan, 2016). The UN's medium projection continues to expect the downward trend in global increment to resume, based on immediate resumption of fertility decline in all high-fertility countries, despite many of them seeing little if any decline recently. As shown in Figure 3, data on actual change in global population, reported annually by the Population Reference Bureau (PRB, 2011-2016) are greatly exceeding the "medium" projection, and instead are approximating the "constant fertility" projection, which assumes all countries continue with the same fertility they had in 2010. If sustained, this projection results in a global population of 28 billion by 2100. Of course, such a population could not be fed – if fertility does not fall, then death rates must rise.

Yet, despite the poor track record of recent projections, most climate impact modellers continue to regard future population as predetermined. They do not consider what measures might be available to influence it. Most do not even acknowledge the uncertainty of population projections and consider any sensitivity analysis, to see how emissions outcomes would be affected if population is higher or lower than expected.

Marangoni et al. (2017) attempted sensitivity analyses on the main drivers of FFI emissions in the SSP scenarios, and concluded population growth was less important than economic growth and energy intensity of the economy, although the latter two tended to offset each other. This outcome was a product of their methodology, which contrasted outcomes to 2050 in SSP2 projections when individual drivers were substituted from SSP1 or SSP3. Hence it highlighted whichever factors varied most in the short term between these three SSP scenarios, due to the arbitrary assumptions underlying those scenarios. They failed to acknowledge that energy intensity of the economy and growth in GDP per capita are not independent factors but tend to off-set each other – increasingly so as energy constraints intensify in the future. In most cases, if a higher assumption is imposed about future economic growth, a lower energy intensity is required to achieve it, so that the net effect is predictably smaller than the individual effects. The effect of population was further understated by omitting land use and non-CO_2 emissions.

In contrast, sensitivity analyses based on historical data have found population growth to be a stronger driver of emissions than economic growth. The studies of Jorgenson and Clark (2010), Casey and Galor (2017), O'Neill et al. (2010) and Bajželj et al. (2014) have already been mentioned. Alexander and coworkers (2015) found that population growth has been the largest driver of land use change, although dietary changes in emerging economies are an increasingly important contributor. The World Resources Institute's exemplary series "Creating a Sustainable Food Future" found that achieving replacement level fertility in sub-Saharan Africa by 2050 would spare an area of forest and savannah larger than Germany from conversion to cropland, and in doing so save 16 Gt of carbon dioxide emissions (Searchinger et al., 2013). The RoSE project, a major international effort to model energy and emissions pathways, discovered that a higher-than-expected population had a far greater impact on deforestation and land use-related emissions than high economic growth (Kriegler et al., 2013).

As illustrated in analyses such as O'Neill et al. (2010) and Casey and Galor (2017), the impact of a modelled change in demographic drivers is relatively small to mid-century, but expands greatly in the second half of this century. The slow divergence of population outcomes after policy change ("demographic momentum") is often used to argue that population measures should have lower priority, compared with energy sector interventions. It should instead be a reason for even greater urgency, to ensure that the substantial gains are not further deferred, and that a higher peak population does not render safe climate scenarios infeasible. Neglect of population policy over the past two decades has likely added over two billion people to the global peak population (Figure 2).

Correlation and causation between development and fertility decline

Lower population outcomes may be widely recognised as beneficial for climate change adaptation and mitigation, and a faster decline in fertility in developing countries is accepted as necessary to achieve a lower population. However, there is disagreement regarding whether direct interventions are effective and appropriate to speed the fertility decline. The SSP scenarios assume that the low population outcomes can be achieved as a result of indirect effects of economic development and education, without any interventions directly aimed at lowering fertility. The historical record does not provide strong evidence for this position. No country has been able to achieve significant enrichment while fertility and population growth remained high, with the exception of those with large mineral or fossil fuel resources. The latter, including Syria and Egypt, did not see fertility falling rapidly as a result of oil wealth, and have suffered a reversal of fortunes as increasing dependence on food imports coincides with declining oil revenue (Ahmed, 2017).

In contrast, there is abundant evidence that population-focused voluntary family planning programs were highly effective in causing rapid fertility decline and subsequently accelerated economic development. Countries such as South Korea, Thailand and Costa Rica, in which voluntary family planning was extended and promoted even to poor, rural and remote communities, saw rapid fertility decline, two to three times as fast as UN projections expect for remaining high-fertility countries (Figure 4). They subsequently experienced broad-based economic development, accelerating only after fertility fell below three children per woman and population growth slowed. The timing of their fertility transition matched that of their family planning programs, with no apparent economic or educational trigger. Meanwhile, some countries whose wealth and female education levels were above regional averages, such as the Philippines, Malaysia and Nigeria, saw little fertility decline. In several countries where family planning programs were neglected before reaching replacement rate, such as in Indonesia, Bangladesh, Algeria and Ghana, the fertility decline stalled and in some cases reversed. Garenne (2017) has similarly documented the relationship between family planning effort and fertility decline in African countries, and the lack of support in longitudinal data for a dominant effect of income or education levels. He notes,

> *"economic development is not the main driver of success in this field: political will matters more."*

