Is the Planet Full?

Edited by
Ian Goldin

OXFORD
UNIVERSITY PRESS

OXFORD
UNIVERSITY PRESS
Great Clarendon Street, Oxford, OX2 6DP,
United Kingdom

Oxford University Press is a department of the University of Oxford.
It furthers the University's objective of excellence in research, scholarship,
and education by publishing worldwide. Oxford is a registered trade mark of
Oxford University Press in the UK and in certain other countries

First Edition published in 2014

Impression: 1

Published in the United States of America by Oxford University Press
198 Madison Avenue, New York, NY 10016, United States of America

British Library Cataloguing in Publication Data
Data available

Library of Congress Control Number: 2013956090

ISBN 978–0–19–967777–1

As printed and bound by
CPI Group (UK) Ltd, Croydon, CR0 4YY

1

Introduction

Ian Goldin

How Full?

Is the planet full? Over 7 billion people currently live on Earth. Sixty per cent live in Asia, 15 per cent in Africa, 11 per cent in Europe, 9 per cent in Latin America and the Caribbean, 5 per cent in North America, and less than 1 per cent in Oceania and elsewhere. In Singapore more than 7,000 people live per square kilometre, whereas in Australia three people on average inhabit the same area.[1]

The number of people and where they live is changing rapidly. The world's population has doubled over the past forty years, but the pace of growth is slowing, with the latest estimates suggesting that the population will increase by as many as 3 billion people to peak at between 9 and 10 billion people by 2050, before contracting after that (UN-DESA 2013a). In Europe, the population has already peaked,[2] and in many developed and developing countries (including China, South Korea, and Taiwan) fertility rates are well below replacement levels. Only sub-Saharan Africa and parts of India and South Asia are expected to see further rapid increases in population in the coming decades, with the growth elsewhere mainly due to rapid population ageing. As Sarah Harper explains in Chapter 4, this brings different challenges.

[1] Continental percentages are derived from UN-DESA (2013a), table I.4. The geographical groupings follow the 'Standard Country or Area Codes for International Use' adopted by the UN (ibid.: viii). The figure for Singapore is from SDS (2013). The population density for Australia has been calculated by dividing the population at the end of 2012 (ABS 2013) by the total area of Australia's states and territories (Geoscience Australia 2013).

[2] Following the United Nations, Europe is defined broadly to cover both Eastern European and Southern European countries including the Russian Federation. The latest statistics indicate that by 2005–10, almost all European countries (with the possible exception of Iceland and Ireland) had fertility rates well below replacement levels, confirming that population levels have indeed peaked (UN-DESA, 2013a: table A.22).

The impact of population growth will be felt acutely in the countries undergoing the most rapid transformation. The consequences are not, however, confined to any one group of countries. All our lives are increasingly intertwined across national borders. We share a global economy and a global commons. Both the opportunities and the risks associated with a fuller planet impact on all of us.

The distribution of effects is nevertheless uneven. At the same time that floods are destroying lives in some places, drought and water scarcity are laying waste to economies, withering crops, and sparking human tragedies elsewhere. This paradox is equally applicable to food: as the population grows, so does the average size of a person in the developed world. Obesity at one end of the spectrum is matched by starvation at the other.

Across the globe, the planet is full *and* empty. Resources are abundant *and* scarce. The problems of the planet reverberate everywhere in ways that are complex and often unpredictable.

In my book *The Butterfly Defect: How Globalization Creates Systemic Risks, and What to Do About It* I show that the number of people, together with the increasing density of our physical and virtual connections dramatically changes the propensity for systemic risks that we all face (Goldin and Mariathasan 2014). But equally, the opportunities are multiplied with increased physical and virtual connectivity. The extent to which the upside potential can mitigate the downside risks is a key determinant of judging whether the planet is full.

Rich and Poor

In considering whether the planet is full, the number of people on the planet is *not* the only or even most critical variable. It is *how* we live that matters. It is not a question of how many people there are but how our individual consumption and production impacts on the planet. The world could be 'overpopulated' with five billion people with unsustainably high consumption levels whereas over ten billion poor people with low consumption levels may not exhaust our planet's carrying capacity. This is not to say that poverty is good; quite the opposite is true and reducing poverty is the most important benchmark of global progress. Income growth and improvements in health, life expectancy, and other dimensions of human progress nevertheless have placed increasing pressure on the planet. The engine of economic progress over the past two hundred years has been fuelled by the burning of fossil fuels (Figure 1.1), but it is only in the last twenty years that scientists have unequivocally found that continuing on this trajectory will lead to disastrous climate change and that the atmosphere has exhausted its carrying capacity for carbon dioxide and other greenhouse gasses. The unsustainable use of other planetary resources—not least, the oceans, forests, and minerals—has

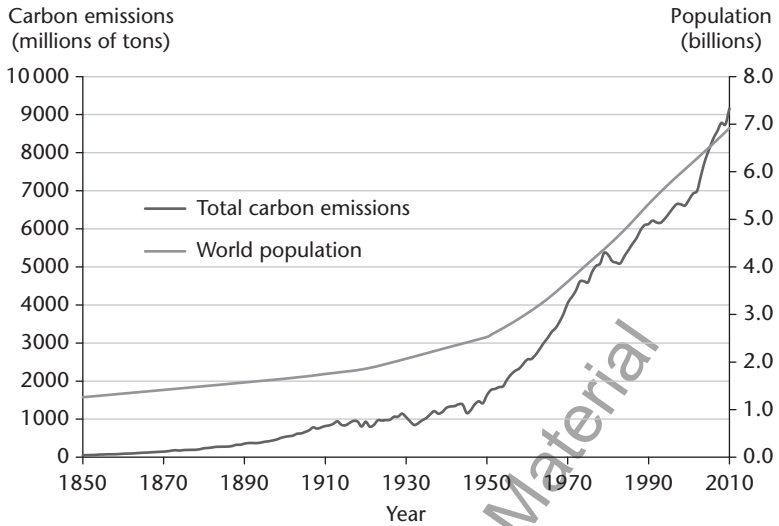

Figure 1.1. World population versus carbon emissions, 1850–2010
Sources: CDIAC (2013); UN-DESA (1999), table 1; UN-DESA (2013a), CD-Rom edition, file Pop/1-1.

given advanced economies a cheap ride to growth, unencumbered by the hidden costs of their growth patterns. While those in the more advanced economies must carry a significant part of the historic responsibility for exhausting the carrying capacity of the planet, the incremental pressure on planetary resources is increasingly coming from developing countries. It is in these countries that virtually all population growth and the lion's share of future income growth is anticipated.

