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Submissions

The journal aims to publish papers exploring all aspects of the relationship between human numbers and environmental issues. It is truly interdisciplinary and invites contributions from the social sciences, humanities, environmental and natural sciences including those concerned with family planning and reproductive health. We also invite contributions from those working for NGOs with interests in population and environmental issues. It is intended that the journal act as an interdisciplinary hub facilitating collaboration and furthering the development of the field. We are interested in publishing original research papers, reviews of already published research and book reviews. For submission details please see our website (www.populationmatters.org) or contact the editor: **journal.editor@populationmatters.org**

The journal is available free of charge at www.populationmatters.org and is published by Population Matters, a membership charity that addresses population size and environmental sustainability. We believe population growth contributes to environmental degradation, resource depletion and other problems. We conduct research, inform the public and advocate improved family planning and sex education, women's empowerment, smaller families and moderate consumption. We are a company limited by guarantee (3019081) and a registered charity (1114109).

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The Journal of Population and Sustainability

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Introduction

DAVID SAMWAYS – EDITOR

Welcome to the first issue of *The Journal of Population and Sustainability*, an interdisciplinary journal with papers from the social sciences, humanities, environmental and natural sciences including those concerned with family planning and reproductive health. *Population and Sustainability* aims to bring together research on all aspects of the relationship between human numbers and environmental issues. It is intended that the journal act as an interdisciplinary hub facilitating collaboration and furthering the development of the field.

In this issue we start with papers from Steven W Sinding and Aubrey Manning considering the state of the population movement in general. Sinding's paper reflects on his long career in the population field and considers the changing nature of the alliance between those concerned with the environmental dimension of population growth and the "family planning" movement. Manning's paper reflects on a lifelong concern with the environment and human numbers and forwards a robust position on the relationship between economic growth, population and inequality.

Manning also touches on the issue of reproductive freedom, an issue which is examined by the moral philosopher Sarah Conly in her paper *One Child: Do We Have a Right to More?*. Conly summarises the argument in her book of the same title, making the case for the moral relevance of family size in the context of the environmental limits of a finite planet.

Colin Kelley's paper, *On Sustainability, Vulnerability, Climate and Conflict*, examines the complex factors of carrying capacity and the part played by population growth and climate change in the vulnerability of some societies to abrupt changes in climate. Drawing on his recent research on changes in

contemporary rainfall patterns in the Fertile Crescent of the Middle East, Kelley argues that population pressure, drought and agricultural collapse have played an important part in the civil conflict and mass migration in the region.

In *Population Projections: Recipes for Action, or Inaction?*, Jane O'Sullivan examines the basis for upward revisions of population projections. She argues that the UN's projections of future population growth display a fatalism which treats population projections as immutable facts rather than estimates that can be changed by action. O'Sullivan argues that this has undermined concerns about population growth and contributed to a decline in international support for family planning programmes. The resultant slowing or stalling of the decline in the rate of fertility has led to this upward revision of the expected peak population.

Finally, David Newton summarises research projects sponsored by Population Matters and carried out by students studying the MSc in Management Science at The London School of Economics and Political Science. The full projects will be available on the Population Matters website.

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Reflections on the Changing Nature of the Population Movement

STEVEN W. SINDING

Following a 20 year career at the United States Agency for International Development, Dr Sinding served as Population Advisor to the World Bank, Director of Population Sciences for the Rockefeller Foundation, and Professor of Population and Family Health at Columbia University. He retired in 2006 as Director-General of the International Planned Parenthood Federation and remains active in the population field as a consultant and through memberships on various boards, such as the Guttmacher Institute and Planned Parenthood of Northern New England.

Many have written about the metamorphosis of the erstwhile "population movement" during the last part of the 20th Century and it is hardly news today that a movement once committed to slowing or halting rapid global population growth became instead a movement committed to the spread of reproductive and sexual rights and improved sexual and reproductive health (generally known as SRHR). It occurred to me that the passage of time since the historic "paradigm shift" represented by the International Conference on Population and Development (ICPD) in Cairo in 1994 – now approaching 22 years – permits one to attempt a reasonably objective assessment of why this shift happened and what its consequences have been.

My own career was largely shaped by this history. As a college and graduate student in the 1960s, I was deeply influenced by the rise of population alarmism during that decade and was delighted when the opportunity came to join in the U.S. government's response to the perceived crisis of rapid population growth across the entire developing world, or Third World as it was then called. At that time there was something of a consensus among American and global elites that

rapid population growth posed a serious obstacle to economic development and political stability in the affected countries, and, by extension, to the world as a whole. This consensus extended to many leaders in east and south Asia in the two decades following the end of World War II.

Long before population, or neo-Malthusian, alarmism gripped the western world and like-minded leaders across parts of Asia, visionary women like Margaret Sanger in the U.S. and Marie Stopes in the U.K. had launched an international birth control movement. Individual efforts in a number of countries across Europe, North America, and Asia coalesced in 1952 in the formation of the International Planned Parenthood Federation (IPPF) and a headquarters was established in London. During the 1950s, and into the early 1960s, the birth control movement slowly spread while, at the same time, concern about rapid population growth was growing in western capitals and a few places in Asia, particularly Japan and India.

Leaders of the population alarmist movement – men like John D. Rockefeller 3rd and William Draper in the U.S, and C.P. Blacker in the UK – saw the birth control movement as a natural ally and for several years through the 1950s they sought to persuade birth control leaders to join them in a global crusade to bring down birthrates, largely through the extension of contraception and contraceptive services throughout the developing world. The discovery and commercial development of modern birth control devices, notably the oral contraceptive pill and the IUD, made this a practical possibility beginning around 1960.

The birth control movement of the post-war years was not primarily motivated by, or even concerned about, population issues. It was largely focused on giving women control over their own reproduction. The main focus was on individual freedom rather than on the broader social goal of lowering birthrates. Indeed, many within IPPF actively opposed taking any money from the growing population control establishment on the grounds that working together with a movement that many in the developing world associated with neo-colonialism would undermine their own goal of expanding women's control over their own reproduction and their autonomy.

Notwithstanding the reluctance of some in the birth control, or what later came to be known as the family planning movement to cooperate with the population

movement, the enormous resources that began to flow to the latter soon made cooperation irresistible and inevitable. As first major American foundations like Ford and Rockefeller, and later governments such as Sweden, and later the U.K. and the United States began to pour money into international population programs, those wishing to expand birth control services around the world found that they had no alternative but to join forces with the large funding agencies.

And so, the industry known as the population movement came into being during the latter years of the 1960s, reaching full fruition with the establishment of the United Nations Fund for Population Activities, – UNFPA, today's UN Population Fund – in 1968. From the beginning, the movement was an unstable alliance, composed as it was of people and institutions of distinctly different orientations. The "family planners" in the movement remained concerned primarily with women's rights and the health of women, infants, and young children, while those with demographic goals in mind wanted to see birthrates decline and population growth rates eventually stabilize. What brought and kept them together was a common commitment to spread the availability of modern contraceptives as quickly as possible to as broad a cross-section of the population of reproductive age as possible.

But even in this commitment to universal access to family planning, the two sides had differing perspectives – a difference that eventually brought the unified movement to its knees. The difference lay in the degree of urgency each side felt about ensuring contraceptive practice. The family planners were always deeply committed to the principle of voluntarism: every couple should have access to information and services but should be free to follow their own consciences on the question of family planning practice. On the other side, some of a more demographic bent, including leaders in some governments, felt that population control was of such a high priority that the practice of family planning should not be a matter strictly of individual choice. The result in some places were policies and approaches that ranged from the outright coercion into forced sterilization, to cash incentives to be sterilized or to use long-acting contraceptive methods such as IUDs or contraceptive implants, to community targets and quotas for contraceptive use.

Not surprisingly, such practices provoked quite a strong reaction among groups concerned with human rights in general and with women's health and rights

in particular. Throughout the 1970s and into the 1980s there was resistance to the population movement in many parts of the developing world. During the height of the Cold War, this resistance was exploited by the socialist bloc, which created a strong coalition of countries that opposed the population movement as a western invention designed to ensure the continued subjugation of poor countries, many of them former colonies. East-west conflict dominated the first World Population Conference at Bucharest in 1974.

However, as the Cold War cooled more and more countries were adopting official policies to permit and encourage family planning. But even as the idea and the practice of family planning spread, violations of the principle of voluntarism continued to motivate important groups in many countries to oppose population policies based on demographic objectives because, they said, such policies often resulted in programs that were at worst coercive and at best disrespectful of women's interests.

So, two things happened through the 1980s and into the 1990s. First, the practice of birth control spread to the point where birthrates throughout the world had fallen and were continuing to fall quite dramatically. According to the authoritative Demographic and Health Surveys program, contraceptive use across the regions of Asia, Africa, the Middle East, and Latin America and the Caribbean rose from under 10% of women of reproductive age in the mid-1960s to nearly 60% by the mid 1990s. Over this same period, the total fertility rate (basically the average number of children born per woman) fell from around 6 to just over 2.5 children. A reproductive revolution had occurred or was well underway in every region except sub-Saharan Africa.

And second, a movement of sufficient strength, size and intensity had grown in opposition to demographically focused population policies that it was able to fundamentally shift the orientation of the movement from population concerns to a focus on individual rights and health. This shift – the famous "paradigm shift" of 1994 – occurred at the ICPD in Cairo in September of that year.

I joined the U.S. Agency for International Development (USAID) in 1971 and worked there for 20 years, serving at headquarters and overseas, and rising eventually to become head of its worldwide population program in the 1980s.

Throughout that period USAID was the primary instrument through which the U.S. Government pursued its interest in reducing high rates of population growth. While the program had always stressed voluntary family planning as a core principle, its emphasis on numbers, as well as its sheer size, made it a target of critics of the population movement. USAID was overwhelmingly the largest single donor agency in the field, accounting for something on the order of half of all external resources going into international population programs.

I spent my last four years at USAID away from population, working as head of the Agency's Mission to Kenya. I retired from USAID in 1991 and, after a year as the World Bank's Population Adviser, joined the Rockefeller Foundation as Director of the Population Sciences Program. It was during the year at the Bank and my first year at Rockefeller that I became aware of the intensity of the women's health and rights movement that had grown up in opposition to traditional population programs. I confess I was alarmed by this development, feeling both that it represented an overreaction to the abuses that had developed in a few countries, most notably in India during the period of forced sterilizations in the 1970s, and in China through its "one child" policy, and worried that a shift in focus away from population would result in diminished government support for family planning programs. I was concerned that the two sides, both contemporary versions of the traditional divide that has characterized the field throughout its existence, were at an impasse that could cripple the movement if not resolved.

While I certainly acknowledged at the time that critics of family planning programs had many valid points, I did not want their movement to result in a wholesale dismantling of the international coalition of governments and agencies that was implementing effective family planning programs. My humble effort in response was to present a paper in 1992 at the 40th anniversary conference of IPPF in New Delhi in which I attempted to show that meeting the unfulfilled demand for contraception around the world would result in significantly lower birthrates than the demographic targets most countries had set. Thus, I called for an end to fieldworker and community quotas and targets and setting a goal of fulfilling the unmet need for contraception in their stead. Doing so, I said, would shift the focus from the supply side to the demand side, genuinely responding to the expressed desires of women and couples.