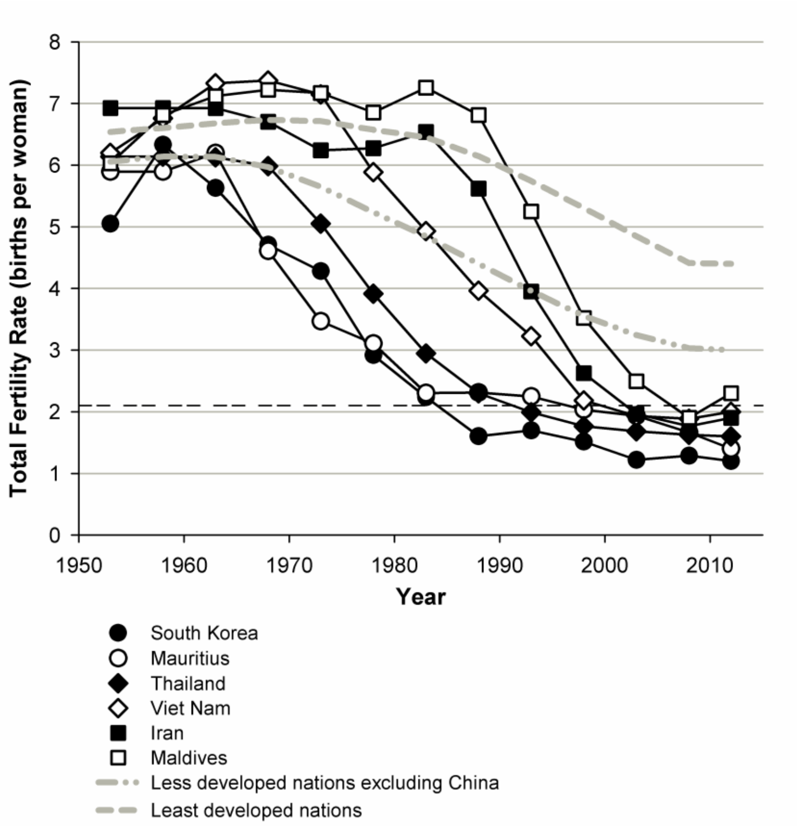

Figure 4. Time course of total fertility rate (TFR, births per woman) for selected countries which implemented population-focused voluntary family planning programs at differing times, showing rapid change in fertility, compared with aggregate TFR for less developed countries (excluding China) and least developed countries. The horizontal dashed line approximates 'replacement level' fertility. Data from UNDESA (2015).

Notwithstanding that these family planning-driven fertility transitions generally preceded economic and educational improvement, the overall correlation between GDP per person and total fertility rate of nations has led to the common assumption that economic development drives the fertility transition. To further investigate the direction of causation, Figure 5 explores whether the level of wealth affected fertility decline, or whether fertility affected economic development. For all countries in each five-year interval for which data were available, the change in fertility over five years was plotted against the level of GDP per capita at the start of the period (Figure 5A). It was found that the rate of fertility decline was unrelated to per capita GDP. The poorest countries could reduce fertility as rapidly as middle-income countries if they were motivated to do so. Conversely, when the change in GDP per capita was plotted against the TFR prevailing at the start of each interval, it is evident that economic development has been severely hampered by high fertility (Figure 5B). While fertility remains above three children per woman, the chance of sustained economic improvement has proven to be extremely low. While low fertility has not guaranteed enrichment in any five year period, over 20 year intervals all low fertility countries made considerable gains in wealth, including those with shrinking populations. Fertility decline appears to be a necessary, if not sufficient, precondition for economic development.

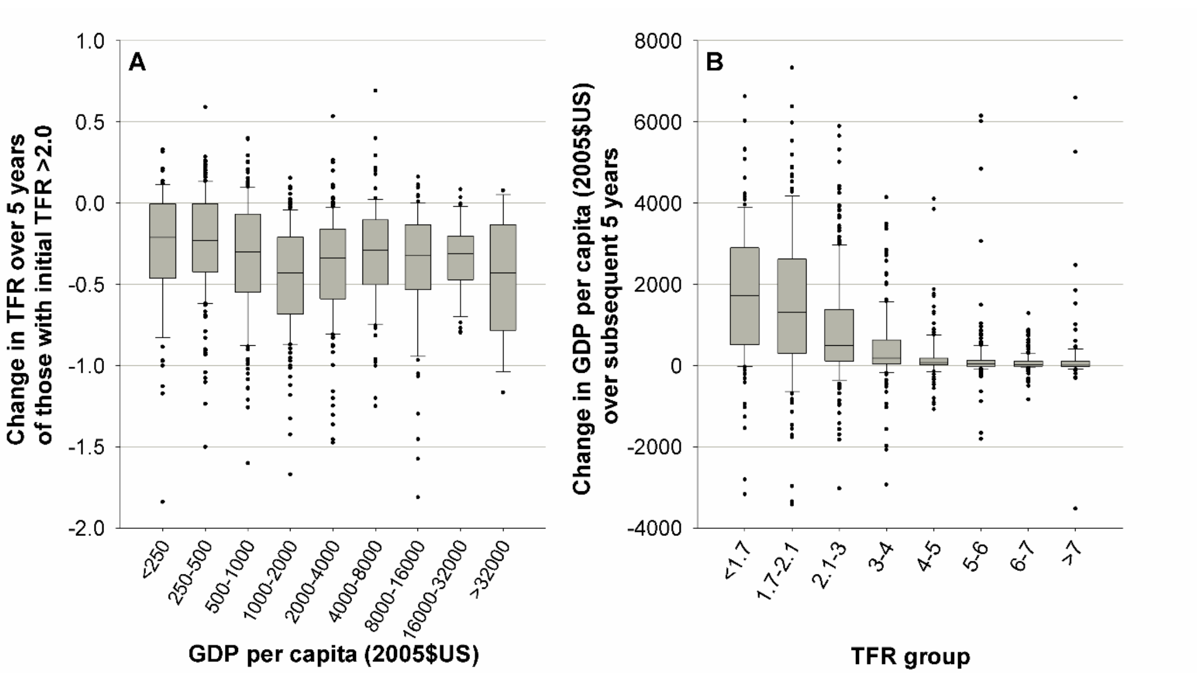

Figure 5. (A) The rate of fertility decline as a function of level of wealth, and (B) rate of economic development as a function of level of fertility. Data points represent each country in each five-year period between 1960 and 2010. All countries and time periods with available data are included. Box plots span 25th percentile, median and 75th percentile and whiskers extend to the 10th and 90th percentile. GDP per capita (inflation-adjusted 2005$US) are from the World Bank economic database, and fertility data from UNDESA (2015).

