Comments Welcome

Socially Embedded Preferences, Environmental Externalities, and Reproductive Rights

by

Aisha Dasgupta* and Partha Dasgupta**

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* London School of Hygiene and Tropical Medicine
e-mail: <aisha.dasgupta@lshtm.ac.uk>

** Faculty of Economics, University of Cambridge; and New College of the Humanities, London
e-mail: <partha.dasgupta@econ.cam.ac.uk>

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Contents

Abstract

Externalities are the unaccounted for consequences for others of actions taken by one or more persons. They are symptoms of institutional failure, which is why they cannot be eliminated without collective action. When externalities are adverse, the moral directives flowing from them can clash with the exercise of personal rights. In this paper we identify a class of environmental externalities in the contemporary world that accompany procreation. We also identify externalities that are allied to socially embedded preferences for family size. Those preferences can give rise to a heightened demand for children, which exacerbates the adverse environmental externalities we impose on future generations. Family planning offers a tool that is complementary to environmental policies. Our analysis indicates that there may be a need for family planning even when the unmet need for it falls to zero. We draw attention to crude but suggestive estimates of the magnitude of adverse environmental externalities accompanying new births. Our analysis is designed only to raise questions that have been neglected, we do not explore policy implications. Much remains unsettled.

Motivation

Among economists and demographers, the dominant view of the impact of growing human numbers on the natural environment has alternated between concern and dismissal. If in the years immediately following the Second World War scholars worried that population growth would retard economic development in poor countries, they have not worried in recent decades. In a series of influential reviews of the modern growth experience, Birdsall (1988), Kelley (1988), Temple (1999), and Helpman (2004) studied cross country data and saw a negligible link - possibly even a slight positive relationship - between population growth and growth in per capita GDP. Their analysis may have looked convincing, but the assumption that economic betterment is best seen in terms of growth in GDP per capita should have been questioned. The presence of the qualifier "gross" in gross domestic product (GDP) signals that the measure does not record the depreciation of natural capital that can accompany the production of goods and services.[1] What economists and demographers have interpreted as economic success may thus have been a down payment for future failure. Other things equal, degradation of the natural environment reduces a nation's wealth; and normative economics tells us that the index we should deploy for assessing the sustainability of human development is the wealth of nations, not the GDP of nations nor the Human Development Index of nations.[2]

Ehrlich and Holdren (1971) in their classic paper coined the metaphor $I=PAT$ so as to trace humanity's *i*mpact on the Earth system to *p*opulation size, *a*ffluence (income per capita), and *t*echnology-in-use. The authors drew attention to the fact that Nature responds to the demands we make of it, not to rates of changes in those demands, let alone to rates of changes in the rates of changes in those demands. The authors' observations on the population-consumption-environment nexus have not had much influence on either economics or demography. That the growth rate of global population has been declining in recent years is frequently noted in the demographic literature (Lutz et al., 2014; World Bank, 2016), but it says little about the prospects for reaching sustainable development. What will matter ultimately is the demand humanity makes of the natural environment when population has stabilized. A long run population of 10-11 billion can be expected to make a far greater demand on the Earth system than one of 3 billion.

Some environmental stresses are global, many are spatially localized; some occur slowly and may therefore miss detection until it is too late, while others are all too noticeable and a cause of persistent societal stresses. The wide divergence in the character of environmental stresses may explain why there is tension among the senses of urgency people express about carbon emissions

[1] The term "natural capital" is now in routine use among ecologists and economists to remind us that Nature is a capital asset with both intrinsic and use value. In what follows we use the terms "Nature", "natural capital", and "the natural environment" synonymously.

[2] The latter index was proposed by UNDP (1990) and has been revised and updated by the organization ever since.

and acid rains that sweep across regions, nations, and continents; about degradation of the oceans arising from the energy and materials we release into them; about the hardship communities face when grasslands transform into shrub-lands; and about declines in firewood, bio-diversity, water sources, and soil productivity that are specific to the needs and concerns of the poor in small, village communities.

In recent years environmental scientists have compiled data on the state of the global environment and their deterioration in past decades.[3] Corresponding data at local levels are scattered and range from the detailed to nothing. But global happenings are an aggregate of large numbers of local happenings. In this paper we develop an analytical framework for studying the population-consumption-environment nexus at the local level. We do that by focusing on reproductive behaviour at the household level and draw attention to unintended consequences of procreation for others that work through the natural environment. Those consequences serve as a backdrop to a discussion on the place of reproductive rights in family planning programmes. Our focus is on poor regions. A parallel study could be made of the impact on the natural environment of rising consumption in today's rich regions, but excepting for a few remarks toward the end, we do not pursue that here.

1 Externalities

Processes driving the population-consumption-environment nexus harbour externalities, which are the unaccounted for consequences for others of actions taken by one or more persons. The qualifier "unaccounted for" means that the consequences in question follow without prior engagement with those who are affected. The environmental externalities accompanying procreation we study here will be found to be of an adverse kind. As they are symptoms of institutional failure, externalities cannot be eliminated without collective action. That is why reasoned reproductive decisions at the individual level can nevertheless result in collective failure.

It could be thought that the way we have formulated the notion of externalities is ineffective, on grounds that our actions inevitably have consequences for future generations who, by the nature of things, cannot engage with us. But that would be to ignore that future people engage with us constantly, albeit indirectly. Parents care about their children and know that they in turn will care about their children. By recursion, rational parents take the well-being of their descendants into account when choosing the rates at which they save for them and invest in them. Intergenerational engagement is imperfect when parents choose without adequate concern for their children (e.g. when they discount the future well-being of their children at overly high rates). Externalities across the generations are rampant in that case. But because there are systematic reasons why choices made even by thoughtful parents do not reflect adequate engagement with *others*' descendants, externalities inevitably extend to future people. One of our purposes here is

[3] MEA (2005a-d) is the standard reference.

to study why.

The institutional failures that underlie externalities are symptoms of the absence of appropriate property rights to goods and services. Unfortunately, property rights to the natural environment are difficult to define and enforce. By property rights we mean not only private rights, but communitarian and public rights too. One reason those rights are difficult to define, let alone enforce, is that Nature is constantly on the move. The wind blows, particulates diffuse, rivers flow, fish swim, birds and insects fly, and even earth worms are known to travel undetected. You cannot contain the atmosphere you befoul. That means you pass on some of the damage caused by a deteriorating environment to others without their consent.

An absence of adequate property rights means that those who suffer from environmental damages are not compensated. That in turn means that the cost incurred by a person for enjoying environmental services (that's the private cost) is less that the cost borne by all (that's the social cost). In cases involving the global environment, such as the atmosphere as a sink for our carbon emissions, the damage an individual suffers from her own emissions is negligible even though the damage to all from the climate change that arises from everyone's emissions is large and positive. From the collective point of view there is excessive use of the atmosphere as a carbon sink. Environmental externalities in this case are adverse.[4]

2 Plan of the Paper

When they are adverse, the moral directives that externalities point to can be at odds with the exercise of personal rights to protected spheres of actions. In this paper we study the clash of those opposing rights by focusing on procreation. In Section 3 we review the legal philosopher Charles Fried's proposed distinction between positive and negative rights. That acts as a backdrop for Section 4, where it is recalled that prominent social scientists have in effect insisted there are no environmental externalities arising from procreation.

In Section 5 we explore the interplay of parental motivations and socio-ecological constraints that help to explain differences in reproductive behaviour across regions and across socio-economic groups within regions. Section 6 looks briefly at what has been called "African exceptionalism" and identifies a class of inter-household externalities that may have contributed to its high fertility rates. In Section 7 reproductive conformism is identified as being a source of inter-household externalities, sustaining high fertility rates. And in Section 8 we identify a particular pattern of adverse environmental externalities at the local level arising from new births. Taken together they create a tension between reproductive rights and the adverse, unaccounted for consequences for others the exercise of those rights give rise to in the contemporary world.

Estimates of environmental externalities arising from reproduction are sparse, perhaps because they have been judged by economists and demographers to be insignificant (Section 4).

[4] The classification of externalities presented here is built on Dasgupta (1993, 2000) and Dasgupta and Ehrlich (2013).

So in Section 9 we rehearse global statistics on the state of natural capital. The statistics are not sufficient to provide economists with the tools they need to estimate the environmental benefits of family planning programmes, but we work with them to show that the missing items are almost certainly significant. In Section 10 we offer a contemporary example to bring into sharp relief the dilemma the clash of rights between present and future people poses for the design and evaluation of family planning programmes. By "rights of future people" we mean just that. We are appealing to a widely shared view, that no matter who and how many our descendants happen to be, they will have a justifiable claim to a reasonably abundant resource base. Future people's personal identities don't matter in this context.

Although the externalities we classify here arise in all contemporary societies, a salient contrast obtains between rich (high consuming) societies with low desired family-size, and poor (low consuming) societies with high desired family-size. Environmental externalities caused by new births in rich countries are included in our analysis (they are due to the high consumption enjoyed by new births over their lifetime), but because our purpose here is to show that benefits of family planning programmes have been under-estimated, we focus on those poor regions where fertility rates are high. We use sub-Saharan Africa as our template (Section 6) because the desired family size there is strikingly high by contemporary standards elsewhere.