I hoped that this approach would represent a sort of common ground on which the two sides could meet: the champions of individual rights and health and those who continued to be concerned about still high rates of population growth. While many agreed that fulfilling unmet need was a good way out of the impasse, the women's health and rights advocates by 1993 had the bit firmly between their teeth and were determined that the forthcoming 1994 International Conference on Population and Development would represent a watershed between the traditional population movement and a new movement for the sexual and reproductive health and rights of every individual.

The Cairo Conference, of course, came down heavily, if not exclusively, on the side of the reformers and left the traditional more demographically oriented community feeling somewhat isolated and demoralized. The almost simultaneous emergence of a full realization on the part of governments of the severity of the HIV/AIDS crisis resulted not in the dismantling of the family planning infrastructure that had been painstakingly erected over the past three decades but in its severe neglect, as resources were swiftly shifted from family planning to AIDS control and other priorities. My own feeling at the time was that those whose fervent efforts so successfully shifted the paradigm had inadvertently set in motion a retrenchment of family planning services that ultimately harmed rather than enhanced women's health.

To make a long story short, the years between 1994 and 2008 or so were dark ones for the international family planning movement, whether looked at from the perspective of reducing fertility or improving women's access to reproductive health services. To be sure, in some countries the paradigm shift did bring about a broader range of services for women and children but the overall effect was a reduction in the priority given to contraception, a plateauing or even a slight rise in birthrates in some places, and a general lethargy in the field. Perhaps most emblematic of the decline in priority was the decision in 2000 to leave population and family planning completely out of the UN's Millennium Development Goals – the central expression of development priorities of the first 15 years of the 21st Century. It is unimaginable that a comparable set of goals established say in 1975 or 1980 would have relegated population concerns and family planning programs to such a low status.

Turning now to IPPF, by the last part of the 20th Century IPPF's role in the movement had changed quite considerably. In the early years, say from 1952 to 1975, IPPF played a pioneering role in establishing the feasibility and credibility of family planning in scores of countries around the world, often taking risky and controversial stands in opposition to traditional foes of birth control and women's rights. But by the late 1970s, as more and more governments assumed responsibility for providing family planning through their own health systems, IPPF became more and more marginal, serving in most places merely as an auxiliary service provider.

I was determined when I arrived at IPPF in the autumn of 2002 to revitalize IPPF's traditional role as advocate and troublemaker. I thought IPPF, both at headquarters and through its 150-odd national member associations, should take on some of the still controversial and unresolved issues in sexual and reproductive health. These could be summarized under the rubric of five A's: **a**bortion, services for **a**dolescents, integration of family planning with HIV/**A**IDS programs, enhanced **a**ccess to meet the unmet needs of the most marginalized and remote populations, and **a**dvocacy as a central element of IPPF's operations. I wanted IPPF once again to be a recognized and powerful voice in the movement and I wanted family planning, as part of sexual and reproductive health, to be restored to a position of high priority within the international development agenda. To that end, I hoped that IPPF would become an effective advocate to belatedly restore family planning as a Millennium Development Goal.

It is for others to judge how successful I was during my brief four-year tenure as Director General of IPPF. I will say, however, that a coalition largely built by the international development agencies of the British and American governments and the Bill & Melinda Gates Foundation has managed to restore some degree of visibility and priority to family planning in the context of sexual and reproductive health programs. This was confirmed at the so-called London Summit on family planning in 2014. The decline in support for family planning programs has been reversed in a number of countries, and the special efforts directed at African states have resulted in considerably more SRHR and family planning activity in a number of countries. Family planning is more visible in the Sustainable Development Goals of 2015 – the UN's successor global agenda to the MDGs.

Did IPPF play an important role in any of this resurgence? I don't know, but I do know that IPPF has had a prominent place at the tables where these developments have occurred. In other words, whether coincidental or not, I think that the revitalization of advocacy energy I tried to instill at IPPF between 2002 and 2006, and which has been sustained by my successors, has tracked with the restoration of priority being accorded to SRHR and family planning in the subsequent years.

A final note: I have not written here about the link between population and sustainability. I take it as a given that those who are concerned about rising human numbers are to a considerable extent motivated by concerns about the sustainability of complex systems, whether these be environmental, economic, social, or political. The connection between human population growth and any one of these systems has long been the subject of debate and exploring any one of these connections is a complex and difficult chore. I was motivated to get into the population field because, as a young man I was convinced that solving any number of human problems – economic, ecological, social or political – would be made easier if the growth in numbers could be slowed. Nothing that I have observed over the past 45 years of working for four major development institutions and in dozens of countries around the world has changed that view.

Population and Sustainability: the Most Inconvenient Truth

AUBREY MANNING

Aubrey Manning is Professor Emeritus of Natural History at the University of Edinburgh. Always involved with conservation and the environment in the broad sense, he is a patron of Population Matters, was president of the Royal Society of Wildlife Trusts 2006-2010 and Goodwill Ambassador for UN International Year of Planet Earth 2008-2010. In 2011 he was awarded the Royal Society of Edinburgh's Senior Beltane prize for Public Engagement.

Sustainability is applied anywhere and everywhere now but rarely has a term been used with such imprecise understanding of what is implied. However vague on the details, seeking 'sustainability' in so many aspects of human activity represents an important shift in the way we look at the world and our place in it. We may not know what is needed but the very fact that we talk about it reveals a recognition that current trends in how we operate are not going to yield it. We are beginning to accept that human activity is having global effects and impinges on the natural resources available to all of us. International action is beginning and currently climate change is the most prominent issue. Whatever the shortcomings of the recent Paris summit and those that preceded it, they represent a remarkable and consistent global consensus that if we go on as we have there will be severe penalties.

Way back in 1966 I joined the recently founded Conservation Society because as a biologist I was attracted by its slogan: '*Population, Resources, Environment.*' Public concerns about 'the environment' were beginning to grow rapidly, especially around the pollution of soil and water, deforestation and the spread of urbanisation with all its associated infrastructure. So far as I could see, the Conservation Society was the only group which recognised explicitly that the

number of humans was a key factor in all these problems. Then, populations were growing rapidly, especially in the poorer, so-called 'developing nations' and various initiatives were beginning to attract attention. In Britain the problems were seen almost exclusively as being 'out there' in the poor countries, although to its great credit the Conservation Society from its inception argued that the rich nations also had a population growth problem.

The message remained, but gradually the emphasis began to shift away from human numbers *per se* and towards the impact we were having on the planet. Some of the gloomier predictions, such as the Paddock brothers' *Famine 1975!* (1967) and Paul Ehrlich's *The Population Bomb* (1968) could be regarded as over dramatized. This was a period of sustained economic growth in the rich world bringing dramatic rises in the standard of living in Europe and North America. The effects soon became obvious, both in the damage caused to the environment and in the gross inequalities in consumption of all natural resources which were developing between the rich and poor nations. Even so, for most it seemed that, as always, the Earth could provide!

In 1972 came the UN Conference on the Human Environment in Stockholm, perhaps the first global recognition of that ***un***-sustainability I mentioned at the outset. This meeting led to the UN Environmental Programme (UNEP) being set up. Twenty years later the meeting was in Rio de Janeiro and further meetings have followed at intervals since. Trawling the web will yield a whole range of reports from the UN and its branches and various development 'think tanks' across the years. There were a number of aspirational statements timed around the Millennium. The UN's *Millennium Development Goals* (MDGs) are from 2000:

1. Eradicate extreme poverty and hunger.
2. Achieve universal primary education.
3. Promote gender equality and empower women.
4. Reduce child mortality.
5. Improve maternal health.
6. Combat HIV/Aids, malaria and other diseases.
7. Ensure environmental sustainability.
8. Develop a global partnership for development.

Each nation has particular targets and is expected to report on progress. There can be no question that the UN and its agencies accept the scale of the problems we face, and that in these aspirations they have 'hitched their wagon to a star.' The requirements are gigantic.

We must note that there is no direct mention of human numbers here. There is certainly some mention of family planning provision, but although it is obvious that advances in MDGs 1, 2 and 3 will be most likely to reduce birth rates, we do not find this result identified as an aim in itself. Indeed, population *per se* was rigorously kept off the agenda in earlier UN meetings under pressure from several powerful religious lobbies. It would not be addressed directly, and even then only in muted terms, until 22 years after Stockholm at the UN Cairo conference in 1994.

Biologists are likely to emphasize that without achieving MDG 7 on the environment the rest will become impossible. Even with the current maldistribution of resources, population problems will not end when growth stops as the Earth is already over-populated. We are grossly out of balance with the life support systems of the planet and effectively living off natural capital of soils, water and biodiversity systems. The balance would be far worse if every MDG were to be achieved and the poor of the world were to achieve living standards even approaching those of a middling rich country.

Whatever the concerns of biologists, progress has to begin from where we are now. While there is persistent recognition that much of human activity across our world is ***un***-sustainable population growth has continued. In the 40 years between Stockholm 72 and Rio+20 in 2012, population grew from just under 4 billion to over 7 billion. However, despite this gigantic change, public emphasis had shifted from population itself to progress on all those other issues listed in the MDGs. There are obvious barriers to our success in achieving the environmental sustainability aspired to in MDG 7, with concern over climate change and the rapid loss of biodiversity currently two of the most prominent.

Why has population growth itself had a reduced profile since the scares of the 1970s? In part it must be accepted that some of the earlier calls for birth control were not well-handled and were easily vulnerable to accusations of neo-colonialism and racism. There were major advances in agricultural productivity

involving new food plant varieties, increased nitrogen from cheap fossil fuels, and more irrigation. We did not experience famine in 1975 – at least not all over the world. Nor was there a perceptible explosion from the population bomb. Malthus was dismissed as obviously wrong. In this optimistic mood discussion about human numbers became awkward and seen as harsh and unattractive. Governments in the rich world developed overseas aid programmes and public opinion was generally enthusiastic about helping poor nations emerge from poverty.

In Britain a number of new and highly successful charities became prominent. Friends of the Earth (FoE) rapidly took over from the middle-aged, middle-class Conservation Society which vanished. It retains the earlier body's emphasis on resources and environment, population is recognised as a factor, but is not directly part of its campaigning. Other fund-raising charities such as OXFAM, Save the Children and CAFOD, stress only the most directly human-centred MDGs and never mention rising numbers as a problem. Of course, there remain groups which do continue to emphasise the problems associated with population growth and, like the Conservation Society, include the rich world in their considerations. Notable amongst these is the Optimum Population Trust, which metamorphosed into Population Matters, and has become increasingly effective in raising issues in a British and European context.