Figure 6 contrasts the experience of all countries which had high fertility in 1950, grouped according to their maximum rate of fertility decline over any twenty-year period. Group 1 contained countries which had TFR above 5 at the start of the series in 1950-55, and where TFR fell after a particular date, with a peak rate of decline exceeding 1.5 units per decade, to near or below replacement (unless insufficient time had elapsed since the start of decline). It was verified that each of these countries adopted voluntary family planning measures around the time that the birth rate began to fall, although not all maintained them until reaching replacement level fertility. Group 2 also showed considerable decline in TFR after a given date, but at a slower rate, between 0.5 and 1.5 units per decade. Group 3 showed no distinct start date for fertility decline, and most still have fertility rates above 3. Group 4 (not plotted) were considered ‘advanced transition’ countries, which had fertility rates below 5 and falling at the start of the data series. Countries where either immigration or emigration contributed more than 15% to population change were excluded. Before averaging each group’s data, they have been synchronised with respect to the timing of their fertility transition by designating Year 0 to be the start of the transition, or 1970 where no distinct change in fertility path is observed (Group 3).

The sixteen countries included in Group 1 were Algeria, Bangladesh, Bhutan, Cambodia, Chile, China, Costa Rica, Iran, South Korea, Libya, Maldives, Mongolia, Oman, Thailand, Tunisia, Viet Nam. Group 1 countries rejected due to high migration were Hong Kong, Macao, Singapore, Aruba, Kuwait and Saudi Arabia (high immigration), and Mauritius and Guyana (high emigration). Note that China is included despite the presence of coercive programs from 1979 because most of the fertility decline occurred under the voluntary family planning program in place from 1970 to 1978. Note also that the data are not population-weighted: China’s data have no more influence on the average than those of Bhutan or Maldives. Group 2 contained 39 included countries and 48 high-migration countries, group 3 contained 26 included countries and 19 high-emigration countries.

Only Group 1 countries have achieved a tapering of their population growth (Figure 6B). Most of these will achieve a peak population around 2 – 2.5 times the population when they started addressing family planning. Group 2 countries have lessened population growth, but have not reduced family size as fast as the number of families has increased. Hence most are still adding more people each year than ever before. Group 3 have seen population triple in the same time. Due to their high proportion of young people yet to start families, they have another doubling in store, if they choose to embrace family planning now (and more if they do not).

The impact of fertility decline on wealth can be seen dramatically in Figure 6C. Rapid fertility decline has been associated with dramatic economic improvement. Slow-transition countries have seen virtually none. Figure 6D plots the fertility rate as a function of wealth. It contains two features which are at odds with the popular belief that development drives fertility decline:

1. The relationship between fertility and wealth is steeply concave, as *fertility fell first* before economic development accelerated.
2. *All three groups have followed the same path.* Those which accelerated fertility decline progressed more rapidly to economic development. With rare exceptions, “development first” has not been an achievable option.