3 Rights

The legal philosopher Charles Fried distinguished "positive" from "negative" rights (Fried, 1978). We are to think of positive rights as a claim *to* something, a share of material goods or some particular commodity such as education when young and medical attention when in need. A negative right is a right that something *not* be done to one, that some particular imposition be withheld. Fried observed that positive rights are asserted to scarce goods and that scarcity implies a limit to their claim. He also suggested that negative rights, for example the right not to be interfered with in forbidden ways, do not appear to have such natural limitations. ("If I am let alone, the commodity I obtain does not appear of its nature to be a scarce or limited one. How can we run out of people not harming each other, not lying to each other, leaving each other alone?" (Fried, 1978: 110).)[5]

Fried's dichotomy is useful as a starting point for studying the place of rights in the design of family planning and reproductive health policies. But his suggestion that the exercise of negative rights doesn't involve costs is questionable. The claim that one's proximity should not be contaminated by cigarette smoke would seem to be a negative right, which is violated when someone smokes in that proximity. To protect that right governments in many countries prohibit people from choosing at will where they smoke. That's a cost to smokers. In contrast, a right to exercise one's agency would appear to be a positive right, but it doesn't inevitably demand

[5] Fried's binary classification of rights corresponds to Isaiah Berlin's classification of freedom into positive and negative categories (Berlin, 1959).

resources from others (e.g. freedom of speech). It isn't so much that negative rights don't suffer from resource limitations and that positive rights do, it is more that the two sets of rights have separate frames of reference. The contrasting phrases, "right to self-determination" and "right to have an imposition withheld", point in different directions.

The 1994 International Conference on Population and Development re-affirmed the language of rights in the sphere of family planning and reproductive health. The widely noted publication that reported the Conference's conclusions was uncompromisingly clear:

"Reproductive rights ... rest on the recognition of the basic right of all couples and individuals to decide freely and responsibly the number, spacing, and timing of their children, and to have information and means to do so, and the right to attain the highest standards of sexual and reproductive health." (UNFPA, 1995: Ch. 7, Sect.3).

The fundamental right of individuals to decide freely and for themselves, whether, when, and how many children to have is central also to the vision and goals of *Family Planning 2020* (FP2020), and is pivotal in the reproductive health indicators of the United Nations' Sustainable Development Goals.[6]

Both positive and negative rights are in play here. Rights to information and other services pertaining to family planning and reproductive health are positive rights. The right to choose one's family size on the other hand would appear to be a negative right.

Even though Fried's classification is not without problems, it is useful for studying the relationship between "externalities" and "rights". First, to insist that the rights of individuals and couples to decide freely the number of children they produce trump all competing interests is to play down the rights of all those (most especially, perhaps, future people) who suffer from the environmental externalities that accompany additions to the population. Second, UNFPA's statement ignores the latent need among those who do not want family planning now but would want it if others among their peer group were using contraception.[7]

4 Reproductive Rights and Environmental Externalities

That reproductive decisions may involve a clash of rights isn't self-evident. In a powerful essay that dismissed concerns on over-population, Bauer (1981: 61-64) wrote: "The comparatively

[6] Kumar and Hardee (2015) offer a useful manual for family planning programmes based on the protection and promotion of reproductive rights. Rights had been deployed as an ethical category in discussions on family planning and reproductive health previous to the 1994 International Conference on Population and Development. Hardee et al. (2014) provide an excellent account of the history. The authors also provide a framework for achieving the goals of FP2020. Cottingham et al. (2012) offer an account of the power of the language of rights in encouraging governments and international agencies to provide the resources needed to meet women's "unmet need" for family planning and reproductive health facilities.

[7] Brock (2010) contains an interesting discussion of possible clashes between parental rights and societal interests and how societies variously resolve them. But he was not concerned with the clash that is embodied in environmental externalities.

high fertility and large families in many ldcs (less developed countries) should not be regarded as irrational, abnormal, incomprehensible or unexpected. They accord with the tradition of most cultures and with the precepts of religious and political leaders... Allegations or apprehensions of adverse or even disastrous results of population growth are unfounded. They rest on seriously defective analysis of the determinants of economic performance; they misconceive the conduct of the peoples of ldcs; and they employ criteria of welfare so inappropriate that they register as deterioration changes which are in fact improvements in the conditions of people."

The problem with the critique is that even when men and women at the household level rationally prefer large numbers of children to small numbers, it doesn't follow there isn't a resource allocation failure they themselves would acknowledge if only they were asked. As in every other field of personal choice we should enquire whether a collection of reasoned decisions at the individual level may harbour collective failure. This is the central question raised by externalities, and it has particular potency in the case of adverse externalities.

The clash between reproductive rights and the rights that are violated owing to the adverse environmental externalities that come allied to procreation suggests that the language of rights suffers from difficulties when applied to family planning. That family planning services bring in their wake many benefits (health, education, income, women's empowerment) to those who make use of them has been documented repeatedly in recent years.[8] Our focus on externalities points to the fact that they bring benefits to others as well. Those additional benefits should be included in the design of social policies. We will find that indicators currently in use by governments and NGOs of the value of family planning services underestimate it.

Policies for curbing adverse reproductive externalities can in principle take several forms. Education, especially female education, is one route, some argue that it is the most effective route (Lutz, 2014; Lutz et al., 2014). But female education is not the only factor driving fertility.[9] Another tool involves demonstrative persuasion, which can be attempted through community discussions on the need for behavioural change. The agency of persuasion could be the community, NGOs, or the state.[10] A further tool is taxation, which permits people to choose as they wish, but at a price. Although taxation as a device for curbing environmental externalities is familiar in wealthy countries, it is not an available tool for reducing the demand for children in

[8] See, for example, Koenig et al. (1992), Debpuur et al. (2002), Cleland et al. (2006, 2012), Tsui et al. (2010), Canning and Schultz (2012), Sonfield et al. (2013), Fabic et al. (2015), Bongaarts (2016), and Miller and Babiarz (2016).

[9] World Bank (2012) reported that in 2010 the proportion of people who would completed primary education was, in India 96%, in Pakistan 67%, and in Bangladesh, 65%. Total fertility rates (TFRs) in those countries were 2.6, 3.4, and 2.2, respectively. It should also be noted that in Bangladesh non-governmental organizations at work on social matters have a far more extensive reach than in India and Pakistan. Reproductive behaviour is not mono-causal.

[10] Nudge theory advocates a weak version of that idea. See Thaler and Sunstein (2008).

poor countries, where the poorest households are most often the ones that have the highest demand. A further policy tool is quota, such as China's previous directive of one-child family, or the government's recently revised two-children-per-couple directive. The classification of externalities we uncover here suggests a variety of policy tools that could be deployed by governments and international agencies for reducing the demand for children. The policy tools differ in terms of the extent to which the right to self-determination is compromised. None are likely to prove uncontroversial. The issues remain unsettled.[11]

5 The Demand for Children

Children are both ends in themselves and means to meeting needs and desires. The mix of motivations depends variously on the customs and institutions we inherit, and on our character and circumstances. That children are ends in themselves is emotionally so compelling that it may seem too obvious to require acknowledgement, but social anthropologists have shown that children are ends not only in the innate desire we have to bear and rear them, but also in the dictates of tradition and religion. One such injunction emanates from the cult of the ancestor, which, taking religion to be the act of reproducing the lineage, requires women to bear many children.[12] This latter motivation was used by Caldwell and Caldwell (1990) to explain why sub-Saharan Africa has for the most part proved so resistant to fertility decline.

A weakness of the argument is that, although it explains why fertility rates in sub-Saharan Africa are high (the total fertility rate (TFR) remains above 5 today, as contrasted with a global TFR of 2.5), it does not explain why the rates have not responded as much to declines in infant mortality than one could have thought on the basis of evidence elsewhere.[13] Even in sub-Saharan

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[11] Quotas are an extreme form of non-linear taxation: zero tax up to the quota, followed by a severe tax beyond it. (The "tax" need not be financial, it could be strong collective disapproval.) An alternative to taxing people if they exceed their quota is to reward people if they stay within their quota. We are thinking of "quota" here in the same way as quotas that are imposed as food rations in periods of extreme shortage; compulsory vaccination against communicable diseases; and prohibition on smoking in public spaces. The former policy ensures equality in the distribution of a positive right; the latter pair protect and promote negative rights. Forced sterilization is a distorted and repugnant application of quotas.

Sen (1982) likens the emission of persistent pollutants to torturing future people. The clash between reproductive rights and adverse environmental externalities allied to new births is at its most striking under his reading.

[12] Writing about West Africa, Fortes (1978: 125-6) said "... a person does not feel he has fulfilled his destiny until he or she not only becomes a parent but has grandchildren... (Parenthood) is also a fulfilment of fundamental kinship, religious and political obligations, and represents a commitment by parents to transmit the cultural heritage of the community ... Ancestry, as juridically rather than biologically defined, is the primary criterion ... for the allocation of economic, political, and religious status."

[13] Between 1965 and 2015 the infant mortality rate in sub-Saharan Africa declined from about 150 per 1,000 live births to something like 60 per 1,000 live births.

Africa, total fertility rates have been below the maximum possible rate. So they should be expected to respond to declines in infant mortality, a matter we come back to in Section 8, where we offer one possible explanation for why sub-Saharan Africa has proved to be resistant to fertility reduction.

In places where formal institutions are underdeveloped, children also substitute for other assets, which is why children as a means to parental ends is most apparent in the poorest regions of the world. Children serve as security in old-age in places that have neither pension schemes nor adequate land markets. They are also a source of labour in households possessing few labour saving devices. Children mind their siblings, tend to domestic animals, pick berries and herbs, collect firewood, draw water, and help with cooking. The need for additional hands is especially strong among rural communities in dry and semi-arid regions of the world. Children in poor countries are valued by their parents also as capital and producer goods.[14]

Caldwell (1981, 1982) put forward the hypothesis that the inter-generational transfer of resources is from children to parents in poor societies, but from parents to children in rich societies. The suggestion has been easier to confirm in rich countries, where the rate of investment in children's education has been found to be as high as 6-7 per cent of GDP (Haveman and Wolfe, 1995). Confirming the reverse flow in poor countries has been a lot harder, in part because data are sparse but in part also because even within poor regions there are significant differences in attitudes toward reproduction. Those differences are traceable to kinship structures, marriage practices, and rules of inheritance. The implied line of thinking says that over the long run it is differences in institutions and social norms - originating perhaps in some measure in geography - that are the reasons behind differences in reproductive behaviour among groups. This form of analysis says that high child mortality rates spur fertility because of parental need to increase the probability of not being childless in old age. Theoretical models have been built on the premise that institutional failure, broadly defined, is the deep cause of pro-natalism. Causality isn't traced to differences in income or wealth. It is not that fertility and mortality rates are high and health status and education attainments are low in poor regions *because* people there are poor, it's that very low incomes go hand in hand with those features of life. The variables are mutually determined over time.[15]

UNFPA (1995) took it that family planning and reproductive health policies should address "unmet need", meaning that they should be made to serve women aged 15-49 who are seeking to stop or delay child-bearing but are not using modern contraception (Casterline and

[14] In South Asia children have been observed to be at work from as early an age as six.