We are now well into the 21st Century and moving inexorably towards our 8th billion, with UN estimates of future population growth mostly being revised in an upward direction. In Britain, those of us who try to link human numbers to the actions required to achieve the Millennial Goals have come across a new barrier: there is a persistent and powerful dichotomy of views within what we might call 'the environmental movement' in the broad sense. If we engage activists in various groups, ranging from popular to academic, to express our concern about numbers, then the commonest response is: 'It's not population! It's poverty, greed, inequality, the position of women etc.…'. Such responses often carry the implication that to stress human numbers is somehow offensive, almost as if we blame the countries which are growing for their own predicament. There is an imbalance here which I experience personally, for if somebody approaches me and, for example, speaks of their concern about poverty in Africa, I do *not* respond: 'It isn't poverty, it's population growth!'. Of course poverty is a huge

problem requiring immediate direct action on many fronts. Reduction of the birth rate will offer no immediate relief – it would manifestly not be *sufficient* – but failing to recognise it as *necessary* is to pursue an illusion.

Africa is the most relevant example here because birth rates remain so high in comparison with other areas which have seen some remarkable declines. More and more African governments now accept that their population growth is too high and cripples their economic development. There are heroic efforts based locally and supported by outside aid groups and the UN, but they still lack sufficient funding or priority. Infrastructure development, food production and health attract the main attention. 'Death control' must always have a high priority, but reducing the birth rate will benefit development in every area and should be linked to overseas aid. Nor is this coercive since every survey shows that there is a huge unmet demand for contraception even before there has been sufficient progress on the empowerment of women. Providing the one will help to accelerate the other and offers extraordinarily good long-term value for money.

However diverse and complicated the contexts in which population growth occurs, it should be recognised as a truly global phenomenon. With every day that passes we add – *net* – about 200,000 more humans and because of the global age structure (with a great preponderance of young people) there is built-in growth momentum. None of the UN estimates predict stabilisation anytime soon. Could there be a more inconvenient truth?

Global estimates conceal diversity: predictions are that whilst Africa will continue to grow rapidly for decades, Europe will slow and soon begin to decline with birth rates below replacement level. But again there is diversity within Europe, and I want to argue that Britain's population deserves close attention.

In 1969 the then Institute of Biology ran a symposium and published *The Optimum Population for Britain* (Taylor, 1970). Over 40 years on I believe it should be remembered as a significant event. Here was a distinguished group including demographers, biologists, medical scientists and economists discussing the future in relation to the number of people in a wealthy, developed Western country. It is no surprise that there was considerable disagreement and several argued that the idea of identifying an optimum population was meaningless: how

could any generation decide an optimum for a Britain in which they would not be living? Again, no surprise that the biologists took a more pragmatic approach based around our natural resources in relation to the rest of the world. A poll of the speakers and their audience (mostly biologists) revealed 90% believed Britain, then at 55.6 million, was already overpopulated.

Since then we have added well over 9 million and, whilst population growth slowed during the 70s, it has risen again and is higher now than it was 50 years ago. We are adding nearly 500,000 extra people each year, about half from so-called 'natural growth' (the surplus of births over deaths) and half from net immigration. There is certainly no shortage of discussion about immigration, but what I find amazing is that there is no discussion or comment about the actual numbers of people: *our population*. Even if there were no net immigration Britain would grow by a million every 4 years; is that a good thing or a bad thing? Is it sustainable or are there limits?

Almost invariably when there is any report of some symposium or discussion on a sustainable path for Britain's future then our population is mentioned but with no further comment: it is taken as 'a given.' There may be much advocacy of switching to renewable energy, accelerating house building, increasing food production etc., but no suggestion that we might also limit numbers.

There are always two obvious questions about population growth: first, should we take action at all, and second what could we do? There are many who oppose any attempt to influence numbers directly here or abroad. They argue that pushing for the MDGs will lead to falling birth rates as they already have in parts of south-east Asia and the Middle East. This is all we can or ought to promote, it is politically acceptable and few would dissent even if we do not regard it as sufficient.

When we turn attention to a wealthy country like Britain, densely populated by world standards, the issues are more complex. 'Growth' is sought always and everywhere. Of course it is *economic* growth to which we refer, but historically population growth has gone with it as part of the phenomenal success of the rich world since the industrial revolution. Increased production and consumption by a growing work force has led to increased wealth and living standards with it. Its advantages have gone unquestioned until recently, but the strains are now

becoming obvious. However, those of us who criticise the continued pursuit of growth are duty bound to acknowledge the enormous benefits our fortunate part of the human race owes to the growth we have experienced until now.

The rich world continues the pursuit of what we might call 'Plan-A' economics as the only way to develop and bring prosperity to all. For all the gross inequalities which persist and the failure of growth alone to address them, it is easy to understand why so many still hold to the faith in Plan-A.

Some 50 years ago the economist and philosopher Kenneth Boulding was reported to have remarked:

> Anyone who believes exponential growth can go on forever in a finite world is either a madman or an economist.[1] (United States. Congress. House (1973) p. 248)

Nevertheless there are still many who simply do not accept that there are any constraints on growth that innovation cannot overcome[2]. Population growth fits so easily into such a mind-set especially as it will yield more young producers to offset the ageing populations requiring wealth generation to support them in the future. But then these young will also age and require support from more young, and so on. Such population growth represents an economic Ponzi scheme with no closure. To get beyond this we shall be forced to accept that other things beyond economic growth must be encouraged. The distribution of wealth within the rich societies is the most obvious. If we can reduce inequality then there are many indicators that beyond a certain level material prosperity and quality of life are not closely linked. The measures we have to examine such quality are not yet precise, but surely they must form part of our search for sustainability.

As the Kenneth Boulding quote suggests, it is physical things which cannot grow indefinitely. Ideas certainly can and we shall need much innovation there. We cannot turn around Plan-A economics quickly, but after decades of neglect there are now some prominent economists contemplating an end to material

1 Attributed to Kenneth Boulding by John S. Steinhart.

2 My favourite quotation here is the title of a piece in *The Times* some 3 years back by Mark Littlewood, CEO *Inst.of Economic Affairs*, 'Triple the population – we'll all be better off.' (2013)

growth and thinking about how to develop economies with a slowly declining population. For the present this is a rich world issue. Economic growth decoupled from population growth is essential for the developing world if any kind of equity is to be achieved.

Britain, already rich (the 5th largest economy worldwide) and densely populated, continues to add people. As *Migration Watch* (2016) points out, a high proportion of this growth is due to net immigration, a highly contentious topic. I suggest that this does not reflect an inherent xenophobia. We do not resent immigration because it makes us feel crowded, it is because we feel crowded already that immigration is resented. Several opinion surveys over the past decade suggest strongly that people are indeed concerned about population growth here and abroad. References to 'these crowded islands' are common with a number of surveys revealing that a large majority believe Britain would be better with fewer people (Migration Watch 2016a). Now I concede that these may be snap judgements, the implications of which are not thought through, but surely it could be the basis for some new thinking. Yet although our large population is almost invariably mentioned when Britain's future development is discussed, it remains part of the 'predict and provide' policies of our planning agencies. There is never a hint that we might try to influence population as a matter of policy. In part this is because our numbers are supposedly linked to our economic growth (Plan-A will not accept that there are limits), but it goes far deeper than this.

To follow through from that YouGov survey implies that too many children are being born, but such a suggestion remains totally unacceptable. The obvious benefits offered by a Britain with a stable or slowly declining population are familiar (they are well set out on the *Population Matters* website) but to link them explicitly to family size seems taboo. Universally this is regarded as a matter of intimate personal choice and hence untouchable.[3] Even groups who emphasise sustainability are evasive. Euphemisms creep in. One of the commonest is talk of 'reproductive health', which on one definition (derived from various UN declarations) implies, that people, '…have the capability to reproduce and the freedom to decide if, when and how often to do so' (World Health Organization 2015).

3 Cynics will note that throughout history governments have not infrequently exhorted people to have ***more*** children when the economics seems to require it – as Italy does at the moment (Badshah 2016).

This freedom is taken as one of the universal human rights. It is adopted by all shades of politics. However admirable its intent, I believe in the modern world this is a dangerous illusion and in a country like Britain it is downright wrong. Deciding to have a child is *not* just a personal choice because the state (i.e. all of us) effectively underwrites every such decision. It undertakes to provide an environment in which each child has reasonable life prospects and if things go wrong it will step in with direct help. Thus government has every right to try to influence the birth rate when seeking sustainability.

How could we translate this conclusion into an acceptable policy? After 50 years of concern about population growth I have learnt to suppress any radical thoughts about control. I would regard it as a major advance if government at all levels takes just the first very modest step to accept – explicitly – that *numbers count*. For example, the Office for National Statistics (ONS) (2016) predicts that by mid-2027 Britain's population will pass 70 million. What are the implications for our future? Nothing could be more important, for while population growth is a global issue, if a rich developed nation begins to question its own growth it could become a powerful influence. It would really mean that Britain thinks globally and acts locally.

Yet we seem unwilling even to discuss possibilities. It would be easily possible to push for smaller families in an acceptable way if we were open about it. The state supports parenthood and it is right to do so, but from 2017 it will not do so beyond a second child[4]. Why not link this policy *explicitly* to our growth and to people's sense of a crowded and unsustainable Britain? This link is particularly important because otherwise restriction of child allowances could suggest a 2-child policy for the poor while larger families for wealthier people are of no account.

For all the concerns about ever-growing requirements we have to recognise that our culture remains strongly pro-natalist. Childless couples may, grotesquely, be called selfish and recently a woman who wished to be sterilized as she was sure she did not want children was bombarded by abusive messages (Gee 2015). Children are marvellous, essential and not going to go away anytime soon, but childbirth fills the popular media with perpetual sentimental chatter with so-called celebrity women and their 'bumps' displayed for adulation. At the other end of

4 Changes in Child Tax Credit mean that from April 2017 support will be limited to two children.

the market, in *The Times* we find a wealthy middle-class columnist agonising about her coming 'empty nest' and whether she was foolish not to have had a third child like some of her friends (Turner 2016). All of this gossipy stuff leaves the impression that one more child is neither here nor there and is *always* wonderful. We need to move to a mind-set which retains that wonder but acknowledges the truly global impact of growing ever more Britons. 'Two will do' and 'every child a wanted child' are slogans from the old days of family planning. In contrast a recent study suggests 40% of pregnancies are unplanned (Sedgh et al, 2014) (which of course is not to say that all the resulting children remain unwanted). In Britain these ideas will now have to be shared with the new immigrants who, because they are young and often from cultures which have traditionally larger families, contribute substantially to our rising numbers. We cannot ignore this, but we can try to change attitudes only if such efforts are seen, again explicitly, to be addressing the problem of too many births from all sections of crowded Britain.

