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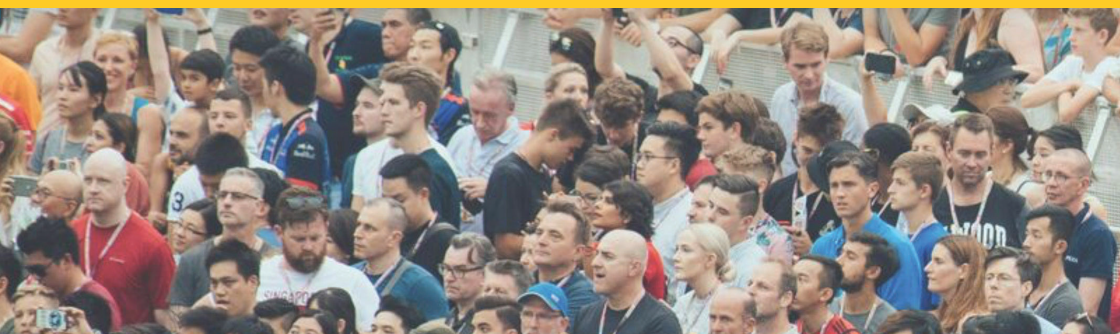

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Information

The Journal of Population and Sustainability (JP&S) is an open access interdisciplinary journal published by The White Horse Press exploring all aspects of the relationship between human numbers and environmental issues. The journal publishes both peer reviewed and invited material. It is intended that the JP&S act as an interdisciplinary hub facilitating collaboration and furthering the development of the field. While generously supported by environmental charity Population Matters, the JP&S is entirely editorially independent and welcomes contributions from scholars with a variety of perspectives on the role of population in environmental problems. The views and opinions expressed by authors are their own and do not necessarily reflect those of the editor, the editorial board or publisher.

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Submissions:

We invite contributions from the social sciences, humanities, environmental and natural sciences including those concerned with family planning and reproductive health. We also invite contributions from those working for NGOs with interests in population and environmental issues. We are interested in publishing original research papers, reviews of already published research, opinion pieces and book reviews.

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Contents

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Editorial introduction

David Samways – Editor

Welcome to the inaugural issue of *The Journal of Population and Sustainability* (JP&S) with our new publishers, The White Horse Press (WHP). This is an exciting time for the JP&S as, with the extensive expertise and experience of the team at WHP, we look forward to further development of the journal including reaching a larger readership and achieving wider citation indexing.

As I write this editorial, the COP26 talks in Glasgow have recently concluded. The final Glasgow Climate Pact has fallen far short of limiting emissions to remain below the Paris Agreement's ambition of no more than 2° C of warming above pre-industrial levels by mid-century. While some progress has been made, it is estimated that current commitments put the Earth on track for 2.4° of warming by the end of the century (CAT, 2021). Tackling population growth was not mentioned in the Pact as a solution to the climate crisis. This was unsurprising: as my own paper in this issue of the JP&S points out, while population growth is a universally acknowledged in the scientific community as a significant driver of the growth of carbon emissions, it has not been the main driver of the massive growth in emissions in the latter half of the twentieth century. More importantly, due to the very long timescales involved in reducing human numbers, measures tackling population size will yield results too slowly to deal with the immediate crisis (Bradshaw and Brook, 2014). Nonetheless, in the longer run, equitable and ethical measures aimed at slowing population growth now will ease future environmental impacts including the level of greenhouse gas emissions (Bradshaw and Brook, 2014; Bongaarts and O'Neill, 2018).

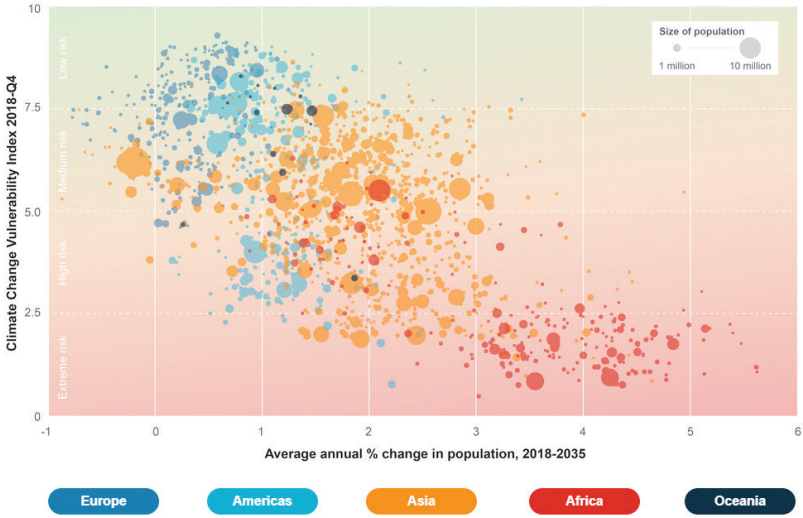
One of the most significant sources of scepticism about the need to address population growth as part of climate change mitigation and adaptation is the observation that a country's fertility rate and its per capita carbon emissions are

generally inversely correlated. Steffen et al. (2015) show that while population growth has been greatest in the Global South, economic growth and consumption – and hence growth in carbon emissions – have been concentrated in the Global North. Indeed, between 1990 and 2015, 52 per cent of cumulative global greenhouse gas emissions were attributable to the wealthiest ten per cent of the global population, while just seven per cent were attributable to the poorest half (Gore, 2020). For many this is sufficient evidence to conclude that population growth is an unimportant distraction from the principle problem of rich world consumption (Monbiot, 2020; Klein, 2014). However, as I argue in the review paper published in this issue, the disjuncture between environmental impact and fertility rates should be understood in terms of the shifting longer-term relationships between economic development, population growth and environmental impact. More importantly, I attempt to show that, in wider questions of environmental sustainability, population size is intrinsically connected with human welfare and wellbeing.

While the cause of the climate crisis is largely attributable to the historically accumulative emissions of the Global North, the poorest regions of the world are particularly vulnerable to the effects of climate change (IPCC, 2014) and will disproportionately suffer adverse effects on health due to extreme heat and growth of disease vectors, increasing water scarcity, soil erosion, crop failure, flooding of low-lying areas, etc.

Importantly, as Figure 1 illustrates, vulnerability to the possible effects of climate change and projected population growth rates are generally positively correlated (Patel, 2018; Price, 2020). There is a broad consensus that high rates of population growth adversely affect development and welfare improvements, and can negatively impact the availability of natural resources (Das Gupta et al., 2011; Beegle and Christianensen, 2019; Price, 2020). The precise relationships between high rates of population growth, low levels of economic development, climate vulnerability, resilience and adaptation are complex and geographically uneven, but, in areas vulnerable to climate change, high rates of population growth have a negative impact on the community's resilience and adaptive capacity (Beegle and Christianensen, 2019; Price, 2020). Moreover existing inequalities of power are often exacerbated, frequently meaning that women are most acutely affected (Kwauk and Braba, 2017; Price, 2020). Poor resilience and adaptive capacity can also lead to social conflict and climate induced migration with associated negative impacts on welfare (Kelley, 2016; Cattaneo et al. 2019).

Figure 1. Climate change vulnerability index. Reproduced with kind permission of Verisk Maplecroft (https://www.maplecroft.com/risk-indices/climate-change-vulnerability-index/)



Despite the evidence linking population growth with climate vulnerability, calls from communities in the Global South to address population growth as part of climate resilience and adaption strategies (e.g. Mcleod et al., 2018), and the potential effectiveness of integrated Population-Health-Environment initiatives (Lopez-Carr and Ervin 2017), discussion of policies designed to tackle population growth remains taboo amongst many environmentalists and those in the field of reproductive health and rights.

In a recent article, Diana Coole (2021) identifies the period between 1974 and 1994 as critical in the genesis of this hostility. Taking a genealogical approach, she argues that prior to the mid-1970s the counter-culture, feminist and early environmental movements associated population policies with economic equality and female emancipation. However, from the mid-1970s to the mid-1990s, population policy per se was recast as racist, misogynist and coercive. Coole argues that the cause for this toxification of population concern lay in broad ideological and geopolitical transformations and shifts in power silencing

some and giving voice to others. In particular she identifies the shift towards an emphasis on identities and rights over collective interests in radical new social movements, the ascendency of neoliberalism and the progressive reframing of population as a developmental rather than an environmental matter. In the context of geopolitical changes and shifting power dynamics, the outputs of the highly influential UN population conferences of 1974, 1984 and 1994 produced a series of paradigm shifts:

> … in 1974 Second and Third World countries rejected American neoMalthusianism; in 1984 an American reversal reflected domestic New Right positions; in 1994 an enhanced role for NGOs endowed the International Women's Movement (IWM) with significant agency. (4)

With the Cairo conference of 1994, the emergent paradigm, frequently known as 'the Cairo consensus', saw a final shift from a concern with the collective environmental risks associated with over-population to a focus on individual rights and aspirations which has dominated the field since. Importantly, the consensus was constructed to reject population policy specifically aimed at achieving broader demographic or environmental objectives. With its emphasis on economic development as the preferred – and supposedly 'natural' – route to fertility reduction, the Cairo consensus, Coole argues, further sedimented the notion that interference in reproductive decisions was unnecessary and that the population question was a 'shameful discourse' (11).

While Coole concedes that criticisms of historical population control discourses were not without substance, and notes that constant vigilance must be paid to the capturing of demographic goals by those pursuing racist agendas, she proposes that there is no fundamental incompatibility between the objectives of securing high-quality reproductive healthcare and addressing population growth to further common environmental interests. Importantly Coole states:

> On a globalised planet on the verge of environmental catastrophe, it seems anachronistic and unnecessary to maintain that the reproductive interests of women are antithetical to their interests in genuinely sustainable development. Women, children and the poor are after all among those most vulnerable to advancing environmental devastation

> ... A demographic-cum-environmental rationale can help mobilise funding commitments for comprehensive family planning services that expand women's rights and opportunities; rational explanations of the connections between mitigating climate change and smaller families could help incentivise responsible reproductive choices... (14–15)

Two of the papers in this issue engage with the reintegration of population into environmental discourses. While recording positive attitudes amongst survey respondents, the authors also note the subject is still unable to entirely shake off the perception that it is a 'shameful discourse'.

Working from the view that synergies may exist between reproductive health and rights and environmental sustainability, Céline Delacroix's paper examines the perceptions of stakeholders in both the reproductive health and rights movement and the environmental sustainability movement regarding links between family planning, population growth and environmental sustainability. Her qualitative research found that both groups overwhelmingly supported the integration of the reproductive health and rights perspective into wider considerations of environmental sustainability. Such 'environmental mainstreaming' of reproductive health and rights not only involves acceptance of the links between population growth and environmental change, but recognition of the role that family planning and the slowing of population growth can play in considerations both of global health and of the resilience and adaptation of vulnerable communities in the Global South to the challenges of environmental change. In particular, the concept of 'planetary health', whereby planetary 'ecological health' is linked to human health, appealed to both stakeholder groups.

However, while Delacroix found high levels support for linking reproductive health and rights to environmental sustainability, a minority rejected the proposition. In particular those in the reproductive health and rights movement were more divided in their support for the 'environmental mainstreaming' of reproductive health and rights. Delacroix identified multiple reasons for this, including questions of global environmental justice, the legacy of colonialism and discrimination and concerns about marginalisation. The first of these are closely related, with respondents seeing population growth in the Global South as a distraction from the responsibilities of the Global North whose wealth is a

result of colonialism and to whom environmental change is largely attributable. Concerns about marginalisation amongst respondents conform most closely to Coole's observations regarding the perception that the population question is taboo, or shameful, or that reproductive health and rights are segregated from, unrelated to and incompatible with environmental sustainability.

Kelley Dennings, Sarah Baillie, Ryan Ricciardi and Adoma Addo's paper, published in this issue, is also concerned with attitudes toward population size and environmental change and draws on the results of an online survey of almost 900 members of the public in the United States. Acknowledging the toxic legacy of the population debate, the authors, who work at the Centre for Biological Diversity (CBD), were specifically interested in understanding public knowledge and perceptions of the relationship between population and environmental degradation. As a campaigning organisation, the CBD were particularly interested in how the survey could be used to inform a 'theory of change' to better tailor their work to increase knowledge, influence attitudes, amplify positive norms and values, and finally enable action and advocacy 'for rights-based solutions to population growth'.

The results of their survey showed that respondents' knowledge of population growth over the last fifty years was poor, with only just over a third of the sample aware of the actual increase in global population, whilst the rest of the respondents believed the figure to be a billion or less. This lack of accurate knowledge contrasted with views about the role of population growth in environmental degradation and the moral responsibility to take action. Over sixty per cent regarded a combination of the growth in population and consumption as responsible for loss of biodiversity and species extinctions, and seventy per cent agreed that, if stabilising population growth would protect the environment then there is a moral duty to do so. Yet, the research also showed that, in terms of personal concern, access to health-care outranked climate change; education came next, followed by inequality, then wildlife extinctions, with concern about immigrant rights pushing population growth into the issue of least concern. Importantly, while Dennings et al. found that two thirds of respondents had no problem talking about population growth with others, the remaining sample showed significant reticence, based upon factors such as their lack of knowledge, lack of interest, or because they perceived the topic to be politically and emotionally sensitive.

Food insecurity is one of the greatest vulnerabilities faced by the world's poorest people. While growth in the production of food has exceeded growth in population, and despite decades of progress in lowering the proportion of the population who are undernourished, the absolute number has recently been rising, currently standing at around 690 million and on track to reach 840 million by 2030. Furthermore, it is estimated that in 2019 close to two billion people did not have access to safe, nutritious and sufficient food. As with other negative impacts of poverty, food insecurity disproportionately affects women (FAO, 2021).

The affordability of food is obviously a critical factor in food security and Stan Becker and David Lam's commentary piece, 'A Wager on Global Food Prices 2001–2020: Who Won and What Does it Mean?' presents the results of their 2011 wager regarding the course of world food prices. The wager echoed that of Paul Ehrlich and Julian Simon in 1980 about the trend in the price of five metals over a ten-year period, in which Ehrlich predicted that due to increasing scarcity that prices would rise. Ehrlich lost the bet as, during the ten-year period agreed upon, the prices had decreased rather than risen. The subject of Becker and Lam's wager was a comparison between UN Food and Agriculture Organization's Food Price Index of 2011–2020 and 2001–2010. Lam contended that, based upon the experience of the last half century, where many health and socio-demographic indicators had shown marked improvement, that neo-Malthusian pessimism was as unwarranted as it was in 1980 and predicted food prices to fall. Becker on the other hand argued that prices were likely to rise due to population growth and environmental factors impacting food supply.