[15] For theoretical models that speak to the mutual determination, see Dasgupta (1993, 2000), Brander and Taylor (1998), Harford (1998), Dasgupta and Ehrlich (2013), and Bohn and Stuart (2015). The mutual determination doesn't entail a demographic trap, but it may. See in particular Dasgupta (2000: Appendix).

Sinding, 2000; Bradley et al., 2012; Alkema et al., 2013). Fabic et al. (2011) defined "total demand" for family planning to be the number of women who want to delay or limit child-bearing (i.e. the sum of contraceptive users and women with unmet need). The role of family planning, the authors argued, is to supply that demand. The success of family planning can then be measured by the ratio of family planning users to the total demand. The United Nations have adopted this measure in their Sustainable Development Goals. Reproductive rights serve as the basis of their recommendation in each of the publications.

The concept of reproductive rights, when used to delineate the boundaries of family planning and reproductive health services, undervalues family planning. In Sections 6-8 we show that there may be a need for family planning even when unmet need falls to zero, or when "wanted fertility" accords with total fertility; in other words when "desired family size" on average equals actual family size.[16] Family planning is a necessary means to reducing the adverse environmental externalities that arise from procreation. Moreover, fertility desires are influenced by the fertility desires and reproductive behaviour of others. There can be collective benefits if members of a community are enabled to alter their fertility desires in a coordinated manner. Family planning can help to bring about changes in such social norms as well. Our analysis doesn't run against the language of rights when it is used as a plank for family planning; it expands the sphere in which rights are acknowledged and promoted.[17]

6 Cost Sharing and African Exceptionalism

A potential source of reproductive externality is the wedge between the private and social costs of child rearing. The costs borne by parents are lower when child rearing is shared among the kinship than when households are nuclear. In sub-Saharan Africa fosterage within the kinship is a commonplace. Children are not raised solely by their parents, the responsibility is more diffuse within the kinship group (Caldwell, 1991; Bledsoe, 1990, 1994). Fosterage in the African context is not adoption. It is not intended to, nor does it in fact, break ties between parents and

[16] Desired family size is estimated from answers to the following question:

"If you could go back to the time when you did not have any children and could choose exactly the number of children to have in your whole life, how many would that be?"

The "wanted total fertility rate", or WTFR, is calculated by first dividing the number of observed births into those that occurred before and after the desired family size is reached (the former are considered as wanted, the latter unwanted). WTFR is obtained with the same procedure as the one used in calculating TFR (that is, from age-specific fertility rates), but only wanted births are included in the numerator of these rates.

There are dangers of biases in responses to the question at the basis of desired family size, but the motivation behind the question is clear enough.

[17] Moral philosophers would argue that the evaluation of family planning programmes should include the quality of lives that will not be lived on account of the programmes. We avoid those further considerations by assuming that thoughtful parents reach their fertility desires by taking into account the potential well-being of their off-spring and, by recursion, the well-being of their dynasty.

children. The institution affords a form of mutual insurance protection in semi-arid regions. It may also be that, as savings opportunities are few in the low-productivity agricultural regions of sub-Saharan Africa, fosterage enables households to smooth their consumption across time. In parts of West Africa up to half the children have been found to be living with their kin at any given time. Nephews and nieces have the same rights of accommodation and support as do biological offspring. There is a sense in which children are seen as a common responsibility. However, the arrangement creates a free-rider problem if the parents' share of the benefits from having children exceeds their share of the costs. The corresponding externalities are confined to the kinship. Other things equal, reduction in those externalities would be accompanied by a fall in the demand for children and all households would benefit.[18]

Related to this is a phenomenon that has been observed by Guyer (1994) in a Yaruba area of Nigeria. In the face of deteriorating economic circumstances, some women bear children by different men so as to create immediate lateral links with them. Polyandrous motherhood enables women to have access to more than one resource network. Desired fertility is consequently higher.

In sub-Saharan Africa, communal land tenure of the lineage social structure offers yet another inducement for men to procreate. This is because a greater amount of land can be claimed by a larger family. In addition, conjugal bonds are frequently weak, so fathers often do not bear the costs of siring a child. Men's "demand for children" is thus high. Anthropologists have observed that the unit of African society is a woman and her children, rather than parents and their children. Frequently, there is no common budget for the man and woman. Descent in sub-Saharan Africa is, for the most part, patrilineal and residence is patrilocal (exceptions are the Akan of Ghana and the Chewa of Malawi). That depresses women's voice; and because women bear a disproportionate amount of the costs of reproduction, it raises the fertility rate. Patrilineality, weak conjugal bonds, communal land tenure, and a strong kinship support system of children, taken together, are a broad characteristic of the region. In principle they provide a powerful stimulus to fertility. Admittedly, patrilineality and patrilocality are features of the northern parts of the Indian sub-continent also. But conjugal bonds are substantially greater there. Moreover, as agricultural

[18] To see that there are no externalities if the shares were the same, suppose c is the cost of rearing a child and N the number of couples within a kinship. Assume that each child makes available y units of output (this is the norm) to the entire kinship, which is then shared equally among all couples, say in their old age. Suppose also that the cost of rearing each child is shared equally by all couples. Let n^* be the number of children each couple other than the one under study chooses to have. If n were to be the number of children this couple produces, it would incur the resource cost $C = [nc+(N-1)n^*c]/N$, and eventually the couple would receive an income from the next generation equalling $Y = [ny+(N-1)n^*y]/N$. Denote the couple's aggregate utility function by the form $U(Y)-K(C)$, where both $U(.)$ and $K(.)$ are increasing and strictly concave functions. Letting n be a continuous variable for simplicity, it is easy to confirm that the couple in question will choose the value of n at which $y\mathrm{d}U(Y)/\mathrm{d}Y = c\mathrm{d}K(C)/\mathrm{d}C$. The choice sustains a social equilibrium when $n = n^*$. It is easy to check that this is also the condition which is met in a society where there is no reproductive free-riding. It follows that there is free-riding if the parents' share of the benefits from having children exceeds their share of the costs.

land is not communally held, large family sizes lead to fragmentation of land-holdings. In contrast, large families in sub-Saharan Africa are (or, at least were, until recently) rewarded by a greater share of land belonging to the lineage or clan.[19]

7 Socially Embedded Preferences and Conformity

That children are an end and not just a means toward other parental goals provides a potentially powerful mechanism by which reasoned fertility decisions at the level of every household could lead to an unsatisfactory outcome from the perspectives of all households. It arises from the possibility that traditional practice is perpetuated by conformity. Reproductive decisions in closely-knit communities are not only a private matter; they are influenced by societal mores, influenced by both family experiences and the cultural milieu. Conformist behaviour would occur if the family size each household desires is positively related to the average family size in the community (Dasgupta, 1993: Ch. 12). The source of a desire to conform could lie in reasons other than an intrinsic desire to be like others. It could be that similar choices made by households generate mutual externalities because a household's choice of actions signals its willingness to belong.[20]

Whatever the basis of conformism, there would be practices encouraging high fertility rates that no household would unilaterally desire to break. Such practice could have had a rationale in the past, when mortality rates were high, rural population densities were low, natural resources were aplenty, the threat of extermination from outside attack was large, and mobility was restricted. But practices can survive even when their original purposes have disappeared. So long as all others follow the practice and aim at large family sizes, a conformist household would not on its own wish to deviate from the practice; however, if all other households were to restrict their fertility rates, every household would wish to restrict its fertility rate as well. Conformism can thus be a reason for the existence of multiple "societal equilibria". A society could get embedded in a self-sustaining mode of behaviour characterized by high fertility and low educational attainment, even when there is another potentially self-sustaining mode of behaviour that is characterized by low fertility and high educational attainment and which is preferred by all.

To illustrate, imagine each household regards 5 to be the ideal number of children if all

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[19] In an early review of fertility intentions Cochrane and Farid (1989) noted that both the urban and rural, the educated and uneducated in sub-Saharan Africa have more, and want more, children than their counterparts in other less-developed regions. Even young women there expressed a desire for an average of 2.6 more children than women in the Middle East, 2.8 more than women in North Africa, and 3.6 to 3.7 more than women in Latin America and Asia. Updated versions of these figures are available, but we are presenting data from the mid-1980s because the income gap between Africa and the rest of the developing world was smaller at that time than it is now.

African society's exceptionalism has been much written about. See in addition Goody (1976), Bledsoe and Pison (1994), Bongaaarts (2011), and Bongaarts and Casterline (2013).

[20] Fads and fashion are short-run expressions of conformity.

other households have 5 children; 4 to be the ideal number if all others have 4; and 2 to be the ideal number if all others have 2. Each is a societal equilibrium. Imagine now that each household prefers the outcome where all households have 2 children. It can nevertheless be that their society is stuck in a situation where each household has 5 children. It is stuck there because no household has a reason for deviating from 5 if all other households have 5: the choice of 5 is self-enforcing. It may be that 2 and 5 are each a stable outcome, in the sense that a small deviation from 2 (resp. 5) would in time return to a situation where each household chooses 2 (resp.5).[21]

That does not mean the society would be stuck forever. As always people differ in the extent of their absorption of traditional practice. There would inevitably be those who, for one reason or another, experiment, take risks, and refrain from joining the crowd. They are the tradition-breakers, and they often lead the way. Educated women are among the first to make the move toward smaller families.[22] A possibly even stronger pathway is the influence that newspapers, radio, television, and now the internet play in transmitting information about other life-styles (Freedman, 1995, was one of the first to detect that pathway). The idea here is that the media could be a vehicle by which conformism increasingly becomes based on the behaviour of a wider population than the local community (i.e. the "peer group" widens), which disrupts

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[21] It can be shown that if fertility rates of 2 and 5 are stable societal equilibria in the example, then the societal equilibrium in which each household has 4 children is unstable. It would take us far afield to explain why, but see Dasgupta (1993: ch. 12) for the reason.

