

# Population, development, and climate change: links and effects on human health



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Global health, population growth, economic development, environmental degradation, and climate change are the main challenges we face in the 21st century. However, because the academics, non-governmental organisations, and policy makers in these specialties work within separate communities, our understanding of the associations between them is restricted. We organised an international symposium in May, 2011 in London, UK, for academics and technical experts from population, developmental, and environmental science to encourage debate and collaboration between these disciplines. The conference provided the impetus for this Review, which describes, in historical context, key events and fundamental intercommunity debates from the perspectives of population, development, and climate change communities. We consider the interconnections between population, development, and climate change and their effects on health, including new analysis of longstanding debates, and identify opportunities for effective collaboration on shared goals.

## Introduction

Because of huge population growth in the 20th century, the world's population is expected to be ten times larger by 2050 (roughly 10 billion) than it was for most of the 19th century (around 1 billion) (figure 1A).<sup>1,4,5</sup> The European Enlightenment (17th and 18th centuries) started this growth and laid the foundation for improvements to public health that triggered a global demographic transition. This transition began in northwest Europe pre-19th century and continues worldwide.<sup>6–8</sup> In pre-transitional societies, high fertility rates offset high mortality rates and population levels remained constant (figure 1A) because, on average, only two children per couple survived to adulthood.<sup>7,8</sup> The fundamental processes of demographic transition—which causes a population to move from high mortality and high fertility to low mortality and low fertility—are associated with a sustained decline in mortality leading to population growth and a decline in fertility leading to population ageing and urbanisation.

Irrespective of its pace and pattern, demographic transition is triggered by decreased mortality—especially from infectious diseases—because improved sanitation, nutrition, and health care allow more children to survive into adulthood. These improvements contributed to the fastest yearly population growth between 1962 and 1963 (2·20%) worldwide (figure 1B).<sup>1</sup> In contrast, fertility rates have decreased over time, and have fallen from an average of 5·0 to 2·5 livebirths per woman between 1950 and 2010.<sup>5</sup> Further reduction to around replacement level—ie, just over two livebirths per woman—is expected by 2050.<sup>5</sup> The different UN projections for future world population (figure 1A) show the substantial effect of fertility rate on future population size; the high and low variants are based on only half a livebirth per woman more or less, respectively, than the medium variant. Global fertility rates mask wide regional differences; rates are worryingly high in sub-Saharan Africa, and are below-replacement level in an increasing number of developed countries.<sup>9</sup> Decreased fertility results in ageing of the population and is most pronounced when reduction in fertility is rapid. Asia is the

most rapidly ageing continent. For example in Japan, the median age is expected to increase from 22 years in 1950 to 52 years in 2050.<sup>5</sup> Such population ageing is happening all over the developed and developing world at varying speeds, and has large implications for health, particularly the increased burden of non-communicable diseases and the subsequent effect on health-care systems.

How important is family planning in the reduction of fertility? Early theories<sup>10</sup> about the association of socioeconomic factors and industrialisation were based on the suggestion that desired family size and birth rates fall when socioeconomic conditions encourage child survival. These theories gave rise to the view (expressed by Karan Singh, former Indian Minister of Health, at the 1974 World Population Conference<sup>11</sup>) that development is the best contraceptive. Although fertility has eventually fallen in countries that have industrialised, the assumption that promotion of family planning cannot succeed in very poor countries is clearly not correct. Countries that have remained largely rural, agricultural and poor (eg, Bangladesh, Thailand, and Ghana) have also seen large reductions in fertility after implementation of culturally

*Lancet* 2013; 382: 1665–73

Published Online

July 11, 2013

[http://dx.doi.org/10.1016/S0140-6736\(13\)61460-9](http://dx.doi.org/10.1016/S0140-6736(13)61460-9)

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For the report of the Population Footprints Symposium see [http://www.ucl.ac.uk/popfootprints/publications/popfoot\\_report](http://www.ucl.ac.uk/popfootprints/publications/popfoot_report)

## Search strategy and selection criteria

We searched Medline, PubMed, Social Science Research Network, ScienceDirect, and Science.gov with a combination of words: "climate change", "health", "global warming", "environment", "family planning", "population", "development", "fertility", and "demographic transition". We included all countries, research methods, and time periods. We included grey literature such as UN reports and conference literature. We also searched reference lists of key articles and consulted experts in the fields of population, development and climate change. As no timeframe was imposed, articles dating back to the 18th and 19th century were located using Google Scholar and JSTOR. Literature was excluded if it was not in English or if it was purely an opinion piece. The full bibliography is available online.

## Key messages

- Associations between population growth, economic development, environmental effect, and climate change are complex, controversial, and have large implications for global health. Shared understanding of these links will need closer collaboration between academics, non-governmental organisations, and policy makers, and should replace the separate discourses that have historically characterised the different fields.
- Improvements to public health started in 18th century Europe and have lowered mortality worldwide and triggered a global demographic transition that has already decreased global fertility by half and will result in the world population being 10 times larger by 2050.
- Climate change is a direct consequence of development based on fossil fuel that started in the European industrial revolution. An accurate simplification is to say consumers, rather than people, cause climate change.
- Since the imperative for the world's poor, who have contributed little to climate change, is to achieve increased wealth and prosperity, the reduction of consumption in rich countries and the development of more sustainable lifestyles is essential to achieve a world suitable for future generations.
- Global health is a relative newcomer to the climate change debate. Reduction of carbon emissions can have substantial health cobenefits that should be integral to the development of climate change policy.
- After decades of debate, emerging consensus emphasises the contribution of family planning to reduced fertility and improved maternal and child health, which bring both short-term and long-term economic benefits. Future population size in poor countries has extensive consequences for health and the environment, as does the inevitable rise in population ageing and urbanisation.
- After two decades of relative neglect, nowadays, the extensive benefits of family planning attracts great global attention. Understanding the politics of population and family planning that existed before the climate change debate started helps appreciate why the linkage of family planning with climate change is so controversial.

For more on historical demographic data of Kenya see <http://www.populstat.info/Africa/kenyac.htm>

sensitive family planning programmes.<sup>12–14</sup> Traces of this chicken and egg argument about the relative importance of improvement of socioeconomic conditions versus promotion of contraception in reduction of fertility persist today.