While Becker won the bet, as food prices in the period 2011–2020 were indeed higher than the period 2001–2010, the picture is somewhat more complex. Food production has continued to increase faster than population has grown which should exert downward pressure on food prices. In fact food prices did fall from the time the wager was struck, but they did not decline enough to fall below those of the 2001–2010 period. As Lam comments, food prices vary due to many factors in the short run, including those on the supply side such as crop failure, or on demand side such as rising incomes, transport costs and speculative trading. He points out that these short-term disruptions tend to even out over the longer run, but other factors such as climate change are a cause for concern. Becker shares Lam's concern about climate change, but also draws attention to a range

of environmental and resource constraints which portend potential catastrophe. Importantly, Becker points out that the consumption of meat is growing, meaning that an increasing amount of grain is being diverted to feed animals. Moreover, the growth in meat consumption is also a driver of deforestation.

In our final paper for this issue, Theodore Lianos presents the argument that only the Steady State Economic (SSE) model can act as a basis for policies to avert environmental catastrophe. Examining other approaches such as Green Growth, Ecomodernism and Degrowth, he finds that such approaches do not adequately address all of the factors of the I=PAT equation, where environmental impact (I) is the result of the combination of population size (P), affluence (or consumption) (A) and technology (T) (which in the case of climate change can be understood as the carbon intensity of economic production or GDP). In particular, Lianos argues that the Green Growth and Ecomodernist positions rely on improvements in technology, and the Degrowth position on consumption. In contrast, only the SSE approach addresses all of the factors driving the environmental crisis: per capita consumption, the technical efficiency of production, and importantly, population size.

Lianos briefly traces the origins of the steady state idea from classical antiquity through J.S. Mill, J.M. Keynes and more recent environmental thinkers such as Kenneth Boulding and Herman Daly, going on to expound the steady state model and graphically demonstrate the relationships between biocapacity, welfare and population size. To remain within biophysical boundaries with any given technology, there is a trade-off between welfare (consumption or ecological footprint) and population size. If a society is operating at the boundary of biocapacity – that is, where the collective ecological footprint is equal to biocapacity – neither consumption nor population can grow without technological improvement. He concludes that to simultaneously remain within ecological boundaries and provide a sufficiently high level of welfare, the objective of population reduction rather than stabilisation must be pursued.

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PEER-REVIEWED ARTICLE

Population and Sustainability: Reviewing the Relationship Between Population Growth and Environmental Change

David Samways[1]

Abstract

At a high level of abstraction, causally connecting population growth and environmental degradation is intuitively appealing. However, while it is clear that population size is a critical factor in the size and power of social systems, and hence in environmental impact, the relationship between human numbers and environmental change is complex. In particular, the long timescales involved in population growth and decline, along with the shifting role of economic development in both population growth itself and environmental impact, obfuscate the role of population size as a multiplier of impact. Moreover, the protracted nature of demographic change makes population size seem like an intractable problem, the outcome of natural processes which are not only beyond choice, but, critically, morally perilous. In this review of the role of population size in environmental impact, I argue that choices, norms, and values, as well as material factors, are interwoven and inseparable in the environmental impact of our species. Furthermore, the consideration of human welfare and wellbeing is central to arguments regarding an environmentally sustainable population.

Keywords: population; sustainability; IPAT; values; consumption; demographic transition; economic growth

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Introduction

It could be argued that the history of human development is the history of population growth and environmental change. Certainly, at a very high level of abstraction, this appears to be the case. In all historical periods environmental degradation has been closely associated with the growth in human numbers. Ehrlich and Holdren's (1972) I=PAT equation appears to clearly capture this relationship: environmental impact (I) is a function of the combination of population size (P) with affluence (A) and technology (T). Indeed, taking climate change as our proxy for all human environmental impacts, comparing the growth of carbon emissions to the growth in global population as shown in figures 1 and 2, it is tempting to conclude that population growth has been the principal driver of environmental impact.

Figure 1: Annual CO2 emissions 1750–2010

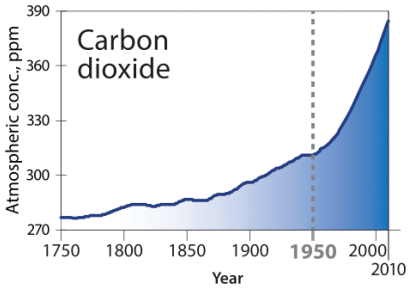
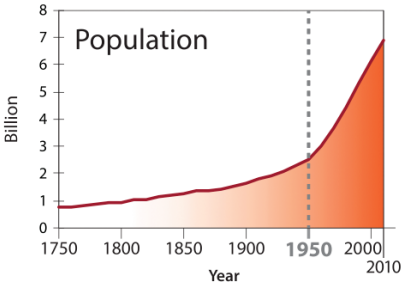


Figure 2: World population 1750–2010



(SOURCE: ADAPTED FROM STEFFEN ET AL. 2015)

However, correlation should not be confused with causation and the relationship between population growth and environmental impact – especially climate change – is more complex than it appears. Perhaps more importantly, as a means of tackling *imminent* environmental threats like climate change, focussing on population growth as a solution will not be effective (Bradshaw and Brook, 2014). Nonetheless, ethical policies to tackle population size are necessary not only to significantly mitigate our longer-term environmental impact but to improve human welfare both now and in the future.

In part, it is the fact that population growth and decline take place over long time periods that makes the problem difficult both to understand and to act

upon. Indeed, the entirety of our current environmental predicament could be understood as the result of a collective failure to appreciate the unintended consequences of aggregated everyday individual behaviours beyond shorter time horizons. However, with population growth, the personal character of reproductive choices confers a 'naturalness' and sanctity to fertility decisions which becomes extended to discourses that see aggregate population dynamics as the result of entirely natural processes and therefore beyond governability. Even if population growth is recognised as potentially amenable to management it has so much momentum and is so politically sensitive that it is frequently regarded as intractable.

There is an obvious tension here between the widely accepted idea of human exceptionalism in escaping limits imposed by nature through agency (choices and actions) and the notion that aggregate human population size is beyond collectively agreed choice and governance. This tension between freedom and determinism in respect of population size is not new, but in the past the positions have been reversed. Thomas Malthus (1998 [1798]) argued that William Godwin's and the Marquis de Condorcet's utopian schemas for a society liberated from poverty would be scuppered by the natural process of the population growing to meet the food supply. In contrast, modern demographic transition[2] from high to low rates of mortality and fertility is often thought to be an autonomous process beyond policy choices (Coole, 2018), while those concerned about population growth argue that, given the context of natural boundaries, our choices make a critical difference. In fact, we will see that choices, norms, values and material factors are interwoven and inseparable in the environmental impact of our species. Furthermore, the consideration of human welfare and wellbeing is central to arguments regarding an environmentally sustainable population.

This review paper attempts to examine the relationship between human population size and environmental change. I begin by addressing the role of population growth and environmental change in the developmental history of

2 Demographic transition refers to the historically observed relationship between fertility and mortality rates and economic development in Western nations. Simply understood, by increasing welfare, economic development leads to a reduction in rates of mortality while fertility rates fall at a later date. The time lag between mortality and fertility becoming balanced produces population growth, followed by stabilisation at a higher figure.

our species. I then turn to the question of what population size can be sustained within planetary boundaries, before finally considering the political and ethical questions surrounding population degrowth. We will see that norms, values and ethical sentiments play a critical role in moving toward an environmentally sustainable population and in determining its quantitative and qualitative nature.

Population growth and environmental change

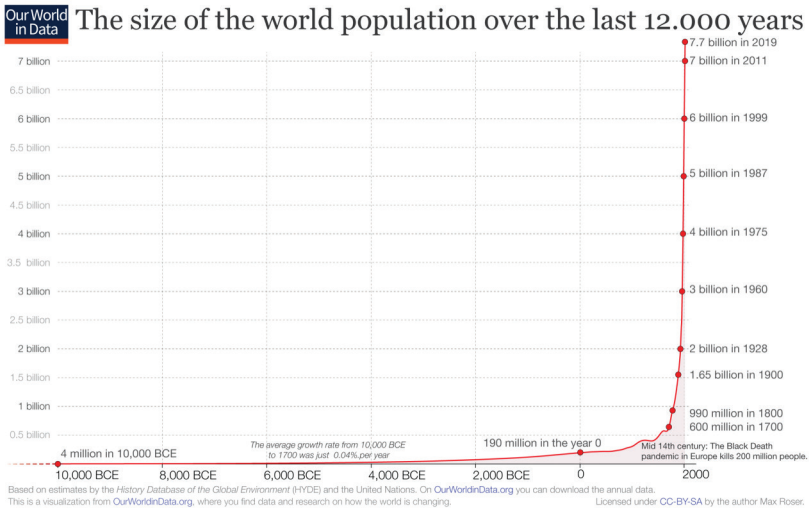
Human beings have always been a dynamic part of their environment. In the conduct of everyday life, all societies, no matter how small, intentionally and unintentionally change their environments, often producing what modern environmental discourses describe as degradation. In terms of environmental sustainability, the extensions in time and space of anthropogenic environmental changes are important and, while no fall from ecological grace can be located in the human past, turning points in the way that human beings have produced their material existence can be seen to correspond with the temporal duration and spatial extent of these changes. At the same time, these changes in the way that human beings have interacted with and manipulated their environment have also corresponded with periods of demographic transition, as the new mode of subsistence enabled numbers to grow then stabilise at a higher level (Bocquet-Appel and Bar-Yosef, 2016).[3]

In prehistory, increasing management of land by hunter gatherer societies followed by the establishment of settled agriculture enabled significant expansion of human numbers (Feeney, 2019; Gignoux, Henn and Mountain, 2011) which in turn multiplied the anthropogenic environmental change that had enabled its growth. At a local level, through the use of fire and other techniques, landscapes and ecologies were transformed by land-managing hunter-gatherers (see Kay, 1994; Krech, 1999; Anderson, 2005; Feeney, 2019) and Neolithic clearance of forest to create farmland and pasture dramatically transformed entire landscapes and ecosystems (Kaplan, Krumhardt and Zimmerman, 2009). Indeed, it has been argued that evidence from ice-cores and ocean sediments shows that, by increasing atmospheric carbon dioxide and methane concentrations, prehistoric agricultural practices, especially deforestation, may have influenced global

3 It is important to note that our knowledge of past population size and growth is provisional and made up of a patchwork of data gleaned from a variety of archaeological, historical and anthropological sources assembled to form estimates that are subject to initial assumptions and conjecture (Cohen, 1995).

climate and played a role in averting the onset of the next ice-age (Ruddiman et al., 2016). Whether entirely natural or augmented by human activity, the warming of the late Holocene contributed towards creating conditions favourable to human development and population growth.

Figure 3: Population growth over the last 12,000 years



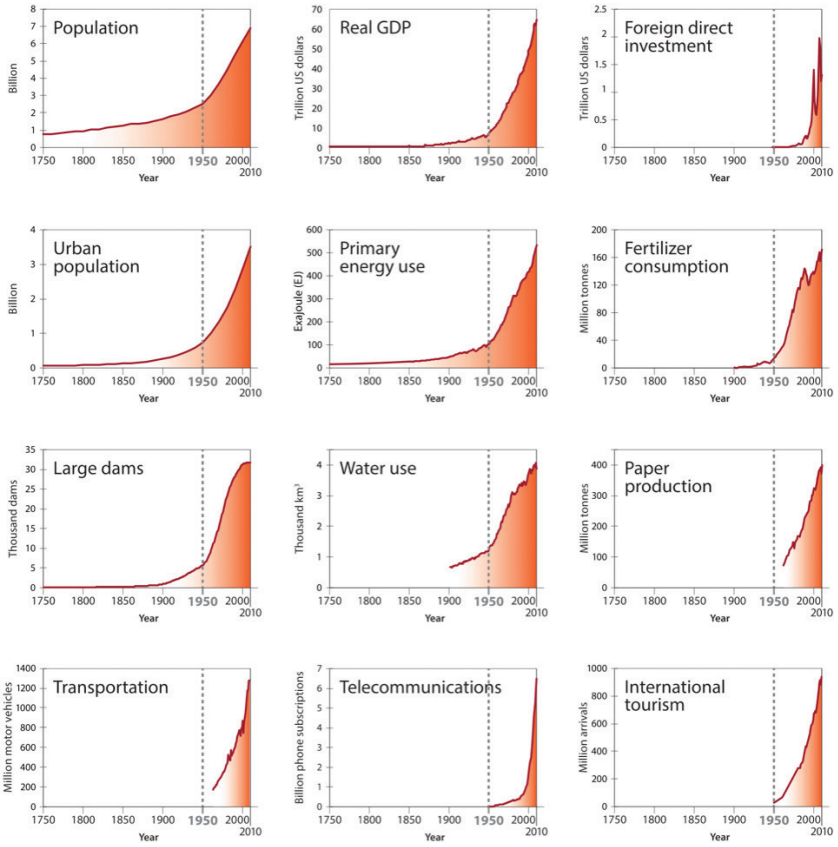
(SOURCE: WWW.OURWORLDINDATA.ORG)

From the medieval period onward, global population size began a path of apparently inexorable growth, only interrupted in the fourteenth century by the Black Death. From the relatively modest growth of the Middle Ages, the eighteenth century saw a further step-change in the rate of growth, followed by yet another after 1950. At the same time, environmental impact expanded from local environmental problems including water and air pollution mainly associated with urbanisation (see Brimblecombe, 1976, 1987), to potentially enduring impacts at the level of the Earth System.[4]

4 'The term Earth System refers to the suite of interacting physical, chemical, and biological global-scale cycles and energy fluxes that provide the life-support system for life at the surface of the planet' (Steffen, Crutzen and McNeill, 2007: 615).