One way to uncover multiple societal equilibria would be to construct questionnaires akin to the ones that seek to measure the desired number of children (see footnote 16), but as a series of questions, which we collapse here for convenience into one:

"If you could go back to the time when you did not have any children and could choose exactly the number of children to have in your whole life, how many would that be, assuming everyone else in your community had *N* children over their whole life?"

The survey could pose the question in an ascending order of *N*, say 0 to 10; thus 11 questions in total. The example in the text imagines that the answers to $N = 2$, 4, and 5 are, respectively, 2, 4, and 5. If the answers to the questions in which $N = 0$, 1, 3, 6-10, respectively, differed from 0, 1, 4, 6-10, those numbers would not reflect desired fertility numbers in societal equilibrium.

No doubt responses to such a questionnaire would be subject to biases, just as in questionnaires aimed at estimating desired family size, but there is probably no sure fire method of eliciting information that is relevant for evaluating family planning programmes.

Thus far, theory. Because people's preferences differ, we should expect the responses to differ, and discover that each individual's preferred number of children is an increasing function of *N*. That would reveal conformist preferences.

The notion of "ideation" (Cleland and Wilson, 1987) has a similar ring to "conformism", but has a different psychological basis.

[22] Farooq et al. (1987) is an early study that spoke to the phenomenon in West Africa. Lutz et al. (2014) is a collection of essays on the effect of education on fertility behaviour. Interactions among the elite and the general public can be a vehicle by which fertility behaviour among the poor can change.

behaviour.[23]

Demographers have made few attempts to discover evidence of behaviour that is guided in part by an "attention to others". Two early exceptions were Watkins (1990) and Hill (1992):

In her study of demographic change in Western Europe over the period 1870-1960, Watkins (1990) showed that differences in fertility and nuptiality within each country declined. She also found that in 1870, before the large-scale declines in marital fertility had begun in most areas of Western Europe, demographic behaviour differed considerably within countries. Differences among provinces within a country were high even while differences within provinces was low. Spatial behavioural clumps suggest the importance of the influence of local communities on behaviour. In 1960 differences within each country were considerably less than in 1870. Watkins explained this in terms of increases in the geographical reach national governments enjoyed over the 90 years in question. The growth of national languages could have been the medium through which reproductive behaviour was able to spread.

Hill (1992) reported a finding that also points to conformism. Starting in 1977, 70 "treatment" villages were serviced by a programme of birth control in Matlab Thana, Bangladesh, while 79 "control" villages were offered no such special service. The contraceptive prevalence in the treatment villages increased from 7 to 33 per cent within 18 months, and then more gradually to a level of 45 per cent by 1985. The prevalence also increased in the control villages, but only to 16 per cent in 1985. Fertility rates in both sets of villages declined, but at different speeds, and by 1980 the difference in fertility rates had reached a figure of 1.5, even though there had been no difference to begin with. If we were to assume that, even though influence travels, geographical proximity matters, we could explain why the control villages followed those "under treatment", but did not follow them all the way. The influence did not spread completely.[24]

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[23] The media are increasingly used to such end. For example, the Development Media International runs media campaigns aimed at changing behaviour.

Basu and Amin (2000) is a commentary on West Bengal (India), where fertility rates declined in the early 1970s, ahead of the northern states of India and neighbouring Bangladesh. The authors attribute the decline in West Bengal to historical and cultural facts there that combined to promote interaction between the elite and the general public. Montgomery and Casterline (1998) distinguished the various pathways by which reproductive practices diffuse within a society.

In contrast, we are concerned here to identify the common structure of all such diffusion processes. That common structure suggests that fertility transitions could be interpreted as disequilibrium phenomena, where current practices change slowly until a tipping point is reached from which societies transit rapidly to a new stable societal equilibrium. On this see Dasgupta (2002).

[24] Watkins' was a historical study, while Hill's was an analysis of data from a long term social programme. Jensen and Oster (2009) in contrast studied a natural experiment. They found that state level fertility rates declined in step following staggered introductions of cable TV in Indian states. For a wide ranging discussion of role of societal norms on fertility behaviour, see Bongaarts and Watkins (1996).

8 Fertility and the Local Commons

The poorest countries are in great part biomass-based subsistence economies.[25] Much labour is needed even for simple tasks. Households do not have access to the electricity, nor do they have water on tap. In semi-arid and arid regions water supply is often not close at hand, nor is fuel-wood near at hand if the local woodlands have receded. In addition to cultivating crops, caring for livestock, cooking food and producing marketable products, household members may have to spend as much as five to six hours a day fetching water and collecting fodder and wood. These are complementary activities. They have to be undertaken on a daily basis if the household is to survive. Each is time-consuming. From about the age of 6, children in poor households in the poorest countries are known to mind their siblings and domestic animals, fetch water, and collect fuel-wood, dung (in the Indian sub-continent), and fodder. Mostly, they do not go to school. Not only are educational facilities in the typical rural school woefully inadequate, but parents need their children's labour. Children between 10 and 15 years have been routinely observed to work at least as many hours as adult males.[26]

In a classic paper, Jodha (1986) studied evidence from over 80 villages in 21 dry districts in India to show that among poor families, the proportion of income based directly on their local commons is 15-25 per cent. Fuelwood and water, berries and nuts, medicinal herbs, resin and gum are the responsibility of women and children. In a study of 29 villages in south-eastern Zimbabwe, Cavendish (2002) arrived at even larger estimates: the proportion of income based directly on local commons was found to be 35 per cent, the figure for the poorest quintile being 40 per cent.

Traditionally rural assets such as village ponds and water holes, threshing grounds, grazing fields, and local forests and woodlands have been managed communally. Communal management enabled households in semi-arid regions to pool risks. To protect the local commons from over-exploitation communities relied on social norms of behaviour and fines for errant behaviour.[27] But the very process of economic development - urbanization and mobility - can erode traditional methods of control. Social norms are also endangered by civil strife and by the usurpation of resources by landowners or the State. Rules practised at the local level are also overturned by central fiat. A number of States in the Sahel imposed rules which in effect destroyed communitarian management practices in forests. Villages ceased to have authority to enforce

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[25] We are referring to countries in sub-Saharan Africa and the Indian sub-continent. There the agricultural labour force as a proportion of the total labour force is of the order of 50-70 percent, and the share of agricultural-value added in GNP is of the order of 20-30 percent.

[26] See Bledsoe (1994) and Filmer and Pritchett (2002).

[27] The literature is huge. See for example Cordell and Mckean (1986), McCay and Acheson (1987); Wade (1988), Chopra et al. (1990), Feeny et al. (1990), Ostrom (1990), McKean (1992), Baland and Platteau (1995), Colchester (1995), and Noronha (1997).

sanctions on those who violated locally-instituted rules of use. State authority turned the local commons into free-access resources. As social norms degrade, parents pass some of the costs of children on to the community by over-exploiting the commons. That is an adverse environmental externality.[28] In principle it can even be that increasing scarcity of environmental resources adds to the need for more hands in the household. If that were to happen, the adverse externalities would be magnified.

9 Quantifying Environmental Degradation

In the absence of national estimates of the environmental benefits of family planning, we move in the opposite direction by studying humanity's demand for ecological services at the global level. To do that it proves useful to regard the biosphere as a single renewable natural resource. The stance involves a heroic aggregation exercise, in which billions of assets are aggregated into a single measure. If that seems an absurd undertaking, we should recall that global fisheries and forest biomes are routinely measured in units of biomass, which also involves giant aggregation exercises. No doubt problems of aggregation are magnified when we study the biosphere as a whole, but they aren't magnified that much in complexity.

One reason the biosphere is hard to aggregate is that the biogeochemical processes shaping natural capital differ widely in both speed and spatial reach. As most global environmental resources have no prices attached to them (recall the absence of property rights to many forms of natural capital; Section 1), indirect methods have to be relied upon if we are to obtain notional prices for them. All that said, there is no escaping the need for imagining the biosphere as a gigantic piece of natural capital if we are to discuss the population-consumption-environment nexus at the global level. We denote the aggregate stock of the biosphere by K, a real number.

A concrete way to imagine the biosphere is to focus on its biomass. In that case K, measured in units of biomass, is the state variable of the biosphere. The composition of biomass (grasslands differ from agricultural fields) is reflected in the aggregate measure K. Let $K(t)$ be the biomass at time t, and let $F(K(t))$ be the net output of biomass over a brief interval of time (say, a year), starting at t. $F(K)$ is a flow, or flux (so many units of biomass per year), whereas K is a stock (so many units of biomass, period). Ecologists call F, "net primary production". When the occasion demands, we will without loss of generality refer to F as "ecosystem services".