Dyson<sup>6</sup> offers a unifying explanation for the decreased fertility by analysis of historical and contemporary demographic transitions in different populations. Although low mortality is the underlying or remote cause of reduction in fertility, conditioning or contextual factors—eg, education, availability of family planning, and economic growth—account for the varied times of onset, speed, and duration of events that exist between different regions and countries.<sup>6,15</sup> Dyson argues that when mortality falls, couples decide that they should have fewer children, irrespective of whether economic conditions are strong, weak, improving, or deteriorating. This decision can be made without family planning, although the main way to control fertility and achieve desired family size is by use of contraception. Widespread availability of the contraceptive pill and intrauterine devices post-1960 made the generalised use of modern contraception possible; however, the reduction in fertility in western Europe that took place between 1880 and 1930 was largely attributed to withdrawal before ejaculation and not widespread

contraception use. In the early 20th century, birth control in England and the USA was achieved despite opposition from government, religious authorities, and the medical profession. Margaret Sanger, an early pioneer of family planning, was arrested in 1916 for opening a birth control clinic in New York.<sup>7</sup>

By contrast, the contraceptive revolution in the late 20th century, which was closely linked to government policy driven by demographic and economic concerns, played a very important part in the reduction of fertility in developing countries.<sup>7</sup> The fall in mortality in the 1950s and 1960s, coupled with persistently high fertility, led to rapid population growth and implied that some countries would double in population every 20 years, for example, in Kenya. However, experiences and outcomes of family planning programmes in developing countries ranged greatly from inept and coercive policies in some countries (eg, Pakistan and China) to popular successes in others (eg, Bangladesh and South Korea).<sup>16</sup>

In the 1990s, a human rights approach to reproductive health became prominent amid a backlash against coercive practices, such as incentive-based sterilisation programmes in India during the 1970s.<sup>7</sup> The 1994 International Conference on Population and Development (ICPD)<sup>17</sup> in Cairo was seen as a landmark because it emphasised the need to integrate family planning programmes into development, and above all, the need to respect the right of individuals to decide freely the number and spacing of their children. Cairo differed greatly from previous population meetings; rather than demographic issues and fertility control, the conference embraced the concept of sexual health and the right to a safe and satisfying sex life.<sup>18</sup> However, the vision of Cairo failed for several reasons: religious opposition (particularly from the Catholic church); political opposition (mainly from the US administration of President Bush); the sense of crisis that surrounded the global HIV/AIDS epidemic; and the suggestion that a 50% decrease in global fertility would mark the completion of family planning.<sup>19,20</sup>

Additionally, the politics of abortion overshadowed rational debate about family planning, and international funding for family planning fell from US\$653 million in 1997 to \$394 in 2006.<sup>21</sup> In this climate, the millennium project was commissioned by the UN in 2002 leading to eight Millennium Development Goals (MDGs)<sup>22</sup> that set the global agenda to 2015: poverty, universal primary education, gender equality, child mortality, maternal health, HIV/AIDS, other diseases, environmental sustainability, and global development partnerships. However, population and family planning were not included in these goals until 2007, when non-governmental organisations secured the inclusion of MDG 5b—ie, the achievement of universal access to reproductive health.<sup>23,24</sup> Nowadays, the contribution of family planning to global health attracts great attention.<sup>25</sup> Increased contraceptive use in developing countries has prevented more than

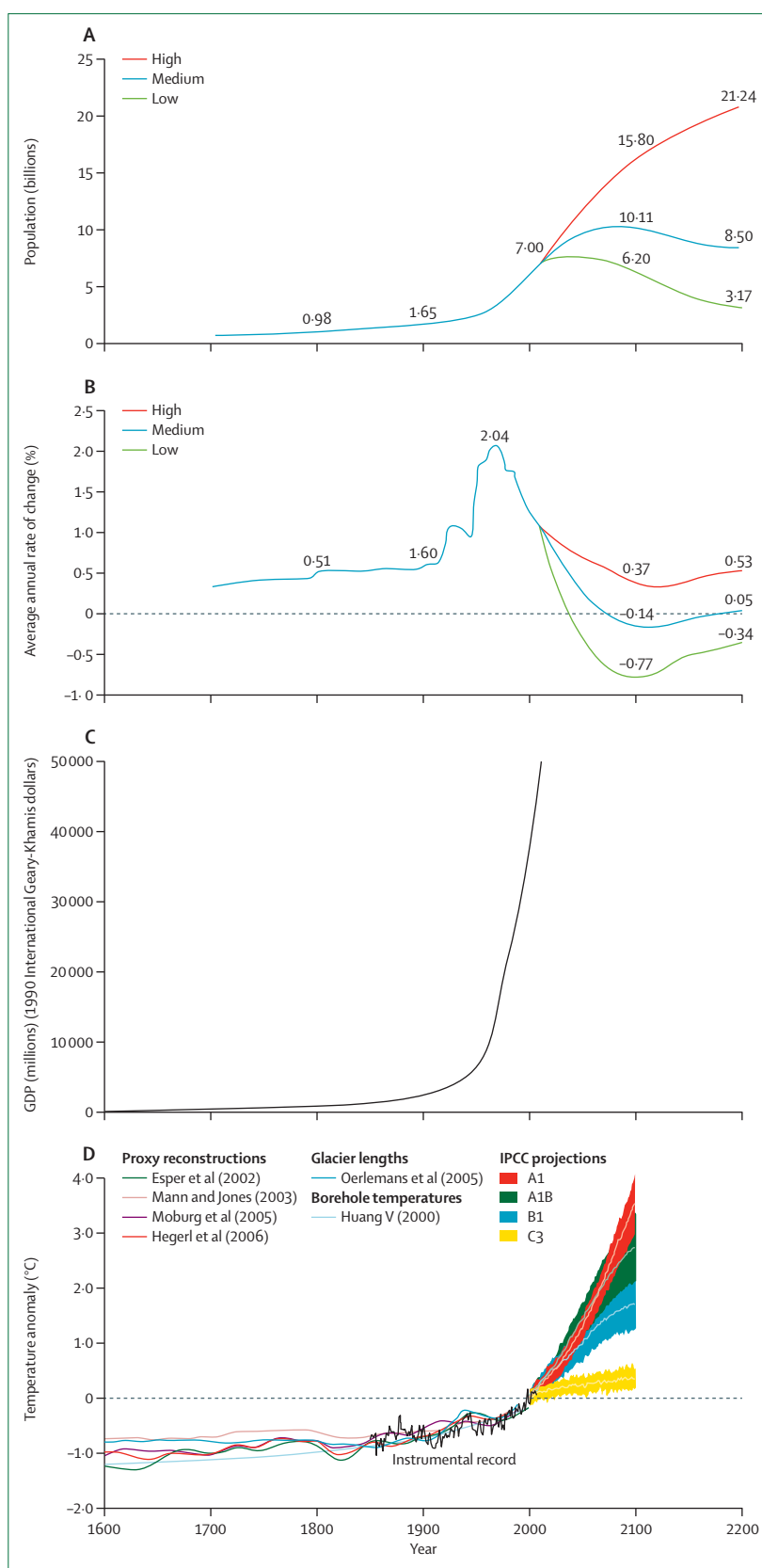
40% of maternal deaths between 1990 and 2008<sup>26,27</sup> and could prevent a further 10% of infant (younger than 1 year) and 21% of early childhood (aged 1–4 years) deaths if all children were spaced by an interval of 2 years.<sup>16,26</sup> Furthermore, if the estimated unmet need for family planning for more than 215 million couples is met, contraception use could prevent an additional 30% of maternal deaths.<sup>27–29</sup>