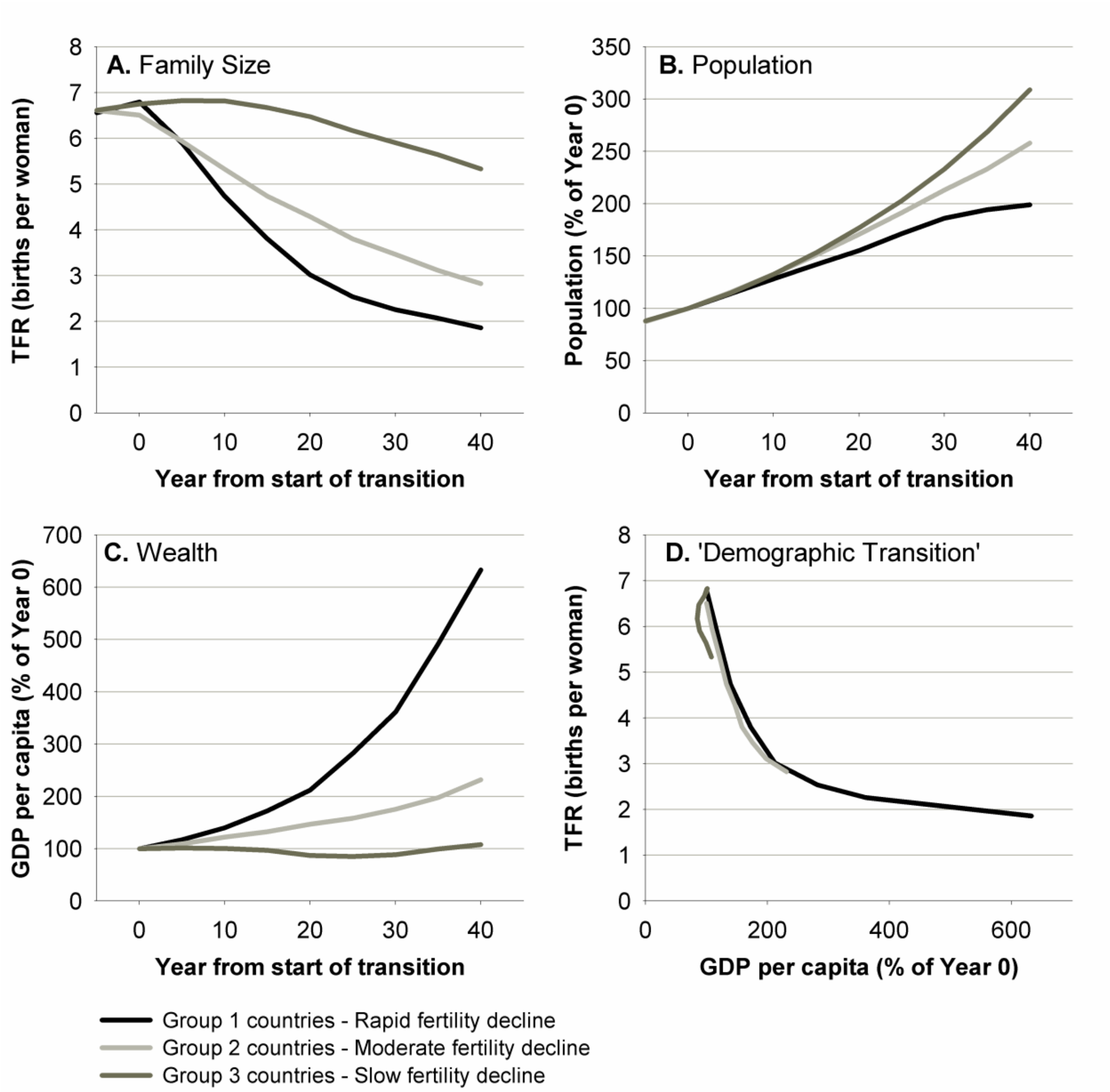

Figure 6. The averaged time-course for (A) fertility, (B) population and (C) GDP per capita (inflation-adjusted US$), and (D) the relationship between TFR and per capita GDP, for developing countries grouped according to the rate of their fertility transition. Each of the rapid transition countries (Group 1) deployed successful family planning programs. Many countries in Group 2 had programs that were weaker or not sustained. Group 3 countries generally did not have widespread family planning efforts. Year 0 is the start of the fertility transition in each country, or 1970 for weak adopters (Group 3). Population and fertility data from UNDESA (2013), economic data from World Bank economic database.

These results do not suggest that ending poverty does not influence family size, but that reducing poverty as a population control strategy simply has not proven possible for most high-fertility countries. High population growth poses such a high economic burden, through the cost of capital widening (O'Sullivan, 2012) together with ongoing crowding of limited natural resources, that significant reductions in poverty have been impossible to achieve. Family planning programs, on the other hand, have proven achievable even in the poorest settings, and the economic benefit to families has translated into societal enrichment.

It must be stressed that the successful voluntary family planning programs of the past did not rely solely on ensuring access to contraception. Large desired family size remains the main determinant of high fertility (Population Media Centre, 2017). Even among those women who do not want to become pregnant, social and spousal pressure, and misconceptions about side-effects, are more commonly cited reasons for not using modern contraception than lack of access and affordability (Sedgh et al., 2016). The successful programs promoted the benefits of fewer, more widely spaced children, employed culturally appropriate means to change social norms around family size and women's roles, and addressed the many barriers to achieving fertility regulation (Campbell et al., 2009).

More recently, Population Health and Environment (PHE) programs, which integrate family planning with livelihood, public health and environmental management interventions, are showing that coherent cross-sectoral programs can greatly increase community acceptance of, and even enthusiasm for family planning, overcoming cultural resistance (PAI et al., 2015). Even in developed countries, where unintended pregnancy is associated with negative outcomes for women and children (Brookings Institute, 2011), proactive advice on fertility regulation is proving effective (Oregon Foundation for Reproductive Health, 2012).

All these programs are consistent with the UN Programme of Action adopted at the1994 International Conference on Population and Development (UNFPA, 1994), widely referred to as the Cairo Agenda, which is still upheld as the current international treaty on population. The Cairo Agenda stresses the negative impacts of population growth on the environment and on the alleviation of poverty, and advocates responsible parenthood, in which parents should "take into account the needs of their living and future children and their responsibilities towards the community" (para 7.3). The extent to which population growth heightens risks of climate change impacts should be among the considerations of prospective parents. Yet such a discourse is shunned by the UN and the development community in the name of the Cairo Agenda, wrongly claiming that demographic agenda by their nature conflict with reproductive rights (Campbell, 2014). This is a misrepresentation of the Cairo Agenda, which states (para 7.12), "Demographic goals, while legitimately the subject of government development strategies, should not be imposed on family-planning providers in the form of targets or quotas for the recruitment of clients." Many successful family planning programs prior to 1994 have demonstrated the strong synergy between pursuing demographic agenda and elevating women's health and rights. The post-1994 taboo on demographic goals has had tragic consequences, not least for women's reproductive health and rights, but also for the security of the next generation in the face of climate change.

How much could population policy measures contribute to the climate change response?

Although the effects of a lower population on greenhouse gas emissions have been previously estimated (eg. O'Neill et al., 2010; Casey and Galor, 2017), the effects of policies and programs intended to reduce population have not been quantified. To address this question, population projections were compared under two scenarios: "business as usual" and a proactive family planning scenario. In the latter, all countries which currently have above-replacement fertility adopt voluntary, client-focused and culturally appropriate family planning measures, which seek to give all women the means to avoid unwanted pregnancy, which promote the advantages of child spacing and small families, and which address cultural and other barriers to fertility regulation. It was assumed that each country would achieve the average path of fertility decline achieved in the past by Group 1 (as depicted in Figure 6A), starting from their 2010-15 fertility rate. This is a conservative scenario, as better contraceptive technologies, communications, education levels and community engagement methods all have the potential to make future programs more effective than in the past. However, the projection is also quickly outdated: each year of delay in implementing such programs would add around 100 million people to the achievable global peak population.