To imagine the biosphere as a renewable natural resource requires facing a further problem. Even two thousand years ago, when global population was under 250 million and per capita income a bit over a dollar a day, it would have been a reasonable approximation to treat humanity as a separate entity from the biosphere. Today it is no longer possible to do that. We are much engaged in transforming the biosphere, by both creating biomass and destroying it. So we

[28] For narratives of the various processes by which communitarian management systems have eroded in practice, see the case studies in Thomson et al. (1986), Baland and Platteau (1996), and Ghate et al. (2008).

have to imagine humanity as being at the same time a constituent of the biosphere and an entity that is separate from it. No doubt that's a stretch, but it is possible to do it without running into contradictions. We avoid contradiction by noting that a portion of $F(K)$, say α, is needed for the maintenance of the biosphere. So, if over a period of time $F(K)$ was to be usurped entirely by humanity, K would shrink and biodiversity would be reduced. If during an interval of time humanity was to consume even more than $F(K)$, K would shrink even more, further drawing down biodiversity. Humanity is doing that now, which is what has led Wilson (2016) to propose that we should leave half the biosphere alone. $(1-\alpha)F(K)$ should therefore be interpreted as the *useable* flow of biomass; useable, that is, by humanity.[29]

It could be thought that $F(K)$ must be an increasing function of K for all values of K; but that would be to overlook that Earth is finite in extent. F should therefore be taken to be an increasing function of K for small values of K, but a declining function of K for large values of K. Earth's "carrying capacity" for the prevailing life-forms - a formidable notion in itself, but one that cannot be avoided - is that positive value of K at which $F(K)$ is zero.[30]

9.1 Ecosystem Losses in the Anthropocene

Humanity's success in raising the standard of living over the past 250 years has involved creating and then utilizing ideas and accumulating reproducible (or manufactured) capital and human capital, while mining and degrading K. The socio-economic processes that drive the production, dissemination, and use of ideas and the accumulation of reproducible and human capital are at the heart of modern growth and development economics, but the decumulation of natural capital has remained unrecognized (e.g. Helpman, 2004). The decumulation is also

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[29] α is not a constant and is most likely a decreasing function of K.

[30] A tractable form of $F(K)$, in wide use among ecologists for a wide variety of ecosystems, is quadratic:

$F(K) = rK(1 - K/K^*)$, where r and K^* are positive constants.

In this equation r is the "intrinsic growth rate" of K (because r at small values of K is the percentage rate of growth of K) and K^* is the system's carrying capacity (because $F(K^*) = 0$).

The view that the biosphere is a renewable natural resource covers pollution as well (e.g. contemporary carbon emissions into the atmosphere). Pollutants are the reverse of natural resources. One way to conceptualize pollution is to view it as the depreciation of capital assets. Acid rains damage forests; carbon emissions into the atmosphere trap heat; industrial seepage and discharge reduce water quality in streams and underground reservoirs; sulfur emissions corrode structures and harm human health; and so on. The damage inflicted on each type of asset (buildings, forests, the atmosphere, fisheries, human health) should be interpreted as depreciation. For natural resources depreciation amounts to the difference between the aggregate rate at which it is harvested and its natural regenerative rate; for pollutants the depreciation they inflict on natural resources is the difference between the rate at which pollutants are discharged into the resource-base and the rate at which the resource-base is able to neutralize it. The task in either case is to estimate those depreciations. It follows that there is no reason to distinguish the analytical structure of resource management problems from pollution management problems. Roughly speaking, "resources" are "goods", while "pollutants" (the degrader of resources) are "bads". Pollution is the reverse of conservation.

unrecorded in official economic statistics.

The bias is not a reflection of an indifference to the natural world, it is more a disconnect between the social and environmental sciences. It is widely known for example that even while industrial output increased by a multiple of 40 during the 20th century, the use of energy increased by a multiple of 16 (contributing to climate change and degrading the oceans), methane-producing cattle population grew in pace with human population (contributing to climate change and degrading the oceans), and fish catch increased by a multiple of 35 (reducing stocks in the open seas).[31] Environmental scientists have found that the application of nitrogen to the terrestrial environment from the use of fertilizers, fossil fuels, and leguminous crops is now at least as great as that from all natural sources combined. They have also found that soil nitrogen and phosphorus inventories have doubled over the past century (nitrate levels in Greenland ice are today higher than at any time in the previous 100,000 years), and that 40-45 per cent of the 45-60 billion metric tons of carbon harnessed annually by terrestrial photosynthesis is now appropriated for human use (Vitousek et al., 1986, 1997). Extinction rates of species since the early modern era have been far above background rates and have increased a lot further since the 19th century (RSPB et al., 2013). These all point to rates of biomass transformation in excess of the useable flux, $(1-\alpha)F$. Consequently, they point to reductions in K.

The Millennium Ecosystem Assessment (MEA, 2005a-d) reported that 15 of the 24 ecosystems the authors had investigated world-wide are either degraded or are being exploited at unsustainable rates. Population pressure on land and the habitat destruction that accompanies human encroachment are the proximate causes. The figures put the scale of humanity's presence on the planet in perspective and record that we are now Earth's dominant species (Ehrlich and Ehrlich, 2008). The statistics also explain why our epoch has now been named the Anthropocene.[32]

9.2 Ecological Footprint

Studying biogeochemical signatures of the past 11,000 years, Waters, Zalasiewicz, Summerhayes et al. (2016) have provided a revealing sketch of the Anthropocene. The authors noted that a sharp increase took place in the middle of the 20th century in the rate of deterioration in the workings of Earth's life support system. They proposed that mid-20th Century should be regarded as the time we entered the Anthropocene.

Their reading is consistent with macroeconomic statistics. World population in 1950 was 2.5 billion. Global GDP was a bit over 5 trillion dollars (PPP). The average person in the world was poor, with an annual income of a bit over 2,000 dollars (PPP). Since then the world has

[31] Carbon and sulphur dioxide emissions rose by a factor of more than 10.

[32] The term "Anthropocene" was popularized by Crutzen and Stoermer (2000) to mark a new epoch that began with the Industrial Revolution some 250 years ago.

prospered materially beyond recognition. World income per capita today in rounded figures is about 14,500 dollars (PPP) and population has increased to 7.3 billion. World output of final goods and services is about 108 trillion dollars (PPP), which helps to explain not only the stresses to the Earth system that we have just reviewed, but also hints at the possibility (one that we confirm below using crude data) that humanity's extraction of biomass has for some time exceeded sustainable levels ($(1-\alpha)F$). So, in addition to the direct benefits of family planning programmes, which are currently assessed on the basis of the extent to which reproductive rights are met, we should estimate the decline in reductions in K owing to a prevented birth and placing a value on that reduction. If the reduction is estimated to be ΔK per prevented birth and the social value of a unit of natural capital is P, then the environmental benefits from a family planning programme would be the product of $P\Delta K$ and the number of births the programme is expected to prevent.[33]

In the field of family planning nothing is simple. Addressing one problem simply leads to several more. If P remains largely un-estimated, determining ΔK from a prevented birth poses problems for the demographer. Some family planning on the part of women involves delaying births, not limiting numbers. Better spacing is a good in itself, but if numbers aren't affected, the environmental consequences would be slight (ΔK would be negligible).

In a review of the state of the Earth's life support system, WWF (2008) reported that in the early years of this century humanity's demand for ecological services exceeded by 50 per cent the rate at which the biosphere is able to supply those services to us. The figure is based on the idea of "global ecological footprint", which is the surface area of biologically productive land and sea needed to supply the resources a human population consumes (food, fibres, wood, water) and to

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[33] The literature on valuing specific types of natural capital is now huge (see for example, Freeman, 2003; Haque et al., 2011). There are now a number of studies in which the value of specific types of natural capital at the local level have been estimated (water, air quality, woodlands, mangroves, coral reefs), but economic demographers estimating the value of family planning programmes at the local level have not made use of them.

In recent years costing the consequences of carbon emissions for the global climate has been a major research topic. The basic idea is to estimate the net present value of the impact over the next 100 years (or more) on, for example, agriculture from changes to the global climate that are traceable to carbon emissions. The net present value has been found to be negative (meaning that global climate change is expected to hurt the world economy), and has been estimated using a range of plausible figures for the rates at which future costs and benefits are to be discounted. See Moore and Diaz (2015), who arrive at a figure of 220 US dollars per ton of carbon emitted into the atmosphere. In contrast, the US Government uses a figure of 37 dollars per ton. The wide difference in the estimates reflects differences in assumptions regarding the effect of carbon emissions on the global climate and in turn the effect of changes in the global climate on the fruits of human activities.

Bohn and Stuart (2015) offer various estimates of the social cost of carbon emissions owing to a new birth (that's $P\Delta K$, but where K is restricted to carbon concentration). In contrast, the literature contains next to nothing on the valuation of changes that humanity is inflicting on the oceans and the biomass they harbour. We do not know P for the biosphere.

assimilate the waste it produces (materials, gases).[34] A footprint in excess of 1 means demand for ecological services exceeds their supply. In the early years of the present century, the footprint was approximately 1.5, which in our terminology means humanity has in recent years been consuming ecological services at the rate $1.5(1-\alpha)F(K)$. Humanity's demand for ecological services can exceed supply for a period, but not indefinitely. Our model would interpret a footprint in excess of 1 as a decline in K (i.e. $\Delta K < 0$). Sustainable development would require that the footprint over time must on average equal 1. To be sure, K can be made to increase by measures that reduce the footprint to less than 1. For example, advances in bio-technology are designed to increase K, but the advances would be successful only if they don't have large, unintended adverse consequences on the biosphere. Moves toward consumption and production practices that make smaller demands on the biosphere would be a more direct approach to reducing our impact on the Earth system.

The greatest contributors to the ecological-footprint overshoot are the OECD countries (a club of rich nations). But many countries in sub-Saharan Africa now also have a footprint in excess of 1, albeit only slightly in excess. Estimating national footprints poses enormous conceptual and practical difficulties. And without notional prices to guide us, it isn't possible to estimate the value of environmental externalities associated with an average new birth. But for the global economy the matter is a bit less opaque. Let us see why.