Do large populations create difficulties for health and wellbeing? In the late 20th century, the main focus of debate in the emerging field of international development was on the relation between population and economic development (figure 1C). Researchers, politicians, and policy makers in countries of the global north (especially the USA and western Europe) raised neo-Malthusian concerns that rapid population growth in countries of the global south (countries in Africa, Asia, Latin America, and the Middle East) was detrimental to economic growth, social cohesion, political stability, and environmental sustainability.<sup>30,31</sup> Although interdisciplinary research did not show a causal relation between population growth and economic development, these concerns caused some policy makers to implement so-called population-control measures. The platform for future concerns about the link between population and development was firmly established by the 1953 UN report,<sup>32</sup> which assessed the short-term and long-term effects of population growth on the economy, and discussed various direct and indirect effects, acknowledged the role of human ingenuity in overcoming constraints, and stressed the importance of different country conditions.<sup>33</sup> The report was described as “the most systematic and comprehensive assessment of the consequences of population growth since Malthus”<sup>33</sup> and raised concerns about the link between population and development.

The first of many studies of economic demography was done by Coale and Hoover<sup>34</sup> in 1958, and assessed the negative effects of rapid population growth on economic progress in poor countries (Mexico and India were used as case studies). Data suggested an inverse relation between population growth and savings and investment, and therefore constrained economic growth. Key studies<sup>35,36</sup> and a popular book<sup>37</sup> in the 1960s and 1970s supported similar conclusions and created a political momentum that provided justification for birth-control policies in so-called third world countries, which the US Agency for

**Figure 1: Estimates of world population, yearly rate of change in population, increase in GDP, and increase in global temperature, 1600–2200**

(A) World population, estimates of world population, and three scenarios based on high, medium, and low total fertility rates, 1700–2200. (B) Average yearly rate of change of the world population, estimates of world population, and three scenarios based on high, medium, and low total fertility rates, 1700–2200. (C) Increase in GDP, 1600–2020.<sup>2</sup> (D) Reconstructed and measured past (1600–2012) and modelled future (2000–2100) global temperatures. Panels A and B modified from United Nations Department of Economic and Social Affairs,<sup>1</sup> by permission of United Nations. Panel D modified from Chapman and Davis,<sup>3</sup> by permission of John Wiley and Sons, which contains the references listed in the panel. GDP=gross domestic product. IPCC=Intergovernmental Panel on Climate Change.



International Development, multilateral agencies, and bilateral aid programmes promoted. Against prevailing trends, which justified population reduction to increase economic growth, in 1965 Boserup<sup>38</sup> attributed the intensification of agricultural production to growth in population. Boserup argued that more people implied more labour, which combined with technology, ingenuity, and the right incentives, resulted in higher yields and, thus, increased economic development. Studies in the 1980s and 1990s<sup>39–41</sup> lent support to these findings, but the debate about the implications of population dynamics for economic growth continued because of methodological considerations<sup>42</sup> and changing international development paradigms. In the 1970s, the failure of so-called trickle down (ie, the theory stating that increased wealth at the top of society will trickle down and benefit poorer members of society by improvement of the economy as a whole) in economic growth policies fuelled subsequent arguments for a recognition of inequality and the redistribution of wealth and resources.<sup>43,44</sup> Included in the wider discussions on global inequality, underdevelopment, and population growth was a strong reaction against coercive birth-control measure supported by foreign aid and some governments in the global south. These debates were central to the 1974 Bucharest world population conference.<sup>45</sup> Similarly, in response to inequalities in health and development, in 1978, the health for all declaration<sup>46</sup> was introduced and a focus on primary health care was announced. The effect of structural adjustment and neo-liberal thinking in the development discourses of the 1980s and 1990s posed many challenges for these distributive debates. In particular, structural reform provided a basis for the withdrawal of the state from population control and more progressive approaches to family planning. Structural reform also affected discussions about cost-effective health strategies in the 1979 conference on health and population development, held at the Bellagio Conference Center, Italy, which resulted in a retreat from the health for all agenda,<sup>47</sup> and a focus on so-called selective aspects of primary health care.<sup>47–49</sup>

In the past few years, research by several authors has confirmed the importance of demographic change in economic growth, whereby decreased fertility leads to lower youth dependency ratios that facilitate growth in income and investment.<sup>50–54</sup> Earlier evidence suggests that policy and institutional settings, as well as size and structure of the population, are key in shaping economic growth.<sup>42</sup> Reduction in fertility also changes the social and economic position of women; it allows more women to enter formal employment and brings long-term economic benefits by increased birth spacing, child health, and development, which raises the health and education of young people entering the workforce.<sup>50</sup>

Three factors are important in any review of international development, human health, and population. The first is urbanisation, which is an integral part of the demographic transition and is closely linked to migration.<sup>6</sup> Nowadays,

more than half the world's population live in urban areas (compared with 5% in 1800) and one in seven people lives in an urban slum.<sup>55</sup> Around 60% of urban growth is accounted for by natural growth and 40% by migration.<sup>56,57</sup> Although studies show positive economic effects in terms of remittances—ie, transfer of money by foreign workers to their home country<sup>58</sup>—the relation between international migration, poverty, and climate change needs to be further explored.