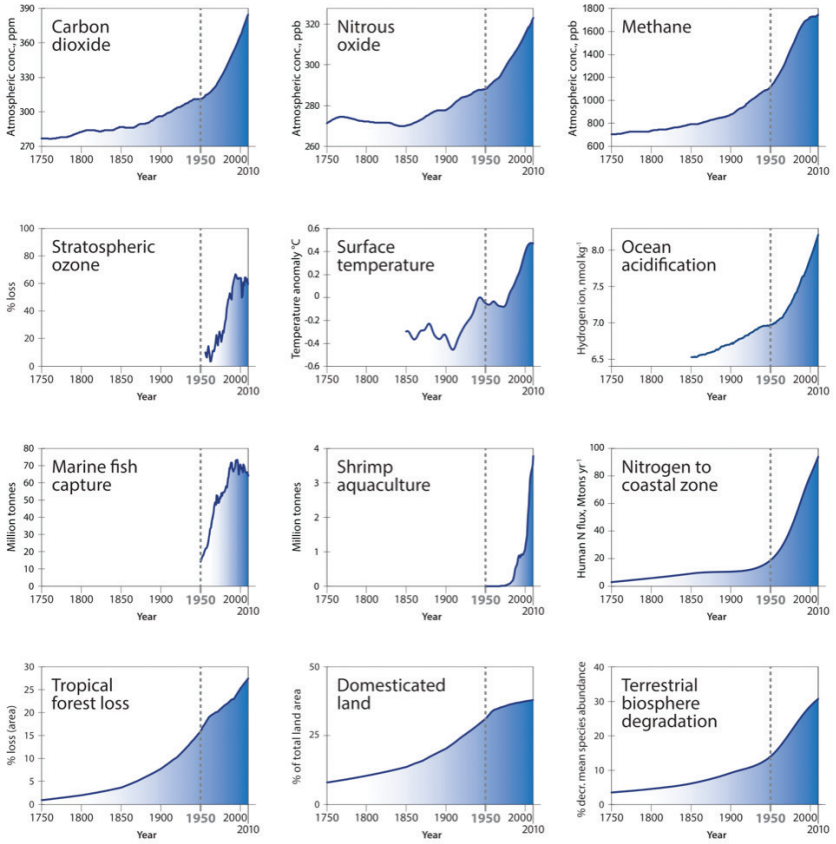
Indeed, the impact of industrial society from 1800 to 1950 was qualitatively and quantitatively so extensive and unprecedented that Will Steffen, Paul Crutzen and John McNeill (Steffen et al., 2007) proposed it as the first stage of the 'Anthropocene' – a new geological epoch succeeding the Holocene where human activity is the dominant influence on the Earth System. However, from 1950 onwards, the human enterprise expanded at such a rate that it has been termed 'The Great Acceleration' (see figures 4 and 5) (Steffen et al. 2007; Steffen et al. 2015).

Figure 4: Socio-economic trends. Reproduced by kind permission of Will Steffen



(SOURCE: STEFFEN ET AL. 2015)

Figure 5: Earth system trends. Reproduced by kind permission of Will Steffen



(SOURCE: STEFFEN ET AL. 2015)

Steffen and his colleagues (Steffen et al. 2007; Steffen et al. 2015) noted a correspondence between growth of a number of key dimensions of the world socio-economic system and changes in critical aspects of the Earth System. However, they argued that, since fossil fuels are a key factor in the generation of the Anthropocene, the growth in CO_2 concentration should serve as a barometer of its progress. While, during the first stage of the Anthropocene CO_2 concentrations

exceeded the upper limit of Holocene natural variation, the Great Acceleration from 1950 produced such spectacular growth that it accounts for nearly three quarters of the total increase in all anthropogenic CO_2. Moreover, half of that total growth took place in the three decades from the mid-1970s. The same period saw similarly rapid and unprecedented growth in all other dimensions of the human enterprise, including massive expansion of the global economy and huge growth in the human population (Steffen, Crutzen and McNeill, 2007).

Understanding the relationship between modern population growth and environmental impact

With the IPAT equation in mind, the population and CO_2 curves in figures 1 and 2 might reasonably be interpreted as showing that a massive increase in affluence, resulting from economic growth, was multiplied by the huge growth in human numbers to cause the increase in CO_2 concentrations. However, a closer analysis shows a much more complex picture, with spatial and temporal unevenness playing an important role. While it is clear that a huge increase in population accompanied the growth of anthropogenic CO_2, the two have not increased proportionately. Indeed, taking 1850 as our starting point, world population increased by a little over sixfold to 2019 (1.26–7.71 billion) (Roser, Ritchie and Ortiz-Ospina, 2013) while, over the same period, anthropogenic carbon emissions have increased by a multiple of more than 180 (0.1969–36.42 billion tonnes per annum) (Ritchie and Roser, 2020). From the time of The Great Acceleration (1950) to the present, world population increased by a little over threefold (2.54–7.71 billion) (Roser, Ritchie and Ortiz-Ospina, 2013) while CO_2 emissions have increased by a factor of six (5.99–36.42 billion tonnes per annum) (Ritchie and Roser, 2020). Clearly, economic growth and affluence must have played a bigger role than population growth in the increase of CO_2 emissions, and this is supported by data which suggests a more than fourteen-fold increase in global per capita GDP between 1820 and 2018 (Roser, 2013).

However, this growth in affluence has not been evenly shared across the globe. Indeed, Steffen et al. (2015) addressed precisely this issue by breaking down the uneven environmental impact of rich world (OECD) countries compared to that of developing economies, finding that, while population growth had been greatest in non-OECD countries, economic activity and consumption were highly concentrated in the Global North. These equity issues have been flagged by

Oxfam who note that the richest ten per cent of the world's population were responsible for 52 per cent of cumulative emissions between 1990 and 2015. In contrast, the poorest half of the global population were responsible for just seven per cent (Gore, 2020). With the greatest population growth taking place in the poorest nations, many commentators have argued that focusing on population growth is irrelevant and a distraction in tackling the climate crisis and the environmental crisis more generally (see for example Monbiot 2020; Klein 2014). However, while it is clear that affluence and consumption, and their vastly unequal distribution between the Global North and South, are at the heart of discussions around environmental justice and the immediate responses to the climate crisis, it would be mistaken to draw the conclusion that population growth has not been a factor in the growth of CO_2 emissions and is therefore irrelevant to thinking about longer-term sustainability.

The temporal nature of population dynamics

One of the greatest problems of attempting to understand the relationship between population growth and environmental impact lies in the role *over time* that economic growth plays in both. The most simplistic and deterministic explanation of demographic transition contends that, by increasing welfare, economic development leads to a reduction in rates of mortality while fertility rates fall at a later date. The time lag between mortality and fertility rates coinciding towards equality produces population growth, which is then followed by stabilisation at the higher figure. However, in terms of environmental impact, the relative impact of population and affluence (consumption) during demographic transition shifts. Crudely put, during the early stages of economic development the growth rate of population is greater than the growth rate of per capita affluence and consequently population growth has a greater environmental impact. However, as economic growth and increasing per capita affluence slows population growth, the growth of per capita consumption becomes the more significant driver of environmental impact. Clearly, this does not mean that population is no longer a factor, since the absolute population of affluent individuals is much greater than that prior to economic development. Thus, this larger but stable population size acts as a multiplier of economic growth and hence of environmental impact.

Beginning around 1800, the demographic transition of the rich world had more or less been completed by the latter decades of the twentieth century; during

that transition the combined population sizes of Europe and the United States quadrupled (Roser, Ritchie and Ortiz-Ospina, 2013). The same period saw the combined per capita GDPs of Western Europe and the United States[5] increase nearly sixteen-fold (Roser, 2013). Throughout the rich world's demographic transition, environmental impact continued to grow, as population size and increasing affluence multiplied the size and power of the social system. However, once population growth had declined and eventually ceased as fertility fell to replacement levels or less, the economies of the rich world continued to grow. At this point, natural population growth[6] ceased to be a source of growth in environmental impact, while increasing affluence and other factors continued to drive the expansion of impacts like CO_2 emissions.

A lack of comprehension of the relationship between economic development, demographic change and environmental impact over time frequently leads to misapprehensions about the role of population growth. A snapshot of world demographic trends at any particular point in time over the last seventy years would likely show developing regions with high rates of population growth and low per capita ecological footprints while rich countries have lower population growth rates and large per capita footprints.

In the period of the Great Acceleration, rates of population growth have been greatest in the Global South, with Asia adding the greatest number of additional people to the global population - 3.2 billion or 62 per cent of the total 5.15 billion increase between 1950 and 2019 (Roser, Ritchie and Ortiz-Ospina, 2013). While economic activity and consumption (and hence proportionate responsibility for global environmental impact) have been greatest in the Global North, during the past three or four decades Asia has undergone considerable economic development, with commensurate improvements in welfare, and at the same time considerably slowed its rate of population growth.

5 Indicative of the extent of the growth in affluence that took place across the whole of the industrialised Global North.

6 Meaning from births minus deaths rather than from immigration. It should be noted that the growth in the population sizes of both Europe and the USA have been due to a combination of natural growth and immigration which complicates a simplistic demographic transition narrative. Moreover, many developed countries are now experiencing fertility rates below replacement levels, leading to population ageing and, in the absence of immigration, population decline.

Comparing demographic, environmental (using CO_2 emissions as a proxy) and economic change in the United Kingdom and South Korea from 1960 to 2017 illustrates the role of population growth in environmental impact over time. In 1960 the UK and South Korea had annual population growth rates of 0.65 per cent and 3.02 per cent respectively (Roser, Ritchie and Ortiz-Ospina, 2013), while per capita CO_2 emissions for the UK stood at 11.15 tonnes compared to South Korea's minuscule 0.5 tonnes (Ritchie and Roser, 2020). Economically, in 1960 the UK was an extremely wealthy country with a per capita GDP of around nine times that of South Korea, which was then one of the world's poorest nations. By 2017 however, Korea had become one of the richest countries in the world with a GDP per capita equal to the UK (Roser, 2013). Moreover, South Korea's population growth rate is now considerably lower than that of the UK (Roser, Ritchie and Ortiz-Ospina 2013), but its per capita carbon footprint at 12.15 tonnes per person is greater than that of the UK in 1960 and more than double current UK domestic per capita emissions (Ritchie and Roser, 2020).

South Korea's economic development and demographic change over the last seven decades should not be taken to demonstrate autonomous, universal or 'natural' laws of demographic transition. In fact, South Korea represents a very particular case in terms of both the rapidity of economic development and fertility reduction, the latter being contributed to by a family planning programme that was so effective that total fertility had fallen to 1.78 children per woman by 1984 (Haub, 2010). Despite this, since the initiation of the programme in 1962 to the present-day South Korea's population has almost doubled (Roser, Ritchie and Ortiz-Ospina, 2013) which, along with its high per capita carbon footprint,[7] means that its environmental impact has massively increased.

While the case of South Korea is certainly not representative of all of Asia, it is nonetheless illustrative of the likely trajectory of environmental impact in the region as a result of the combination of economic development and population

7 It's important to point out that, as a manufacturing and exporting economy, South Korea's carbon emissions are not entirely due to domestic consumption. However, to some extent the same could be said of the UK in 1960 and the reduction of the UK's carbon emissions in recent years can be partially attributed to deindustrialisation and 'offshoring' of consumption emissions. Nonetheless, the Global Footprint Network (2021a) calculate South Korea's ecological footprint as 6.2 global hectares (gha) per person compared to the UK at 4.2 gha.

growth. The world's two most populous countries, China and India, despite both having declining rates of population growth, are not predicted to reach peak population size (China 1.46 and India 1.65 billion) until 2026 and 2053 respectively (Roser, Ritchie and Ortiz-Ospina, 2013). Using CO_2 emissions as a proxy, environmental impact has also grown and between 1990 and 2019 China and India, along with Iran and Indonesia, accounted for eighty per cent of the growth in carbon emissions of global emissions, with China alone being responsible for more than half this growth (Chaurasia, 2020). Moreover, from 2017 Asia's annual emissions eclipsed those of the rest of the world and China emitted more CO_2 per annum than the USA (Ritchie and Roser, 2020).

These gross figures must be treated with caution of course, since not only are the populations of these regions large, but emission figures include both those from domestic consumption and emissions embedded in goods for export. The shift of industrial manufacturing from the Global North to developing countries has also shifted emissions from the point of consumption in the rich world to the point of manufacture in countries such as China. Despite this, as incomes and welfare increase, domestic consumption emissions are growing in developing countries. China's economic growth and success in eradicating extreme poverty have been largely fuelled by coal and, as a result of rising incomes, per capita domestic consumption emissions are now approaching those of EU countries (Ritchie and Roser, 2020). While the economic development of the Global South will further slow the rate of population growth, the emergence of a middle class in countries like China and India, in combination with large and still growing populations and a reliance on coal, will significantly increase emissions (Steffen et al., 2015; Bongaarts and O'Neill, 2018).

Issues related to global economic inequality and environmental impact, as we will see, remain critical, yet continued population growth represents a serious challenge to achieving sustainability. This is confirmed by recent research (Chaurasia 2020) that showed that, although between 1990 and 2019 economic growth was the most important source of global growth in CO_2 emissions (around two thirds), population growth accounted for around a third of the increase in emissions. Significantly, it was also shown that the growth in emissions accounted for by population growth cancelled out more than three quarters of the CO_2 emission savings resulting from energy efficiency improvements, the use of lower emission fuels and renewables.

Nonetheless, although population growth has been a significant driver of carbon emissions, as Bradshaw and Brook (2014) show, demographic momentum (the forward growth of total population as the offspring of a higher fertility generation go on to have (fewer) children themselves) means that reductions in the fertility rate will take many decades to bring about a reduction in population size. Thus, as a policy instrument to tackle the imminent climate crisis, population degrowth will be ineffective and the immediate focus should be on policies and technologies designed to curb and reverse resource consumption. However, Bradshaw and Brook conclude that tackling human population size would have longer-term environmental (especially with respect to biodiversity and pressure on resources) and social benefits. Moreover, in respect of climate change, O'Neill et al. (2012) estimate that emissions could be reduced by forty per cent in the long-term with slower future population growth.

Population, welfare, sustainability.