I struggle to retain some optimism against a background of evasion and denial. Discussion of how to reduce birth-rates seems completely taboo. Amongst many of the public my comments above will automatically lead to cries of fascist, racist and anti-human. But it is even worse: over the past year or more I have approached five well organised academic/business/political 'think tanks' whose aims are to consider all aspects of how Britain should prepare for and adapt to the social and environmental future. They have covered education, employment, energy, food, transport and all aspects of the associated infrastructure. As a biologist, I have suggested in, I trust, moderate and rational terms, that Britain's population – just the numbers – should come onto their programme. Two groups, reasonably enough, claimed other immediate priorities but three, even after repeated tries, did not reply. I was not even dignified with an acknowledgement. It is all too embarrassing and contentious - best to deny the issue altogether and just soldier on, working round the elephant in the room as best we can.

In conclusion, I have to concede that my prediction for the future is only one of many and has a biological bias. Thus I would hope our very limited number of great grandchildren could grow up in a world that still has elephants and all that their survival implies. There are alternatives: we could just let things go on as now

or even concentrate on maximising humans (although they would have to accept many compromises in the way they lived). From a strongly left-wing perspective, in *Population and Development* (1997) the sociologist Frank Furedi argues that those in favour of population control erode the necessary confidence that we can tackle future problems and fail to accept that human life should always be treated as precious and special. He asks, 'How can there possibly be too many of us?' (2007). Any biologist could provide an answer.

Between the extremes there are an infinity of intermediates. At least a much lower population would leave our descendants with some alternatives for their future. As we are set at present we are trudging up a down escalator and we risk the Earth's life support systems slowly being swept down with us. The technological innovations for recovery which we will need are relatively simple. It is the mindset within us that we must struggle to change and this will not be easy.

> 'Go, go, go, said the bird: human kind
> Cannot bear very much reality.'
>
> T.S. Eliot, *Four Quartets*

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One Child: Do We Have a Right to More?

SARAH CONLY

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We love our children, and for many of us the time we spend with our children is the best part of our lives. The time has come, though, to acknowledge that we need to have fewer of them, and that indeed we don't have a right to give birth to more than one.

The United Nations has predicted a global population of 11.2 billion by the year 2100. They know, of course, that the fertility rate – the number of children a woman has over her lifetime – has dropped a great deal, to 2.5 per woman. Even so, given the high number of young people who will themselves be having children, we still arrive at the mind-boggling figure of 11.2 billion. If 2100 seems too far away to think about, the prediction is 9.7 billion by 2050, well within the lifetime of many of us (UN 2015).

No one who is familiar with these facts doubts that such a growth in population will be a great danger, both to humans and the environment at large. The question has been what to do about it. Many people believe that while having more than one child per couple is dangerous, the most we can do about this is plead for people to refrain. People have a right to have as many children as they want, it is argued, and so there is nothing we can actually do that might interfere with childbearing. Education about the dangers of overpopulation is permissible, since education doesn't actually prevent people from doing what they want; in fact, it helps people do what they want, since they can better see the effects of their actions. Anything else would violate a fundamental human right, and it

is morally wrong to violate fundamental human rights, even when we think that would benefit society at large. That's why we don't allow slavery, even if lots of people would enjoy it: there are certain things you just can't do to people, no matter how much other people benefit from them.

In fact, however, having as many children as you might happen to want isn't a fundamental right. In my book, *One Child: Do We Have a Right to More?* (2016), I argue that when you claim something as a right you need to justify that claim, and you simply can't justify the claim that you have a right to have as many children as you want when that will be as harmful to others as this much overpopulation is bound to be.

We claim moral rights sometimes just because we want something a lot, but wanting something and having a right to it aren't the same thing. People who study rights generally argue that there are two possible justifications for claiming that you have a right to do something. First, many people argue that if you absolutely have to have something in order to have a chance at a decent human life, then you can claim that thing as a right. For this reason, many people believe that we have a right to food, because it's impossible to live a decent life if we are starving. Now, having food doesn't guarantee a life of human happiness, but it gives you something no one can be happy without. Other people argue that we have a right to education for a similar reason – we might be contented even if we are completely ignorant, but for one thing, that is less likely, and for another, even if we are contented in a state of complete ignorance it seems less than a human life. For a decent human life we need the basics for mental and physical health.

The fact that there is a justified claim to food, though, doesn't mean you can claim a diet of lobster, truffles, and champagne, no matter how much you might prefer that. We have a right to basic nourishment, what we need for a chance at satisfaction and good health, not to whatever might most please us. Similarly for education: we think there is a right to education, but that doesn't mean that everyone has a right to go to Harvard or Oxford, or a right to be maintained by others in the study of particle physics for all of life. What you can claim from other people is limited to what you need for a decent life, not for the life you would most want.

Similarly for children. Some people think that having a child is necessary for a decent life. I actually find this unlikely, given the number of happy, flourishing, productive people we all know of who are childless, but let's say, for purposes of argument, that most people need the experience of childbearing and childrearing to have a decent life. It doesn't follow from that that you have a right to as many children as you want, any more than the right to food gives you a right to lobster and champagne. A family with one child is just as much a family as a large family. Any parent with one child experiences both the cares and rewards of childbearing and childrearing. The fact that you would like more doesn't mean you have a right to more, any more than the fact that I would really like to work fewer hours for the same salary I get now means I have a right to work fewer hours for the same salary.

So, the fact that we can make reasonable claims to have our own basic interests met doesn't mean we can claim a right to have as many children as we may happen to want. However, basic interests aren't the only thing that can justify a claim to a right. Often we claim a more general right to live our lives as we want, to shape our lives in line with our own values. Here, we say that respect for our autonomy as persons gives us the right to do certain things. We say, for example, that we have a right to freedom of speech, whether or not speaking freely makes us better off. Even if our basic interests in food, education, etc. can be met without our having access to these freedoms of self-expression, we feel these freedoms are morally ours to claim. Indeed, we usually claim these rights even if what we want to do is downright bad for us – the idea is that we should be allowed to craft a life in accordance with our own values.

Do we then have a right to have as many children as we want, arising from our general right to live autonomously?

Well, it depends. Right now we don't. The truth about these autonomy rights, these rights to choose to live your life the way you want, is that which of these rights you have is always sensitive to context. We say we have a right to free speech, but we also say you don't have the right to falsely yell "Fire!" in a crowded theater. John Stuart Mill, who wrote one of the most eloquent defenses of freedom that we have, conceded that of course when and how you can permissibly say something depends on how much harm that might do. We have a general right to practice

our religion, but if our religion required human sacrifice, we obviously wouldn't have a right to that. We often have a right to do things that are somewhat harmful (saying mean things, for instance) but we don't have the right to do things that are devastatingly harmful. Right now, having more than one child is just that: a world of 11.2 billion is a world of climate change, water shortages, soil depletion, overcrowding, species extinction, and many fear, insufficient food. It's just too harmful to be something we have a right to do.

But what can we do? One problem is that we often don't see how we can stop people from having too many children for the planet to bear. The Chinese one-child policy famously led (at least sometimes) to forced abortions and forced sterilizations, and people rightfully see these as violating the right to bodily integrity. Even if you don't have a right to do something, if I can't stop you without violating a right you do have I'm not allowed to do that. If, say, the only way I can stop you from trespassing through a distant corner of my field is to shoot you, I am not allowed to shoot you, even though you have no right to trespass. So if there is no morally permissible way to prevent people from having more than one child, what is the point of talking about it?

Fortunately, there are morally permissible ways to influence people's childbearing practices. First, of course, we do need education, as was mentioned above. Whatever else we do, we will need to explain how the fact that the fertility rate has dropped does not mean that we need not worry about population. Demographic momentum, the fact that with so many young people replacing themselves the population will continue to grow past, as far as we can tell, the breaking point, needs to be explained. We need to teach, too, that so far we don't see a technological fix that will allow 11.2 billion people to live happily – many people seem sure that we can easily produce lots of fresh water from sea water (not realizing how much energy this takes), or that we can "fix" global warming despite our continued increase in greenhouse emissions, or even that we can colonize other planets to relieve the population burden. These things may perhaps be possible, but we have no reason to think they are going to happen. Trusting in such fanciful solutions would be like introducing your child to cigarettes on the chance that someday we will know how to cure cancer – just plain irresponsible. We need to teach that this isn't something anyone has a right to do.

As I have said, though, education is probably not enough. Habits are hard to change, and the habit of thinking of something as harmless is particularly hard to get over. We've always celebrated the birth of children, and the idea that it can be dangerous requires a real conceptual shift, and we are very slow to do that. More is needed. We could, for a start, cut down on the number of unplanned pregnancies. There is a huge unmet need for contraception in the world, especially (not surprisingly!) in some of the places with the highest fertility rates, such as Sub-Saharan Africa. Women who would like to have fewer children aren't able to, because they have no way to control their own fertility. This is something the richer countries of the world could help with, making universal access to family planning facilities a priority. This would, honestly, be the right thing to do even if overpopulation were not a danger.

However, the worst contributors to greenhouse emissions are those of us in countries where contraception is relatively easy to get. In these places more is needed than simply the ability to have no more than one child. We need the desire. And here the government can take important steps. We could, for example, give tax benefits to one-child families. Alternatively, we could give tax penalties to those with more than one. Or, we could change the expressive power of the message by simply saying that we are fining those who have more than one child. We know that the number of children people have is sensitive to finances – each economic depression and recession sees a drop in the fertility rate, and each recovery sees a rise. And the fact that the fertility rate has fallen as far as it has is probably due at least in part to financial considerations – education and general childrearing cost a fair amount of money, in most places, and may also require that a two-income family become a one-income family, at least while the child is small. There is good reason to think, then, that financial incentives and disincentives would be enough to reduce the fertility rate. When a financial disincentive is great enough to change our behavior that may strike some as coercive, but again, the pressure here is to prevent us from doing something we don't actually have a right to do.

Would everyone be sensitive to such pressures? Perhaps not, but we should bear in mind that sanctions for undesirable activities are not generally designed to make those actions literally impossible. We disapprove wholeheartedly of theft, and we punish it, but we don't do everything we possibly could to stop it. We don't

have cameras that follow the activities of every citizen every second, because that would be too intrusive. We don't require that thieves have their hands cut off even if that would persuade more people not to steal, because that would be too brutal. We do what, combined with education and shared cultural values, will prevent the vast majority of people from stealing. Similarly with children: we want to reduce the fertility rate, but the fact that there are some who would rather accept the sanction than refrain from having more than one child doesn't mean the policy has failed. It means it is like other public policies, where we would like 100% compliance, but don't expect to get it. We need enough to bring about the requisite change.

Even if we have no right to more than one child, is trying to prevent that a good idea? There are disadvantages to a one-child policy, of course. It would involve personal losses. First and foremost is simply that some people who want more children will be disappointed. Secondly, it means that children would not have siblings. While earlier beliefs that an only child would be predictably lonely and/or spoiled have been shown to be false, it may still be a loss not to have a sibling. There are also ethical concerns: will a one-child policy lead to sex selection in procreation of the sort that will lead to a society that is disproportionately male? And then there are more material concerns: some ask how an economy based on unending growth can succeed with a population that isn't constantly growing. If we adopt a one-child policy, the population will fall. Eventually we will reach a sustainable number, and at that point, of course, we would aim for stability, with an average of two children per couple, or replacement value. Even then, though, our economy would have to run differently. Our economy so far as been based on a plan of infinite growth, and with a stable population rather than a growing population our economy would need to function differently.