World income per capita today is about 14,500 dollars (PPP). Assuming that the global ecological footprint is 1.5, the conclusion should be that to maintain the current global average living standard at the prevailing distribution of income, we would need 1.5 Earths. The most recent projection by the United Nations Population Division of world population in year 2100 is 11.2 billion. More than three-quarters of the increase from today's population is forecast to be in Africa, where population in 2100 is expected to rise to 4 billion. If family planning programmes were intensified to meet unmet need everywhere in Africa, some 1-2 billion births could be prevented. That would lower the global projection for 2100 to 9.2-10.2 billion.[35] It is against this backdrop that, in what follows, we offer a quantitative account of the adverse environmental externalities that prevail at the population-consumption-environment nexus. No doubt estimates of the global ecological footprint are very, very crude. That there is an overshoot (ecological footprint in excess of 1), however, is entirely consistent with a wide range of evidence on the state of the biosphere, some of which we have reviewed here. Moreover, the figures are the only ones

[34] For pioneering work on the idea of ecological footprints, see Rees and Wackernagel (1994) and Rees (2006). See also Kitzes et al. (2008). The Global Footprint Network (www.footprintnetwork.org/public), founded by Mathis Wakernagel, regularly updates their estimates of the global ecological footprint. Wakernagel was a lead author of WWF (2008).

[35] We are grateful to John Bongaarts for correspondence on this.

we have that summarise contemporary human-nature engagements at the global level of aggregation. So we make use of them.

9.3 How Many People Can Earth Support in Comfort?

Ecologists estimating sustainable world populations have sought to calculate the human numbers Earth can support at a reasonable standard of living. In an important and interesting paper Daily, Ehrlich, and Ehrlich (1994) studied the problem by quantifying the stresses to the biosphere that are being caused by humanity's use of energy. The authors considered a rate of energy consumption that would offer the average person options to pursue a wide variety of life's projects and choices. In the early 1990s world population was 5.5 billion and global energy consumption was an annual 13 terawatts (13 trillion watts). The authors took it as given that an annual consumption of 13 terawatts of energy is unsustainable (it would play havoc with K). As we now know from the on-going work of climate scientists, their presumption was right. The authors noted the vast differences in energy use between the world's rich and poor, but on assuming an equitable distribution of energy-use they estimated that a population of 2 billion (world population in the early 1930s) could enjoy a very comfortable life based on an annual 3 terawatts of energy consumption; and that a population of 1.5 billion (world population at the start of the 20th century) could enjoy an even more comfortable life based on an annual 4.5 terawatts of energy consumption.[36]

The Daily-Ehrlich-Ehrlich estimates were a first cut on a neglected problem. An alternative procedure is to identify a standard of living that can be justified on grounds that it supports a high quality of life - we will identify one from surveys on "reported happiness" - and ask how many people can be supported at that quality of life. We pursue that line of enquiry here.[37]

An analysis of one set of global surveys on happiness and their relationship with household incomes has revealed that in countries where per capita income is in excess of 20,000 dollars (PPP), additional income is not statistically related to greater reported happiness. We work with that figure, even though we are not at all sanguine we understand the finding. 20,000 dollars is the per capita income in Panama, Cuba, and Uruguay today, and it is hard to imagine that happiness hits a roadblock at 20,000 dollars. Nevertheless, for want of price estimates of natural capital (P),

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[36] The Daily-Ehrlich-Ehrlich study was based on the assumption that the sources of energy will continue to be fossil fuels. Today there is hope that energy will in due course altogether be obtained from renewable resources. But that's still some ways ahead. Meanwhile K will have been further depleted. And climate change is not the only source of stress to the Earth system.

Cohen (1995) collated a wide range of estimates that had been published in the past century of Earth's capacity to support human numbers and their demands.

[37] The literature on reported happiness is huge. See Helliwell et al. (2013) for a fine review of the large scale surveys that ask people to report their feelings and emotions and collate their responses.

we follow the lead of studies on reported happiness.[38]

World income (or global GDP) today is about 108 trillion dollars (PPP). Using 1.5 as the figure for the global ecological footprint today and assuming that the demand on ecological products and services is proportional to GDP, we can conclude that sustainable world GDP is an annual 108 trillion/1.5 (i.e. 72 trillion), dollars (PPP). That level of global economic activity would be sustainable because *K* would not decline. If we now regard 20,000 dollars (PPP) as the desired standard of living for the average person, maximum sustainable population comes to 3.6 billion.

Notice how close this estimate is to the ones obtained by Daily, Ehrlich, and Ehrlich. Each arrives at a global population under half of what it is today. That suggests, at least tentatively, that the Earth system offers tight bounds on global population if a decent living standard is to be sustained. World population was about 3.5 billion in the early 1970s, so we are not talking of unfamiliar figures. But suppose our goal was less demanding; suppose humanity would be content with an average income of 10,000 dollars, a figure that is below the global per capita income today.[39] Sustainable global population would then be 7.2 billion. We are now 7.3 billion in numbers, moving toward 11 billion in year 2100. And we haven't built into the analysis deep inequalities in living standards and the human migration that are often a response to the distress that they give rise to. We turn to that now.

9.4 Poverty and the Distribution of Global Income

By the Global Footprint Network's reckoning the world's ecological footprint in 1960 was about 0.6. If the figure is accepted, we can conclude that humanity's reliance on the biosphere at that time was sustainable and that the biosphere's composition was a lot different at that time from what it is now. World population in 1960 was about 3 billion and per capita income approximately 3,000 dollars (PPP). These statistics are consistent with the conclusion reached by Waters, Zalasiewicz, and Summerhayes et al. (2016), that the Anthropocene is only a couple of generations old.

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[38] Layard (2011: 32-35) reports the finding and commends it. A number of explanations can be given for the finding, one being that what matters most to a household beyond a certain level of income is its income relative to the average income in its peer group. Veblen (1899,[1925]) based his theory of the leisure class on this particular psychology of consumption. Veblen's observation on human psychology found a telling expression in a remark attributed to a Garry Feldman of Stamford, Connecticut, one of the wealthiest towns in the USA: "I might be in the top one per cent, but I feel that I am in the bottom third of the people I know." (*The Guardian*, Saturday 16 February 2013)

Another explanation for happiness saturation bases itself on the idea that people are conformists even on styles of living. The problem isn't that either explanation is implausible (they are both all too believable), but that either dominates all other factors affecting the demand for goods and services beyond 20,000 dollars. We use the figure only for illustration.

[39] To convey an idea of 10,000 dollars per person, it is the per capita income in contemporary Albania and Indonesia.

But to talk in terms of global averages, as we have been doing so far, is to ignore poverty and income inequality. How does the balance of rights change when we cease talking exclusively in terms of global averages?

Most economists believe that success in reducing the proportion of the world's population in absolute poverty from 37 per cent in 1990 to just over 10 per cent today can be traced to strong growth in GDP that prominent developing countries have enjoyed since then (China and India in particular) and the investment in health and education that was made possible by that growth.[40] In international discourses it is today almost universally taken as given that eliminating absolute poverty and narrowing health disparities require robust GDP growth.[41]

Related to poverty and the distribution of living standards is the question whether global ecological footprint is proportional to world GDP. In our previous calculation we assumed the answer is "yes" without comment. The assumption requires that household footprint is proportional to household income; that is, the composition of household expenditure doesn't matter to the biosphere. That is in all probability incorrect (Liu et al., 2003). So then consider by way of example the case where ecological footprint increases less than proportionately with income. If the distribution of income remains the same, an X per cent growth in global GDP would be accompanied by a less than X per cent growth in ecological footprint. And that's a good thing.[42]

But what if absolute poverty was to be eliminated by a redistribution of incomes toward greater equality? Such a policy has a strong appeal to egalitarian convictions. But policy makers would be faced with a cruel dilemma: Even if average income was to remain the same, the ecological footprint would increase. That means improving the distribution of income among today's contemporaries, a good thing in itself, would worsen the economic prospects of future generations. There is a clash here between present and future rights.[43]

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[40] See for example the regular commentaries in *The Economist*. The absolute poverty line is currently taken by the World Bank to be 1.90 dollars (PPP) a day. It is an adjustment to the dollar-a-day figure that was introduced by the organization in the 1980s.

[41] See for example Jamison, Summers et al. (2013).

[42] To confirm this suppose population size is N; people are indexed by i (= 1,2,...,N); and y_i is person i's income. Let e_i be i's demand for ecological services. A simple way to formulate the assumed relationship between income and biomass consumption is

$$e_i = Ay_i^{\pi}, \qquad \text{where } 0 < \pi < 1 \text{ and } A > 0 \text{ are constants.}$$

Global demand for ecological services is then

$$E = \Sigma e_i = A[{}_i\Sigma y_i^{\pi}],$$

where "${}_i\Sigma$" denotes summation over i.

Suppose there is an X percent increase in all incomes. Then the global demand for ecological services (E*) would be

$$E^* = (1+X)^{\pi}E < (1+X)E.$$

[43] To see why, we use the notation introduced in the previous footnote and consider the extreme case where there is complete equality of incomes following the redistribution. For vividness, label people so that $y_1 < ... < y_i < ... < y_N$. Write the mean global income as y*. Then

If ecological footprint increases more than proportionately with income, our conclusions are reversed: Equalizing incomes among contemporaries would improve the economic prospects of future generations, but an X per cent growth in global GDP would be accompanied by a more than X per cent growth in ecological footprint.[44] Either way, the environmental consequences of growth and distribution point in opposite directions. That's another problem for the hapless policy maker.

10 The Dilemma

In this paper we have identified a body of adverse environmental externalities in the contemporary world that accompany procreation. We have also identified externalities that are allied to socially embedded preferences for family size. Those preferences can give rise to a heightened demand for children, thus exacerbating adverse environmental externalities. Our analysis indicates that to justify family planning programmes solely on the basis of reproductive rights is to undervalue the role family planning can play in not only meeting unmet need but also in lowering desired fertility, thereby total fertility. Estimates of global ecological footprint and a body of work by environmental scientists on humanity's usurpation of biomass were used to show that that in recent decades humanity has been making unsustainable demands on the biosphere. Quantitatively the adverse environmental externalities are not negligible.