Given the history of the relationship between population growth and environmental impact, it might be asked when the population of the Earth became unsustainable. According to the Global Footprint Network (GFN), humankind's demands did not overshoot the regenerative capacity of the Earth until after 1970 (GFN, 2021; Lin et al., 2018). The global population at that time stood at 3.7 billion (Roser, Ritchie and Ortiz-Ospina, 2013). At first glance, one might conclude that this is the point at which we trespassed beyond a maximum sustainable population, but once more this would be far too simplistic. In one sense it could be reasoned that the GFN data imply that, if humanity's resource consumption and production of wastes along with population had been instantaneously frozen at 1970 levels, this, assuming no other natural changes, could have been indefinitely supported by the Earth. However, a major problem with such an observation is that it conveys nothing of the global distribution of welfare at the time.

It is estimated that in 1970 around sixty per cent of the global population lived in poverty while 36 per cent lived in extreme poverty (Roser and Ortiz-Ospina, 2013), and the vast majority of these people lived in the Global South. The level of human welfare and its distribution is therefore a critical normative dimension of what can be considered an environmentally sustainable population size and, as we will see, features in all definitions.

It is an enduring misconception that, since the Malthusian Trap has been transcended by technical and economic development, the persistence of poverty is mostly a distributional issue and the equal sharing of wealth would give all a good life (see Raworth, 2017). Such reasoning implies that, if this was achieved at a collective global environmental footprint equal to one Earth, then such a population would be environmentally sustainable.

However, taking 1970 once again as our datum of maximum population and environmental impact, the equal distribution of global GDP would have more than eradicated poverty, but it would not have provided a high quality of life for all, with income levels of those in Western Europe falling by nearly two thirds to somewhat below those enjoyed in Eastern Europe at the time (Roser, Ritchie and Ortiz-Ospina, 2013). This 'back-of-the-envelope' calculation is provided for illustrative purposes alone; however, as we will see, others have applied similar reasoning and rigorous analysis to arrive at what might constitute an environmentally sustainable population size – a figure which is considerably less than half the present world population (Lianos and Pseiridis, 2015). Critically though, since 1970 the global population has more than doubled and planetary boundaries have been exceeded by seventy per cent (Lin et al., 2018). Today, the potentially sustainable consumption levels of 1970 must be shared between nearly eight billion people.

A good life for all within planetary boundaries

Further refutation of the idea that environmental sustainability at high welfare standards for all is simply a question of distribution was provided by research carried out by Dan O'Neill and his colleagues (2018) which attempted to understand the level of welfare that could be provided within planetary boundaries to a population of more than seven billion. O'Neill et al. showed that, in principle, an equal distribution of resources could meet the physical needs (including nutrition, sanitation, access to electricity and the elimination of extreme poverty) of seven billion within planetary boundaries. However, achieving the universal welfare standards aspired to in the UN's Sustainable Development Goals (SDGs) would require between two and six times the level of resources that are sustainable within planetary boundaries and would have 'the potential to undermine the Earth-system processes upon which development ultimately depends' (O'Neill et al., 2018: 93). Moreover, Jason Hickel (2019a) notes that, factoring in population

growth, meeting the economic objectives of SDG 8 would lead to the global economy being 55 per cent larger in 2030 than it was in 2015.

To meet the sort of higher welfare standards that most people in the developed world take for granted ('life satisfaction, healthy life expectancy, secondary education, democratic quality, social support and equality' (92)), O'Neill et al. argue that 'provisioning systems' – the complex of socio-technical systems which mediate the relationship between resource use and welfare provision (see Fanning, O'Neill and Büchs, 2020) – must become two to six times more efficient. However, this is more than just a technical challenge since, while technical efficiency improvements will be significant in lowering resource consumption, social structural changes will also be necessary to prevent rebound effects, reduce inequality and enhance social support.

Building on O'Neill et al.'s data, but relying on existing policy options rather than an improvement in global 'provisioning systems', Hickel (2018) has calculated that it is possible for all to have a good life within planetary boundaries, but that a reduction in the environmental footprint of the developed world of between forty and fifty per cent will be necessary, requiring degrowth strategies and the adoption of a post-capitalist economy. This would involve a shift in values and norms and a redefining of what constitutes a good life away from resource intensive social practices and aspirations. O'Neill et al. argue that by recognising the social and environmental burdens of overconsumption and focusing on sufficiency, resource use could be significantly reduced in developed countries without affecting social wellbeing. Necessary to this shift will be the abandoning of GDP as a measure of social progress.

However, O'Neill et al. point out that, without addressing the growth in population, the task of achieving a good life for all within planetary boundaries will become increasingly difficult. Indeed, since rich countries must reduce their aggregate economic activity, Hickel suggests that:

> One approach would be to gradually reduce the size of the population (in an equitable, progressive, and non-coercive way), so that GDP per capita can be maintained even while total economic activity shrinks. But if we assume that the population grows according to existing

> projections and stabilises at 9–11 billion, this will require de-growth in both absolute and per capita terms. (Hickel, 2018: 13)

Hickel's suggestion chimes well with the observation that reducing fertility in the rich world can also have significant effects on global environmental impact since the environmental footprint of each child born into the developed world is up to thirty times greater than each born in the poor world (Maxton and Randers, 2017; Wynes and Nicholas, 2017).

While O'Neill et al. and Hickel are not primarily concerned with population size, it is obviously a critical dimension of their work and makes clear that development, human welfare and equity are directly related to the notion of an environmentally sustainable population size. Those who have examined the notion directly have also accepted the same basic assumptions and focus on the size of population compatible with both a good life and a sustainable relationship with nature to arrive at an 'optimum population'.

What is an optimum population?

In 1994 two groups of researchers, employing differing methodologies but arriving at similar conclusions, tackled the question of optimum population size. Gretchen Daily, Anne Ehrlich and Paul Ehrlich (1994) took energy consumption as a surrogate for consumption in general and argued that given a maximum energy production compatible with environmental limits and a global convergence toward what they reasoned to be per capita energy consumption compatible with a good standard of living, the optimum population size amounted to no more than two billion people. In contrast, David Pimentel and colleagues (1994) based their argument upon a calculation of the amount of sustainably managed land needed to support a single individual, concluding that three billion people might be adequately fed, but only between one and two billion could live in relative prosperity (assuming a self-sustaining and renewable energy system). In 2010 Pimentel et al. revisited the question and arrived at the conclusion that the planet could support two billion people at a European lifestyle.

More recently, Theodore Lianos and Anastasia Pseiridis (2015) examined optimum population from the perspective of sustainable Gross World Product (GWP). Exploring the notion of what might be considered optimal, they concede that

optimum population is impossible to estimate with any degree of accuracy. Indeed, Daily et al. (1994) similarly point out that shifting societal goals and technology will change what might be considered an optimum, and Tucker (2019) argues that Daily et al.'s energy constraint assumptions are now technically surmountable.

Importantly, Lianos and Pseiridis consider their value assumptions in some detail, basing their notion of welfare upon Aristotelian notions of 'the best life' in which the lower and upper bounds of population size are of consequence. Such a concept extends beyond meeting basic needs to a more expansive notion of social flourishing, including more subjective ideas regarding the value of nature. However, while what constitutes a good life may be subjective, ecological footprint and conservation of natural capital provide objective criteria from which to work, and with these assumptions stated, Lianos and Pseiridis provide an economic interrogation of optimum population showing the trade-off between welfare and population size if humanity remains within the Earth's biocapacity. With sustainable welfare rather than economic development per se as a goal, they argue that the adoption of European levels of welfare as a standard for a comfortable life could sustain a population size of 3.1 billion without exceeding the planet's biocapacity.

Christopher Tucker's (2019) *Planet of 3 Billion* arrives at an optimum population size similar to that of Lianos and Pseiridis, but he does so with differing assumptions. Tucker's 'biogeographical' approach rests on three assumptions: the necessity of rewilding a large portion of the planet, a degree of technological optimism regarding resource use efficiency, and a modern industrial level of welfare equivalent to a Swiss standard of living. Importantly, his concept of sustainability draws heavily upon E.O. Wilson's Half-Earth (2016) thesis, which aims to reverse the ongoing current mass extinction by rewilding half of the planet, with Tucker making the case that the conservation and restoration of ecosystem services are essential to not only the survival but the thriving of humankind. Thus, while Tucker adopts a similar measure of welfare to Lianos and Pseiridis and is perhaps more technologically optimistic, due to his subscription to the Half-Earth thesis, he has a far more restrictive conception of natural boundaries. Yet, it is also worth noting that Tucker's assumptions regarding ecosystem services and global catastrophic or existential risk are not universally endorsed (see Kareiva and Carranza, 2018), leaving a degree of uncertainty about one of the key 'objective' limiting assumptions in his estimate of sustainable human population.

While the estimates of optimum population in the above studies have ranged between one and three billion, there appears to be a convergence around three billion people as the maximum number at anything above basic need. Moreover, (as noted by Daily et al., 1994 and by Lianos and Pseirides, 2015) even if the figures obtained in these studies underestimated the environmentally sustainable population size by a hundred per cent they would still be below current and projected population sizes. Such estimates are somewhat supported by O'Neill et al.'s conclusion that, based on current socio-technical arrangements, a high-quality lifestyle for seven billion people would require resource consumption of between two and six times the sustainable level, implying that at this level of welfare the environmentally sustainable population size is between 1.2 to 3.5 billion. However, a critical insight of O'Neill et al.'s article is that, with a concerted effort, substantial social, economic and technical changes could considerably improve the ability to provide good welfare to the existing population, but that a growing population makes this more difficult:

> Given that the United Nations 'medium variant' prediction is for global population to rise to 9.7 billion people by 2050, and 11.2 billion by 2100, the challenge will be even greater in future if efforts are not also made to stabilize global population. (92)

Assumptions, values and sustainability

We see, then, that modelling assumptions and values are central to the question of what might be an 'optimum' population size. As O'Neill et al. (2018) show, in theory it is possible that with current social and technical arrangements the basic needs of the present world population could be met within planetary boundaries. However, basic needs fall very short of what many consider to be a good life. What is considered a sustainable maximum population not only depends upon planetary boundaries, but upon our definition of the good life and of what we value. O'Neill et al.'s and Hickel's work shows that it may be theoretically and technically possible to provide a good life for seven billion within planetary boundaries but only if our social values are changed. Moreover, our values are not de facto restricted to notions of human welfare, but may be expanded to include the consideration of members of other species, of entire ecosystems and of landscapes.

From this perspective, the concept of 'sustainability' itself becomes more complex and intangible. While the value placed upon different parts of the natural world must be arrived at through debate and discussion, our knowledge of the impact of the growth in the size and power of the social system upon the Earth system itself hypothesises boundaries to a safe operating space for humanity (Rockström et al. 2009). Since the environmental conditions of the Holocene have been conducive to the development and thriving of humankind, the precautionary principle provides good reasons to assume that, in order to avoid human suffering, sustain our civilisation and preserve the environments and other species we value, we must roll back our influence to remain within the parameters of the Holocene. Environmental sustainability is therefore a complex of both natural physical boundaries and values relating to both human wellbeing and the natural world – including the 'nature' which is the outcome of thousands of years of human action.

Inequality, justice and sustainability

We have seen how sustainability and a sustainable population size are profoundly value-laden, political and ethical notions dependent on the articulation of arguments defining the good life, what we consider to be just and fair, and the sort of environment in which we wish to live. Pimentel et al. (1994: 364) saw the choice before humanity as follows:

> Does human society want 10 to 15 billion humans living in poverty and malnourishment or 1 to 2 billion living with abundant resources and a quality environment?

Unfortunately, Pimentel et al.'s choice omits a critical dimension: global inequality. Those calculating sustainable population size, whilst rebutting simple distributional arguments, usually start with the assumption of equal resource distribution, but there is little reason to be optimistic that this might be achieved in the future. It is an unpalatable fact that the degree to which wealthier people are willing to tolerate the suffering of the poor in far-off places is also a choice relevant to the environmental sustainability of a given population size. Vast inequality between the Global North and South has been an enduring feature of the modern world and, while extreme poverty has declined, this is not due to a drive towards equality and the voluntary redistribution of resources but a

consequence of economic development and growth of the global economy. Cohen's (2017) observation regarding the persistence of malnutrition amongst millions as being partially the result of the food choices (consumption of meat and dairy) of those in the rich world pricing the poorest out of the global food market speaks volumes regarding the unintended consequences of everyday habits (see also Pseiridis 2012).

Without addressing the extent of global inequality, it is likely that the poor will bear the greatest cost of population growth and indeed of environmental degradation. Hickel (2018) argues that a fundamental reorientation of our approach to development is required to avoid this and, instead of concentrating on the deficiencies of poor countries, we should attend to the excesses of rich ones. While this is unquestionably true, redressing the imbalance between rich and poor whilst also attempting to live within planetary boundaries becomes increasingly less effective at improving welfare if population growth itself is left unattended to, since fewer resources must be distributed between an ever-greater number.

Yet the reticence of many in the environmental movement to acknowledge population growth as a problem is frequently based upon observations regarding the inequality between the Global North and Global South. Much of this is related to confusion surrounding the temporal disjuncture, noted above, between population growth rates and the growth of environmental impact consequent upon economic growth and increasing welfare and affluence. This confusion frequently leads to the accusation that those concerned about population growth are blaming the poor for an environmental crisis in which they have little culpability.[8] Indeed, when it is considered that the ecological footprint of the average American citizen is eight times greater than that of a citizen of Nigeria (GFN, 2021) this argument is understandable. Yet, like many other developing countries, a high rate of population growth is a significant driver of Nigeria's growing per capita ecological deficit. In contrast, since achieving a low rate of population growth, the USA's ecological deficit is almost entirely the result of the growth of affluence.

8 While it is the case that climate change and other environmental problems have been disproportionately generated by the rich world, as in previous eras, poverty and population growth can have a significant association with local environmental degradation such as deforestation (Lopez-Carr and Burgdorfer, 2013).