The critical question we need to resolve is: how can we ensure that people born now and in the future are given the opportunity to live a high-quality life without wrecking the planet? Are current levels of consumption among the richer people sustainable and can we envisage an extension of such consumption patterns to all humanity without causing potentially catastrophic spillovers for everyone? If not, how can the imperatives of development be reconciled with the constraints of the planet? While the specific characteristics of questions and their answers vary from place to place, people and places are increasingly interconnected and the implications are global. Our focus is on the drivers of change that have a global or planetary impact.

Complex Lives, Complex Solutions

Our response to the question 'is the planet full?' draws on a variety of perspectives. By providing an interdisciplinary analysis of the question we aim to

provide fresh insights. Real world challenges, and especially those as complex as our question, cannot be resolved through the narrow disciplinary lenses which too often bedevil scholarly approaches.[3] Complex challenges necessarily require insights from a wide variety of physical, life, and social science perspectives as well as from the humanities. Insights derived from philosophy, ethics, and history are just as valuable as those from hydrology or atmospheric physics. By bringing together these different disciplines, we offer fresh perspectives. In considering the prognosis for the future it is useful to be rooted in an understanding of history. The past is prologue—what happened before may give us clues to what will happen next. This is as true for individual lives as it is for society. One such extraordinary life is that of Fritz Haber.

In 1868, when Fritz Haber was born in Breslau, Germany, just over one billion people lived on Earth. Since then, population growth has soared dramatically, rising in the 20th century at a pace unparalleled in human history. Arguably, no individual contributed more to such rapid population growth than Haber, a German-born Jew who became a brilliant chemist.

From 1894 to 1911, Haber and his colleague, Carl Bosch, developed a process that created ammonia from hydrogen and atmospheric nitrogen when subjected to high pressure and high temperature. This breakthrough gave birth to large-scale industrial production of fertilizer, substantially increasing food production capacity and crop yields. It has since been argued that two billion people on Earth owe their continued survival to the Haber process (Charles 2005).

Less than five years after the discovery, Europe split apart in the 1914–18 World War. The Haber process—which gave life—also took it away. Just as it was used to make agricultural fertilizer, Haber discovered that he could develop lethal chlorine gas with the same method.

When the war ended, Haber was given the Nobel Prize. Then, as Germany began its devastating campaign against Jews, Haber was forced into exile. He died in 1934. A few years later, German scientists developed Zyklon B gas using the Haber process, and his breakthrough was used to exterminate millions in the Holocaust, including members of Haber's family.

Haber's process created 'bread from air', and sparked a population boom, through the development of fertilisers. It was also used to assist the largest genocide in history. This remarkable story illustrates the power of humanity, and at times, individuals, to affect population in dramatic ways. The lesson is important: innovation that may seem like progress can also have unexpected effects.

The story also reflects the scope, scale, and complexity of this volume, which asks: 'is the planet full?' Perhaps, without the Haber process and the

[3] The value added by interdisciplinary forms of research is discussed by Clark (2006), Harriss (2002), and Hulme and Toye (2006).

agricultural yields made possible by fertilizer, our answer would be a resounding 'yes!' but as the contributors make clear in this volume, answers are never quite so simple. Further technological developments to enhance agricultural yields or to create clean energy would make a dramatic difference to the answer. So too, as we show in the final chapter of this volume, would radical reforms in global governance.

Not a New Question

The question as to whether the planet is full is not new. Throughout history, intellectuals have sounded warnings of the imminent threat of overpopulation. 'What most frequently meets our view (and occasions complaint) is our teeming population. Our numbers are burdensome to the world, which can hardly support us…' Such a quote makes it sound like global collapse is imminent, yet the 'teeming population' referred to here was estimated to be around 190 million globally, and the alarmist thinker responsible is Tertullian, a resident of Carthage writing in the 2nd century AD (Osterfeld 1993).

For centuries the world population expanded slowly but steadily.[4] Thinkers such as Machiavelli and Otto Diederich Lutken echoed Tertullian's views and kept alive an ongoing debate. The issue was brought to the fore when Reverend Thomas Malthus published *An Essay on the Principle of Population* in 1798. Malthus (1798) warned that excessive population growth was slowing progress and derailing any chance of attaining a modern utopia. He argued that there were two forms of checks on population growth: positive checks (such as elevated death rates) and preventive checks (such as lowering the birth rate). These two checks, Malthus argued, were the key to avoiding poverty induced by overpopulation as well as natural corrections such as pestilence, war, and famine—phenomena that came to be known as Malthusian catastrophes (or checks). The impact of Malthus was widespread, infiltrating the intellectual context of nearly every field, from parliament passing new laws, to Darwin's writing on evolution, to literature, where Dickens' Scrooge insists: 'If they would rather die they had better do it, and decrease the surplus population' (Dickens 2009: 58).

Though Malthus wrote in England, scholars elsewhere issued similar warnings. For example, Hong Liangji, a Chinese philosopher, wrote about population pressures in his 1793 work, 'Zhi Ping Pian (治平篇, On Governance and Well-beings of the Empire)'.[5] Even though he wrote prior to Malthus's treatise, he reached similar conclusions: 'Small wonder that everywhere men die of

[4] For historical data spanning two millennia see UN-DESA (1999), table 1.
[5] See de Bary (2008: 88) and Dunstan (2006).

hunger and cold, in wind, storm and frost, and of the dew in the morning. Does Heaven know a remedy? Flood and drought, plague and pestilence are what nature offers us as remedies [to temper the population problem]...' (quoted in Silberman 1960: 262).

Malthus's writings influenced population debates long after his death. Their lasting legacy was challenged in the mid-1960s by Ester Boserup, a Danish economist. Boserup (1965) took aim at the core assumptions underlying Malthusian alarmism. Foremost, she inverted the Malthusian conclusion that food dictates population, suggesting that since 'necessity is the mother of invention,' population growth dictates food supply (p. 13). In other words, population growth should spur innovation. Humans, she argued, were innovative enough to figure out ways to feed an ever-growing population. Food supply is therefore not a fixed limit. For Boserup ostensible limits exist as catalysts to launch ingenuity; technological advancement out of necessity is a clear by-product of population growth. We can cope—even thrive—she argues, with our backs up against the proverbial global walls.

Not everyone shared Boserup's optimism. Earlier in the 1960s, a number of ecological works were published, including Rachel Carson's wake-up call, *Silent Spring* (1962). Paul Ehrlich's (1968) *The Population Bomb* challenged Boserup's rosy assumptions. Ehrlich adapted Malthus's work to the modern era (albeit with less moralizing) arguing that the pressures of population growth and elevated consumption would severely deplete resources and cause prices to soar. High food prices, he argued, would condemn millions, maybe billions, to famine.