To better appreciate the clash of rights that has been the focus of this paper, it pays to look at an extreme case:

In Niger the total fertility rate (TFR) is currently 7.6. It is estimated that only 12 per cent of married (or in union) women in the country use modern methods of contraception. But unmet need for family planning is low: under 17 per cent among married (or in union) women say they do not wish to get pregnant and are not using contraception. They also say their desired number of children is 9.5. Income per capita is 940 dollars (PPP), meaning that the *average* person there is not much above the internationally accepted level of absolute poverty (1.90 dollars (PPP)). The country's population in 2012 was 17.6 million and is projected to rise to over 72 million in 2050. It is more than just difficult to imagine what resources will be available for the millions who will be born there in the coming years. And yet, using reproductive rights as the ethical basis of family planning programmes in Niger could even dictate that married (or in union) women there should be helped to raise their fertility rate. The clash of rights we have drawn attention to here is self-evident. The moral problems it raises are not easy to resolve. But that is no reason for avoiding

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$y^* = {}_i\Sigma y_i/N$. Suppose $X = 0$ (global GDP does not change). By assumption $0 < \pi < 1$. That means $NA(y^*)^\pi > A[{}_i\Sigma y_i^\pi]$. But $NA(y^*)^\pi$ is the global demand for ecological services under complete equality.

[44] To confirm, one could use the model in footnote 43, but assume $\pi > 1$.

them.

References

Alkema, L., V. Kantorava, C. Menozzi, and A. Biddlecom (2013), "National, Regional, and Global Rates and Trends in Contraceptive Prevalence and Unmet Need for Family Planning Between 1990 and 2015: A Systematic and Comprehensive Analysis," *Lancet*, 381, 1642-1652.

Baland, J.-M. and J.-P. Platteau (1995), *Halting Degradation of Natural Resources: Is There a Role for Rural Communities?* (Oxford: Oxford University Press).

Basu, A.M. and S. Amin (2000), "Conditioning Factors of Fertility Decline in Bengal: History, Language, Identity, and Openness to Innovations," *Population and Development Review*, 26(4), 761-794.

Bauer, P.T. (1981), *Equality, the Third World and Economic Delusion* (London: Weidenfeld and Nicolson).

Berlin, I. (1959), *Two Concepts of Liberty* (Oxford: Oxford University Press).

Birdsall, N. (1988), "Economic Approaches to Population Growth," in H. Chenery and T.N. Srinivasan, eds., *Handbook of Development Economics, Vol. 1* (Amsterdam: North Holland).

Bledsoe, C. (1990), "The Politics of Children: Fosterage and the Social Management of Fertility Among the Mende of Sierra Leone," in W. Penn Handwerker, ed., *Births and Power: Social Change and the Politics of Reproduction* (London: Westview Press).

Bledsoe, C. (1994), "'Children are Like Young Bamboo Trees': Potentiality and Reproduction in sub-Saharan Africa," in K. Lindahl-Kiessling and H. Landberg, eds., *Population, Economic Development and the Environment* (Oxford: Oxford University Press).

Bledsoe, C. and G. Pison, ed. (1994), *Nupitality in Sub-Saharan Africa: Contemporary Anthropological and Demographic Perspectives* (Oxford: Clarendon Press).

Bohn, H. and C. Stuart (2015), "Calculation of a Population Externality," *American Economic Journal: Economic Policy*, 7(2), 61-87.

Bongaarts, J. (2011), "Can Family Planning Programs Reduce High Desired Family Size in sub-Saharan Africa?" *International Perspectives in Sexual and Reproductive Health*, 37(4), 209-216.

Bongaarts, J. (2016), "Slow Down Population Growth," *Nature*, 530, 409-412.

Bongaarts, J. and J.B. Casterline (2013), "Fertility Transition: Is sub-Saharan Africa Different?" *Population and Development Review*, 38(1), 153-168.

Bongaarts, J. and S.C. Watkins (1996), "Social Interactions and Contemporary Transitions," *Population and Development Review*, 22(4), 639-682.

Bradley, S.E.K., T.N. Croft, J.D. Fishel, and C.F. Westoff (2012), "Revising Unmet Need for Family Planning," *DHS Analytical Studies No. 25* (Calverton. MD: ICE International).

Brander, J.A. and M.S. Taylor (1998), "The Simple Economics of Easter Island: A Ricardo-Malthus Model of Renewable Resource Use," *American Economic Review*, 88(1), 119-138.

Brock, D. (2010), "Shaping Future Children: Parental Rights and Societal Interests," in J. Fishkin and R. Goodin, eds., *Population and Political Theory - Philosophy, Politics and Society*

8 (Chichester: Wiley-Blackwell).

Caldwell, J.C. (1981), "The Mechanisms of Demographic Change in Historical Perspective," *Population Studies*, 35(1), 5-27.

Caldwell, J.C. (1982), *The Theory of Fertility Decline* (New York: Academic Press).

Caldwell, J.C. (1991), "The Soft Underbelly of Development: Demographic Transition in Conditions of Limited Economic Change," *Proceedings of the Annual Bank Conference on Development Economics 1990* (Supplement to the World Bank Economic Review), 207-54.

Caldwell, J.C. and P. Caldwell (1990), "High Fertility in sub-Saharan Africa," *Scientific American*, 262(5), 82-89.

Canning, D. and T. Paul Schultz (2012), "The Economic Consequences of Reproductive Health and Family Planning," *Lancet*, 380, 165-171.

Casterline, J.B. and S.W. Sinding (2000), "Unmet Need for Family Planning in Developing Countries: Implications for Population Policy," *Population and Development Review*, 26(1), 691-723.

Cavendish, W. (2000), "Empirical Regularities in the Poverty-Environment Relationships of Rural Households: Evidence from Zimbabwe," *World Development*, 28(11), 1979-2003.

Chopra, K., G. Kadekodi, and M.N. Murty (1990), *Participatory Development: People and Common Property Resources* (New Delhi: Sage Publications).

Cleland, J. (1996), "Population Growth in the 21st Century: Cause for Crisis or Celebration?" *Tropical Medicine and International Health*, 1(1), 15-26.

Cleland, J., S. Bernstein, A. Ezeh, A. Faundes, A. Glasier, and J. Innis (2006), "Family Planning: The Unfinished Agenda," *Lancet*, 368(9549), 1810-1827.

Cleland, J., A. Conde-Agudelo, H. Peterson, J. Ross, and A. Tsui (2012), "Contraception and Health," *Lancet*, 380(9837), 149-156.

Cleland, J. and C. Wilson (1987), "Demand Theories of the Fertility Transition: An Iconoclastic View," *Population Studies*, 44(1), 5-30.

Cochrane, S. and S. Farid (1989), "Fertility in sub-Saharan Africa: analysis and explanation," World Bank Discussion Paper No. 43 (Washington DC: World Bank).

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

Colchester, M. (1995), "Sustaining the Forests: The Community-Based Approach in South and South-East Asia," *Development and Change*, 25(1), 69-100.

Cordell, J.C. and M.A. Mckean (1986), "Sea Tenure in Bahia, Brazil," in *Proceedings of the Conference on Common Property Resource Management* (Washington, DC: National Academy Press).

Cottingham, J., A. Germaine, and P. Hunt (2012), "Use of Human Rights to Meet th Unmet Need for Family Planning," *Lancet*, 380, 172-180.

Crutzen, P.J. and E.F. Stoermer (2000), "The Anthropocene," *Global Change Newsletter*, 41, 17-18.

Daily, G.C., A.H. Ehrlich, and P.R. Ehrlich (1994), "Optimum Population Size," *Population and Environment*, 15(6), 469-475.

Dasgupta, P. (1993), *An Inquiry into Well-Being and Destitution* (Oxford: Clarendon Press).

Dasgupta, P. (2000), "Reproductive Externalities and Fertility Behaviour," *European Economic Review*, 44(2000), 619-644. (Presidential Address to the European Economic Association Annual Conference 1999.)

Dasgupta, P. (2002), "A Model of Fertility Transition," in B. Kristrom, P. Dasgupta, and K.-G. Lofgren, eds., *Economic Theory for the Environment: Essays in Honour of Karl-Goran Maler* (Cheltenham: Edward Elgar).

Dasgupta, P. and P. Ehrlich (2013), "Pervasive Externalities at the Population, Consumption, and Environment Nexus," *Science*, 19 April, Vol. 340, 324-328. (DoI:10.1126/science.1224664)

Debpuur, C., J.F. Phillips, E.F. Jackson, A. Nazzar, P. Nigom, and F.N. Binka (2002), "The Impact of the Navrongo Project on Contraceptive Knowledge and Use, Reproductive Preferences, and Fertility," *Studies in Family Planning*, 33(2), 141-164.

Ehrlich, P.R. and A.H. Ehrlich (1981), *Extinction: The Causes and Consequences of the Disappearance of Species* (New York, NY: Random House).

Ehrlich, P.R. and A.H. Ehrlich (2008), *The Dominant Animal: Human Evolution and the Environment* (Washington DC: Island Press).

Ehrlich, P.R. and J.P. Holdren (1971), "Impact of Population Growth," *Science*, 171 (3977), 1212-1217.

Fabic, M.I., Y. Choi, J. Bongaarts, J.E. Darroch, J.A. Ross, J. Stover, A.O. Tsui, J. Upadhyay, and E. Starbird (2015), "Meeting Demand for Family Planning Within a Generation," *Lancet*, 385(9981), 1928-1931.

Farooq, G., I. Ekanem, and S. Ojelade (1987), "Family Size Preferences and Fertility in South-Western Nigeria," in C. Oppong, ed., *Sex Roles, Population and Development in West Africa* (London: James Currey).

Feeny, D., F. Berkes, B.J. McCay, and J.M. Acheson (1990), "The Tragedy of the Commons: Twenty-two Years Later," *Human Ecology*, 18(1), 1-19.