These are legitimate concerns. However, none of them provides a sufficient reason to oppose a modern one-child policy. To take the last first: it's true, we don't know how to run an economy with a falling or stable population. At the same time, we don't know how we are going to run an economy with constant growth, either. A constant increase in the use of resources just isn't possible on a finite planet. It can't happen – we will simply run out of resources. Not everyone is happy with the economy as it is working now, given the increasing inequality we see between rich and poor, but even those who do think it functions well must

admit that it just can't keep running the same way. We will simply run out of stuff. Given this, a number of economists have suggested that we need to make a change – that we need to figure out how to have satisfying lives that aren't based on the prospect of producing more and more things. No one wants a crashing economy, but the way to avoid that isn't just to keep doing what we have been doing. Better to change now, while we still have fuel, water, food, and precious minerals, than later.

Sex selection, too is something we want to avoid. The evidence, though, is that sex selection is a phenomenon distinct from falling fertility rates. People in the United States, Western Europe, and the Far East have greatly reduced their fertility rates without this resulting in any disproportion between boys and girls. And one of the places that does show a clearly unnatural sex ratio is India, where people can have as many children as they like. The cause of sex selection is, to make a long story short, sexism. When women are not allowed to earn as much as men, or are much more expensive to raise (if, say, they need unaffordable dowries for marriage) they will naturally be the second choice for many people. This can change, though, as we have seen. When women have equal standing, there is no preference for boys.

The loss of the larger family one might have wanted, and the loss of siblings, are real losses for some of us. There will be parents who would be happier with more children, and children who would be happier with siblings (as well as parents and children who wouldn't be any happier with more children). For some families, adoption may be possible, but of course with a smaller number of children in the world this wouldn't be possible for everyone. I don't think it can be denied that some people will be worse off with fewer children in a family than they would be in a family with more. Still, even if they have lost something of value, that haven't lost as much as would be lost in an overpopulated world. Small families are still families, as said above, and bring the rewards of family life. The fact that some people would have found a larger family more rewarding doesn't mean they need one for a happy or rewarding life. A life in which we lack food, or water, or space, or any access to the natural world, is a not a decent life. And of course a shortage of resources like these leads, typically, to conflict – civil wars and international wars as people struggle for what they need. Having a happy family in the midst of war is virtually impossible.

We need, then, to change our ways. We need to recognize that those who have more than one child when they could do otherwise are doing something they don't have a right to do, and the consequences will be disastrous.

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On Sustainability, Vulnerability, Climate and Conflict

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Introduction: vulnerability and resilience

The human population of the Earth is over 7.4 billion and growing.[1] Population growth inherently increases demand for resources, such as humans' most basic needs, water and food. In 1798 Thomas Robert Malthus (1798) introduced the theory that, if left unchecked, the population of our planet will, at some point, outgrow its resources, exceeding the planet's carrying capacity. Malthus's theory did not foresee technological advances in food production (Green Revolution)[2] and it is similarly difficult for us to envision what the future holds with respect to the relationship between resource supply and demand. It is fair to say, however, that the Earth is on an unsustainable trajectory. Now, over 200 years after Malthus introduced the theory, the world's population growth is still outpacing the growth in food production.

One characterization of a nation's sustainability lies in the balance between the supply and demand of its resources. Changes in demand, due to population growth for example, or supply, such as declining access to food and water, act to increase the strain on existing vulnerability. Every region and nation comprises

1 http://www.worldometers.info/world-population/

2 See Evenson and Gollin (2003)

a unique combination of population, geography, governance, economy, access to natural resources, social and religious structure/diversity, climate and other characteristics. The interdependence between these many factors is distinctive and often quite complex, on both spatial and temporal scales. Each nation varies with respect to its inherent vulnerability, or alternately its fundamental lack of resilience to change, and therefore in its capacity to adapt.

Many nations/regions are disproportionately vulnerable to changes, particularly abrupt changes (or 'shocks'), due to inherently limited access to water or other resources, for instance. Semi-arid and arid regions certainly fall in this category. When such changes occur, these nations are more likely to exceed their thresholds of resilience, sometimes leading to conflict, ranging from small-scale land and water disputes to full-scale war. This is not to suggest a climate determinism however, as there are also examples where extreme climatic changes have resulted in increased cooperation rather than violence (Subramanian et al., 2015). When large-scale conflicts do occur they further compound existing difficulties, sometimes leading to forced migration internally and perhaps even spilling over national boundaries when people seek refuge elsewhere, further increasing the strain on resources in those host countries, and so on.

A society's climate has a central influence on its ability to succeed and flourish or conversely to suffer and fail. Climate change is thought by many to be the greatest challenge facing our planet and its inhabitants (not only humans) now and for the remainder of this century (and perhaps much longer). When the climate changes, particularly in abrupt or extreme ways, it can directly impact access to water and food. Water is of course vital for human consumption and for cultivation of agriculture and livestock. Hence a society's vulnerability is, and has always been, directly linked to changes in climate.

Climate and civilisation in history

Links between the rise and decline of ancient civilizations and changes in their climatic conditions have long been theorized. Such changes are directly associated with access to water and, by extension, agricultural potential. The collapse of the highly developed Akkadian Empire that ruled in Mesopotamia roughly four millennia ago was attributed to a sudden shift to more arid conditions. Similar collapses occurred in Egypt and in India during the same period (Cullen, 2000).

The Mayan civilization flourished during a period of wetter than normal conditions over two centuries and then collapsed after an ensuing period of declining rainfall that lasted three centuries. This climate change triggered a fragmentation of society and governance and an increase in warfare, and was followed by an extended drought and a population collapse (Kennett et al., 2012).

The demise of Angkor in the Khmer empire in Cambodia has been attributed to the combination of drought and intense monsoonal rainfall that impacted the city's water supply and agricultural productivity and damaged its water control infrastructure (Buckley et al., 2010).

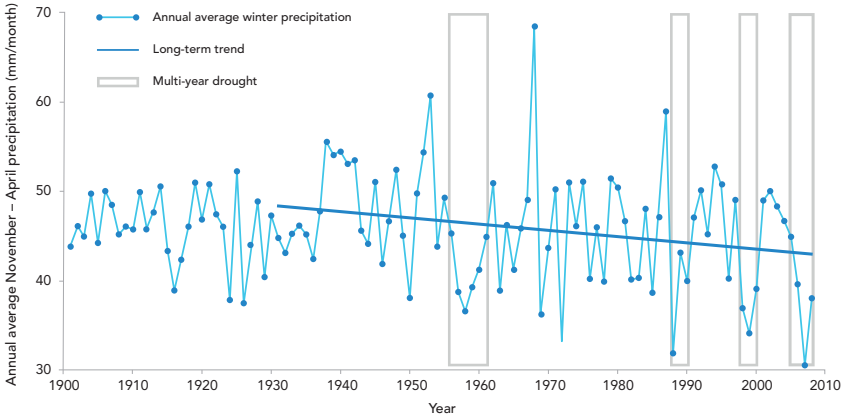
The Roman Empire rose during a period of stable and favorable climatic conditions, and then fell into crisis during the Empire's third century under deteriorating climatic conditions. The Empire recovered in a second, briefer period of favorable conditions, after which regional differences in climate conditions coincided with the diverging fates of the eastern and western Empires in subsequent centuries. Additionally, climate conditions beyond the Empire's boundaries played an important role by affecting food production in the Nile River valley, and by encouraging two major migrations and invasions of pastoral peoples from Central Asia (McCormick et al., 2012).

These are merely examples and are not listed here to imply that climate is the single determining factor in a civilization's relative success or lack thereof. As mentioned above, the relationship between the many important factors is quite complex; but it is reasonable to conclude that climatic factors have often played an important role. This applies to modern times as well.

Climate change and violence today

There have been a number of studies linking climate to violence in the modern era (Cane et al., 2014; Hsiang and Burke, 2014), but other studies downplay the importance of such links. Although this body of literature has at times been contentious (Hsiang and Meng, 2014), climate can play a role, whether small or large, in a society's ability to flourish or even succeed. Abrupt changes in climate can often push a society's resilience beyond its ability to effectively adapt.

This leads to the example of Syria. The Fertile Crescent, where agriculture and herding began over ten thousand years ago, receives most of its yearly rainfall during the winter months, from late October to early April. A study conducted by myself and others and published in the Proceedings of the National Academy of Sciences (PNAS) in early 2015 (Kelley et al., 2015), found that from 2006–2010 the region experienced its worst multi-year winter drought in the observed record.

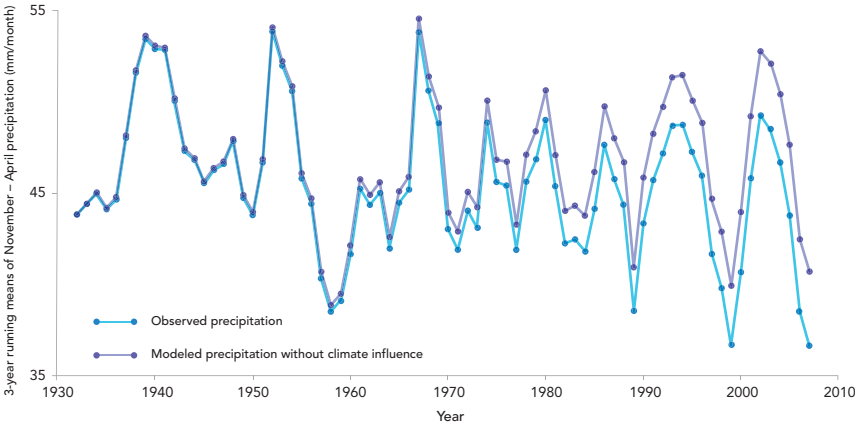


GRAPHIC BASED UPON LA FOND (2016)

Figure 1. Rainfall (1901–2008): Precipitation patterns are changing in the Fertile Crescent. Rainfall from November through April, when most of it occurs, has decreased 13% since 1931. The gray boxes represent multi-year droughts, which are defined as three or more consecutive years when precipitation is below the century-long average.

This unusually severe drought directly preceded Syria's Arab Spring uprising (in early 2011). The severity and duration of the drought caused an agricultural collapse and a subsequent mass migration of farmers and their families to the urban areas in Syria's west. The influx of internally displaced people into the cities after the prior arrival of Iraqi refugees and on top of robust natural population growth, led to overcrowding, a lack of employment and resources, a sharp increase in crime in the urban peripheries and, perhaps most importantly, little or no relief from the government. The Syria conflict escalated into a prolonged and bloody civil war that led to Syrians fleeing the country for their safety and causing a global refugee crisis.