Lester Brown was another prolific voice to enter the debate for the first time (but certainly not the last) in the mid-1960s. Brown, who has since written dozens of books warning of the environmental impacts of population expansion and unsustainable behaviour, published *Man, Land, and Food* in 1963. His analysis identified how food supply and demand trends would create a worldwide challenge of feeding an expanding population.

The rising concerns prompted the Club of Rome to commission the influential *The Limits to Growth* compiled by Meadows et al. (1972). For the first time, population ecology was put to the test of systematic and systemic computer modelling. As Ian Johnson, the current Secretary General of the Club of Rome, notes in Chapter 5 of this volume, these models offered a set of 'simulated scenarios, allowing the reader to gauge a series of potential outcomes on the basis of reasonable and plausible assumptions' about population growth, ecological impacts, consumption, and more. *The Limits to Growth* also introduced the concept of 'overshoot'; the notion that human population could exceed the environmental carrying capacity of the Earth. The report's impact was impressive; it sold millions of copies and was translated into thirty languages.

Policymakers also took note. Two years after *The Limits to Growth* was published, Henry Kissinger ordered the secret drafting of National Security Study Memorandum 200. The memo, later declassified, argued that population growth in the world's least developed countries posed a grave threat to American security interests. The logic, Malthusian at heart, suggested that swelling populations would spark conflict and destabilize regions, jeopardizing access to vital minerals and other resources for consumption in the United States (United States Department of State, 1974).

The debates concerning the merits of population growth and the future availability of resources continued to divide opinion well into the 1980s and beyond. Julian Simon (1981), for example, echoed Ester Boserup's earlier optimism by arguing that there is no resource crisis as technological breakthroughs and human adaptation—the 'ultimate resource'—can resolve the world's problems. At the heart of Simon's argument was the hypothesis that critical resources are becoming less scarce, as will be verified by lower prices. This controversial claim became the foundation of a famous ten-year wager between Simon and the author of *The Population Bomb*, Paul Ehrlich, in October 1980. Ehrlich formed a consortium with John Harte and John Holdren (energy and resource specialists at the University of California, Berkeley), and bet Simon $1,000 that the prices of five base metals—chrome, copper, nickel, tin, and tungsten—would rise over the next ten years. The debate continued to rage through the 1980s, but despite an increase in world population of 800 million, Ehrlich and associates eventually lost the bet (see Tierney 1990). The matter wasn't settled however, with Ehrlich pointing to the impact of the 1980s recession as an aggravating factor, and Simon refusing to accept the proposed terms of a second bet (see Ehrlich and Ehrlich 1996: 100–4).

Since the 1970s, debates on population limits and the implications of population growth have largely been launched within the borders of a single discipline. In philosophy, as Anthony Atkinson discusses in Chapter 2 and Toby Ord explores in Chapter 3, Derek Parfit's (1984) 'Repugnant Conclusion' renewed discussions of population ethics. In Economics, Elinor Ostrom's (1990) groundbreaking analysis of the commons established 'design principles' for effectively managing common pool resources.

Global actors began to devote attention to overpopulation in earnest in the late 1980s, marked in particular by the publication of the Brundtland Report (WCED 1987). The report coined the term 'sustainable development', which at its core was the imperative of meeting all current needs for the global population without damaging the ability of future generations to meet their own needs.

This contributed to the 1992 United Nations Conference on Environment and Development held in Rio de Janeiro, informally billed as the 'Earth Summit'. With representatives from 172 governments in attendance, the

summit produced the 'Rio Declaration on Environment and Development', which enshrined 27 principles to guide global efforts for sustainable development. This conference marked an important change: global governance was beginning to come to terms with the strains of population growth on the environment and the prospects for future development efforts (UN 1992).

Twenty years after the original Rio summit, Rio + 20 (held in 2012) reaffirmed the principles of the original conference, adding an updated resolution called 'The Future We Want' to the already-agreed shared principles. The non-binding document encouraged member states to make sustainable development a priority, affirming that 'fundamental changes in the way societies consume and produce are indispensable for achieving global sustainable development' (UN 2012: 43, Article 224). The negotiations also highlighted the need to follow scientific advice when preparing policy related to population, growth, ecology, and environmental management.

Scientists were eager to give such advice. Rockström et al. (2009) provided a framework for the analysis of 'planetary boundaries'. Their analysis of the data suggests that we have already surpassed three of nine breaking points: climate change, rate of biodiversity loss, and interference with the phosphorous and nitrogen cycle (the last accelerated, no doubt, by heavy reliance on fertilizers made by the Haber process).

This 'on the brink' view is taken even further by *Ten Billion*, a recent work by Stephen Emmott. His outlook is the epitome of pessimism, perhaps best captured by his statement that: 'We urgently need to do—and I mean actually do—something radical to avert a global catastrophe. But I don't think we will' (Emmott 2013: 202). At the other extreme, Peter Diamandis and Steven Kotler (2012) echo Boserup's techno-optimism in their book *Abundance: The Future is Better than You Think*. They argue that leapfrogging technological breakthroughs mean that we will soon have the ability to meet and exceed the basic needs of everyone on the planet and that 'abundance for all is actually within our grasp' (ibid: 9). While Emmott sees the source of failure as self interest and failure to act, these issues are barely considered by Diamandis and Kotler.

Emmott is right that we need to change, but underestimates the extent to which radical change is already underway in key areas. Dorling (2013) suggests that population growth rates are falling more rapidly than the UN medium projections and that the world's population is likely to peak at around 9 billion by 2050 and then decline to below 7 billion by 2100.

A large part of the explanation is due to lower fertility rates. The trend has already begun; thirty years ago a sliver of the global population lived in countries below 'replacement' fertility rates (defined as 2.1 children per woman in populations with low mortality rates). Today, more than 60 per cent of the world population lives in countries with 'replacement' or below

fertility rates, trends that hold true in China, and even areas of southern India (Winter and Teitelbaum 2013). As Sarah Harper explains in Chapter 4, there are three main reasons for this sustained drop. First, falling mortality rates (from better health care and less poverty) reduce the need to have a large number of children, as more will survive. Second, there is evidence that widespread access to contraception is reducing unplanned pregnancies and empowering women to have fewer children by choice. Third, there is significant evidence that urbanization, access to education, and entering the labour force are major drivers of lower fertility. This is a good thing. But declining fertility rates now will not have a major impact on global population trends for some time. Jeffrey Sachs (2006) nonetheless points out that promoting policies that accelerate the drop in fertility rates is also a wise investment in the short term, as 'High fertility represents a disaster for the children themselves, who suffer from profound under-investments in education, health and nutrition, and are thereby far more likely to grow up impoverished' (ibid: 42). Econometric studies, such as a recent publication by Ashraf, Weil, and Wilde (2011), concur, suggesting, for example, that a decrease in the fertility rate of one child per woman in Nigeria would boost per capita GDP by 13 per cent over the next 20 years, an illustration of the 'dependency effect'—having fewer children to look after, feed, clothe, educate, and care for, unleashes additional economic potential for the parents.