The "business as usual" scenario would see the international community continue to direct a derisory level of funding and program attention to family planning (which receives less than 1% of international aid) and family planning programs continue to lack the scale and visibility needed to reach the majority of disadvantaged people and to achieve rapid fertility decline. The fertility path applied to high fertility countries was that depicted for Group 3 in Figure 6A, continued forward using the UN's medium projection. However, each country's start-point on this path matched their current fertility, so that countries with current fertility above 5.5 experienced a further period of slow change before reaching the more rapid phase modelled in the UN projection. In addition, it was assumed that very low fertility countries (below 1.5) were successful in boosting birth rates, and achieved the UN's high projection (while remaining below replacement rate fertility).

Under these assumptions, a "business as usual" approach is likely to see growth exceed the UN's current medium projection, reaching 13 billion before the century's end (Figure 7). It is questionable whether such a population would be achieved, but the risk is that it will be curtailed by widespread conflict and famine. Apart from being a catastrophe in its own right, such a scenario would likely derail climate action.

On the other hand, if the remaining high-fertility countries were to embrace voluntary family planning programs, a global population path close to the UN's current low projection could be achieved. This would put the IPCC's best-case, SSP1 scenarios into the realm of possibility.

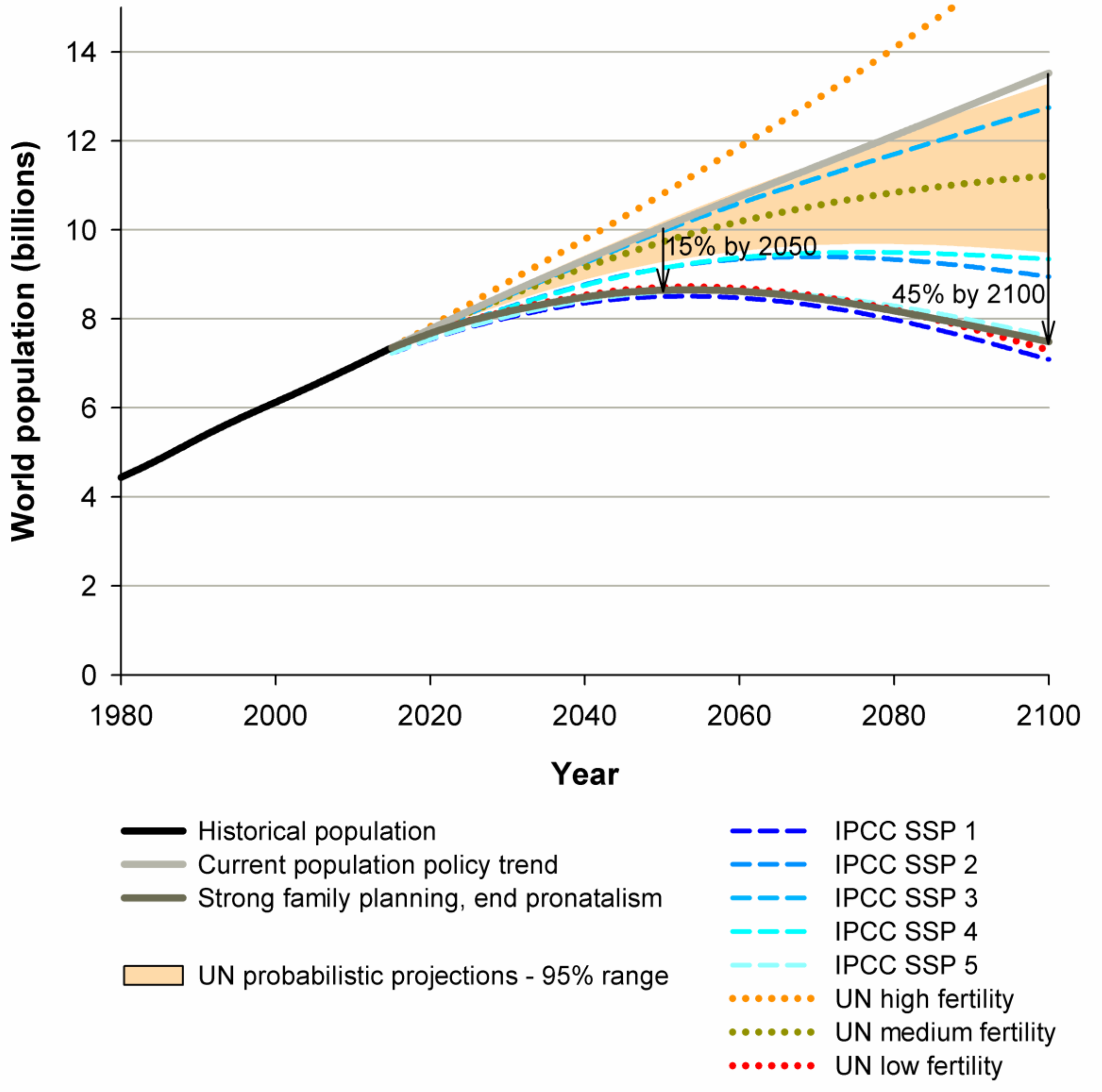

Figure 7. Projections of future global population based on population policy, comparing a business-as-usual scenario a (countries continue their recent trends), and a proactive scenario (remaining high fertility countries adopt nationwide voluntary family planning programs, achieving the average fertility path that past programs achieved, and low-fertility countries abandon attempts to increase births). Also depicted for comparison are the UN high-, medium- and low-fertility projections and 95% probability range (UNDESA, 2015) and the IPCC's Shared Socioeconomic Pathways (KC and Lutz, 2014).