The second factor is a gender perspective, which was institutionalised internationally during the first UN decade for women (1976–85), and sought to recognise women in international development. Critical of previously instrumental views of women in population and development studies that did not recognise gender and age,<sup>59,60</sup> activists and researchers shifted the primary focus of development interventions related to population to reproductive rights, women's health, dignity, and political rights.<sup>31,61–63</sup> This shift was reflected by the debates that surrounded the 1994 ICPD conference.

The third factor has been crucial in studies of population and economic growth, and is the effect on the environment, where research has focused on rural areas and natural resource systems.<sup>42,64</sup> The difference in consumption between developed and developing countries challenged earlier Malthusian concerns about the negative effect of population growth on the environment.<sup>36,65,66</sup> Malthusian and neo-Malthusian concerns were discarded by the 1992 Rio declaration,<sup>67</sup> which listed poverty alleviation, the role of women, and improved health as key concerns to be addressed by sustainable development.<sup>68</sup> Increasingly, the effects of highly unequal patterns of distribution (eg, land and other resources), production, and consumption are regarded as major challenges to sustainable development.<sup>66</sup>

The past few years have seen a renewed focus on understanding the conditions of human health; the WHO commission<sup>49</sup> on the social determinants of health highlighted the ubiquitous links between inequalities in numerous development conditions, including power relations, income, and social investment, and persistent health inequalities. Linked to the social determinants of health are changing regional patterns of morbidity and mortality that reflect the rapid rise of non-communicable diseases, accidents, and injuries in addition to infectious diseases in low-income and middle-income countries. The greater understanding of the potential effects of anthropogenic climate change has intensified the need to bring population, development, and human health into urgent multidisciplinary dialogue.

### Development, climate change, and human health

Modern climate change is the direct consequence of fossil fuel consumption in the European industrial revolution (figure 1D). Concerns about global warming did not surface until the mid-1980s, despite earlier measurements showing a substantial rise in atmospheric carbon dioxide

worldwide.<sup>69,70</sup> Extension of these measurements back in time with air bubbles trapped in ice suggested that pre-industrial carbon dioxide concentrations were roughly 280 parts per million by volume (ppmv).<sup>71</sup> In 1958, the concentration of carbon dioxide was 316 ppmv;<sup>72</sup> this has increased every year, and in 2012 almost reached

400 ppmv.<sup>73</sup> A substantial increase in global annual mean temperature in the late 1980s caused attention to be focused on dormant scientific evidence from the late 1950s and 1960s<sup>74</sup> and the subsequent establishment of the Intergovernmental Panel on Climate Change (IPCC) in 1988 by the UN Environmental Programme and World

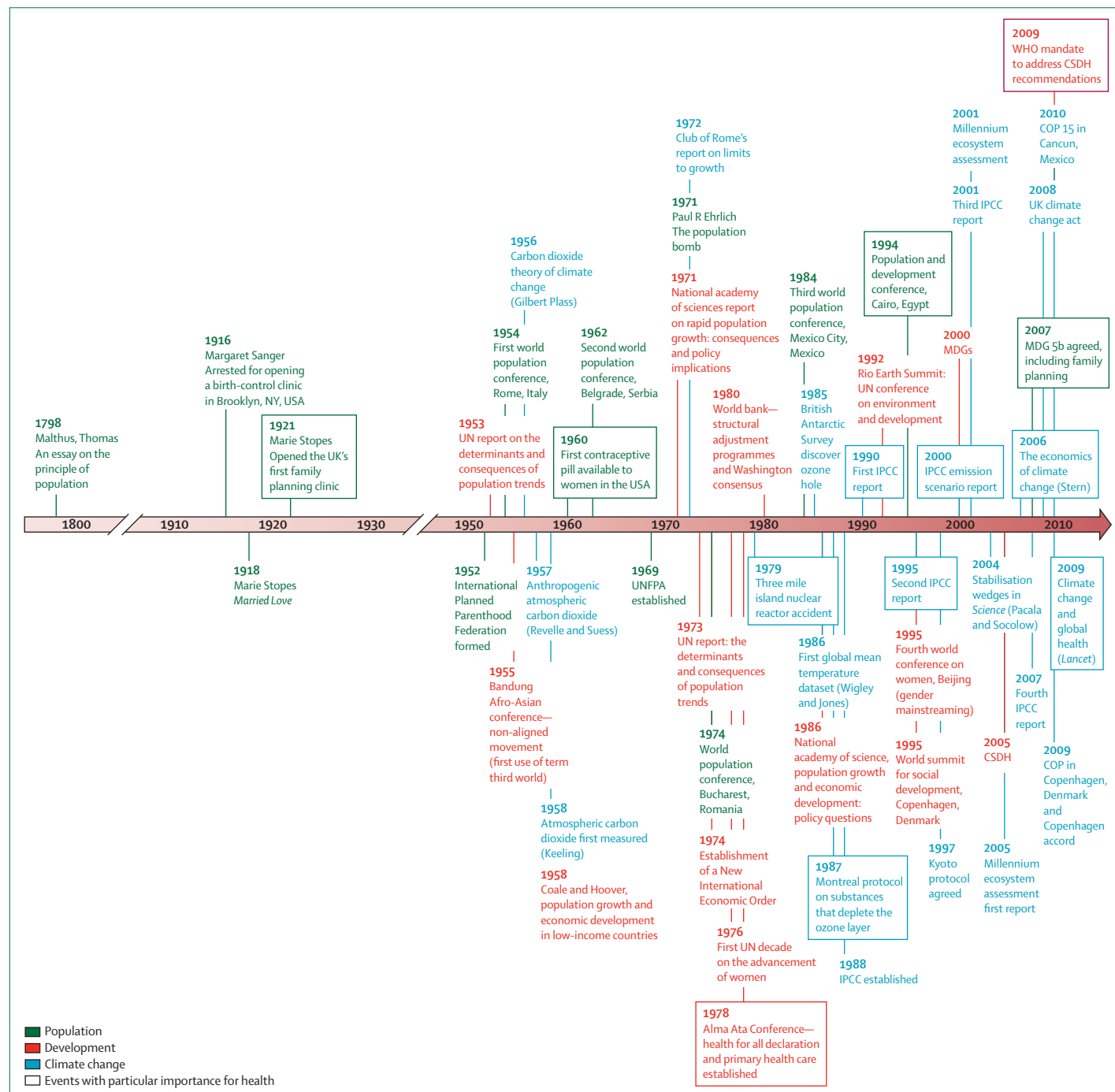


Figure 2: Timeline of key events in population, development, and climate change, and interconnections with health

UNFPA=UN Population Fund. IPCC=Intergovernmental Panel on Climate Change. MDGs=Millennium Development Goals. CSDH=Commission on Social Determinants of Health. COP 15=15th Conference of the Parties.