However, as the fertility rate drops, there is also evidence that it magnifies inequality. Education, urbanization, access to contraception, and entry into the labour force tend to be disproportionately the realm of the comparatively well off in any given developing society. So, even if the overall national fertility rate drops, the poor are more likely to continue being stuck in a fertility trap, while the middle and upper classes start having fewer children—exacerbating what are often already grotesque levels of inequality (Bloom et al. 2009).

This spillover effect is indicative of the complexity of population debates. Even though the falling fertility rate is positive, the complex challenges that lie ahead are daunting. Strategic and creative long-term thinking is required to address them.

Getting Out of the Silos

In recent decades, the debates on whether the planet is full have been echoing around disciplinary silos—economics, natural sciences, ethics, philosophy, politics, and even theology. In part, those debates revolved around forecasting and have been stuck in back-and-forth arguing over the merits of certain data. This is not necessarily bad; data are critical to discerning whether the planet is

full. But it is a problem when the disciplinary silos and data obscure the larger picture.

This volume offers a remedy. By tackling the question, 'is the planet full?' from a range of disciplines, with attention paid to the interconnectedness and spillover effects of population changes, our ambition is to provide a multifaceted analysis of the problems facing humanity as we move forward from an Earth of just over 7 billion people to one that recent projections suggest will approach 10 billion people by 2050 (UN-DESA 2013a).[6]

Such projections paint a dramatic picture. While the developed world is likely to maintain a steady population, 'the 49 least developed countries are projected to double in size from around 900 million people in 2013 to 1.8 billion in 2050' (UN-DESA 2013b: 1). If current trends continue, India is poised to surpass China shortly as the world's most populous country. It is probable that there will be more Nigerians than Americans before 2050.

While there is inevitably great uncertainty about future outcomes, on the basis of the experience of the past sixty years we can be reasonably optimistic that average life expectancies will continue to increase by about two years per decade. As falling fertility takes time to be reflected in declining populations, this implies that at least for the coming forty years the global population will grow, with the global population currently rising by over 230,000 people per day, a total increase of 84 million every year (PRB 2012: 2). Virtually all this increase is in developing countries. Each additional person needs a place to live, food to eat, water to drink, air to breathe, health care to maintain them, and natural resources to support a modern lifestyle. Moreover, each additional person deserves the chance to live a decent life.

These considerations are central to how we answer the question: 'is the planet full?'. In a purely physical sense, the planet is not full; explore rural Montana, Australia, Mongolia, or Siberia and it would be hard to be overwhelmed by a sense of anything other than emptiness. The question is not, however, about physical space, nor is it about how many people occupy that space. Instead, it is about how many people there are and how those people live.

That most of the population growth is in countries where incomes are rising most rapidly is a source of tremendous optimism. More people have escaped poverty in our lifetimes than in any previous comparable period. Is this sustainable and what are the planetary implications? The Environmental Kuznets Curve depicts a stylized relationship between the growth in incomes and pollution. It shows that as development lifts more and more people out of

[6] These projections acknowledge uncertainty, with estimates ranging from low (8.3 billion) to high (10.8 billion) by 2050. The most likely outcome according to UN models, however, is that there will be roughly 9.6 billion people by that time. That number is cited most commonly.

poverty, they consume more resources and pollute more, extracting resources and damaging the environment (Grossman and Krueger 1995; Stern 2003). Pollution keeps increasing until societies reach middle-income levels. At these levels a 'tipping point' is identified; consumption of many (but not all) goods and services with high levels of negative spillovers begins to level off and as incomes rise the use of certain pollutants can even decrease. The archetypical example is economies transitioning from dirty, industrial production to services and investing in public transport and other pollution-reducing technologies. Underlying the analysis is an implicit view that poorer countries need to prioritize poverty reduction but as basic needs are satisfied societies have both the resources and the luxury of choice to consider the environment rather than simply survival.

As I show in *The Economics of Sustainable Development*, which I edited with Alan Winters, the Environmental Kuznets Curve and the notions underlying it have come in for fierce criticism as being overly simplistic (Goldin and Winters 1995). Not only is there a very wide range of pollutants, the production of which peak at different levels of income, but there is also a strong cultural and political foundation for decisions. Low-income countries have been shown to be capable of making decisions which are highly compatible with lower pollution, whereas many high-income countries have not. Nevertheless, underpinning the hypothesis of the curve are a number of robust observations regarding the increase in a range of externalities as incomes rise. With two-thirds of the world's population in countries which are making the critical transition to higher levels of income, where consumption of energy, food, water, and other planetary resources peaks, understanding the relationship between economic growth and environmental spillovers is vital. These relationships are not automatic and can be strongly affected by policy. However, they do imply in aggregate a sharply rising claim on our planet's resources by the rapidly growing world population.

As has been made abundantly clear by the lag associated with the burning of fossil fuel and our understanding of the consequences, and many other environmentally disastrous consequences of decisions that were taken in the past, we do not and cannot know the full consequences of our actions. The decisions taken today will be crucial in determining our future. Every time decisions are made regarding infrastructure or other major investments, the consequences are being locked in for years, if not decades, to come. Power plants built today typically are anticipated to have a thirty- to fifty-year life. If they are not green now, they never will be. Getting a better understanding of the potential outcomes and allowing prudence to become a part of our planning is urgently required. As with other explorations of risk and uncertainty, this calls for a multifaceted examination of the issues.