Governance is perhaps chief among the factors that led to Syria's instability. The Syrian government had for decades encouraged wheat and even water-intensive cotton production, and Syria had succeeded in becoming a net exporter of wheat, to the point that it reached 25% of their total GDP. When the drought occurred Syria abruptly went from a net exporter to a net importer of wheat, which put them at the mercy of global food prices, high at the time. Another example of poor governance is the clear failure by the Assad regime to address the suffering of the displaced rural population.



GRAPHIC BASED UPON LA FOND (2016)

Figure 2. Separating the influence of climate change (1932–2007): Using measurements of carbon dioxide concentrations in the atmosphere coupled with climate models and statistical analysis, scientists were able to estimate what rainfall in the Fertile Crescent would have looked like without the influence of climate change.

The Syrian government's strong dependence on agriculture, which was initially implemented in the interest of national security, ironically depended not only on the rain that typically falls in Syria, but also the water that flows in through the Tigris and Euphrates rivers, and perhaps most importantly on groundwater. Groundwater, in semi-arid and arid regions in particular, has long been a vital complement to rainfall for irrigation purposes. Exponential population growth was responsible for a dramatic increase in the extraction of groundwater. In 1950, Syria's population was roughly 5 million and has since grown to nearly 25 million. This increased stress alone put Syria in an untenable position. Declining

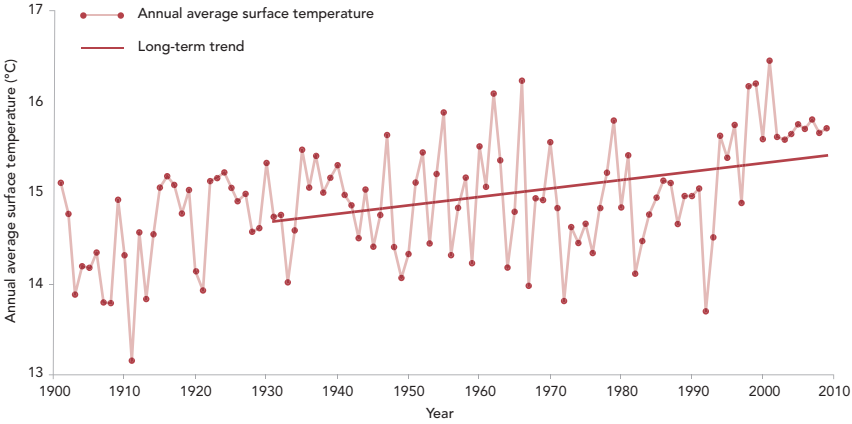
groundwater in the Fertile Crescent is merely an example of a systemic problem globally, one that is a very real threat to sustainability even before the deleterious effects of climate change are considered.

A newly released study, using tree-ring data from throughout the greater Mediterranean, characterized the natural rainfall variability over the last 900 years (Cook et al., 2016). Much of the region's weather is linked to atmospheric variability over the North Atlantic. This natural variability ranges from very short to much longer time scales. The latter manifests itself in consecutive decades of drier or wetter than normal conditions over Europe. The greater Mediterranean region has experienced a significant decrease in winter rainfall over recent decades, and at least part of the drying is due to climate change (Kelley et al., 2011). In the eastern Mediterranean, Fertile Crescent/Levant region, the longer-term natural variability over the North Atlantic holds less sway and the climate change signal is therefore more distinct (Kelley et al., 2011). Thus the increase in the frequency and the severity of multi-year droughts in this region over recent decades is believed to be due to human-induced climate change. Droughts such as the most severe one that occurred just prior to Syria's collapse were estimated to be two to three times more likely due to the climate change influence (Kelley et al., 2015). The new tree ring study provides compelling convergent evidence that the recent drying in the Levant/Fertile Crescent is well outside the range of natural variability over the last 900 years and is therefore very likely to be human-induced.

Yemen, another Arab Spring nation, is one of the poorest and most food insecure nations in the world and has been for some time. Yemen and Syria are similar in a number of ways. They have faced nearly identical population increases since 1950, both are highly agrarian societies and both depend strongly on groundwater, which has declined rapidly. Again, these are factors associated with high vulnerability before the effects of climate change are even considered. Most of Yemen's population resides in its west, near the mountains that run parallel to the Red Sea coast. Although this region does not receive an abundance of rainfall it is easily the wettest in all of the Arabian Peninsula. As such, western Yemen has the capacity for fairly diverse agriculture; but Qat, the mild narcotic that has been grown for many generations, has begun to supplant food crops due to its more regular yield and high profitability. Clearly, for a nation that is poor and food insecure, the decline in food crops is alarming. Worse, however, is that Qat

is highly water dependent, much more so than food crops, and is increasing the strain on Yemen's rapidly declining groundwater.

It has been suggested by some that Yemen's capital city of Sanaa may be the world's first to run out of water. Unlike Syria, Yemen has not seen a significant decline in rainfall over the last 40 years, although both nations, like much of the greater Middle East, have experienced a strong increase in surface temperature.



GRAPHIC BASED UPON LA FOND (2016)

Figure 3. Temperature (1901–2009): Temperature has shown a long-term increasing trend in the Fertile Crescent. Every year from 1994 through 2009 was warmer than the century-long average for the region.

This is important because higher temperatures, among other factors, cause more water to evaporate from the soil. The enhanced drying of the soil during the dry months has a cumulative effect, inhibiting groundwater recharge. Although Yemen did not experience a climate 'shock' similar to the extreme drought in Syria, in early 2015 it too collapsed into large-scale conflict.

As with Syria, it is important to reiterate that Yemen's conflict owes its existence to many important factors, not only to conditions made worse by climate change. Again, each nation is distinct in not only its response to climate change, but in the relationship between the many factors that combine to produce vulnerability. There

are numerous other examples of nations experiencing climate change in one form or another and how it has added to their existing vulnerabilities and heightened the overall water and resource stress, with differing outcomes. To accurately assess each country's (or region's) threshold of resilience, with an eye toward building the capacity to predict when that threshold may be crossed, is a tremendous challenge.

As of this writing, tentative ceasefires have been agreed upon for Syria and Yemen. The future of these two nations is far from clear. What is clear, however, is that Syria's civil war has had a profound effect on the rest of the world. Thus, it stands as a primary example of how climate change can combine with other key factors to exacerbate existing food and water security and social challenges and to push a vulnerable region beyond its resilience. As such, the security communities, including Department of Defense (2014), have taken climate change very seriously for some time now.

The examples of Syria and Yemen perhaps beg the question of who will be next? Prior to its uprising, Syria was widely viewed by experts as stable and largely immune to the effects of the Arab Spring. According to a recent study (Werrell et al., 2015) certain popular indices of nation-state fragility (Fund for Peace's Fragile State Index, for instance) corroborated this belief; in hindsight it was not in fact the case. This leads to the conclusion that, while prediction of state failure or conflict is clearly a highly complex task involving numerous variables, there is strong reason to believe that closer examination of regional climate change and resource availability change could greatly improve existing state fragility indices, providing policy makers with better information with which to make informed decisions.

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Population Projections: Recipes for Action, or Inaction?

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Introduction

Population projections, for the world or for individual countries, are often cited as context for discussions of the future. The most commonly cited projections are those of the Population Division of the United Nations Department of Economic and Social Affairs (UNDESA) (2016), but some, including the International Panel on Climate Change (IPCC) socioeconomic pathways, use projections from the International Institute for Applied Systems Analysis (IIASA) (2007).

From food, water and energy security to the strength of the workforce, population projections contribute to the landscape against which various scenarios are played out. Yet oddly, despite the unreliability of past projections, current projections are usually taken as immoveable fact in such analyses. The scenarios tested rarely include any alternative population paths, and even more rarely consider that any policies or programme options might influence the population path. Where alternative paths are considered, such as the IPCC scenarios, they are viewed as outcomes of socioeconomic pathways, not as determinants of those pathways.

An analogy may be the role of day length in the yield of solar energy. There is an unquestionable link, but because we can't alter day length, it is not a variable that is given any consideration in analysis of renewable energy options. It is there in the technical calculations, but not in the discussion of determinants or strategic implications. So it is with population, in most treatments of future challenges and opportunities.

Cognitive dissonance: the fixed point that keeps moving

Last July, the United Nations announced their 2015 global population projections to a near-empty room. A few brief news items dutifully reported that the new estimate for the year 2100 was 11.2 billion people.

Nobody mentioned that this was more than a billion higher than the UN's 2010 projection, only five years ago, which was already a billion higher than its 2004 forecast (Figure 1). Nobody speculated how much higher it might be revised before we actually get to the end of the century. Nobody questioned why upward revisions have become a regular occurrence. Since 2002, each UN projection has been higher than the last.

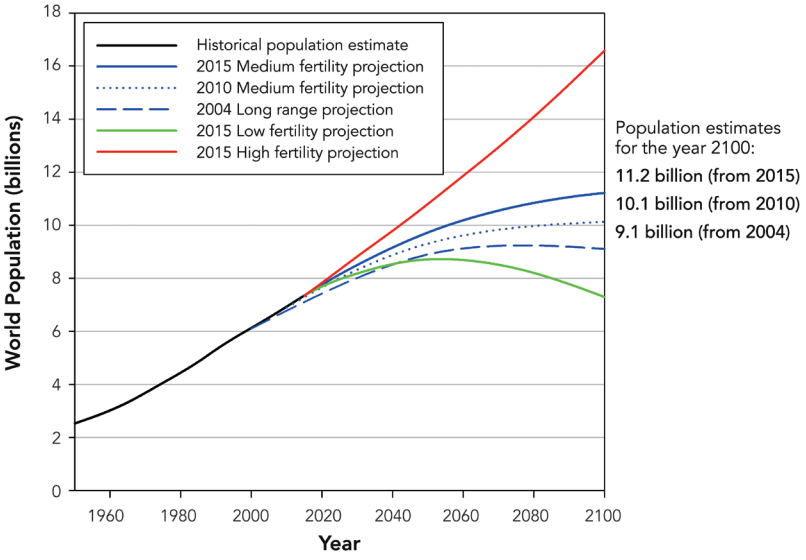

Figure 1. The United Nations population projections, estimated in the 2010 and 2015 revisions (UNDESA 2011). Prior to 2010, the projections in the UN's World Population Prospects series only extended to 2050, but a long-range forecast in 2004 gave estimates to 2300 (UNDESA 2004).

What does this tell us about where the global population is heading? Over short periods of time, trends are more visible in the annual change in population, rather than the population itself (Figure 2). Through the 1990s, the human population

increased by a smaller number each year, building belief that peak population was on the way. But from 2000, the increment started rising again. The UN's medium fertility projection expects the downward trend will resume forthwith, but annual tallies of actual population increase, published in the Population Reference Bureau's 'World Population Data Sheet' (2015), have recorded increments well above the last medium projection. The 2015 edition already raises the UN's new year-2050 number to over 9.8 billion – having increased this estimate each year for quite some time. Should we now believe they've got it right?