Filmer, D. and L. Pritchett (2002), "Environmental Degradation and the Demand for Children: Searching for the Vicious Circle in Pakistan," *Environment and Development Economics*, 7(1), 123-146.

Fortes, M. (1978), "Parenthood, Marriage and Fertility in West Africa," *Journal of Development Studies*, 14 (Special Issue on Population and Development), 121-49.

Freedman, R. (1995), "Asia's Recent Fertility Decline and Prospects for Future Demographic Change," Asia-Pacific Population Research Report No. 1, East-West Center, Honolulu.

Freeman III, A.M. (2003), *The Measurement of Environmental and Resource Values: Theory and Methods* (Washington, DC: Resources for the Future).

Fried, C. (1978), *Right and Wrong* (Cambridge, MA: Harvard University Press).

Ghate,R., N.S. Jodha, and P. Mukhopadhyay, eds. (2008), *Promise, Trust and Evolution: Managing the Commons of South Asia* (Oxford: Oxford University Press).

Goody, J. (1976), *Production and Reproduction* (Cambridge: Cambridge University Press).

Guyer, J.L. (1994), "Lineal Identities and Lateral Networks: the Logic of Polyandrous Motherhood," in C. Bledsoe and G. Pison, eds., *Nupitality in Sub-Saharan Africa: Contemporary Anthropological and Demographic Perspectives* (Oxford: Clarendon Press).

Haque, A.K.E., M.N. Murty, and P. Shyamsundar, eds. (2011), *Environmental Valuation in South Asia* (New York: Cambridge University Press).

Hardee, K., J. Kumar, K. Newman, L. Bakamjian, S. Harris, M. Rodriguez, and W. Brown (2014), "Voluntary. Human Rights-Based Family Planning: A Conceptual Framework," *Studies in Family Planning*, 45(1), 1-18.

Harford, J.D. (1998), "The Ultimate Externality," *American Economic Review*, 88(1), 260-265.

Haveman, R. and B. Wolf (1995), "The Determinants of Children's Attainments: A Review of Methods and Findings," *Journal of Economic Literature*, 33(4), 1829-1878.

Helliwell, J.F., R. Layard, and J.D. Sachs, eds. (2013), *World Happiness Report 2013* (New York: Earth Institute).

Helpman, E. (2004), *The Mystery of Economic Growth* (Cambridge, MA: Belknap Press).

Hill, K. (1992), "Fertility and Mortality Trends in the Developing World," *Ambio*, 21(1), 79-83.

Jamison, D.T., L.H. Summers et al. (2013), "Global Health 2035: a world converging within a generation," *Lancet*, 382 (December 7), 1898-1955.

Jensen, R. and E. Oster (2009), "The Power of TV: Cable Television and Women's Status in India," *Quarterly Journal of Economics*, 124(3), 1057-1094.

Jodha, N.S. (1986), "Common Property Resources and the Rural Poor," *Economic and Political Weekly*, 21, 1169-1181.

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

Kitzes, J., M. Wakernagel, J. Loh, A Peller, S. Goldfinger, D. Cheung, and K. Tea (2008), "Shrink and Share: Humanity's Present and Future Ecological Footprint," *Philosophical Transactions of the Royal Society, B*, 363(25 July), 467-475.

Koenig, M.A., U. Rob, M.A. Khan, J. Chakraborty, and V. Fauveau (1992), "Contraceptive Use in Matlab, Bangladesh in 1990: Levels, Trends and Explanataions," *Studies in Family Planning*, 23(6), 352-364.

Kumar, J. and K. Hardee (2015), "Rights-Based Family Planning: 10 Resources to Guide Programming," *Resource Guide: the Evidence Project* (Washington DC: Population Council).

Layard, R. (2011), *Happiness: Lessons From a New Science* (London: Penguin).

Liu, J., G.C. Daily, P.R. Ehrlich, and G.W. Luck (2003), "Effects of Household Dynamics on Resource Consumption and Biodiversity," *Nature*, 421, 530-533.

Lutz, W. (2014), "A Population Policy Rationale for the Twenty-First Century," *Population and Development Review*, 40(3), 527-544.

Lutz, W., W.P. Butz, and K.C. Samir, eds. (2014), *World Population and Human Capital in the Twenty-First Century* (Oxford: Oxford University Press).

McCay, B.J. and J.M. Acheson (1987), *The Question of the Commons: the Culture and Ecology of Communal Resources* (Tucson, AZ: University of Arizona Press).

McKean, M. (1992), "Success on the Commons: A Comparative Examination of Institutions for Common Property Resource Management," *Journal of Theoretical Politics*, 4(2), 256-68.

MEA - Millennium Ecosystem Assessment - eds., R. Hassan, R. Scholes, and N. Ash - (2005a), *Ecosystems and Human Well-Being, I: Current State and Trends* (Washington, DC: Island Press).

MEA - Millennium Ecosystem Assessment - eds., S.R. Carpenter, P.L. Pingali, E.M. Bennet, and M.B. Zurek (2005b), *Ecosystems and Human Well-Being, II: Scenarios* (Washington, DC: Island Press).

MEA - Millennium Ecosystem Assessment - eds., K. Chopra, R. Leemans, P. Kumar, and H. Simmons - (2005c), *Ecosystems and Human Well-Being, III: Policy Responses* (Washington, DC: Island Press).

MEA - Millennium Ecosystem Assessment - eds., D. Capistrano, C. Samper K., M.J. Lee, and C. Randsepp-Hearne - (2005d), *Ecosystems and Human Well-Being, IV: Multiscale Assessments* (Washington, DC: Island Press).

Miller, G. and K.S. Babiarz (2016), "Family Planning Program Effects: Evidence from Microdata," *Population and Development Review*, 42(1), 7-26.

Montgomery, M.R. and J.B. Casterline (1998), "Social Networks and the Diffusion of Fertility Control," Policy Research Division Working Paper No. 119 (New York: Population Council).

Moore, F.C. and D.B. Diaz (2015), "Temperature Impacts on Economic Growth Warrant Stringent Mitigation Policy," *Nature Climate Change*, 5, 127-131.

Noronha, R. (1997), "Common-Property Resource-Management in Traditional Societies," in P. Dasgupta and K.-G. Maler, eds., *The Environment and Emerging Development Issues, Vol. 1* (Oxford: Clarendon Press).

Ostrom, E. (1990), *Governing the Commons: The Evolution of Institutions for Collective Action* (Cambridge: Cambridge University Press).

Rees, W.E. (2006), "Ecological Footprints and Biocapacity: Essential Elements in Sustainability Assessment," in J. Dewulf and H.V. Langenhove, eds., *Renewable-Based Technology: Sustainability Assessment* (Chchester, UK: John Wiley & Sons).

Rees, W.E. and M. Wackernagel (1994), "Ecological Footprints and Appropriated

Carrying Capacity: Measuring the Natural Capital Requirements of the Human Economy," in A.M. Jansson et al., *Investing in Natural Capital: The Ecological Economics Appropriate for Sustainability* (Washington, DC: Island Press).

RSPB et al. (2013), *State of Nature 2013* - Report issued jointly by the Royal Society for the Protection of Birds and 19 other UK conservation and research associations - (London: RSPB).

Sen, A. (1982), "Approaches to the Choice of Discount Rates in Social Benefit-Cost Analysis," in R.C. Lind, ed., *Discounting for Time and Risk in Energy Policy* (Baltiomore, MD: The Johns Hopkins University Press).

Sonfield, A., K. Hasstedt, M.L. Kavanaugh, and R. Anderson (2013), *The Social and Economic Benefits of Women's Ability to Determine Whether and When to Have Children* (New York: Guttmacher Institute).

Temple, J. (1999), "The New Growth Evidence," *Journal of Economic Literature*, 37(1), 112-156.

Thaler, R. and C. Sunstein (2008), *Nudge* (New York: Penguin).

Thomson, J.T., D.H. Feeny, and R.J. Oakerson (1986), "Institutional Dynamics: the evolution and dissolution of common property resource management," in *National Research Council, Proceedings of a Conference on Common Property Resource Management* (Washington DC: US National Academy of Science Press).

Tsui, A.O., R. McDonald-Mosley, and A.E. Burke (2010), "Family Planning and the Burden of Unintended Pregnancies," *Epidemiological Reviews*, 32(1), 152-174.

UNDP (1990), *Human Development Report* (New York: United Nations Development Programme).

UNFPA (1995), *Programme of Action of the International Conference on Population and Development* (New York: United Nations Population Fund).

Veblen, T. (1899, [1925]). *The Theory of the Leisure Class: An Economic Study of Institutions*. Originally published in 1899. Reprinted (London: George Allen & Unwin), 1925.

Vitousek, P.M., P.R. Ehrlich, A.H. Ehrlich, and P. Matson (1986), "Human Appropriation of the Product of Photosynthensis," *BioScience*, 36, 368-373.

Vitousek, P.M., H.A. Mooney, J. Lubchenco, and J.M. Melillo (1997), "Human Domination of Earth's Ecosystem," *Science*, 277, 494-499.

Wade, R. (1988), *Village Republics: Economic Conditions for Collective Action in South India* (Cambridge: Cambridge University Press).

Waters, C.N., J. Zalasiewicz, C. Summerhayes, *et al*. (2016), "The Anthropocene is Functionally and Stratigraphically Distinct from the Holecene," *Science*, 351(6269), aad2622-(1-10).

Watkins, S. Cotts (1990), "From Local to National Communities: The Transformation of Demographic Regions in Western Europe 1870-1960," *Population and Development Review*, 16(2), 241-272.

Wilson, E.O. (2016), *Half-Earth: Our Planet's Fight for Life* (New York: Liveright

Publishing Corporation).

World Bank (2012), *World Development Indicators* (Washington DC: World Bank).

World Bank (2016), *Development Goals in an Era of Demographic Change* (Washington DC: World Bank)

WWF - World Wildlife Fund - (2008), *Living Planet Report 2008* (Gland: WWF International).