Innovative Thinking Required

In answering the question as to whether our planet is full this book draws on insights from economics, the physical and natural sciences, politics, philosophy, and other disciplines to find answers. For example, although questions of population size and sustainability are the realm of demographers and scientists, the subject is laced with normative and philosophical considerations. Would it be better to increase the aggregate amount of happiness on the planet by simply adding to the population, even if average individual happiness declines? Is it just and fair that the 19.5 million residents of New York State consume as much energy as the 800 million residents of sub-Saharan Africa? (IEA 2010: 10)[7]

Philosophical concerns bleed into economic ones; how does the quest for growth affect the sustainability of our consumption levels? Part of the explanation is to be found in a better understanding of the implications of technological change and the results of the latest findings of scientists. Ecology, biology, geology, and chemistry all make enormous contributions to our understanding of the implications of population growth. Without those contributions, we could never hope to forecast how resource depletion will affect biodiversity, or how deforestation will affect climate change, or how climate change will alter the global water supply. The insights that scientists provide to these questions feed back to the analysis provided by other disciplines, informing philosophical and ethical judgements and economic policymaking.

The judgements of ethics, principles of economics, and data from natural science are all of limited value without good governance. Problems cannot be solved without capable institutions. As I argue in my concluding chapter to this volume, knowing whether the planet is full or not is inconsequential unless something can be done.

Drawing on ethics, economics, natural science, and governance, the authors of the chapters of this book collectively answer the question: 'is the planet full?'. In addressing this question they respond to four underlying questions:

1) What are the ethical implications of population growth?
2) How will population growth affect incomes, inequality, and resource allocation?
3) What is the current physical state of the planet and the ecosystem, and how is this likely to change with population and income growth?
4) What can individuals, firms, and governments do to stop the negative effects of population growth and harness the positive effects?

[7] The figure for sub-Saharan Africa excludes South Africa.

This Book's Contribution

In answering these four questions, this volume breaks through the stale debates on overpopulation and contributes to the literature in three main ways.

First, it provides a long-overdue update to the debates on population growth. There has been remarkably little written, for example, on how *The Limits to Growth* fared as a predictive tool over the forty years since it was written.[8] This volume fills that gap, by not only providing up-to-date facts, figures, and forecasts across a wide array of subjects, but by going further to provide fresh perspectives. This is an essential contribution, particularly given the impact that technological advancement has had on key projections. After all, Malthus could never have predicted that pestilence could spread into a global pandemic in just 48 hours, as a result of global aviation networks, and *The Limits to Growth* could not have included the million-fold improvement in computing power over the past forty years in its modelling.[9]

A noteworthy forerunner to this book is Joel Cohen's (1995) *How Many People Can the Earth Support?* Cohen considers the history of population growth and asks what is known about the future of human population. At the time of his writing the global population stood at 5.6 billion and had expanded by at least 1.6 per cent per annum since 1950 (a rate that implies the population will double in size in less than 44 years) (Cohen 1995: 8, 13, 18). Over the last thirty years population growth has steadily slowed (averaging 1.4 per cent between 1980 and 2013) and even the United Nations' high estimate for 2013–50 (1.3 per cent per annum) is well below the post-1950 average reported by Cohen (UN-DESA 2013a: table I.3). Indeed, Cohen himself warns against the long-term accuracy of population projections. In short, the time is ripe for a reassessment.

Cohen also revisits a large number of historical and contemporary attempts to estimate the human carrying capacity of the Earth. In particular, he scrutinizes some of the 'unstated assumptions' behind these estimates, which vary widely. He argues that any estimate of the planet's carrying capacity can only be valid at a given point in time. This is because any estimate depends on the choices we make now and in the future, as well as environmental and resource constraints. He concludes

[8] A noteworthy exception is Turner (2008).

[9] The growth in the potential for infectious diseases to cross borders and the rapid expansion in computer processing power are both manifestations of globalization, and are discussed further by Goldin and Mariathasan (2014). The increasingly rapid spread of disease and computing power have both been identified as critical issues likely to shape the future of humanity and to pose potentially grave challenges by the Oxford Martin Commission for Future Generations (2013).

> . . . that estimates of human carrying capacity may usefully serve as dynamic indicators of humans' ever-changing relations to the Earth. At any given time, a *current* but changing human carrying capacity is defined by the *current* states of technology; of the physical, chemical and biological environment; of social, political and economic institutions; of levels and the styles of living; and of values, preferences and moral judgements (Cohen 1995: 17, original emphasis).

Instead of taking a firm stand on the question of whether or not the planet is full (or is likely to reach maximum human-carrying capacity in the foreseeable future), Cohen attempts to provide a balanced assessment of available scientific knowledge and understanding from the perspective of a demographer. He tentatively suggests an 'infrastructure for problem solving' in place of concrete 'proposals for action' (p. 12) and reviews the suggestions of others for tempering population growth and easing resource constraints. In keeping with the present volume, Cohen's pragmatism and emphasis on the importance of critical choices underline the importance of good governance and sound management for expanding the carrying capacity of the planet. In contrast to Cohen, however, many of the chapters in this volume offer more decisive answers to the central question—is the planet full?—from a variety of disciplines and perspectives that transcend demography and engage with the factors identified by Cohen as 'defining' the planet's capacity to sustain a sizeable population.

Second, unlike most works that focus on one aspect of the planet's carrying capacity, from the outlook of a single discipline (such as Cohen's brand of non-technical demography), this volume is holistic, merging different perspectives to inform our answer. Derek Parfit may have pioneered modern population ethics, but his essays do not incorporate the lessons of population ecology or climate chemistry; Rockström et al. (2009) have provided new ways of understanding the planetary balances and highlighted the dire state of affairs in our physical environment, but their work gives little attention to how we can get ourselves out of our predicament. This is not a criticism; scientists are supposed to do scientific research, and philosophers are supposed to address moral questions. However, as global challenges are interconnected, full of feedback loops, and rife with spillover effects, interdisciplinary thinking is required.

Third, this book examines the externalities of population growth with reference to the most recent scientific evidence which, as it is evolving so rapidly, did not inform the debates of previous decades. Externalities refer to the spillover effects of population growth and resource consumption; a principle illustrated simply by the fact that upstream run-off from farming in Minnesota and other states along the Mississippi River is extinguishing life in an 8,000-square-mile dead zone in the Gulf of Mexico—thousands of miles away (Dell'Amore 2013). The fact that what happens in one place reverberates

across the globe is not a new idea, but it has been conspicuous by its absence from the debate on overpopulation. Moreover, the understanding of climate change adds a critical new component that we bring to bear on the population debate. It affects everything—from our ethical obligations to future generations to current water supplies to economic distribution and global governance. Relying on Malthus, or even the forty-year-old *The Limits to Growth*, as our starting point is no longer appropriate, given that neither work paid enough attention to externalities and could not take into account our newfound appreciation of complex interdependencies.