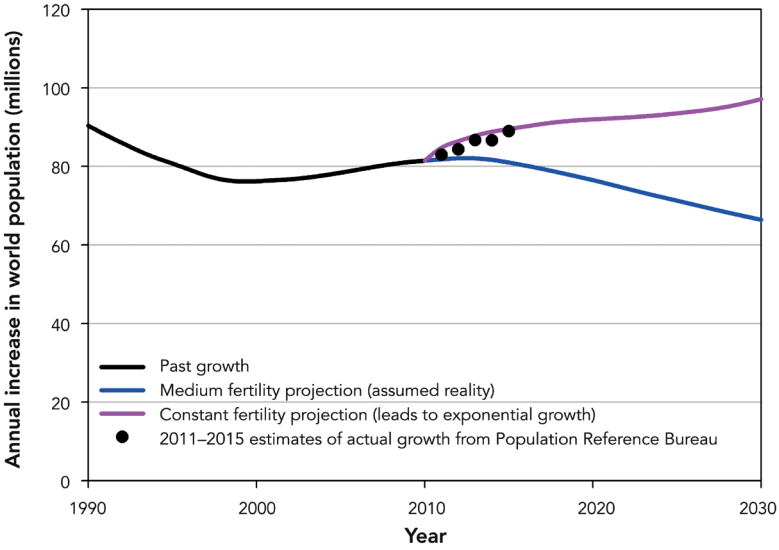

Figure 2. How have we tracked since the last projection? The annual increment of global population from 1990 to 2010 (black), and those projected in the UN's 2012 revision of the medium fertility projection (blue) and the constant fertility projection (pink) (UNDESA 2013). With the latter, in which each country's fertility is held constant, world population grows to reach 28 billion in 2100 (unless checked by famine and war). Superimposed are the estimates of actual increase from the Population Reference Bureau's annual World Population Data Sheets, from 2011 to 2015.

Indeed, these annual increments have been closer to a projection based on no change in national fertility rates. This 'constant fertility' projection would reach 28 billion this century if not checked by catastrophic mortality.

It is sobering to reflect what such a check would involve. It would require approximately 100 million extra premature deaths per year, every year for decades, to bring down the global population through more deaths rather than fewer births. In contrast, the recent Ebola epidemic killed around 10 thousand people. The AIDS epidemic has killed around 40 million over 30 years. Since a population of 28 billion is extremely unlikely to be supported by Earth's resources, catastrophic mortality is the path we are currently choosing.

The projections don't match reality

The UN's medium fertility projection has been based on an assumption that all high fertility countries will progress steadily to below two children per woman. On release of the 2012 revision, director of the UN's Population Division, John Wilmoth, noted that recent falls had been lower than expected, but the projections continue to be on the same basis as before. He concluded,

> *The medium-variant projection is thus an expression of what should be possible … [it] could require additional substantial efforts to make it possible.* (emphasis in the original) (2013 p. 1)

The UN's projections expect all countries to follow a similar smooth S-curve shape of fertility transition, if at different rates (Raftery et al. 2012). The main reason that the projections keep being revised upward is that a lot of countries are not following this story-line. Since the mid-1990s, fertility declines in most mid-transition African and Asian countries slowed or stalled. This has been attributed to a marked decline in international support for family planning programmes (Sinding 2009). Bongaarts found that "among countries in [fertility] transition, more than half are in a stall" (2008 p. 109) A number of countries, including Indonesia, Egypt, Algeria, Kazakhstan, have seen fertility rebound to a higher level. Several sub-Saharan countries have not really begun to decline. These realities are not possibilities in the model used for projections.

A few high-fertility countries, like Rwanda, Ethiopia and Malawi, are now tracking downwards faster than anticipated by the UN. They may seem unlikely candidates on the basis of the most often-cited drivers, such as wealth, women's education and industrialisation. But in each case, there have been conspicuous recent efforts from both governments and NGOs to address population pressure through family

planning programmes and women's empowerment (USAid 2012; PHE Ethiopia Consortium 2016). Like the family-planning adopting countries of the 1970s and 80s, they are finding that deliberate interventions to engage communities and increase access and acceptability of contraception can be highly effective, despite low levels of wealth and education.

Yet this good-news story is missing from the UN's commentary. Instead we are given a fatalistic view. Indeed, the latest communications from the UN make no reference to 'additional efforts'. It presents the medium projection as the most likely "based on an implicit assumption of a continuation of existing policies" (Gerland et al. 2014 p. 2).

What we measure limits what we do

This fatalism infects most efforts to anticipate the future. As mentioned above, a wide range of studies use the UN's population projections as the multiplier of human demands and impacts, when testing which policy options might maximise future prospects. By choosing not to vary population pathways, they provide no advice on the benefit or otherwise of addressing population growth. Indeed, they rarely discuss population growth as a factor affecting outcomes.

There are rare exceptions, and their findings are salient. O'Neill et al. (2010) estimated the difference in projected greenhouse gas emissions between scenarios assuming UN's medium population projection and those assuming the low projection, taking account of impacts of changing age structure, household size and urbanization. They concluded that achieving the low population projection could provide 16-29% of the emissions reductions needed by 2050, and could reduce fossil fuel demand by 37-41% by the end of the century. In a recent study, Bajželj and co-workers (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. The World Resources Institute's exemplary series "Creating a Sustainable Food Future" (2013) found that achieving replacement level fertility (around two children per woman) 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 Futures Group found

that a modest acceleration in contraceptive uptake in Ethiopia could completely compensate for the anticipated impacts of climate change on food security in 2050 (Moreland and Smith 2012).

Mathematical complexity doesn't necessarily improve accuracy of projections

The change in rhetoric, which saw the medium projection shift from 'what should be possible' to 'the most likely', is linked to a methodological change. The most recent UN projections adopt a Bayesian probabilistic methodology. This is a step up from the previous method, in which high and low fertility projections merely assume a fertility rate 0.5 units (children per woman) higher or lower than the medium course in every country – greatly underestimating the range of possibilities in high-fertility countries, and exaggerating them in low-fertility countries.

The new methodology makes more nuanced assessments of likely variation from the central ("medium") projection, but the medium projection itself is determined in much the same way as it was before. It finds the average course that countries have taken in the past, from whatever time their fertility started to fall in earnest, and presents this as the most likely course that each high-fertility country will follow from now on. The model forces the stereotypical S-shape of fertility transition by encoding it as a double-logistic mathematical function, and researcher judgements define the spread of each variable in the function.

Hence it is still a narrow interpretation of possible futures. The mathematical form cannot accommodate stalls and reversals in fertility decline, and the researcher assumptions do not allow for further delays before individual countries establish a downward trend. Nor does the formula consider as likely the very high rates of fertility decline that family planning countries have achieved in the past.

The narrowness can be seen in the relationship between each country's total fertility rate (TFR, average number of live births per woman) and the rate at which it falls (Figure 3). For the projection (open symbols), the rate of fall is tightly related to the fertility rate. All remaining high-fertility countries are assumed to start their fertility decline immediately and in earnest, despite their recalcitrance to date. Data from the most recent decade (solid symbols) show much wider diversity, with many countries falling faster, but also many near-stalled in mid-transition or rebounding

before reaching replacement level, and some have yet to make a start. Data from the 1980s (crosses), when family planning programmes were widely supported, show many higher rates of transition and few stalls or rebounds.

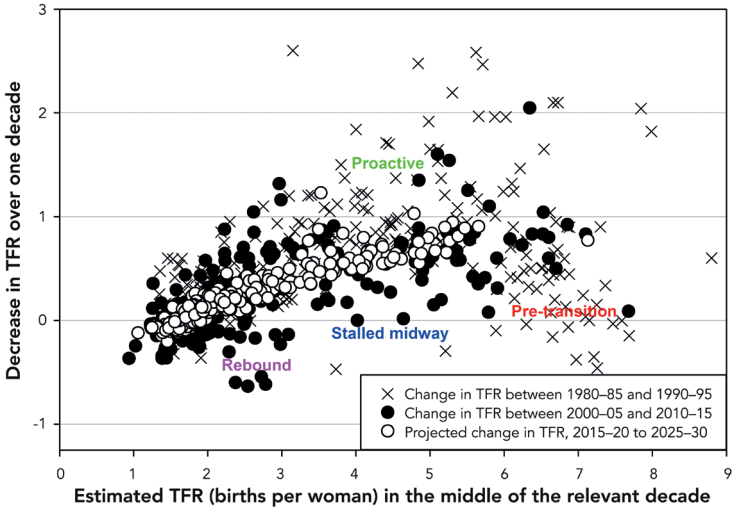

Figure 3. The relationship between the fertility rate of each country and the rate at which its fertility falls, for the most recent decade (black dots), compared with the first projected decade (open dots) and with the 1980s (crosses). Over time, the fertility of individual countries undergoing fertility transition moves from right to left. The projections depend on what is anticipated to be the average pathway, the variation around that average pathway, and when each country embarks on their transition.

History's lessons unheeded

The UN's deterministic approach to projection overlooks the role of choices, rather than chance, in the different paths each country has followed.

It was programme choice which saw Thailand's fertility fall rapidly in the 1970s, Iran's pull abruptly away from those of its neighbours, Costa Rica lead the pack in Central America, and Rwanda now diverging so strongly from neighbouring Burundi and Uganda. These choices are not being talked up by the UN. Indeed, by presenting the projections as "probabilistic", the impression is given that direct action is futile. There are no policy levers attached to model, determining

whether fertility rate is higher or lower than the average – only unidentified external factors acting randomly.

For lack of volition, most of the highest fertility countries do not yet have fertility falls as fast as the medium projection expects. Why, then, does the medium projection assume that all remaining high fertility countries will commence steady fertility decline immediately, when history tells us that these abrupt starts have depended on policy change? Since these countries have the greatest influence on future global population, we can only expect that the next revision will also be upwards.

This is the crux of the matter: *assuming a continuation of existing policies*, the UN's methodology poses that it is *most likely* that the highest fertility countries, which have seen the slowest fertility reductions to date, will show the fastest reductions from now on. Moreover, despite many mid-transition countries having stalled or increased fertility in the past decade, it finds that none are likely to do so in the coming decade, without any change of policy.

I am reminded of the saying, probably wrongly attributed to Albert Einstein, that "the definition of stupidity is doing the same thing over and over again and expecting different results." By reapplying the same model for each revision, does the UN Population Division expect its next projection to be any more reliable than the last?

The future will be shaped by our choices

We could choose a different result, but it would require doing things differently. Much faster fertility transitions are possible, if family planning and small family norms are promoted alongside women's health and rights. Many developing countries have successfully achieved below-replacement or near-replacement fertility in this way. Figure 4 shows the time course of fertility for some of them. In each case, the abrupt start to fertility decline coincided with initiation of voluntary family planning programmes. Rates of fertility decline have been two to three times those expected in the UN projections. No economic or educational trigger was evident, but in each case economic development, including improvement in educational and health outcomes, followed as a consequence of lower population growth (O'Sullivan 2013).