Moreover, 'population control' has been associated with imperialism, racism, eugenics and past coercive population policies such as those in China and India, and has somewhat understandably made the subject of population growth taboo. Even when the long-term desirability of accelerating the declining rate of population growth is acknowledged, many are uncomfortable with influencing fertility decisions because they are regarded as inseparable from personal autonomy and basic human rights. However, few actions are entirely self-regarding, and Diana Coole (2018) has noted that reproduction is an other-regarding act that has the potential to undermine the socio-ecological conditions of possibility for exercising individual basic rights. Perhaps most importantly though, ethical policies whose object is to lower fertility are in many instances emancipatory, transforming female subjectivity, enabling both men and women to take control of their own fertility and exercise choice in their family size, and frequently producing general improvements in welfare.

Moreover, it has been shown that, in conjunction with access to modern contraceptives, education, particularly of girls, is one of the most important factors in reducing fertility (Lutz, Butz and KC, 2014; Vollset et al., 2020). Not only does education develop the potential of individuals, enabling them to make informed decisions and improve their own lives, but it also improves the life chances of their offspring and of their communities. Improvements in female education are critical in breaking down patriarchal structures and roles, enabling women to participate more fully in the economy and develop occupations and careers, typically resulting in later marriage, lowering the fertility rate through increased birth-spacing and fewer pregnancies. Importantly, since the impact of climate change is likely to be greatest in developing countries with high rates of population growth, ethical family planning can not only support economic and social development, but strengthen the resilience and adaptive capacity of poor communities (Dodson et al., 2020).

Conclusion

The growth in the size of the human population is an indisputable factor in the unprecedented size and power of our social systems and their impact on the Earth system. Yet, as I have shown, the growth of population alone cannot account for the massive anthropogenic environmental impacts of modern society. As a powerful heuristic device, the I=PAT equation reminds us that environmental

impact is the result of the collective outcome of three factors: the level of resource consumption, the technologies employed and the level of population. In theory, changing any one of these factors will change our environmental impact. However, in the relationship between population and sustainability, values play a critical role both in how we materially provide for our current and projected populations and in understanding what size of future population might be environmentally sustainable and how we might achieve it.

The Holocene provided environmental conditions in which humankind thrived, but the growth in power and size of our social systems has led to environmental changes that threaten the stability of these conditions. In order to remain within the parameters of the Holocene, and thus avoid human suffering, sustain our civilisation and preserve the environments and other species we value, we must curtail our influence, including the size of our population. The possible size of an environmentally sustainable population is therefore a complex of both natural physical boundaries and values relating to both human wellbeing and the natural world.

Acknowledging and tackling population growth as a driver of environmental change requires a long-term perspective: the 'optimum' populations mentioned in this paper, even with a concerted effort, could take hundreds of years to achieve (Lutz and KC, 2010). However, the greater the delay in tackling such problems the more insurmountable the problem becomes. Bradshaw and Brook (2014) observe that demographic momentum could have been retarded if population growth had been tackled immediately after 1945 and the present environmental and social problems would thus have been avoided. Tackling the size of the human population is therefore a long-term investment in improving welfare for all whilst staying within planetary boundaries. There is an irony in the population denial of some environmental stakeholders who, whilst critical of the short-termism of modern society, fail to embrace the role of population in achieving the long-term objective of universally good welfare within planetary boundaries.

Adopting a long-term perspective means that ethical policies aimed at bending the population growth curve must be seen as complimentary to measures tackling the more responsive drivers of the environmental crisis: consumption and technology. The necessity of such an approach is demonstrated by the fact

that, so far, increases in CO_2 emissions due to population growth have been greater than the reductions achieved through technical advances (Chaurasia, 2020). As O'Neill et al. (2018) and Hickel (2018; 2019a; 2019b) have indicated, to provide everyone on the planet with the opportunity to have a good life, a radical restructuring of the global economy and provisioning systems is required. Reducing the footprint of the Global North and allowing that of the Global South to increase whilst simultaneously reducing the overall footprint of humanity to sustainable levels will require a reappraisal of what is meant by a good life across the world. Continuous growth in consumption is clearly incompatible with such ambitions, but so too is ignoring population growth.

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PEER REVIEWED ARTICLE

Stakeholders' Perceptions of the Linkage Between Reproductive Rights and Environmental Sustainability

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Abstract

The fulfilment of reproductive health and rights may have a synergistic relationship to environmental sustainability because it leads to lower fertility levels. With this in mind, and with the objective of increasing the legitimacy, funding and acceptance of reproductive health and rights, I conducted a mixed-methods qualitative study consisting of an online survey followed by in-depth interviews. I reached out to two groups of participants: stakeholders of the reproductive health and rights movement, and stakeholders of the environmental sustainability movement. I explored how stakeholders perceived the linkages between family planning, population growth and environmental sustainability. Results indicate that these stakeholders overwhelmingly support the integration of the reproductive health and rights ideological framework in a wider sustainability frame reflecting environmental considerations. I identified three barriers to both addressing and implementing the linkage: responsibility allocation injustice, colonialism and discrimination, and marginalisation. Environmental sustainability and reproductive health and rights stakeholders appear in favour of applying what could be considered 'environmental mainstreaming' to the reproductive

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health and rights field. Environmental sustainability stakeholders were more likely than reproductive health and rights stakeholders, who were more divided on this issue, to endorse the linkage and related concepts.

Keywords: family planning; reproductive rights; environmental sustainability; population ethics; population growth.

Scholars are increasingly drawing attention to the linkage between global population size, environmental degradation and climate change (Coole, 2016; Newman et al., 2014; The Lancet Planetary Health, 2019). My goal in this article is to analyse whether this linkage should be harnessed to increase the legitimacy, funding and acceptance of reproductive health and rights.

Access to reproductive health care and other programmes that facilitate the exercising of reproductive health and rights are underfunded (Girard, 2017; Pathak and Tariq, 2018) and politically vulnerable (Gilby and Koivusalo, 2020; Kaufman, 2020). Progress is unacceptably slow for reproductive rights, as numerous barriers to family planning continue to exist, particularly for vulnerable groups such as migrants, refugees and adolescents (UNFPA, 2016a, 2016b; United Nations Meetings Coverage and Press Releases, 2015). For these reasons, new pathways to respect, protect and fulfil reproductive rights need to be pursued.

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 the information and means to do so, and the right to attain the highest standard of sexual and reproductive health (United Nations Population Fund, 1994). As such, inadequate supplies of safe and effective contraceptives, including the range of methods available, general barriers to contraception and poor-quality services all contribute to reproductive rights violations (Hardee et al., 2014).

Studies of global emission scenarios demonstrate that slowing population growth could lead to substantial emissions reductions and play an important role in avoiding dangerous climate change (Bongaarts and O'Neill, 2018; O'Neill, et al., 2010). Population dynamics can therefore be perceived as a variable in climate change adaptation and mitigation. While much research still needs to be done

to better understand the drivers of human fertility (Sear et al., 2016), we know that access to family planning lowers fertility levels (Engelman, 2009; Engelman et al., 2016; Intergovernmental Panel on Climate Change, 2014). In turn, because the fulfilment of reproductive health and rights lowers fertility levels, these rights can be considered as positively related to environmental sustainability. Fulfilling reproductive health and rights may benefit environmental sustainability in multiple ways, going beyond its impact on fertility. For example, it might facilitate greater women's agency and, through that, improved stewardship of the environment (Bell and Braun, 2010; Lv and Deng, 2019; Morgan and Winkler, 2020).

Conversely, reproductive health and rights may benefit from environmental sustainability. Research demonstrates that climate change and environmental degradation are a direct threat for global health, and an important driver of health inequities (Costello et al., 2009; Patz et al., 2007; Sellers and Ebi, 2018; Watts et al., 2018) Moreover, linking the fulfilment of reproductive health and rights with improved environmental sustainability may change how reproductive health and rights are perceived, as they give rise to a different type of social appeal. Kimport (2016) documented how framing a sensitive issue in a new light (in that case, marriage equality) enabled it to appeal to new audiences, widen the cultural resonance of its claims and diversify its organisational structure. Reframing reproductive health and rights to include beneficial outcomes on environmental sustainability has the potential to strengthen these rights, and could generate new or broader programmatic and funding opportunities (Newman et al., 2014; The Lancet, 2009). It is with this in mind that I asked participants if the reproductive health and rights ideological framework should be integrated in a wider sustainability frame reflecting environmental considerations.

Yet the reproductive health and rights and environmental sustainability linkage (hereafter referred to as 'the linkage'), despite the opportunities that it might represent for both fields, remains largely understudied (Engelman, 2009; Murtaugh and Schlax, 2009; The Lancet, 2009). Scholars have documented many reasons for this status quo, at the heart of which are ethical dilemmas, the spectre of coercive population control programmes and misconceptions associated with population policy (Bongaarts and O'Neill, 2018; Kopnina and Washington, 2016; Newman et al., 2014). The need for a sustained critical analysis of the questions surrounding the linkage, and for finding ways to frame them in a politically and

ethically acceptable manner is well established (Coole, 2016; Newman et al., 2014). I address this understudied facet of the linkage by exploring how stakeholders of the reproductive rights and environmental sustainability movements perceive these issues.

Methods

A qualitative approach was chosen as the most appropriate methodology for this research project because it allows for exploring people's insights and perceptions of an experience or phenomenon, informing the development of interventions and understanding better barriers and facilitators to their successful implementation (Denny and Weckesser, 2019). I conducted a multi-methods qualitative research with data collection between March and September 2019. The study consisted of an online survey (N=153) followed by in-depth interviews (N=14) with key informants. I chose to perform an online survey to reach out to a large and global audience in a fast and efficient manner (Evans and Mathur, 2005). The in-depth interviews provided an opportunity to gather participants' perceptions and opinions in a more flexible and thorough manner. In both the survey and interviews, I focused on the perspectives and experiences of active stakeholders in the reproductive health and rights and environmental sustainability movements about the linkage and on how they dealt with its controversial nature. Eligibility was based on self-identification as being active in the reproductive health and rights and/or environmental sustainability movements. By 'active' I meant to identify people with a marked interest or concern for one or both of these movements and/or for whom these issues influence their work, activism, and/or engagement.

Data Collection: Online Survey

I recruited participants by contacting researchers, organisations and governmental bodies active in the reproductive health and rights and/or environmental sustainability fields as well as by circulating invitations through listservs, personal and professional networks and word-of-mouth. Conscious efforts were made in recruitment efforts to reach out to a wide variety of experts to reflect different viewpoints and to reach out to participants in various parts of the world for global representation. In total, we sent over 900 invitations. I made the survey available via SurveyMonkey, an online survey software, for a period of 46 days. The survey contained eight introductory background questions followed by sixteen multiple choice (close-ended) questions and thirteen open-ended questions, broadly

ordered by level of sensitivity. I used survey design guidelines to generate rich and clear content. For example, I ended the survey with an invitation to share any additional information that the participant felt was relevant (Braun et al., 2020).

Broadly, the survey consisted of questions on participants' backgrounds, perceptions and framing of the linkage, including on its controversial nature, opinions on the potential scope of related interventions, and perspectives on social norms related to fertility.

I obtained 153 complete responses, a number that is lower than but comparable to another expert survey on population and climate change (van Dalen and Henkens, 2021). I adopted a flexible approach to choose the sample size, one that recognises that an adequate number is relative, and must balance the richness of data with the depth of analysis (Sandelowski, 1995). Determining sample size was thus an iterative process guided by the adaptive approach of thematic saturation (Sim et al., 2018). Broadly speaking, thematic saturation is reached when no new ideas that critically change the overall findings emerge in new data (Mason, 2010).

Data Collection: In-depth Interviews

After completing the survey, participants were directed to a separate webpage and asked whether they wished to participate in a telephone/Skype interview. All participants who expressed an interest in the follow-up interview were contacted, and fourteen telephone/Skype in-depth, semi-structured interviews were conducted with those that responded to the invitation. The number of in-depth interviews conducted depended primarily on the number of online survey participants who agreed to participate in follow-up interview, but after completing the fourteen interviews, thematic saturation was achieved.

After obtaining each participant's consent, I conducted, recorded and transcribed all interviews in English. These lasted approximately 45 minutes. The interview guide consisted of 21 open-ended questions, broadly ordered by level of sensitivity. Each interview began with a review of the participant's background (age group, profession, country of origin/living) and engagement with the linkage. Questions followed on perception, framing, sensitivity, opportunities and governance related to the linkage, as well as on the acceptability of global population policies. These questions were drafted with the preliminary results of the online survey in mind. The in-depth interviews provided opportunities for

participants to steer the conversation towards their concerns and interests and allowed for a rich exchange experience.

Data Analysis

Across all the steps of this project, I engaged in researcher reflexivity by acknowledging and describing my position on this issue, and by bracketing my own biases during the research process (Tufford and Newman, 2012). I situated this project in a framework resting on the following axioms: anthropogenic impact creates environmental degradation and climate change (Whitmee et al., 2015); population size is a variable in anthropogenic impact (Ehrlich and Holdren, 1971); widening the ideological framework of reproductive rights to include environmental sustainability may present opportunities to advance the reproductive rights and health field (Newman et al., 2014). In order to avoid restricting the inquiry of participants' lived experience of the linkage, I refrained from adopting a pre-defined theoretical framework, a method known as 'theoretical agnosticism' (Pidgeon and Henwood, 2004).

Throughout the data collection process, I used memos to capture important themes and reflect on the meaning and significance of individual responses as well as on the data collection process and positionality. Each component of the study was analysed separately and sequentially, starting with the online survey. Excel and Survey Monkey were used to obtain descriptive statistics.

Online survey results were analysed by reviewing each participant response individually and sequentially. I strived to identify underlying themes presented through the data. To do so, I organised responses in a combination of pre-determined and emergent codes and categories (Elo and Kyngäs, 2008). In parallel, I paid special attention to outliers, or responses that did not fit in conceptual categories, and treated them as relevant findings manifestations of important human diversity (Mcpherson and Thorne, 2008). The NVivo software was used to help organise and manage individual responses data.

I developed the in-depth interview questionnaire while analysing the online survey results, and integrated some of the survey findings into the in-depth interview questionnaire. For example, I asked, 'In the survey results, numerous participants indicated that the population factor should be omitted because its relation to environmental impact isn't direct ... How would you react to this?'

I studied in-depth interviews in the light of the preliminary online survey themes. I also produced memos after each interview to reflect on the content and process of the interview (DeJonckheere and Vaughn, 2019). Memos were organised as a running list of thoughts and comments.