Meteorological Organization. The 2007 IPCC scientific assessment predicted a global temperature rise of between 1·8°C and 4°C by 2100, dependent on the amount of greenhouse gases we add to the atmosphere.<sup>71</sup> The next IPCC scientific assessment in 2013 is expected to substantiate this prediction.

The 1980s marked the beginning of a new global environmental awareness<sup>74</sup> (figure 2). In 1985 the findings from the British Antarctic Survey<sup>74</sup> showed the depletion of the ozone over Antarctica and the global connectivity of our environment. This discovery led to a new political arena—the international management of the environment—in which environmental diplomacy led to the signing of key agreements. Climate change has developed slowly in international politics and little has been achieved in terms of regulation and implementation, largely because of uncertainties about the science and the potential effects and large economic costs of tackling the problem. In the past few years, consensus is that local and regional environmental degradation, resource depletion, and loss of biodiversity are as important as climate change in the short to medium term. Population pressure can have a detrimental effect on human-scale environments, and produce a vicious cycle that increases local vulnerability to natural disasters, especially in combination with poverty.<sup>73</sup>

How can decreases in fertility versus reduction in consumption contribute to the reduction of future carbon emissions? The population of the world reached 7 billion in 2011; this has created a sensitive debate about the relation between fertility, other demographic changes, and carbon emissions.<sup>75</sup> To focus on global population as the denominator of all that we do misses important regional differences over time. Countries with historically low or negligible contributions to climate change—mainly in Africa—have some of the highest fertility rates. Nonetheless, growth in consumption exceeds growth in population in developing and developed countries;<sup>76</sup> therefore, “consumers cause climate change” is a more accurate simplification than “people cause climate change”.

Suggestions that populations are a key driver of climate change are an oversimplification that arises from underappreciation of the complex relations between demographic variables (eg, ageing, migration, and urbanisation) and carbon emissions in different regions, coupled with uncertainty about demographic projections, economic development, and future consumption patterns. Why is the topic of population neglected in the climate change debate? Several reasons exist: underappreciation that significant population growth arises despite reduced fertility; the relation between population growth and emissions changes very rapidly in middle-income countries; concern that the linkage of population to climate change shifts attention away from the primary problem of high consumption in developed countries and blames people in developing countries who are worst affected by

climate change, but have contributed very little to carbon emissions; and the possibility that the linkage of population with climate change could spark a return to inept or coercive family planning that neglects women's rights. As a result, assessment of population and climate change has focused on climate change adaptation, which is less contentious than mitigation because adaptation strategies can be aligned with good development practices.<sup>77</sup>

The absence of sophisticated quantitative analyses of the demographic changes caused by carbon emissions restricts constructive debate in this area. For example, population barely featured in the IPCC reports.<sup>71</sup> The 2000 IPCC special report<sup>78</sup> on emissions scenarios constructed four scenarios; each had different technological emphases that created different greenhouse-gas emissions to the year 2100. Two scenarios assumed population would rise to 9 billion in 2050 and then fall, the other two assumed slower, but continuous population growth to the end of the century. However, the major controls in all these scenarios are the speed of development, the level of technological innovation, and adaption to low-carbon energy and consumption, rather than population. The next generation of climate model results to be published in the 2013 IPCC science report will use greatly improved emission scenarios called representative concentration pathways. These pathways consider a much wider detailed variable input to the socioeconomic models including detail global and regional population projections, land use, energy intensity, energy use, and regional differentiated development.<sup>79</sup> However, in view of the nature of global emission scenarios, the approach to population is large-scale and lacks detail.

A few studies<sup>80–82</sup> have investigated the effect of demographics on global emissions of carbon dioxide and suggest that different population growth paths could substantially affect emissions in the 21st century, and that ageing and urbanisation could play a more important part than they have in the past. According to UN projections,<sup>1</sup> if the world's population follows a low, rather than a medium, growth path, global emissions will fall by 15% in 2050 and by 40% in 2100. Conversely, a high population growth path will increase emissions by 17% in 2050 and by 60% in 2100.<sup>81</sup> Family planning in developing countries (except in China) would reduce fertility by about 0·7 births,<sup>80</sup> which is similar to the difference assumed between the high, medium, and low population growth scenarios used in these studies.<sup>80,81</sup> This decrease in fertility would not be sufficient to avoid dangerous levels of climate change, but could contribute to various mitigation strategies.<sup>83</sup> The same model-based scenarios show major contrasting effects of urbanisation and ageing on climate change: urbanisation can increase projected emissions mainly by labour supply and consumption preference (ie, economic growth and income); ageing is associated with reduced emissions because retirement age might affect low labour supply. An assessment of the environmental effect of demographic

change in the UK<sup>84</sup> suggests that factors such as household size and ageing are more important than is size of the population, and that patterns of consumption have a greater effect on the environment than all demographic factors do.

Concerns about global health in relation to climate change have only recently attracted attention<sup>85–88</sup> with some reviews concluding that water and food insecurity could substantially affect wellbeing. Careful assessment shows that if climate change is unchecked, the results could be devastating, particularly in the poorest communities that contributed the least. In contrast, many health co-benefits could emerge through effective mitigation strategies in energy, transport, food, and agricultural sectors—eg, a reduction in obesity as cars are replaced with physical activity. Renewed interest in the benefits that voluntary family planning brings to global health is encouraging.<sup>25–27</sup>

The links between population growth, development of human settlements, and future carbon dioxide emissions are complex and controversial.<sup>77</sup> In figure 2 we relate population, development, and climate change to human health in a historical context. In the past 20 years, events related to family planning have fallen by contrast with numerous climate change events. An understanding of the politics of population and family planning before climate change happened helps to explain why the linkage of family planning programmes with climate change issues is so controversial. China has nearly half a billion fewer people and consumers as a direct consequence of its one-child policy; this situation produces quite different reactions from different disciplines. Contrastingly, the value of family planning in empowering women to determine their own fertility is widely recognised, except by some religious groups.