Is the Planet Full? The Answer in Ten Chapters

Our answer to the question: 'is the planet full?' is broken down into ten chapters. The first chapters, 2 and 3, are devoted to debate on whether the planet is full, with a consideration of ethical, resource, and economic questions. Chapters 4 and 5 discuss the population issues. In Chapters 6, 7, and 8 the authors analyse resource availability before considering, in Chapters 9, 10, and 11 some of the broad challenges, political considerations, and possible solutions.

The book examines the question of whether our planet is full from a wide variety of disciplinary perspectives. Part of the originality of this volume is that we are able to bring together insights from leading scholars of economics, ethics, philosophy, physics, earth sciences, geography, biology, zoology, medicine, and demography, to provide a rounded response to our question. To this end, the book proceeds as follows.

In Chapter 2, the eminent economist Sir Anthony Atkinson brings the question 'is the planet full?' to the crossroads of economics and ethics. After establishing that the question is best grounded on an 'optimum-quantity-of-people' approach, he highlights the failings of classical utilitarian models and the 'Repugnant Conclusion' that they impel us to draw—that the pursuit of maximum utility warrants extreme population growth, even if individual lives are miserable. To cope with what he regards as this misguided way of thinking, Atkinson suggests that Amartya Sen's conception of poverty as the denial of capabilities is a useful compass to guide us as we grapple with the question of population growth. With Sen's approach other considerations become central, such as whether the allure of technological advancement and creative and economic dynamism justify higher population levels; in other words, 'In a larger population, one is more likely to find a new Shakespeare, . . . a new Mozart' or a new Bill Gates. Atkinson concludes by arguing that inequality—both between and within countries—is a crucial but often overlooked factor as we decide whether to answer 'yes', or 'no' as to whether the planet is full.

Following Atkinson's insights, philosopher Toby Ord in Chapter 3 argues that population ethics is too often focused solely on the costs of population growth while ignoring the instrumental and intrinsic benefits of having more people on Earth. He suggests that instrumental benefits—such as the added value brought by information goods (including things like intellectual property and medical breakthroughs)—must be considered alongside the intrinsic value of the joys and loves of human lives. As Ord contends, those benefits cannot be adequately weighed using the scales of the discredited 'total happiness view' or 'average happiness view', of population ethics. Instead, emerging theories must weigh the instrumental and intrinsic benefits of additional lives against the costs of capacity, which should be defined in terms of 'soft limits' and 'hard limits'. While the hard limits may be absolute, Ord suggests that technological advances can be coupled with social and behavioural changes to shift the soft limits of population capacity. Given this malleability of population constraints, Ord calls for a re-evaluation of population ethics, with more attention paid to the benefits of larger populations.

After exploring the prevailing ethical considerations, in Chapter 4, Sarah Harper provides perspectives on demographic transitions—particularly with regard to fertility rates, consumption, and environmental impact. She outlines how global demographics are changing and how the world population is becoming more urban, more mobile, and older. These changes are not uniform, though—fertility rates vary substantially, from 0.99 children per woman in Hong Kong to 7 children per woman in Niger. Harper explains that the outliers such as Niger are dotted across sub-Saharan Africa, where the 'demographic transition' toward replacement-level fertility rates has stalled. Harper highlights that the key to lower fertility rates is lower child mortality, access to family planning, and women's empowerment through education. Climate change, Harper concludes, accentuates the problems associated with high fertility and sees more rapid progress with the demographic transition as a key element in addressing the devastating impact of climate change, particularly in the lowest-income countries.

In Chapter 5, Ian Johnston surveys what has changed since *The Limits to Growth* first appeared in 1972. Johnston identifies how the concept of 'overshoot' advanced by Meadows et al. launched a new era of systemic thinking about human sustainability and highlighted the implications of 'business as usual'. In the subsequent years, free market ideologies have become more widespread, Johnston argues, at the expense of an understanding of the public costs of market behaviour. Johnston explores the consequences with reference to oil exploration and the pricing and distribution of water resources. The failures of modern consumption, Johnston contends, could be addressed by a return to a more systemic, holistic paradigm that departs from a too narrow

concept of GDP growth and returns to the moral philosophy about human wealth advanced in early economic history.

Chapter 6 explores the issue at the centre of Boserup's critique of Malthus: global food. Charles Godfray explains how population growth will affect global food supply and distribution. We live in a paradox; the world is burdened with a pandemic of obesity in tandem with malnourishment and hunger. These pressures—on both ends of the scale—are likely to intensify. Similarly, citizens in developed countries spend less, proportionately, than ever on food, while higher food prices have, Godfray points out, 'triggered civil unrest in a number of low-income countries'. Volatility may rise in equal measure from the 'nutritional transition', as additional wealth (and urbanization) pushes the world's current poor into a more varied, richer, and more resource-intensive diet. Add the challenge of climate change, and Godfray outlines a recipe for a global calamity. Thankfully, he also provides insights on how this may be avoided: sustainable intensification of food production; altering global diets (particularly reduced avoidance on high-intensity meat production); reducing food waste and production inefficiency, and addressing global governance issues that warp world food markets. If we do not adopt these measures, Godfray warns, the planet may become full, but the stomachs of its people will not be.

Food is of little use without water. In Chapter 7, Mark New explores the implications of continued population growth for water availability, particularly under the new stresses of climate change. After differentiating between blue, green, and grey water, New explains that per capita water consumption mirrored population growth until 1945, but that subsequently per capita water usage has increased sharply due to increased irrigation, urbanization, and expanding middle classes across the developed world. New shows that since the 1980s total demand has soared while per capita usage has declined, as behavioural change and government regulation have mitigated water stress in developed economies. In developing countries, meanwhile, the challenge continues to become more intense as income and population growth place growing stress on global water supplies and ecological balance. Climate change is predicted to make water scarcity 'hotspots' more widespread and more acute. New concludes, however, that there is still hope: the virtual water trade, efficiency gains and water reuse, and a renewed drive for desalination powered by green energy could ensure that there is adequate global water supply for generations to come, even if the planet is home to many more people.

What determines how much food and water are needed to support us? In Chapter 8, Yadvinder Malhi provides a whole-system approach. He explains that the two vital resources for human survival—food and water—are also affected by the level of human activity and the resulting metabolic demands of our lifestyles. All biological organisms from bacteria upwards have a

metabolism—the rate at which they process chemical energy to perform the processes that are required for survival and growth. Humanity is unusual in having an extended 'sociometabolism': we consume and process energy far beyond our direct biological requirements. This sociometabolism has grown through human history, with sharp transitions at the onset of agricultural and industrial activity. Globally, human sociometabolism is currently around 17 per cent of the metabolism of the land biosphere. This proportion is likely to double by 2050, and at some stage may exceed the natural metabolism of the land biosphere. Human sociometabolic history can be viewed as a constant struggle between metabolic limitation and innovation. The challenge of our time is to create the innovations in technology and governance that can sustain both humanity and planet at a time when the sociometabolism of a single species is approaching and surpassing the natural metabolic activity of the biosphere.