Although the proactive family planning scenario achieves a similar population outcome to the SSP1 model and the UN low-fertility variant, it does so in a different and more plausible way. It is important to recognise that an avoided birth has more impact on future population if it occurs sooner, rather than later. Delayed fertility decline allows the demographic momentum to build, so that greater fertility decline is ultimately required to achieve the same population. The UN's low-fertility projection is unrealistic, because, while it assumes a very modest reduction in fertility (half a child per woman) compared with the medium scenario, it applies this reduction within the first decade, and to all countries including those with current low fertility. The SSP1 model begins with an out-dated, low estimate of current fertility in high-fertility countries, and subsequently assumes a steady decline, continuing to an extraordinary extent: fertility settles around 1.1 – 1.3 children per woman across today's developing countries, despite developed countries remaining or rebounding to around 1.7 – 1.8 children per woman (Wittgenstein Centre for Demography and Global Human Capital, 2015). No explanation is offered for this astonishing assumption. In the proactive family planning model offered in the current study, fertility decline is rapid over the first three decades as a result of family planning programs, but is expected to stabilise fertility around 1.7 children per woman. Hence a similar population path is achieved without unrealistically low fertility.

This analysis concludes that, without urgent promotion of voluntary family planning, the population projection of SSP1 is not possible and "safe" climate change pathways are unlikely. In a world of 11 billion people, let alone 14 billion, considering the requirements for arable land, fresh water, nitrogenous fertiliser and building materials together, even assuming 100% renewable energy, net draw-down of atmospheric carbon would require implausible levels of carbon capture and storage (CCS). It seems rash to turn our backs on technologies as cheap, reliable and widely beneficial as voluntary family planning in favour of technologies as unproven, costly and potentially damaging as CCS.

Conclusion

A safe climate future depends on minimising the further growth in the human population. Strengthening efforts to empower women, to avoid unwanted births and to popularise smaller families through voluntary, rights-based family planning programs, are necessary measures without which low-emissions scenarios cannot be achieved (Guillebaud, 2016).

The IPCC socioeconomic scenarios which achieve low emissions, consistent with less than 2ºC global warming, assume very low population growth, far lower than current UN expectations (Riahi et al., 2017, Schellnhuber et al., 2016). Yet no programs are included in these scenarios to achieve this lower population, because it is assumed that strong economic development and educational advances will achieve it. Evidence presented in this chapter finds that:

a) Current trends are for a higher, not lower, population than current UN expectations, rendering most future emissions scenarios invalid.
b) In most countries, economic advance has not been a major driver of fertility decline, but on the contrary, fertility decline, driven by voluntary family planning programs, has enabled economic advance. Such programs have been neglected in recent decades, to the great detriment of the world's poorest people and their environment.

Restoring the international support for voluntary family planning programs, which existed in the 1970s and 1980s, could reduce the peak human population by many billions. Such action would reduce emissions at lower cost than almost all other options, while simultaneously improving climate change resilience of disadvantaged communities and achieving a wide range of co-benefits with respect to health, the status of women, economic development of least developed nations, nutrition and food security, conflict avoidance and protection of biodiversity.

The United Nations' Sustainable Development Goals include target 3.7: *"By 2030, ensure universal access to sexual and reproductive health-care services, including for family* *planning."* Achieving other SDG targets depend to a considerable extent on achieving this long-neglected goal (Starbird et al., 2016).

As Cleland et al. (2006) emphasised, *"No contradiction needs to exist between respect for reproductive rights and strong advocacy for smaller families and for mass adoption of effective contraceptive methods."* Past population-focused family planning programs greatly accelerated the empowerment of women and the adoption of more liberal social attitudes to women's roles and rights. Their daughters benefited from the improvement in social attitudes, from less economic strain in the household and from greater parental investment in their outcomes, including better nutrition and improved access to schooling and employment opportunities. The economic and environmental benefits for entire nations were evidently substantial. All of these improvements lessen vulnerability to the impacts of climate change. Yet these manifold benefits have not proven compelling enough for the international community to provide the modest resources needed to extend reproductive freedom to women in the remaining high-fertility countries. The imperative of avoiding dangerous climate change may be the incentive that is needed, to harvest what is clearly the low hanging fruit for sustainable development.

References

Ahmed NM (2017) *Failing States, Collapsing Systems: Biophysical Triggers of Political Violence.* Springer 94 pp http://www.springer.com/us/book/9783319478142

Alexander P, Rounsevell MDA, Dislich C, Dodson JR, Engström K and Moran D (2015) Drivers for global agricultural land use change: The nexus of diet, population, yield and bioenergy. *Global Environmental Change* 35:138–147.

Bajželj B, Richards KS, Allwood JM, Smith P, Dennis JS, Curmi E and Gilligan CA (2014) Importance of food-demand management for climate mitigation. *Nature Climate Change* 4:924–929. http://www.nature.com/nclimate/journal/v4/n10/full/nclimate2353.html

Bigas H. (ed.) (2012) *The Global Water Crisis: Addressing an Urgent Security Issue.* Papers for the InterAction Council, 2011-2012. Hamilton, Canada: UNU-INWEH. http://inweh.unu.edu/wp-content/uploads/2013/05/WaterSecurity_The-Global-Water-Crisis.pdf

Bongaarts J (2008) Fertility Transitions in Developing Countries: Progress or Stagnation? *Studies in Family Planning* 39(2):105–110.

Brookings Institute (2011) *The High Cost of Unintended Pregnancy.* Report. https://www.brookings.edu/research/the-high-cost-of-unintended-pregnancy/

Bryant L, Carver L, Butler CD and Anage A (2009) Climate change and family planning: least-developed countries define the agenda. *Bulletin of the World Health Organisation* vol.87 n.11 http://www.scielosp.org/scielo.php?pid=S0042-96862009001100014&script=sci_arttext

Campbell M, Sahin-Hodoglugil NN and Potts M (2009) Barriers to Fertility Regulation: A Review of the Literature. *Studies in Family Planning* 37(2):87–98.