Experience of bringing different disciplines together, through informed public and expert debate and high-level working groups<sup>75</sup> is promising. The Royal Society reported “population and the environment should not be regarded as two separate issues” and that “natural and social scientists need to increase their research efforts on the interactions between consumption, demographic change and environmental impact”.<sup>73</sup> In view of the complex interaction and profound consequences of climate, environmental, and demographic change, it is easy to identify knowledge gaps or challenging research priorities.<sup>77,86</sup> We suggest three methods to address urgent priorities and inform government action by increased interdisciplinary commitment (panel).

Although uncertainty exists about future population and emissions projections,<sup>89</sup> consequences of the present demographic transition are unavoidable; for example, the increased dominance worldwide of non-communicable diseases in an ageing population. Global temperature will continue to rise this century and MDGs will not be achieved in all countries despite substantial progress. Population ageing and urbanisation will increase

#### Panel: Broad research directions that need closer interdisciplinary collaboration

- Apply experience of international development and Millennium Development Goals to devise sustainable development goals that can effectively help poor countries to develop rapidly without a huge increase in carbon emissions or environmental effects
- Explore the causes and effects of demographic change on global carbon emissions through collaborative engagement with women and men in communities combined with more sophisticated mathematical modelling, while acknowledging the lessons learnt from past family planning programmes
- Realise the potential of urbanisation and migration to reduce material consumption and effect on environment while improving socioeconomic levels and human welfare

worldwide and will be particularly rapid in countries that have had sharp reductions in fertility such as China. The net effect of such demographic factors on global emissions is unclear, but can be determined by various identifiable factors. In regions where fertility remains high, mainly sub-Saharan Africa where population is predicted to increase by 2·6 billion in the 21st century,<sup>5</sup> the rate of fertility reduction will have a major effect on final population size and the country's capacity to meet all of the MDGs. In other regions such as Asia, where projected population growth this century is substantially lower (400 million), but where emissions and urbanisation are rapidly increasing, the way in which populations urbanise will have a major effect on health, livelihoods, and global carbon emissions.<sup>90</sup>

Future research should use suitable models to examine the causes, not only the effects, of demographic change, such as improved family planning services and education. The world's poor, who have contributed little to climate change, need to achieve increased wealth and prosperity, as a result, future population size in poor countries has major long-term implications for the environment. To create a world suitable for future generations, reduced consumption in rich countries and development of more sustainable lifestyles is essential.<sup>73</sup> In the agreement of new goals for sustainable development, the challenge will be how to achieve development while restricting growth in carbon emissions.

#### Conclusions

Up to now, the fields of population, development, global health, and climate change have evolved separately; however, to deliver more rational and effective joint policies, and to improve health and wellbeing, greater understanding and interaction between these specialties is needed. The argument that low population growth is the solution to climate change can be misleading and unhelpful. Similarly, although universal access to family

planning would bring major health and economic benefits, it is not a panacea to the problems associated with climate change. In the short term, consumption patterns, ageing, and urbanisation in some countries have bigger implications than do total number of people on health and the control of greenhouse-gas emissions. In the long term, final world population and the extent of inequality have major implications for sustainability. Entrenched perspectives on population growth and climate change make likely the repetition of debates on population and economic growth. An effective future response will need engagement between developing and developed countries and an understanding of how people live their lives. Additionally, the climate change debate needs to be re-framed to emphasise connections between health and demographic changes, and to accentuate the role of local innovation in the reduction of greenhouse-gas emissions and population vulnerability, while improving health and wellbeing (panel).

#### Contributors

All authors contributed to design of the review, literature search, and draft of the final paper.

#### Conflicts of interest

We declare that we have no conflicts of interest.

#### Acknowledgments

This Review arose out of discussions held during a Leverhulme-funded UCL symposium Population Footprints in May, 2011. We thank Ndola Prata (Bixby Center for Population, Health and Sustainability, University of California, Berkeley, CA, USA) for her contribution to an earlier draft.