In the last phase of the analytic plan, I finalised a list of themes and key points emerging from both the online survey and in-depth interviews to discuss and went back to the raw data for further data investigation and quote extraction. Table 1 presents this list. All the emergent themes were included in the analysis of this paper, with the exception of education and fertility desire, which will be addressed in a separate paper.

Table 1: Emergent themes

Abortion
Capitalism
Climate skepticism
Colonialism
Cultural norms
Discrimination
Earth carrying capacity
Education
Environmental degradation and climate change
Fertility desire
Food security
Gender equality
Ignoring the linkage
Individual v collective rights
Interdisciplinary nature of the linkage
Marginalization
Population control and coercion
Population growth, size and reduction

Population size as a taboo
Poverty
Racism
Religion
Responsibility allocation injustice
Sexuality education
Strong emotional reactions

The themes arising from the in-depth interviews were broadly aligned with those of the online survey. While I start by presenting the results of the close-ended survey questions exclusively below, the rest of the paper presents the survey and in-depth interviews conjointly. Two investigative approaches were thus used: an online survey and in-depth interviews. Using different research methods contributes to enhancing the confidence in the ensuing findings. This process is called methodological triangulation (Mayer, 2015).

Ethics

I received approval to conduct this study from the Social Science and Humanities Research Ethics Board at the University of Ottawa (File #12-17-05). To protect the identity of the participants, all personally identifying data was masked or redacted.

Results

Participants' Characteristics: Online Survey

Table 2 provides an overview of online survey participants' characteristics.

Table 2: Online survey participant characteristics (N=151)

Characteristics		%	Number of participants
Regional group	Africa	21	32
	Asia	5	7
	Europe	25	37
	North America	43	65
	South America	3	4

Characteristics		%	Number of participants
	Global/ International	3	5
	No response	0.7	1
Age group	Under 35	28	43
	Between 35-50	38	57
	Over 50	33	50
	No response	0.7	1
Identified as	Environmental sustainability policymaker, academic or advocate	51	77
	Reproductive health and rights policy maker, academic or advocate	31	47
	Identified as both of the above	14	21
	Other	3	5
	No response	0.6	1
Participant titles	Director/CEO/ President/ Manager	17	25
	Officer/Advisor/ Consultant/ Specialist	38	57
	Engineer/ Scientist	5	8
	PhD/Master Student	22	33
	Teacher/Professor	9	14

Characteristics		%	Number of participants
	Other	5	8
	No response	4	6

Participants' Characteristics: In-depth Interviews

Of the fourteen in-depth interviews participants, ten came from the United States or Canada, and the four others came from Egypt, Holland, Nigeria and South Africa. I asked participants about their age: eleven were between the ages of 25 and 45 and three were over fifty. Their professions focused on reproductive health and/or rights (#6), the natural sciences (#4), law (#1) or both reproductive health and/or rights and environmental sustainability (#3).

Survey Results: Framing Reproductive Health and Rights in a Climate Emergency

In the online survey, I asked a series of close-ended questions to evaluate how participants felt that reproductive health and rights could or should be framed in the context of heightened environmental degradation and climate change. When participants were asked whether they were in favour of widening the ideological framework of the reproductive health and rights movement to reflect environmental sustainability considerations, a large majority from both movements agreed: 93 participants (62 per cent) accepted the proposition that the impact of environmental degradation on global health increased the relevance of population dynamics for reproductive health and rights policy (37 were unsure (24 per cent), and eighteen disagreed (eleven per cent)). Participants who identified as stakeholders of the reproductive health and rights field were more likely to disagree with this proposition.

Of all the participants, 92 (61 per cent) found that family planning could be considered as a pathway to resilience because of its impact on fertility levels (28 were unsure (eighteen per cent), and 28 disagreed (eighteen per cent)); 84 participants (56 per cent) found that the fact that slowing population growth could play an important role to avoid dangerous climate change should influence our understanding of reproductive health and rights (26 were unsure (seventeen per cent), forty disagreed (26 per cent)). Again, participants identifying as stakeholders of the reproductive health and rights movement were more likely to disagree with this proposition.

A large majority of participants (101, or 67 per cent) felt that we needed to strive to reconcile and integrate the linkage's fields to advance them both (21, or fourteen per cent, disagreed and eleven, or seven per cent, were unsure). Participants identifying as stakeholders of the reproductive health and rights movement were twice as likely to reject this premise and were less likely to approve it as well.

I asked whether population size related to environmental sustainability, and 127 participants (86 per cent) agreed with this proposition, indicating overwhelming agreement. Some pointed to the arithmetical role of population size to generate impact, 'YES – size is related to the magnitude of environmental impact', while others indicated that population size influenced land, water, and natural resource use as a whole. Survey participant 24, from the United Kingdom, wrote: 'Bangladesh has now over 160 million population and 85% of all cultivatable lands are already used. If population doubles what will happen?' Table 3 summarises online survey participants' reactions to statements about the connections between family planning, population growth and environmental sustainability.

Table 3: Participants' reactions to statements on the relationship between environmental degradation, family planning, and population growth

Statement/question	Answers	Number of participants	%	Notes
The impact of environmental degradation on global health increased the relevance of population dynamics for reproductive health and rights policy.	Agree	93	62	
	Unsure	37	24	
	Disagree	18	12	
	No response	3	2	
Family planning could be considered as a pathway to resilience because of its impact on fertility levels.	Agree	92	61	Reproductive health and rights field more likely to reject this proposition.
	Unsure	28	19	
	Disagree	28	19	
	No response	3	2	

Statement/question	Answers	Number of participants	%	Notes
Slowing population growth could play an important role to avoid dangerous climate change and should influence our understanding of reproductive health and rights.	Agree Unsure Disagree No response	84 26 40 1	56 17 26 1	Reproductive health and rights field more likely to reject this proposition.
We need to strive to reconcile and integrate the linkage's fields to advance them both.	Agree Unsure Disagree No response	101 11 21 18	67 7 14 12	
Does population size relate to environmental sustainability?	Agree Unsure Disagree No response	104 21 24 2	69 14 16 1	

Whilst a large majority of participants endorsed the linkage, a minority disagreed with the idea that reproductive health and rights and environmental sustainability should be linked. Many others were supportive of the idea of integrating reproductive health and rights and environmental sustainability but expressed concerns as to how to achieve this both at the conceptual and practical levels.

Survey Results: Outliers

A small number of participants' answers stood out from the majority of the data obtained, and these were considered as outliers. Two groups of outliers were identified: those who were sceptical of climate change and/or the depletion and degradation of natural resources, and those who considered that addressing the family planning and environmental sustainability linkage was a disguised way

to promote abortion and coercive reproductive health methods. Both groups consisted of a small number of participants, with nine for the first, and four for the latter. I hereafter present the three emerging themes that summarise the barriers that participants identified to address or implement the linkage: responsibility allocation injustice, colonialism and discrimination, and marginalisation.

Barriers to Addressing the Linkage: Responsibility Allocation Injustice

Many participants felt that there was a fundamental injustice inherent in the linkage, stemming from the contrast between the high consumption patterns/low fertility levels of the Global North, and the low fossil-fuel consumption/high fertility of the Global South. Survey participant 140, from Nigeria, wrote: 'While population size does have a role to play on environmental sustainability, the main culprits of climate change are countries whose populations are either stable or in decline.' Addressing the linkage was therefore contradictory or difficult for some as it was perceived as an unjust displacement of responsibility, targeting the wrong group (the Global South) with the wrong intervention (population size). Many participants stressed that consumption patterns, and a reliance on fossil fuel-based energy, constituted the primary driver of environmental impact. Whilst a large majority of participants agreed that population size was related to environmental sustainability, several were reluctant to address the role of population size because they perceived other factors to be more important in determining environmental impact.

One follow-up interview participant from the United States explained that she had developed a strategy to address the linkage without being perceived to unjustly allocate responsibility to groups with higher fertility levels. She stressed the importance of acknowledging this problematic:

> When I started out … I would make presentations in Sub-Saharan Africa, and the first thing I would get up and say is 'OK, let's just get this out: Climate change is my fault. It is my consumption and my country.' That sort of cleared the air. It wasn't me standing up and saying, 'Oh, you know, you people need to look at how many kids you have.'

A few participants feared that the linkage might exacerbate global injustices by spreading the idea that countries with higher levels of fertility were responsible

for environmental degradation and climate change, thereby freeing the Global North from part of its historical and ongoing responsibility in this matter. Survey participant 49, from the United States, wrote:

> In many ways, this focus on family planning and population size as a mitigating factor for climate change gives oil companies, western governments and others a pass when it comes to their culpability for the climate.

While many participants indicated that it tended to be the highest fertility groups that had the lowest environmental footprints, few addressed how changing standards of living might impact this status quo, despite global efforts to eradicate extreme poverty. Survey participant, 153, from the United States, wrote:

> You can have a relatively small population and with high living standards and a large environmental impact. Vice versa, you can have a relatively large population with many people living in poverty and a relatively small environmental impact. 'The rubber hits the road' where you want to raise living standards for a large and growing world population.

The relation between poverty, environmental degradation and climate change is a complex one, and participants identified poverty as being both a driver of environmental degradation and a barrier to addressing the linkage. Survey participant 77, from Canada, wrote:

> I worked in protected area conservation. Population pressures were often an issue. Some protected areas are the only remaining sources of cheap fuel (wood), food (bushmeat) or wildlife (for the wildlife trade). Poverty, more than population pressure, was the biggest risk factor.

Many participants stressed that achieving environmental sustainability was intimately associated to social justice goals. Survey participant 93, from Canada, wrote:

> The world has a carrying capacity for humans and economic activity that has to be determined and respected, otherwise humans and the environment will both suffer. Living within the [earth's] means is possible

> but the distribution of wealth needs to be considered so that there is enough for everyone instead of too much for a minority. Here is a new economic growth paradigm to consider pursuing, 'enough is best'.

Barriers to Addressing the Linkage: Colonialism and Discrimination

The next barrier to the linkage expressed by participants is closely related to the first one in that it is also rooted in the injustice stemming from systemic power imbalances between the Global North and Global South, and/or between discriminating and discriminated groups more broadly. The history of population control programmes and proponents' discrimination and human rights abuses contributed to the reluctance of several participants to perceive the linkage as a way to advance reproductive health and rights.

To a large extent, the above-described responsibility allocation injustice was associated to the systemic power imbalances illustrative of colonialism and discrimination towards women and marginalised populations, including indigenous people, racial/ethnic/religious/socio-cultural minority communities and people with disabilities, thereby creating a double injustice. Survey participant 109, from the United States, wrote:

> This feels like a tool to instrumentalize already vulnerable populations into serving a priority need identified by the Global North … It feels like another misguided attack on populations that are already subjected to the throes of Western powers.

Addressing the linkage involves delving deep into sensitive ethical questions related to reproductive health and rights, at the centre of which are access to family planning and fertility preferences. A few participants raised concerns of cultural imperialism. Survey participant 37, from Canada, wrote:

> I've heard women such as Nigerian scientist Obianuju Ekeocha argue that Western advocacy for contraception in Africa amounts to a kind of neocolonialism, an imposition of Western views that is contrary to some African views on fertility.

A few participants stressed that indigenous people's voices on the linkage needed to be heard because of their related history of abuse by colonialist powers and because of the wealth of their traditional wisdom on this subject.

Participants referred to the tangible and concrete negative environmental consequences of an increasing population size. While participants from all geographical locations expressed concern for the impact of population growth on land use, deforestation and water pressure, those from the Global South were more likely than those from the Global North to express this view. Survey participant 57, from Nigeria, wrote:

> Population size relates very much to environmental sustainability. In the days of our grandparents, farmers were able to practice shifting cultivation and that allows the soil to regenerate naturally. At the present, the population increase has reduced the size of cultivable lands available to individuals, and these lands are put into production yearly which leads to decrease in yield. Unless a conscious effort is put in place to replenish the soil, famine will be the end result in the future.

Participants from Africa referred to ongoing programmes aiming to stabilise or reduce fertility levels in their own countries (Democratic Republic of Congo and Nigeria), or to broader governmental interest on this issue. These participants did not express concern for the compatibility of these programmes with human rights, but pointed to the fact that they contributed to removing barriers to family planning. Survey participant 73, from the Democratic Republic of Congo, wrote:

> In my country, we have the department of Sexual and Reproductive Health. More activities are being implemented in this area: we have programs based on family planning, the use of condoms and contraception methods aimed at reducing the numbers of births and increasing births that are desired and birth spacing.

One participant from Sub-Saharan Africa explained that she avoided documenting the benefits of the linkage out of fear of displeasing external, Global North funders. Survey participant 140, from Nigeria, wrote:

> In my own context when implementing family planning programs, we tend to avoid references to the demographic and economic benefits of family planning and focus almost entirely on health benefits. This is largely because family planning is funded by external donors and as such viewed as being a means of population control by foreign governments.

Global North participants thus expressed fears of engaging in forms of neo-colonialism and Western imperialism by promoting or acknowledging the linkage. While such fears were echoed by some Global South participants, this group was also more likely to refer to the tangible and concrete negative environmental consequences of an increasing population size.

Barriers to Addressing the Linkage: Marginalisation

Marginalisation processes took place at multiple levels surrounding the linkage. First, because addressing the linkage is sensitive, it is easily and often avoided, ignored or minimised. Survey participant 8, from the United States, wrote:

> The environmental movement doesn't want to touch reproductive health and rights because they have become so sensitive. The reproductive rights movement is suspicious of efforts to link population dynamics with climate change – we need each community to be better educated on the topics – but minds are hard things to change.

At least thirteen participants also referred to religion as a related matter, constituting a barrier to recognising and acting upon the linkage. They pointed to the difficulty of addressing this issue with others from a different religion or culture, to the rejection of family planning by some religious traditions/interpretations and to the likely disapproval by some religious leaders and religious traditions of messaging encouraging smaller families.

Secondly, the linkage is marginalised because it is of an interdisciplinary nature, being situated at the crossroads of the fields of reproductive health and rights and environmental sustainability. Participants referred to the interdisciplinary nature of the linkage in several ways. Several pointed to opportunities that might arise for the environmental and reproductive health and rights movements

respectively, should they engage in a more inter- or trans-disciplinary approach. Survey participant 84, from Indonesia, wrote: 'Now more than ever there's a need to break down barriers and work for common, interlinked global goals.' However, many also identified interdisciplinarity as a barrier to addressing the linkage. Participants pointed to segregated funding streams, lack of multidisciplinary skills and training, and different language and interaction spaces as barriers created by the interdisciplinary nature of the linkage.