Campbell M (2014) Ending the silence on population. In: Hempel M (ed) *Facing the Population Challenge: Wisdom from the Elders*. Blue Planet United, pp 65–71.

Carter RC and Parker A (2009) Climate change, population trends and groundwater in Africa. *Hydrological Sciences Journal* 54(4):676–689.

Casey G and Galor O (2017) Is faster economic growth compatible with reductions in carbon emissions? The role of diminished population growth. *Environmental Research Letters* 12: 014003. Doi:10.1088/1748-9326/12/1/014003

Cleland J, Bernstein S, Ezeh A, Faundes A, Glasier A and Innis J. (2006) Family planning: the unfinished agenda. *The Lancet* 368(18):1810–1827.

Colorado Department of Public Health & Environment (2015) *Preventing Unintended Preganancies is a Smart Investment.*

https://web.archive.org/web/20151110092403/https://www.colorado.gov/pacific/sites/default/files/HPF_FP_UP-Cost-Avoidance-and-Medicaid.pdf
Dos Santos S, Adams EA, Neville G, Wada Y, de Sherbinin A, Mullin Bernhardt E and Adamo SB (2017) Urban growth and water access in sub-Saharan Africa: Progress, challenges, and emerging research directions. *Science of The Total Environment* 607–608:497–508.
Garenne M (2017) Persistent high fertility in rural Africa. *N-IUSSP* 14 September 2017. http://www.niussp.org/article/persistent-high-fertility-in-rural-africa/
Guillebaud J (2016) Voluntary family planning to minimise and mitigate climate change. *British Medical Journal* 353:i2102 doi: 10.1136/bmj.i2102
IPCC (2000) *Special Report on Emissions Scenarios.* A Special Report of Working Group III of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press.
IPCC (2014) *Climate Change 2014: Mitigation of Climate Change: Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Edenhoger O et al. (eds), Cambridge University Press, Cambridge 2014.
Jorgenson AD and Clark B (2010) Assessing the temporal stability of the population/environment relationship in comparative perspective: a cross-national panel study of carbon dioxide emissions, 1960-2005. *Population and Environment* 32:27–41.
KC S and Lutz W (2014) The human core of the shared socioeconomic pathways: Population scenarios by age, sex and level of education for all countries to 2100. *Global Environmental Change* doi:10.1016/j.gloenvcha.2014.06.004
Kriegler E et al. (2013) *Roadmaps towards Sustainable Energy futures and climate protection: A synthesis of results from the RoSE project* (1st edition). Potsdam Institute for Climate Impact Research, Potsdam.
Lagi M, Bertrand KZ, Bar-Yam Y (2011) *The food crises and political instability in North Africa and the Middle East.* New England Complex Systems Institute. http://arxiv.org/pdf/1108.2455.pdf
Marangoni G, Tavoni M, Bosetti V, Borgonovo E, Capros P, Fricko O, Gernaat DEHJ, Guivarch C, Havlik P, Huppmann D, Johnson N, Karkatsoulis P, Keppo I, Krey V, Ó Broin E, Price J and van Vuuren DP (2017) Sensitivity of projected long-term CO_2 emissions across the Shared Socioeconomic Pathways. *Nature Climate Change* 7:113–117. doi:10.1038/nclimate3199 http://www.nature.com/nclimate/journal/v7/n2/full/nclimate3199.html
Moreland S and Talbird S (2006) *Achieving the Millennium Development Goals: The contribution of fulfilling the unmet need for family planning.* USAID. http://pdf.usaid.gov/pdf_docs/Pnadm175.pdf
Murtaugh PA and Schlax MG (2009) Reproduction and the carbon legacies of individuals. *Global Environmental Change* 19:14–20.
Mutunga C and Hardee K (2010). Population and reproductive health in national adaptation programmes of action (NAPAs) for climate change. *African Journal of Reproductive Health* 14(4): 133–146..
O'Neill BC, Dalton M, Fuchs R, Jiang L, Pachaui S, Zigova K (2010) Global demographic trends and future carbon emissions. *Proc Natl Acad Sci* 107:17521-17526.
O'Neill BC, Kriegler E, Riahi K, Ebi K, Hallegatte S, Carter TR, Mathur R, van Vuuren DP (2013) A new scenario framework for climate change research: The concept of shared socio-economic pathways. *Climate Change Special Issue* 122(3):387–400. doi:10.1007/s10584-013-0905-2
Oregon Foundation for Reproductive Health (2012) One Key Question: "Would You Like to Become Pregnant in the Next Year?" http://www.onekeyquestion.org/
O'Sullivan JN (2012) The burden of durable asset acquisition in growing populations. *Economic Affairs* 32(1):31–37.
O'Sullivan J. (2016) Population Projections: Recipes for Action, or Inaction? *Population and Sustainability* 1(1),45–57. https://www.populationmatters.org/wp-content/uploads/2016/06/Population_and_Sustainability_Vol_1_No_1.pdf
PAI, Pathfinder International, Sierra Club (2015) *Building resilient communities: the PHE way.* http://womenatthecenter.org/wp-content/uploads/2015/07/Building-Resilient-Communities-The-PHE-Way.pdf
Population Institute (2015) *Demographic Vulnerability: Where Population Growth Poses the Greatest Challenges*. https://www.populationinstitute.org/demovulnerability/

Population Media Center (2017) *Overcoming bias against contraception in the world's developing countries: The case for social norm interventions.* PMC, Washington DC. http://3lh07xhlls346a7ggo9psa1d-wpengine.netdna-ssl.com/wp-content/uploads/2017/08/PMC-Unmet-Need.pdf

PRB (2011-2016) *World Population Data Sheet.* Population Reference Bureau http://www.prb.org/Publications/Datasheets/2015/2015-world-population-data-sheet.aspx

Riahi K, van Vuuren DP, Kriegler E et al. (2017) The Shared Socioeconomic Pathways and their energy, land use and greenhouse gas emissions implications: An overview. *Global Environmental Change* 42:153–168.