#### References

- United Nations Department of Economic and Social Affairs. World population to 2300. Proceedings of the United Nations expert meeting on world population in 2300. New York; March 24, 2004.
- Maddison A. Development centre studies. The world economy: historical statistics. Paris: OECD, 2003.
- Chapman DS, Davis MG. Climate change: past, present, and future. *Eos Trans AGU* 2010; **91**: 325.
- Lee R. The demographic transition: three centuries of fundamental change. *J Econ Perspect* 2003; **17**: 167–90.
- United Nations department of economic and social affairs, population division. 2011. World population prospects: the 2010 revision. <http://esa.un.org/wpp/> (accessed Jan 16, 2013).
- Dyson T. Population and development: the demographic transition. London: ZED Books, 2010.
- Cleland J. Contraception in historical and global perspective. *Best Pract Res Clin Obstet Gynaecol* 2009; **23**: 165–76.
- Galloway P. Long-term fluctuations in population and climate in the pre-industrial era. *Popul Dev Rev* 1986; **12**: 1–24.
- Demeny P. Population policy dilemmas in Europe at the dawn of the twenty-first century. *Popul Dev Rev* 2003; **29**: 1.
- Notestein FW. Population-the long view. In: Schultz TW, ed. Food for the world. Chicago: University of Chicago Press, 1945.
- Mathai M. Bulletin of the World Health Organization. The global family planning revolution: three decades of population policies and programmes. <http://www.who.int/bulletin/volumes/86/3/07-045658/en/index.html> (accessed April 15, 2013).
- Simmons R, Baqee L, Koenig MA, et al. Beyond supply: the importance of female family planning workers in rural Bangladesh. *Stud Fam Plann* 1988; **19**: 29–38.
- Shevasunt S, Hogan DP, Thaithong K. Fertility and family planning in rural northern Thailand. *Stud Fam Plann* 1978; **9**: 212–21.
- Debpuur C, Phillips JF, Jackson EF, Nazzar A, Ngom P, Binka FN. The impact of the Navrongo project on contraceptive knowledge and use, reproductive preferences, and fertility. *Stud Fam Plann* 2002; **33**: 141–64.
- Cleland J, Wilson C. Demand theories of the fertility transition: an iconoclastic view. *Pop Stud-J Demog* 1987; **41**: 5–30.
- Cleland J, Bernstein S, Ezeh A, Faundes A, Glasier A, Innis J. Family planning: the unfinished agenda. *Lancet* 2006; **368**: 1810–27.
- United Nations. Report of the international conference on population and development. Cairo 5–13 September 1994. New York: United Nations, 1995.
- Gillespie DG. Whatever happened to family planning and for that matter, reproductive health? *Int Fam Plann Perspect* 2004; **30**: 34–38.
- Campbell M, Cleland J, Ezeh A, Prata N. Return of the population growth factor. *Science* 2007; **315**: 1501–02.
- Mazur L. Population matters: why population growth is so hard to talk about and why we should talk about it anyway. *Conscience* 2010; **31**: 13–18.
- UN Economic and Social Council. Flow of resources for assisting in the implementation of the programme of action for the international conference on population and development: report of the secretary general, New York: UN, 2009.
- The millennium development goals report. Online: The United Nations Department of Economic and Social Affairs (DESA), 2010. <http://www.un.org/millenniumgoals/reports.shtml> (accessed Jan 16, 2013).
- Greer G, Chau K, Hinz C, Thanenthiran S. Sex, rights and politics—from Cairo to Berlin (Comment). *Lancet* 2009; **374**: 674–75.
- Speidel JJ, Weiss DC, Ethelston SM, Gilbert SM. Population policies, programmes and the environment. *Philos Trans R Soc Lond B Biol Sci* 2009; **364**: 3049–65.
- Carr B, Gates MF, Mitchell A, Shah R. Giving women the power to plan their families. *Lancet* 2012; **380**: 80–82.
- Cleland J, Conde-Agudelo A, Peterson H, Ross J, Tsui A. Contraception and health. *Lancet* 2012; **380**: 149.
- Ahmed S. Maternal deaths averted by contraceptive use: an analysis of 172 countries. *Lancet* 2012; **380**: 111–25.
- Collumbien M, Gerressu M, Cleland J. Non-use and use of ineffective methods of contraception. In: Ezzati M, Lopez AD, Rodgers A, Murray CJL, eds. Comparative quantification of health risks; global and regional burden of disease attributable to selected major risk factors. Geneva: World Health Organisation, 2004: 1255–320.
- Singh S, Darroch JE, Ashford LS, Vlassoff M. Adding it up: the costs and benefits of investing in family planning and maternal and newborn health. New York: Guttmacher Institute, 2009.
- Furedi F. Population and development: a critical introduction. Cambridge: Polity Press, 1997.
- Kabeer N. Gender, demographic transition and the economics of family size: population policy for a human-centred development. June 7, 1996. Geneva; UN Research Institute for Social Development, 1996.
- United Nations. The determinants and consequences of population trends. 1953. Department of Social Affairs, Population Division, Population Studies No. 17. New York: United Nations, 1953.
- Kelley AC. The population debate in historical perspective: revisionism revised. In: Birdsall N, Kelley AC, Sinding SW, eds. Population matters: demographic change, economic growth and poverty in the developing world. New York: Oxford University Press, 2001.
- Coale AJ, Hoover EM. Population growth and economic development in low income countries. Princeton: Princeton University Press, 1958.
- Becker GS. An economic analysis of fertility. Demographic and economic change in developed countries. Princetown: Princetown University Press and NBER, 1960.
- National Academy of Sciences. Rapid population growth: consequences and policy implications. Baltimore: The John Hopkins University Press, 1971.
- Ehrlich P. The population bomb. New York: Buccaneer Books, 1968.
- Boserup E. The conditions of agricultural growth: the conditions of economic change under population pressure. Chicago: Aldine, 1965.
- Simon JL. Population growth and Phelps' technical progress model: interpretation and generalization. *Res Popul Econ* 1981; **3**: 239–54.
- Tiffen M. Malthus controverted: The role of capital and technology in growth and environment recovery in Kenya. *World Dev* 1994; **22**: 997.