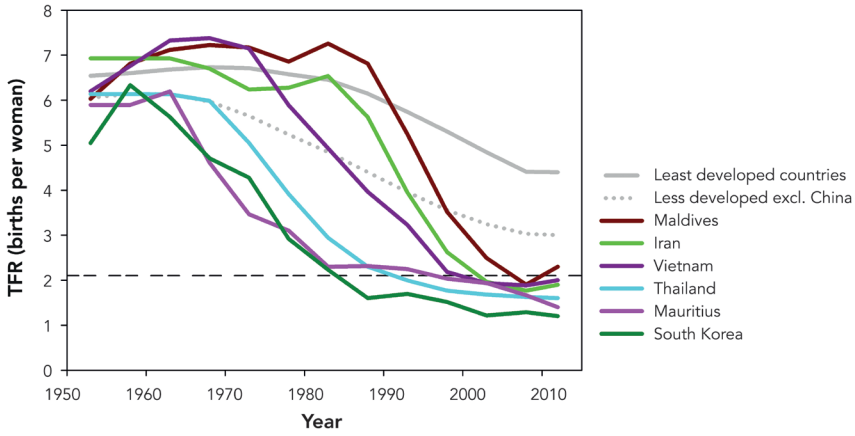

Figure 4. Time course of total fertility rate (TFR, births per woman) for selected countries which implemented population-focused voluntary family planning programmes at differing times, showing rapid change in fertility, compared with aggregate TFR for less developed and least developed nations. Data from UNDESA (2011) and Population Reference Bureau World Population Datasheet (2013).

These programmes involved providing access to family planning information and services to all citizens, through culturally appropriate channels. They also involved addressing barriers to women exercising their reproductive choices, such as child marriage, women's access to education and economic autonomy, and attitudes of men towards women and their roles. They did not rely on coercion, such as China's one-child policy. Indeed, China's fertility decline was also driven by a voluntary family planning programme, which preceded the one-child policy by a decade. By the time the one-child policy was rolled out in 1979, the job was largely done. However, over the past two decades concern about coercive fertility control has been heightened to the extent that merely discussing the benefits of fewer children is treated as coercive. It is assumed that access alone is sufficient, and women will make the 'right' choice about family size without being given any information on which to base that choice. Yet the main reasons given by women for not using contraception are not related to access or affordability (Ryerson 2010). The successful voluntary family planning programmes of the 1970s and

80s were generally characterised by widespread promotion of fewer, more widely spaced children, and sound information about contraceptive options, dispelling myths of their dangers.

Recently, Population Health and Environment (PHE) programmes, which integrate family planning with livelihood, public health and environmental management interventions, are showing that coherent cross-sectoral programmes can greatly increase community acceptance of, and even enthusiasm for, family planning, overcoming cultural resistance (PAI 2015). New contraception technologies, including implants and injectables, are making family planning delivery much cheaper, more reliable and less dependent on medical personnel. New communications technologies and more literate populations exposed to cultures beyond their own allow information and attitudinal change to spread more easily. These advances could mean that the next generation of family planning programmes is even more effective than in the past. Nor are such interventions costly: a UN study estimated that "for every dollar spent in family planning, between two and six dollars can be saved in interventions aimed at achieving other development goals" (UNDESA 2009 p.1).

It's still possible for the world population to peak under 10 billion. Each year such action is deferred increases the achievable peak by around 100 million people. Time is of the essence, but if political will could be rallied quickly enough, perhaps a peak around 9 billion could yet be achieved.

Such an outcome would ease many challenges, particularly food security, climate change mitigation and adaptation, and biodiversity loss (Speidel et al. 2015). It could head off mass mortality on a scale humanity has never seen. But first we have to care how many people there will be.

Conclusion

Projections should arm us to prepare for the future and take pre-emptive action to avoid threats. Recent population projections have had the opposite effect. By failing to acknowledge the impact of choices, they have undermined pre-emptive action. This fatalistic approach has probably already contributed to a global slow-down in fertility decline over the past two decades, which has already added billions to the likely peak population. By giving little weight to the recent

slow-down, projections have recently over-estimated fertility decline. In turn, by presenting overly optimistic expectations of fertility decline, they have given false reassurance that population growth will end within decades regardless of what we do, allowing legitimate concern about overpopulation to be dismissed as naïve and pointless paranoia. Partly to avoid such condescension, many researchers avoid treating population as a variable. They consequently fail to measure its profound impact on so many of the challenges now faced by humanity and by the many other species we are crowding out. A new narrative is urgently needed, to reinstate the importance of population policies and programmes for human development and environmental sustainability (Bongaarts 2016).

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Three MSc Student Projects for Population Matters

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Introduction

This article is about a number of studies conducted by students for Population Matters in 2015. The MSc in Management Science offered by LSE is a one-year programme which covers various analytic, statistical and problem structuring techniques. By its nature it is an applied science, and the climax of the programme is a summer project, in which students tackle real-world problems for a variety of sponsor organisations.

For the students, this is an opportunity to take the skills and techniques they have learnt and act as a genuine consultant, working with and within organisations to provide valuable insight and influence key decisions. For the organisations, they get access to bright minds backed up by the LSE's world-class academic staff. Sponsor organisations come from many sectors including health, finance, logistics, housing, education, tourism, publishing, media research, and the third sector.

LSE Management Science students have conducted projects for Population Matters for several years, analysing the impact of population growth on matters as diverse as health, housing, energy, jobs, education, and biodiversity. Initially these projects focused mainly on the UK but in recent years they have taken a more global perspective. This article summarises three reports from projects in 2015. The full reports will be made available on the Population Matters website.

Project 1: Mothers' Index by Guangjie Shi

Save the Children, a major international charity, devised the Mothers' Index (MI) as a way to compare the quality of life for women in countries around the world, based on certain core criteria. While the MI does not include any specific reference to population, there is good reason to expect that population growth may influence many factors which are included. The aim of this project is to assess whether demographic indicators, particularly population growth rate and total fertility rate (TFR, the average number of children a woman has in her lifetime), correlate with ranking on MI.

Over the period from 2000–2014, MI has been constructed in 3 different ways. For the first two of these, the index was applied to all countries while for the third, countries were divided into 3 tiers – developed, developing and least developed. This study correlates population factors with both MI as a whole, and key individual components of the index, over the spectrum of countries for which full information is available. Some global data analysis was presented, but much of the analysis focused on small groups of countries, closely related to each other geographically.

There was a broad general correlation in which countries with a high population growth rate were associated with a poor – and deteriorating – MI. However, it was clear that in developed, industrialised countries, the correlation between population growth and MI ranking was relatively weak, whereas for developing and least developed countries, population growth was a much clearer indicator of the likely MI. To take two extreme examples, the MI of South Korea rose to the top of its tier as its population stabilised (due to firm government policies), whereas the MI for Niger (with the highest TFR in the world) remained at the bottom.

In some parts of the world, such as the Arab oil producing countries, rapid population growth was not associated with a falling of MI ranking, probably due to the affluence of these countries and perhaps because much of the population increase is due to immigration. Population growth is fastest in sub-Saharan Africa and this is strongly reflected in the poor Mothers' index for many countries in this region. The sparkling exceptions are Rwanda and Ethiopia, where governments have focused more on family planning and have made considerable progress

in stabilising their populations. Rwanda has also made giant leaps forward in education since the genocide in 1994. This suggests governments should focus on both education and reproductive health to promote development.

The study proposes that while Mothers' Index stresses education, it would be of more value if it included an explicit consideration of population growth in each country. Another important aspect that is not explicitly addressed by the Mothers' Index is income inequality. This is of note in Central American countries where the Gini index (a measure of inequality) is highest. Amongst large countries, inequality is most evident in India where the elite have high quality health and other services, but the poor majority have much less.

In summary, it is concluded that there is an overall correlation between population growth and Mothers' index, particularly in developing and least developed countries. The Mothers' Index would be improved if it included explicit factors related to population growth and income inequality.

Project 2: Correlating population growth with real GDP growth by Ciying Chen
National GDP growth statistics are prominently reported and avidly followed, because it is usually assumed that real national GDP growth corresponds to a rise in income per person, and ultimately higher living standards. However, it can be argued that it is real GDP *per capita* that is more likely to reflect the outcome experienced at an individual level, which means that population growth needs to be taken into account. An earlier student project had investigated the UK economy, and found that despite forecast GDP growth, GDP per capita would be static until 2030 after taking into account population growth in this period.

In 2015, the methodology used in the UK analysis was extended and applied to other EU member countries, taking population, GDP and inflation data from 1992 to 2014. The countries selected were UK, France, Germany and Italy, the four largest countries, plus Cyprus and Latvia, which had the highest and lowest population growth rates respectively.

The analysis found different correlations between population growth and GDP Growth. In the UK, GDP growth was positively correlated with population growth. This could be because as population grew, more investments were being

made in infrastructure. In Greece, France and Italy, however, population growth was negatively correlated with GDP growth. These countries had a shrinking ageing population. Consequently fewer working-aged people were creating GDP, shared among a higher percentage of aged people. This might explain the negative correlation.

In Cyprus and Latvia, GDP growth was primarily (and negatively) correlated with inflation. Both countries experienced high levels of inflation during the period under analysis.

Overall, the results suggested that it was not just population growth that had a bearing on real GDP per capita, but the change in demographic structure, which could be the explored further in future projects

Project 3: Comparative study of the impact of population momentum across four countries by Yushu Zou

An important factor in projecting future population growth is the phenomenon known as 'population momentum'. This is the name given to the factor that, for countries which have a fertility rate above the replacement rate, even if this were to fall to the replacement rate immediately, the population would continue to increase for a considerable time.

The main objective of the study was to explore the effects of several demographic indicators, namely the total fertility rate, mean age of childbearing (MAC) and life expectancy on population growth. The project also studied the momentum effect and its associated population ageing during the demographic transition process towards a stationary population.

Four countries were studied in this project, including China, India, Nigeria and Germany. A cohort model was built to forecast future population, assuming different demographic indicators. Second, following Preston (1997), the momentum factor was calculated, which is an indicator that measures the extent of momentum effect, for each country. Third, applying the method in Andreev et al (2013), the contribution of each demographic indicator to population growth was calculated.

The study found that TFR is positively correlated with population growth, most notably in Germany, where if TFR increased by one child, the population in 2050 would increase by 77% compared to its population size in 2010. Surprisingly, MAC is positively correlated with population growth for China and Germany, but negatively for India and Nigeria. This is because delaying childbearing would raise fertility among the more populous cohort of older women in China and Germany, thereby increasing the population.

Comparing the momentum factor across the four countries, Nigeria has a highest at 1.45, implying that its population would increase by 45 per cent even if the fertility rate in Nigeria were suddenly to drop to the replacement level today. The momentum factors for China, India and Germany are 1.07, 1.42 and 0.71 respectively. The negative momentum effect in Germany implies that population in Germany will continue to decline even if the TFR were raised to the replacement level.

Turning to the contribution of demographic factors to population growth, in Nigeria the biggest single contributory factor is fertility, while in India it is the increase in life expectancy, plus the momentum effect, which contribute most to population growth.

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