After exploring the direct physical constraints for supporting life (the equation of food, water, and metabolic rates), Robyn Norton turns to the escalating cost of health care in Chapter 9. The dangers posed by contagious diseases such as TB, malaria, and HIV/AIDS are well known (WHO 1996; Cockerham and Cocherham 2010; Gaimard 2013). These diseases are likely to remain 'global killers' and will inevitably contribute to the rising cost of health care. They may also become more of a challenge as population density, global connectivity, and climate change continue to accelerate; these phenomena typically spur the risk of pandemics, heighten concern about potential contamination of the food chain (with 'foreign' animal meats), or shift tropical disease boundaries further from the equator as cooler climates warm up. They also underline the need to tackle oligopolistic behaviour amongst drug companies and explore alternative models of high-return and low-cost health care models. Robyn Norton puts the very real dangers posed by contagious disease aside in order to focus on the burgeoning costs imposed by non-communicable diseases. She warns that the world will soon face a tsunami of rising costs of care in the developed world and increasing demands for cost-prohibitive models of health care in the developing world. Most people do not have access to safe, effective, and affordable care, and unless something drastic is done, life expectancy and quality of life could fall in the face of rising global population. Norton outlines current challenges: a surge of tobacco use, unhealthy eating, physical inactivity, and obesity in low-income countries. These concerns coincide with soaring costs of care, as health care technology advances begin to replace acute care and communicable disease deaths with expensive long-term chronic care. To avoid the impending crisis in health care, Norton shows that we need to make the transition to a model that revolves around task shifting from doctors to other health care professionals. Preventive care should be aggressively expanded and treatment in mobile

settings and low-cost technologies should be deployed. In addition, affordable medicines should be made available around the world. Norton believes it is feasible to ensure the provision of high-quality, low-cost care to the world's rapidly increasing population.

Beyond food, water, and basic health, we also need minerals. That is the focus of Chapter 10, as Anthony Hartwell delivers a mixed forecast for the impacts of population growth on mineral resources. Technological advancement has allowed humans to extract resources from places that previously were impossible to even explore. Deep-water resource mining has grown, and estimates of overall resource reserves are continually being adjusted upwards. So, if minerals are abundant, what's the problem? The answer, in its most singular form: climate change. Hartwell explains that mineral extraction is not only energy intensive itself, but that any vectors used to reduce climate change will require mineral resources to implement. Without major changes, a growing population will accelerate mineral demands, with cataclysmic consequences. Recycling offers an important opportunity; for some metals, such as aluminium, reuse requires only 5 per cent as much energy input as initial extraction. The planet may not be full, Hartwell concludes, but '[N]ew ways of designing, using, and re-manufacturing or reusing materials and products must be developed.'

Finally, I conclude the volume, arguing that governance is central to addressing every one of these challenges. We live in a 'global village', and we are at peril because we do not have village elders to guide us. The question 'is the planet full?' is not about numbers—how many babies are born or how many tonnes of emissions are produced—but about how those numbers are managed. Global governance substantially affects every major global challenge. I draw on my book *Divided Nations: Why Global Governance is Failing and What We Can Do About It* (2013) to show that these challenges transcend national borders, yet supranational bodies and sovereign states have failed thus far to tackle them. The biggest challenge is the benign neglect of the planet. In a system punctuated with veto points, policy viscosity derails global solutions. I explore how this occurs with reference to climate change, food and water supply, and migration. These examples illustrate the extent to which national decisions alone cannot deal with the challenge and often may be counterproductive. Population growth and income growth are the result of globalization. The unprecedented benefits for humanity are, however, matched by new systemic risks arising from the difficulties associated with managing an increasingly complex and interconnected world. These global risks invite global cooperation and provide ample opportunity for collective action. Whether the planet is full depends on our capacity to harvest the benefits of globalization to manage, mitigate, and adapt to the spiralling negative spillovers.

Our conclusion is neither alarmist nor complacent. The planet may not yet be full, but it is filling up. Our imperative is to understand the implications of our actions to ensure that the planet can continue to provide a home that can meet the aspirations of all the Earth's current and future citizens.

References

ABS (2013). '3101.0—Australian Demographic Statistics [December Key Figures]', Australian Bureau of Statistics. Last accessed 16 August 2013. <http://www.abs.gov.au/ausstats/abs@.nsf/mf/3101.0>.

Ashraf, Q., Weil, D. and Wilde, J. (2011). 'The Effect of Interventions to Reduce Fertility on Economic Growth', *NBER Working Paper No. 17377*. Cambridge, MA: National Bureau of Economic Research. Last accessed 13 August 2013. <http://www.nber.org/papers/w17377>.

Bloom, D., Canning, D., Fink, G. and Finlay, J. (2009). 'Fertility, Female Labor Force Participation, and the Demographic Dividend', *Journal of Economic Growth*, 14(2): 79–101.

Boserup, E. (1965). *The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure*. London: Allen & Unwin.

Brown, L. (1963). *Man, Land, and Food*. New York: Arno Press.

Carson, R. (1962). *Silent Spring*. Boston: Houghton Mifflin.

CDIAC (2013). 'Global Fossil-Fuel CO_2 Emissions', Carbon Dioxide Information Analysis Centre, Oak Ridge National Libratory. Last accessed 16 August 2013. <http://cdiac.ornl.gov/trends/emis/tre_glob_2010.html>.

Charles, D. (2005). *Mastermind: The Rise and Fall of Fritz Haber*. New York: Harper Collins.

Clark, D. A. (2006). 'Development Studies in the Twenty First Century' in D. A. Clark (ed.), *The Elgar Companion to Development Studies*. Cheltenham: Edward Elgar, pp. xxvi–xli.

Cockerham, G. and Cockerham, W. (2010). *Health and Globalization*. Cambridge: Polity Press.

Cohen, J. (1995). *How Many People Can the Earth Support?* New York and London: W. W. Norton and Company.

de Bary, W. T. (2008). *Sources of East Asian Tradition: The Modern Period*. New York: Columbia University Press.

Dell'Amore, C. (2013). 'Biggest Dead Zone Ever Forecast in Gulf of Mexico', *National Geographic*, 24 June.

Diamandis, P. and Kotler, S. (2012). *Abundance: The Future is Better than You Think*. New York: Free Press.