Compounding this problem were the general marginalisation of reproductive health and rights and environmental sustainability issues and how conceptually unrelated to each other these disciplines stood from each other. Survey participant 142, from the United States, reflected on the barriers to the integration of the reproductive health and rights and environmental sustainability movements:

> Perhaps the greatest barrier is that both the reproductive rights and environmental sustainability movements feel that they already have their backs to the wall on their siloed issue, a situation that can only worsen if they take on the other controversial issue.

Finally, at least one participant pointed to the fact that the environmental movement and discourse were more associated with a natural science approach. Survey participant 28, from the United States, wrote:

> As climate change has grown more salient within the environmental movement, the actors working within it have become more strongly integrated with the energy field, which is composed of more cautious, STEM-oriented professions than the more activist, liberal arts-oriented population that advocates most strongly for reproductive rights.

In the online survey, I also asked participants about topic sensitivity – that is, 'the level of uneasiness with which they would talk about an issue to others'. I asked participants to rate the linkage's topic sensitivity both in their professional and everyday lives. A large majority identified the linkage as highly or moderately sensitive, as opposed to somewhat or not at all sensitive. Table 4 presents these results.

Table 4: Topic Sensitivity

Setting category	Answers	Number of participants	%
Professional life	Highly sensitive	48	32
	Moderately sensitive	50	33
	Somewhat sensitive	29	19
	Not at all sensitive	20	13
	No response	4	3
Everyday life	Highly sensitive	39	26
	Moderately sensitive	60	40
	Somewhat sensitive	28	19
	Not at all sensitive	22	15
	No response	2	1

Several participants talked about the need to integrate the linkage into policy agendas and found that reducing sensitivity constituted one step towards this. Survey participant 8, from the United States, wrote: 'Thanks for doing this survey – we need to keep talking about this topic – and hopefully desensitize it'. I also asked whether participants felt reluctant to express their opinions in their professional fields on the linkage because of its associated stigma. A majority of those that responded indicated that the linkage was so important that it shouldn't be ignored. Survey participant 80, from Zimbabwe, wrote: 'No (I am not reluctant). Despite the stigma, this concern is to be addressed at all cost. I always find ways to engage the participants'. Those who felt reluctant to address the linkage feared being perceived as promoting a message that was at odds with reproductive autonomy or societal norms; evocative of past population control measures; or sexist or racist. Survey participant 13, from Kyrgyzstan, explained being reluctant to address the linkage because of the existence of strong patriarchal norms and practices. Participants pointed to the need to adopt a careful language when

raising the linkage to avoid being perceived negatively. Many also expressed that their reluctance was situation-dependent, where those who were in government or had to communicate to the public, media or policymakers found it more difficult than those who were in employment at research-based or academic workplaces. When asked about reluctance to address the linkage, survey participant 29, from Germany, wrote: 'Among colleagues, no. But when speaking to the public or policymakers or media, yes'. Participants who were reluctant to express their opinions explained that this was due to their professional environment's limited awareness on this issue, or to the fact that they expected their opinions to be dismissed if they expressed them.

Two categories of factors contributing to the marginalisation of the linkage as a subject matter can be identified. First, results indicate that conceptualising the fulfilment of reproductive health and rights as a tool or opportunity to further goals that reach beyond private and individual rights is a proposition that is highly contentious for some. A few participants perceived that the linkage epitomised the tension between individual and collective rights, and/or was evocative of the coercive practices that took place under population control policies.

The second factor contributing to the marginalisation of the of the linkage was uncertainty. Some participants had never encountered or reflected upon this issue prior to taking the survey, whilst others reflected on how little they knew of it. Many pointed to the lack of knowledge and unavailability of data surrounding this issue. Survey participant 137, from the United Republic of Tanzania, wrote: 'There is limited data and information on these linkages.' There was also widespread confusion about the positions of the reproductive health and rights and environmental sustainability movements towards the linkage. While a majority perceived it as being ignored or rejected by those working in their fields, a few viewed it as an accepted premise. Survey participant 129, from Canada, wrote: 'There is a common understanding that reproductive rights will result in population reduction which will reduce pressure on limited natural resources and the environment.'

Environmental sustainability stakeholders were much more likely than reproductive health and rights stakeholders to state that those working in their field recognised, or acknowledged, the linkage. Survey participant 147, from

Canada, wrote: 'Realistically, few people in reproductive health probably consider links with environmental sustainability.' Participants from both fields noted that younger persons working in their fields were more likely to endorse the linkage.

Marginalisation processes also took place at the individual level, as the linkage gave rise to strong emotional responses. Participants' responses indicated that they experienced a (sometimes very strong) emotional response when reflecting on the linkage. On one hand, the linkage's absence in the policy sphere caused a sense of disempowerment and anguish for many participants. They felt an urgent and strong need to include the role of population as a variable in generating environmental impact. Others expressed relief and gratitude for being given the opportunity to reflect, and/or for disciplinary inquiry into this field through this research. Survey participant 139, from India, wrote: 'I'm so glad you have created space to discuss this … And when you have high income country governments encouraging higher fertility it really makes me angry.' On the other hand, some participants expressed anger and frustration at the survey questions, which some felt were leading or offensive. Survey participant 108, from the United States, wrote:

> This survey made me really upset. It seems to be geared to finding ways to make neo-Malthusian arguments more palatable and politically correct. However, blaming climate change on Global South women's childbearing habits is insidious and fundamentally misguided.

Discussion

Results indicate that stakeholders of the reproductive health and rights, and environmental, movements find that population size and family planning influence environmental sustainability, and overwhelmingly find that the reproductive health and rights ideological framework should be integrated in a wider sustainability frame reflecting environmental considerations. A majority of participants agreed with a number of propositions related to that central idea, such as: the impact of environmental degradation on global health increases the relevance of population dynamics for reproductive health and rights policy; family planning could be considered as a pathway to resilience because it lowers fertility levels; our understanding of reproductive health and rights should consider the fact that slowing population growth could play an important role to avoid dangerous climate change; the fields of reproductive health and rights and environmental sustainability

ought to be further integrated. Participants also overwhelmingly considered the concept of planetary health as being relevant to the reproductive rights field, with 104 participants (seventy per cent) in favour, 24 (sixteen per cent) in disagreement, and 21 (fourteen per cent) unsure. Based on the idea that human health and the health of the planet are related, planetary health adopts a multidisciplinary, cross-sector and transborder approach. It views population numbers as one of the factors triggering human-induced environmental change and identifies the reduction of population growth as an essential step to move humanity towards a more sustainable trajectory of development (Whitmee et al., 2015).

I deduce from these results that environmental sustainability and reproductive health and rights stakeholders are in favour of applying a planetary health approach, or what could be considered as 'environmental mainstreaming' to the reproductive health and rights field. Environmental mainstreaming is defined as 'the informed inclusion of relevant environmental concerns into the decisions of institutions that drive national, local and sectoral development policy, rules, plans, investment and action' (Dalal-Clayton and Bass, 2009, p.19, as cited in Bizikova et al., 2018) social and environmental dimensions of sustainable development. Existing multilateral environmental agreements (MEAs). Scholars have suggested two mutually supportive approaches for environmental sustainability: mainstreaming, or integration of related objectives, and the dedicated approach, which is developing stand-alone policies and programmes (Runhaar et al., 2018). A majority of participants were in favour of applying environmental mainstreaming to the reproductive health and rights field, an approach already called for by reproductive health and rights researchers (Newman et al., 2014).

A minority of participants favoured a dedicated approach for reproductive health and rights concerns, one that would exclude environmental considerations from its theoretical framework. Dedicated approach supporters perceived a fundamental incompatibility between human rights, perceived as individual, and environmental objectives, perceived as collective. Recent reproductive health and rights research calling for 'a radical reconceptualisation of family planning goals and measurements to focus exclusively on reproductive health, rights and justice' illustrates this position (Senderowicz, 2019, p.1).

We have seen that environmental sustainability stakeholders were more likely than reproductive health and rights stakeholders to endorse the linkage and related

concepts. The conceptual divide between proponents of a more integrated as opposed to a more dedicated approach to the linkage has the potential to create a schism both within the reproductive health and rights movement and with other disciplines, as reproductive health and rights are re-conceptualised in the context of a climate emergency and as sustainability is mainstreamed across sectors (Chakrabarty, 2009; The Lancet Planetary Health, 2019; Urwin and Jordan, 2008). Such a schism risks isolating the reproductive health and rights movement from other disciplines, and might also weaken the base of the reproductive health and rights movement as conflicting discourses emerge. Moreover, endorsing the linkage means that the reproductive health and rights movement could diversify and broaden the moral appeal of its rights, and access a range of new programmatic and funding opportunities associated with environmental sustainability. Rejecting the linkage would thus constitute, at the very least, a missed opportunity for the reproductive health and rights movement. As Newman, Fisher, Mayhew and Stephenson already concluded in 2014, 'if sexual and reproductive health and rights advocates do not participate in the population dynamics discourse, the field will be left free for those for whom respecting and protecting rights may be less of a priority' (2014, p. 53).

The survey and in-depth interview findings highlight that the linkage is shrouded in uncertainty, with many participants indicating that they had no or very little knowledge on this issue. The findings show that the positions of the reproductive health and rights and environmental sustainability movements on the linkage were unclear, with stakeholders expressing contradictory views on what those positions were. Many deplored the lack of discussion and research on this. These findings corroborate the fact that the linkage is generally absent from environmental policy and research, even more so from the reproductive rights field, where a resistance to discussing population is rife (Bongaarts and O'Neill, 2018; Engelman, 2009; McFarlane, 2014; Newman et al., 2014; Speidel et al., 2009). There were inconsistencies in the way in which Global North and Global South participants perceived each other's positions. Several Global North participants felt that, on the grounds that they had shrinking fertility levels, endorsing the linkage risked amounting or amounted to a form of neo-colonialism targeting the Global South, and should therefore not be raised by them. On the other hand, a few Global South participants stressed that they wished to acknowledge the linkage in their work but were limited from doing so because their Global North funders were reluctant to engage with the population size question.

The interdisciplinary essence of the family planning and environmental sustainability linkage brings both opportunities and challenges. Focusing on the linkage and adopting interdisciplinarity is needed to tackle complex problems such as global environmental degradation and climate change (Orr et al., 2020). It allows a movement out of restricted disciplinary boundaries and provides unique opportunities to advance such questions (Bammer, 2013; Orr, et al., 2020). Yet interdisciplinarity also brings limitations, both procedural and conceptual, many of which were identified by participants. In this case, barriers associated with interdisciplinarity are compounded in several ways. Firstly, the lack of funding and volatility of political commitments to address both reproductive health and rights and environmental sustainability exacerbates the sensitive nature of the linkage (Howes et al., 2017; Starrs et al., 2018). Secondly, the disciplines at play in the linkage are so fundamentally different that knowledge exchange and communication are problematic between their actors. Moreover, not only are the disciplines separate, but they are also unequal. Climate change and environmental degradation have been primarily studied and represented from a natural sciences perspective, one where social sciences (including interdisciplinary perspectives that focus on human rights) are largely under-represented, and often relegated to a secondary position (Corbera et al., 2016; Hulme, 2011; Mason and Rigg, 2019, p.6; Paterson, 2019)we explore the social scientific networks informing Working Group III (WGIII.

Limitations

The goal to reach stakeholders from all United Nations regional groups to have a global representation wasn't met. Not only did the survey lack representation from the Eastern European Group, but participation disproportionally came from Western Europe and North America, which skewed the results. Language was also a limitation in this study, with the survey offered only in English, thereby creating a significant bias for global representation. Last, the sample size of the in-depth interviews was limited to those that responded to the invitation after the online survey. While the determination of sample size depends on the scope and nature of the study in qualitative research, general guidelines for this method of inquiry tend to be over twenty, which is above our number of fourteen (Marshall et al., 2013). I countered some of the limitations associated with surveys by undertaking in-depth interviews with a sub-section of participants, and by identifying myself in the same way as the study participants, as a stakeholder in the environmental and reproductive health and rights movements (Pfadenhauer, 2009).

Conclusion

We conclude that a large majority of stakeholders of both the reproductive health and rights and environmental sustainability fields wished to reflect and act upon the linkage between reproductive rights, population size and environmental sustainability in a more systematic manner.

We identified that stakeholders of the reproductive health and rights and environmental sustainability fields overwhelmingly supported the idea of integrating reproductive rights in a sustainability frame, thereby opening significant programmatic and conceptual opportunities for both movements. More specifically, these findings corroborate that the linkage can play a role to increase the legitimacy, funding and acceptance of reproductive health and rights. Acknowledging the linkage may mean that reproductive health and rights become eligible for climate funds, for example (Davies, 2021).

We found that stakeholders of the reproductive health and rights movements were more likely to be divided on the re-framing of reproductive rights in an over-arching sustainability context than their environmental peers. The latter overwhelmingly supported the integration option, which we equated to a process of environmental mainstreaming. Proponents of integrating environmental sustainability considerations into the ideological framework of the reproductive health and rights ideological framework are at the crossroads with those who adopt a more dedicated approach, one where reproductive rights are perceived as incompatible with larger environmental goals (Newman et al., 2014; Senderowicz, 2019). More research will be required to identify ways to bridge the divide and promote environmental mainstreaming in ways that are responsive to the concerns that were associated with the linkage (the responsibility allocation injustice, colonialism and discrimination, and marginalisation). Additionally, further research is warranted to better understand how Global South stakeholders perceive the linkage.

The findings also highlight that uncertainty surrounding the linkage is pervasive, and suggest that policy makers and organisations active in the fields of reproductive health and rights and environmental sustainability should make their position on this issue more explicit.

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PEER REVIEWED ARTICLE

Public Perceptions on Population: US Survey Results

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Abstract

The Center for Biological Diversity conducted a paid, self-selected, national online survey on the knowledge, attitudes, behavioural intentions and norms around population growth to inform a theory of change that highlights education and reproductive healthcare as solutions. We surveyed 899 people across the US. The sample was recruited via MTurk and Survey Monkey was used to collect the data. Results were segmented by demographics to assist in building culturally sensitive, inclusive and effective campaigns advocating for rights-based solutions to population growth. Results demonstrated that the public draws a correlation between the number of people on the planet and the alarming rate of animal extinction.