Rockstöm J, Gaffney O, Rogelj J, Meinshausen M, Nakicenovic N, Schellnhuber HJ (2017) A roadmap for rapid decarbonisation. *Science* 24 Mar 2017, 355(6331):1269-2171. http://science.sciencemag.org/content/355/6331/1269.full

Ryerson WN (2010) Population, the multiplier of everything else. In: Heinberg R and Lerch D (eds) *The Post Carbon Reader: Managing the 21st Century's Sustainability Crises*, Healdsburg, CA: Watershed Media, 2010. http://www.postcarbonreader.com

Schellnhuber HJ, Rahmstorf S and Winkelmann R (2016) Why the right climate target was agreed in Paris. *Nature Climate Change* 6:649–653.

Searchinger T, Hanson C, Waite R, Lipinski B, Leeson G and Harper S (2013) *Achieving Replacement Level Fertility*. World Resources Institute working paper, Instalment 3 of "Creating a Sustainable Food Future" http://www.wri.org/publication/achieving-replacement-level-fertility

Sedgh G, Ashford LS and Hussain R (2016) Unmet Need for Contraception in Developing Countries: Examining Women's Reasons for Not Using a Method. Guttmacher Institute, New York. 93pp. https://www.guttmacher.org/report/unmet-need-for-contraception-in-developing-countries

Sinding SW (2009) Population poverty and economic development. *Phil. Trans. R. Soc. B* 364:3023–3030. doi: 10.1098/rstb.2009.0145

Starbird E, Norton M and Marcus R (2016) Investing in family planning: key to achieving the Sustainable Development Goals. *Global Health: Science and Practice* 2016 doi: 10.9745/GHSP-D-15-00374

Tavernise S. (2015) Colorado's effort against teenage pregnancies is a startling success. *The New York Times* 5 July 2015. https://www.nytimes.com/2015/07/06/science/colorados-push-against-teenage-pregnancies-is-a-startling-success.html

UNDESA (2004) *World Population in 2300.* Population Division, United Nations Department of Economic and Social Affairs. http://www.un.org/esa/population/publications/longrange2/WorldPop2300final.pdf

UNDESA (2011) *World Population Prospects, the 2010 Revision*. Population Division, United Nations Department of Economic and Social Affairs. http://www.un.org/en/development/desa/publications/world-population-prospects-the-2010-revision.html

UNDESA (2013) *World Population Prospects, the 2012 Revision*. Population Division, United Nations Department of Economic and Social Affairs. http://www.un.org/en/development/desa/publications/world-population-prospects-the-2012-revision.html

UNDESA (2015) *World Population Prospects, the 2015 revision*. Population Division, United Nations Department of Economic and Social Affairs. https://esa.un.org/unpd/wpp/Graphs/Probabilistic/POP/TOT/

UN Economic and Social Council (2010) *Report of the Secretary-General on the flow of financial resources for assisting in the implementation of the Programme of Action of the International Conference on Population and Development*. E/CN.9/2010/5 http://www.un.org/en/development/desa/population/documents/cpd-report/index.shtml

UNFPA (1994) *Programme of Action: Adopted at the International Conference on Population and Development*. Cairo, Egypt: United Nations Population Fund (UNFPA).

van Vuuren DP, Kriegler E, O'Neill B, Ebi K, Riahi K, Carter TR, Edmonds J, Hallegatte S, Kram T, Mathur R, Winkler H (2014) A new scenario framework for Climate Change Research: scenario matrix architecture. *Climatic Change* Special Issue 122(3):373–386. doi:10.1007/s10584-013-0906-1

Vidal J (2017) As flood waters rise, is urban sprawl as much to blame as climate change? The Guardian, 3 September 2017. https://www.theguardian.com/world/2017/sep/02/flood-waters-rising-urban-development-climate-change

Vörösmarty CJ, Green P, Salisbury J and Lammers RB (2000) Global water resources: vulnerability from climate change and population growth. *Science* 289:284–288.

Wynes S and Nicholas KA (2017) The climate mitigation gap: education and government recommendations miss the most effective individual actions. *Environ. Res. Lett.* 12 074024. http://iopscience.iop.org/article/10.1088/1748-9326/aa7541

Wheeler D and Hammer D (2010) *The economics of population policy for carbon emissions reduction in developing countries.* Center for Global Development, Working Paper 229, November 2010. http://www.cgdev.org/publication/economics-population-policy-carbon-emissions-reduction-developing-countries-working

Wittgenstein Centre for Demography and Global Human Capital (2015). Wittgenstein Centre Data Explorer Version 1.2. www.wittgensteincentre.org/dataexplorer

Worldwatch Institute (2015) *Vital Signs report: Food Trade and Self-Sufficiency*. http://vitalsigns.worldwatch.org/vs-trend/food-trade-and-self-sufficiency

Young MH Mogelgaard K and Hardee K (2009) *Projecting Population, Projecting Climate Change: Population in IPCC Scenarios.* PAI Working Paper WP09–02. Population Action International. https://www.researchgate.net/publication/237249604_Projecting_Population_Projecting_Climate_Change_Population_in_IPCC_Scenarios

Zeng N, Neelin JD, Lau KM and Tucker CJ. (1999) Enhancement of interdecadal climate variability in the Sahel by vegetation interaction. *Science* 286:1537–1540.