Dickens, C. (2009). *A Christmas Carol*. New York: Bantam Classics.

Dorling, D. (2013). *Population 10 Billion: The Coming Demographic Crisis and How to Survive It*. London: Constable.

Dunstan, H. (2006). 'Official Thinking on Environmental Issues and the State's Environmental Roles in Eighteenth-Century China' in M. Elvin and T.-J. Liu (eds). *Sediments of Time*. New Haven: Yale University Press, pp. 585–616.

Ehrlich, P. (1968). *The Population Bomb*. New York: Ballantine.
Ehrlich, P. and Ehrlich, A. (1996). *Betrayal of Science and Reason*. New York: Island Press.
Emmott, S. (2013). *Ten Billion*. London: Penguin Books.
Gaimard, J. (2013). *Population and Health in Developing Countries* (2014 edition). London: Springer.
Geoscience Australia (2013). 'Area of Australia—States and Territories', Australian Government. Last accessed 16 August 2013. <http://www.ga.gov.au/education/geoscience-basics/dimensions/area-of-australia-states-and-territories.html>.
Goldin, I. (2013). *Divided Nations: Why Global Governance is Failing and What We Can Do About It*. Oxford: Oxford University Press.
Goldin, I. and Mariathasan, M. (2014). *The Butterfly Defect: How Globalization Creates Systemic Risks, and What to Do About It*. Princeton, NJ: Princeton University Press.
Goldin, I. and Winters, L. A. (eds) (1995). *The Economics of Sustainable Development*. Cambridge: Cambridge University Press.
Grossman, G. M. and Krueger, A. B. (1995). 'Economic Growth and the Environment', *The Quarterly Journal of Economics*, 110(2): 353–77.
Harriss, J. (2002). 'The Case for Cross-Disciplinary Approaches in International Development', *World Development*, 30(3): 487–96.
Hulme, D. and Toye, J. (2006). 'The Case for Cross-Disciplinary Social Science Research on Poverty, Inequality and Well-Being', *Journal of Development Studies*, 42(7): 1085–107.
IEA (2010). *Energy Poverty: How to Make Modern Energy Access Universal*. Paris: International Energy Association. Last accessed 17 August 2013. <http://www.unido.org/fileadmin/user_media/Services/Energy_and_Climate_Change/Renewable_Energy/Publications/weo2010_poverty.pdf>.
Malthus, T. R. (1778) [1993]. *An Essay on the Principles of Population* (Reprinted). Oxford: Oxford World Classics.
Meadows, D. H., Meadows, D. L., Randers, J., and Behrens, W. W. III (1972). *The Limits to Growth*. New York: Universe Books.
Osterfeld, D. (1993). 'Overpopulation: The Perennial Myth', *The Freeman*, September, 1993. Last accessed 13 August 2013. <http://www.fee.org/the_freeman/detail/overpopulation-the-perennial-myth>.
Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge: Cambridge University Press.
Oxford Martin Commission for Future Generations (2013). *Now for the Long Term: The Report of the Oxford Martin Commission for Future Generations*. Oxford: Oxford Martin School. Last accessed 21 October 2013. <http://www.oxfordmartin.ox.ac.uk/commission>.
Parfit, D. (1984). *Reasons and Persons*. Oxford: Clarendon Press.
PRB 2012. '2012 World Population Data Sheet'. Washington, D.C.: Population Reference Bureau. Last accessed 13 August 2013. <http://www.prb.org/pdf12/2012-population-data-sheet_eng.pdf>.
Rockström, J., et al., (2009). 'A Safe Operating Space for Humanity', *Nature*, 461: 472–5.
Sachs, J. (2006). 'Lower Fertility: A Wise Investment', *Scientific American*, 295(3): 42 (21 August).

SDS (2013). 'Latest Data [Population & Land Area]', Singapore Department of Statistics. Last accessed 16 August 2013. <http://www.singstat.gov.sg/statistics/latest_data.html>.

Silberman, L. (1960). 'Hung Liang-Chi: A Chinese Malthus', *Population Studies*, 13(3): 257–65.

Simon, S. L. (1981). *The Ultimate Resource*. Princeton, NJ: Princeton University Press.

Stern, D. I. (2003). 'The Environmental Kuznets Curve', *Internet Encyclopaedia of Ecological Economics*. International Society for Ecological Economics. Last accessed 13 August 2013. <http://isecoeco.org/pdf/stern.pdf>.

Tierney, J. (1990). 'Betting on the Planet', *New York Times*, 2 December. Last accessed 19 August 2013. <http://www.nytimes.com/1990/12/02/magazine/120290-tierney-magazine.html?pagewanted=1>.

Turner, G. M. (2008). 'A Comparison of *The Limits to Growth* with 30 Years of Reality', *Global Environmental Change*, 18: 397–411.

UN (1992). *Agenda 21: Rio Declaration, Forest Principles*. New York: United Nations.

UN (2012). 'The Future We Want', *Resolution Adopted by the General Assembly 66/288*, 19 September. New York: United Nations. Last accessed 13 August 2013. <http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/66/288&Lang=E>.

UN-DESA (1999). *The World at Six Billion*. New York: United Nations, Department of Economic and Social Affairs, Population Division. Last accessed 16 August 2013. <http://www.un.org/esa/population/publications/sixbillion/sixbillion.htm>.

UN-DESA (2013a). *World Population Prospects: The 2012 Revision, Volume 1 Comprehensive Tables*. New York: United Nations, Department of Economic and Social Affairs, Population Division. Last accessed 13 August 2013. <http://esa.un.org/unpd/wpp/Documentation/publications.htm>.

UN-DESA (2013b). 'World Population to Reach 9.6 billion by 2050 with Most Growth in Developing Regions, especially Africa', *World Population Prospects: The 2012 Revision, Press Release*, 13 June. New York: United Nations, Department of Economic and Social Affairs, Population Division. Last accessed 13 August 2013. <http://esa.un.org/unpd/wpp/Documentation/pdf/WPP2012_Press_Release.pdf>.

United States Department of State (1974). *National Security Study Memorandum 200: Implications of Worldwide Population Growth for US Security and Overseas Interests*, 10 December. Last accessed 13 August 2013. <http://pdf.usaid.gov/pdf_docs/PCAAB500.pdf>.

WCED (1987). *Our Common Future* (World Commission on Environment and Development). Oxford: Oxford University Press.

WHO (1996). *The World Health Report 1996: Fighting Disease, Fostering Development*. Geneva: World Health Organization.

Winter, J. and Teitelbaum, M. (2013). *The Global Spread of Fertility Decline*. New Haven: Yale University Press.