- 41 Malakoff D. Are more people necessarily a problem? *Science* 2011; **333**: 544–46.
- 42 Das Gupta, M, Bongaarts, J, Cleland J. Population, poverty and sustainable development: a review of evidence. Policy research working paper 5719. June 2011. Washington DC; World Bank, 2011.
- 43 Heath J, Binswanger H. Natural resource degradation effects of poverty and population growth are largely policy induced: the case of Colombia. *Environ Dev Econ* 1996; **1**: 65–84.
- 44 Mason A. Saving, economic growth, and demographic change. *Popul Dev Rev* 1988; **14**: 113–44.
- 45 Mauldin WP, Choucri N, Notestein FW, Teitelbaum M. A report on Bucharest. The world population conference and the population tribune, August 1974. *Stud Fam Plann* 1974; **5**: 357–95.
- 46 The Alma-Ata conference on primary health care. World Health Organization; 1978. [http://www.who.int/publications/almaata\\_declaration\\_en.pdf](http://www.who.int/publications/almaata_declaration_en.pdf) (accessed Jan 16, 2013).
- 47 Walsh J, Warren K. Selective primary health care, an interim strategy for disease control in developing countries. *N Engl J Med* 1979; **301**: 967–74.
- 48 Cueto M. The origins of primary health care and selective primary health care. *Am J Public Health* 2004; **94**: 1864–74.
- 49 Friel S, Marmot MG. Action on the social determinants of health and health inequities goes global. *Annu Rev Public Health* 2011; **32**: 225–36.
- 50 Canning D, Schultz T. The economic consequences of reproductive health and family planning. *Lancet* 2012; **380**: 165–71.
- 51 Higgins M, Williamson JG. Age structure dynamics in Asia and dependence on foreign capital. *Pop Dev Rev* 1997; **23**: 261–93.
- 52 Bloom DE, Williamson JG. Demographic transitions and economic miracles in emerging Asia. *World Bank Econ Rev* 1998; **12**: 419–55.
- 53 Bloom DE, Canning D. Global demographic change: dimensions and economic significance. National Bureau of Economic Research; 2004. Report No.: Working Paper 10817. <http://www.nber.org/papers/w10817> (accessed Jan 16, 2013).
- 54 Lee R, Mason A. Fertility, human capital, and economic growth over the demographic transition. *Eur J Pop* 2010; **26**: 159–82.
- 55 United Nations Human Settlements Programme (UN-HABITAT). Global urban observatory, urban indicators programme, phase III. New York: UN-HABITAT, 2005.
- 56 UNFPA. State of world population: unleashing the potential of urban growth. New York: UNFPA, 2007.
- 57 Montgomery MR. The urban transformation of the developing world. *Science* 2008; **319**: 761–64.
- 58 Harris N. Thinking the unthinkable: the immigration myth exposed. London: I.B.Tauris, 2002.
- 59 Folbre N. The black of four hearts: towards a new paradigm of household economics. In: Bruce J, Dwyer D, eds. A home divided: women and income in the third world. Stanford: Stanford University Press, 1988.
- 60 Sen G. Woman, poverty and the population: issues for the concerned environmentalist. In: Harcourt W, ed. Feminist perspective on sustainable development. London: Zed Books, 1994.
- 61 McIntosh CA, Finkle JL. The Cairo conference on population and development: a new paradigm? *Popul Dev Rev* 1995; **21**: 223–60.
- 62 Dasgupta P. The population problem: theory and evidence. *J Econ Lit* 1995; **33**: 1879–902.
- 63 Hartman B. Reproductive rights and wrongs: the global politics of population control and contraceptive choice. New York: Harper and Row Publishers, 1987.
- 64 Dasgupta P. Population, resources and poverty. *Ambio* 1992; **21**: 95–101.
- 65 Redcliff M. Sustainable development (1987–2005). *Sust Dev* 2005; **13**: 212–27.
- 66 Harvey D. Justice, nature and the geography of difference. Oxford: Blackwell, 1996.
- 67 United Nations. Report on the United Nations conference on environment and development, Rio de Janeiro, June 3–14, 1992. Rio declaration on environment and development. <http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm> (accessed May 30, 2013).
- 68 Allen A. Managing sustainable urban development: a technical or political task? In: Gupta KR, ed. Urban development debates in the new millennium: studies in revisited theories and redefined praxes. New Delhi: Atlantic Publishers and Distributors, 2005. 1–24.
- 69 Revelle R, Suess HE. Carbon dioxide exchange between the atmosphere and ocean and the question of an increase of atmospheric CO<sub>2</sub> during the past decades. *Tellus* 1957; **12**: 18–27.
- 70 Keeling CD. Is carbon dioxide from fossil fuel changing man's environment? *P Am Philos Soc* 1970; **114**: 10–17.
- 71 Intergovernmental Panel on Climate Change. Climate change 2007: the physical science basis. Contribution of working group I to the fourth assessment report of the Intergovernmental Panel on Climate Change. Solomon S, Qin D, Manning M, et al, eds, Cambridge: Cambridge University Press, 2007.
- 72 Keeling C. The concentration and isotopic abundances of carbon dioxide in the atmosphere. *Tellus* 1960; **12**: 200–03.
- 73 Royal Society. People and the planet. The Royal Society Science Policy Centre; 2012. <http://royalsociety.org/policy/projects/people-planet/report/> (accessed Jan 16, 2013).
- 74 Corfee-Morlot J, Maslin MA, Burgess J. Global warming in the public sphere. *P T R Soc A* 2007; **365**: 2741–16.
- 75 Smith K. We are seven billion. *Nature Clim Change* 2011; **1**: 331–35.
- 76 Shi A. The impact of population pressure on global carbon dioxide emissions, 1975–1996: Evidence from pooled cross-country data. *Ecol Econ* 2003; **44**: 24.
- 77 Stephenson J, Newman K, Mayhew S. Population dynamics and climate change: what are the links? *J Public Health* 2010; **32**: 150–56.
- 78 Nakicenovic N, Alcamo J, Davis G, et al. Special report on emissions scenarios: a special report of working group III of the intergovernmental panel on climate change. New York: Cambridge University Place, 2000.
- 79 van Vuuren DP. The representative concentration pathways: an overview. *Climatic Change* 2011; **109**: 5.
- 80 O'Neill BC, Dalton M, Fuchs R, Jiang L, Pachauri S, Zigova K. Global demographic trends and future carbon emissions. *Proc Natl Acad Sci USA* 2010; **107**: 17521–26.
- 81 O'Neill BC, Liddle B, Jiang L, et al. Demographic change and carbon dioxide emissions. *Lancet* 2012; **380**: 157–64.
- 82 Dyson T. On development, demography and climate change: the end of the world as we know it? *Popul Environ* 2005; **27**: 117–49.
- 83 Pacala S, Socolow R. Stabilization wedges: solving the climate change problem for the next 50 years with current technologies. *Science* 2004; **305**: 968–72.
- 84 The Royal Commission on Environmental Pollution. Twenty-ninth report: Demographic change and the environment. February, 2011 UK: HM Stationery Office; 2011. <http://www.official-documents.gov.uk/document/cm80/8001/8001.asp> (accessed Jan 16, 2013).
- 85 Costello A, Abbas M, Allen A, et al. *Lancet* and UCL institute for global health commission: managing the health effects of climate change. *Lancet* 2009; **373**: 1693–733.
- 86 Haines A, McMichael AJ, Smith KR, et al. Public health benefits of strategies to reduce greenhouse-gas emissions: overview and implications for policy makers. *Lancet* 2009; **374**: 2104–14.
- 87 McMichael AJ, Neira M, Bertollini R, Campbell-Lendrum D, Hales S. Climate change: a time of need and opportunity for the health sector. *Lancet* 2009; **11**: 2123–25.
- 88 McMichael AJ, Butler CD. Promoting global population health while constraining the environmental footprint. *Annu Rev Public Health* 2011; **32**: 179–97.
- 89 Maslin MA. Cascading uncertainty in climate change models and its implications for policy. *Geogr J* 2013; published online Feb 27, 2013. DOI:10.1111/j.1475-4959.2012.00494.x.
- 90 Rydin Y, Bleahu A, Davies M, et al. Shaping cities for health: complexity and the planning of urban environments in the 21st century. *Lancet* 2012; **379**: 2079–108.