Keywords: population; wildlife; perceptions; survey; segmentation

Background

Our growing population is taking a devastating toll on wildlife and the environment (Bologna and Aquino, 2020). The effects can be seen on the climate (Stephenson et al., 2010), ecosystems (O'Bryan et al., 2020) and biodiversity (Ceballos et al., 2015). Over the past fifty years, as human populations have doubled, wildlife populations have plummeted by more than half (World Wildlife

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Fund, 2020). Human population pressure imperils wild plants and animals and the habitat they need to survive in myriad ways, including agriculture, grazing, fossil fuel development, logging, urban sprawl, climate change, invasive species and pollution (Czech et al., 2000; Díaz et al., 2019; Ganivet, 2019; World Wildlife Fund, 2020). Researchers have warned that, in order to avoid climate catastrophe and disastrous biodiversity loss, we must slow population growth and decrease consumption (Ripple et al., 2017; Díaz et al., 2019; Bradshaw et al., 2021).

Currently over 200,000 people are added to the planet every day, but the rate of growth varies by region. Europe has the lowest total fertility rate of 1.61 children per woman, followed by North America (1.75), Latin American and the Caribbean (2.04), Asia (2.15), Oceania (2.36) and Africa (4.44) (United Nations, Department of Economic and Social Affairs, 2019). Meanwhile, a 2019 UN report on biodiversity loss says a million species are at risk of extinction in the coming decades due to human activity (United Nations, 2019). Fifty per cent of the world's habitable land has been converted for crops or grazing (Ritchie and Roser, 2019) contributing to a 68 per cent reduction in wildlife population sizes across the globe since 1970 (World Wildlife Fund, 2020).

There is little doubt that humans are responsible for the species extinction crisis we are currently experiencing. While our impact has accelerated since industrialisation (Ceballos et al., 2015), with 94 per cent of species loss occurring in just the past century (Ceballos et al., 2020), this is not a new phenomenon. Human colonisation patterns can serve as predictors of increased extinction rates going back thousands of years (Andermann et al., 2020). The presence of people affects wildlife in positive and negative ways. In response to the sounds of humans, pumas left their prey, took longer to return to their prey and reduced their overall feeding time by more than half (Smith et al., 2017). Similarly, hearing humans affected badgers' feeding regimes – when they started, their vigilance, time spent foraging and number of badgers feeding (Clinchy et al., 2016). Such responses have cascading implications for whole ecosystems. Alternatively, land managed by Indigenous people and local communities can help maintain biodiversity and experience a lower decline in nature compared to other areas (Díaz et al., 2019). Traditional practices of species-diverse farming, habitat restoration and prevention of deforestation and other extractive processes help protect ecosystems (Díaz et al., 2019; Project Drawdown, 2020).

Our addiction to fossil fuels, massive habitat destruction and unsustainable consumption not only drives the extinction and climate crises but also disproportionately harms Black, Indigenous and other communities of colour that face outsized threats to their air, drinking water and neighbourhoods (Sellers, 2020). The disparity between those contributing to climate change via carbon dioxide emissions and those experiencing the effects most drastically is also seen on the global scale. The impact of a region is rarely proportional to its population size. North America makes up five per cent of the global population but is responsible for nineteen per cent of consumption-based carbon dioxide emissions, which includes direct emissions, plus the emissions caused by the production of imported goods and minus the emissions of exported goods. Asia has sixty per cent of the global population and is responsible for 52 per cent of emissions, and Europe has ten per cent of the global population and is responsible for eighteen per cent of emissions. In the regions threatened by some of the worst impacts of climate change, such as sea-level rise and high temperatures, emissions are significantly lower particularly in relation to population. Latin America and the Caribbean has nine per cent of global population and six per cent of emissions, Africa has sixteen per cent and three per cent respectively, and Oceania just 0.5 per cent of population and 1.3 per cent of global emissions (Le Quéré et al., 2018; Ritchie and Roser, 2020).

Affluence influences consumption, both individually and systemically, and has been deemed an environmental threat in and of itself, inspiring dedicated warnings from experts (Wiedmann et al., 2020). A country's affluence expands its impact beyond its own borders. The land and ocean footprint of nations increased by a third for each doubling of income. This increase came primarily from imports, which grew proportionally to income, demonstrating the disproportionate global environmental and economic impact wealthier countries have because of higher consumption (Weinzettel et al., 2013). Consumption per capita has been increasing over time, while the Earth's ability to support this decreases. Some researchers argue that overconsumption drives unsustainable economic growth (Barrett et al., 2020). Although consumption rates and destructive production practices, particularly in the energy and agriculture sectors, have exceeded the rate of population growth in recent decades, it cannot be ignored that global population has more than doubled over the past fifty years, increasing ecological demands to meet basic needs. Thus, we argue that global population growth and the associated uptick in level of consumption are inherently intertwined and both

put pressure on the environment equally. Even though consumption patterns appear to be inversely related to fertility rate, it doesn't mean that one is a bigger threat than the other; both must be addressed since they are interacting threats.

Solutions exist for reducing consumption and related ecological impacts while conserving biodiversity; however, this paper will focus on the solutions to population growth. Education, empowerment and gender equity can slow population growth and improve environmental and health outcomes. Project Drawdown lists the education of women and girls and family planning as top climate change solutions that can save more than 85 gigatons of carbon dioxide emissions by 2050, since women with more years of education have fewer and healthier children and actively manage their reproductive health (Project Drawdown, 2020).

Having one less child is one of the most effective ways for individuals in the United States to reduce their greenhouse gas emissions (Wynes and Nicholas, 2017). In fact, it's more effective at reducing emissions over a lifetime than many other personal actions, like recycling and driving a hybrid car, combined (Wynes and Nicholas, 2017). Yet government resources on climate change from the European Union, United States, Canada and Australia fail to educate people about this solution, instead focusing recommendations on lower-impact actions (Wynes and Nicholas, 2017).

Despite the cross-disciplinary evidence demonstrating the links between human population growth and environmental crises, the topic is often treated as controversial. Diana Coole, professor of political and social theory at the University of London, analysed five perspectives found predominantly in high-income countries that drive the pushback on population advocacy work. They include population-shaming (population work is inherently racist), population-scepticism (population density is beneficial), population-diclinism (population isn't an issue because growth rates are slowing), population-decomposing (only addressing the components of population pressures, rather than population growth as a whole) and population-fatalism (the problem is too big and complicated to even try to solve). Population-shaming and population-scepticism are especially powerful because they, respectively, make the work morally untouchable and attempt to dismiss the issue by invoking pro-growth arguments (Coole, 2013).

The lack of acknowledgment of population growth as an environmental problem also creates a self-perpetuating knowledge gap. One study analysed this gap by surveying educators about their perspectives on the topic and found that lack of expertise is among the reasons for hesitancy about discussing population growth in their classes (Alkaher and Carmi, 2019).

Despite these barriers to discussing human population growth, many people are making the connection between family planning and the environment. In one study, nearly sixty per cent of climate-concerned respondents reported being 'very' or 'extremely concerned' about the carbon footprint of having children (Schneider-Mayerson and Leong, 2020). More than 96 per cent of respondents were 'very' or "'extremely concerned' about the wellbeing of their current, future or hypothetical children in a world altered for the worse by climate change (Schneider-Mayerson and Leong, 2020). Another study found that participants cited the unsustainable number of people on the planet as a major concern about starting a family, in addition to how human population growth contributes to overconsumption (Helm et al., 2021).

The most effective and ethical solutions to population growth are those that advance human rights, such as education for all, voluntary family planning, universal access to contraception and reproductive healthcare, including abortion (Engelman and Johnson, 2019; Guillebaud, 2016; Liu and Raftery, 2020; Vollset et al., 2020). When people have the ability to choose if and when to have children, they tend to have smaller families. And when there is gender equity, including girls staying in school and having equal opportunities, they tend to delay starting a family, increase the length of time between births and have fewer children overall, which also benefits the planet.

Objective and Scope

In the winter of 2019, the Center for Biological Diversity conducted a nationally representative survey to analyse awareness, knowledge, beliefs, attitudes, perceptions, actions, behavioural intention and norms/morality around the topic of population. By including questions about population growth in the survey, we hoped to understand whether the public draws a correlation between the number of people on the planet and the alarming rate of animal extinction and to use the results to help us inform a theory of change. For campaigning organisations, such

as The Center for Biological Diversity, creating an internal theory of change can help in building effective campaigns to reach people, no matter where they fall on the scale of understanding. Each question in the survey corresponded to a step in our draft theory of change which includes:

1. Knowledge: Move people from total unawareness of the issue to becoming aware and increase their knowledge of issue.

2. Attitudes: Alter people's attitudes and perceptions of the issue, measured by an increase in awareness and knowledge.

3. Norms/Morality: Amplify positive social norms, some specific to morality, related to the issue so that people begin to see and hear the norms more regularly.

4. Behaviour Change: Help people prepare to change their behaviour by increasing their behavioural intentions around the issue. Support the removal of barriers to action, leading one to finally act at both the individual and systemic levels.

Methods

Survey sampling plan

We surveyed 899 people distributed evenly across each of the fifty US states and the District of Columbia proportionate to the US Census Bureau's 2018 Current Population Survey estimates to achieve statistically accurate results (95 per cent confidence level). To calculate a minimum sample size for a 95 per cent confidence level, we used the Sample Size Calculator available online at OpenEpi2 (Dean et al., 2013). We assumed a large population (N = 1,000,000), a fifty per cent frequency in the population of each measure with +/- 3.5 per cent confidence limits and a design effect of 1.00. Given these criteria, a 95 per cent confidence level required a minimum of 784 survey respondents. Given available resources, we were able to fund a total of 899 surveys, after quality control removals (detailed below). Therefore, the 95 per cent confidence level margin of error for an 899 individual survey is less than +/- 3.5 per cent. The sample was recruited online via the Amazon Mechanical Turk (MTurk) platform (Available at: www.mturk.com) using both an English and Spanish survey instrument; and Momentive Inc. Survey

Monkey (Available at: www.momentive.ai) was used to collect the data. We paid respondents between $0.60 and $1 to take the eight-minute survey. In short, we employed a stratified voluntary response sampling method.

Survey content

The survey contained questions about population, consumption, voluntary family planning and climate change. Some of the questions were also included in a previous survey, conducted in 2013, allowing us to gauge change over time. Specifically, we asked two knowledge questions, thirteen new attitude/perception questions, five previous attitude/perception questions, two barrier and benefit questions, fourteen behavioural intention/behaviours conducted questions, two social norming/morality questions, two quality control questions and twelve demographic questions. This article summarises the subset of questions about population. The survey asked respondents to indicate the importance of a variety of social issues and tested basic knowledge around population growth. Finally, it asked whether people were comfortable talking about population and what types of actions they'd already taken or would be willing to take to advocate around the issue. Demographic questions included age, gender identity, race, state, political affiliation, income, education and religion, as well as whether respondents already have children and if they plan to have more. This broad range of demographic questions, as well as the variety of questions around knowledge, perceptions and willingness to take action, allowed for an in-depth analysis of how different audiences may vary on these issues.

Survey analysis

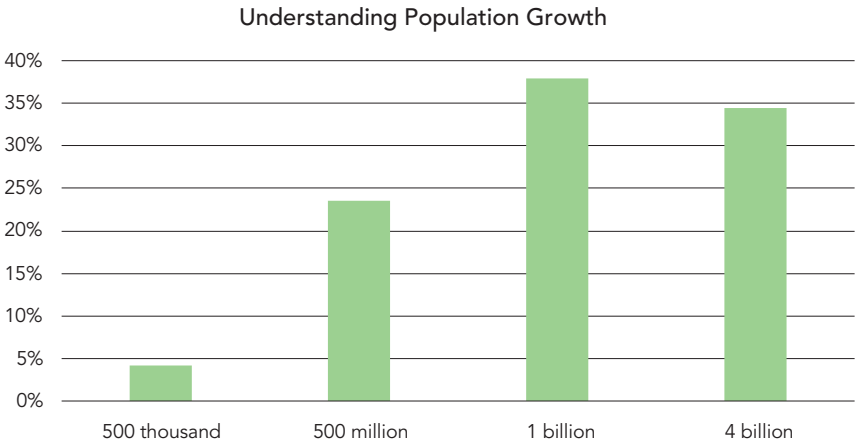
We used a series of basic statistical approaches to conduct survey analysis using SPSS. Demographics of the sample were summarised with univariate (descriptive) statistics, in particular frequencies and proportions for categorical variables. We treated Likert Scale-styled items categorically. We further described subpopulations of our survey sample with bivariate statistics ('crosstabs'). We implemented several quality-control (QC) measures into our survey. We eliminated respondents who completed the survey in under four minutes, as it could not be taken thoughtfully in less time than that. We asked respondents' age and birth year at separate points within the survey. This allowed us to compare the birth-year derived age with the reported age and we eliminated respondents whose stated age and birth-year derived age deviated by more than one. We also removed those who failed the attention check questions.

Results

The survey was broken down into categories to help build a theory of change cycle to inform future Center for Biological Diversity campaigns. The theory of change included increasing awareness of these interconnected issues, altering attitudes and perceptions around the topics, and increasing behavioural intention that leads to action, advocacy and a change of social norms. As such, certain questions were about population knowledge level, morality, norms and actions. Below is a summary of key findings related to population growth.

Knowledge: As shown in Chart 1, only 34 per cent of respondents knew that four billion people have been added to the world's population since 1970. Four per cent answered 500,000, 24 per cent answered 500 million, 38 per cent answered one billion.

Chart 1: Knowledge: Approximately how many people do you think have been added to the world's population since 1970?



Attitudes: Respondents were asked to rank the issue most important to them from a list of social and environmental concerns. According to Chart 2, lack of healthcare access was the most critically important topic (43 per cent) for respondents, followed by the climate crisis (37 per cent). Human population growth was ranked last.

Chart 2: Attitudes: Indicate the level of importance each topic is to you

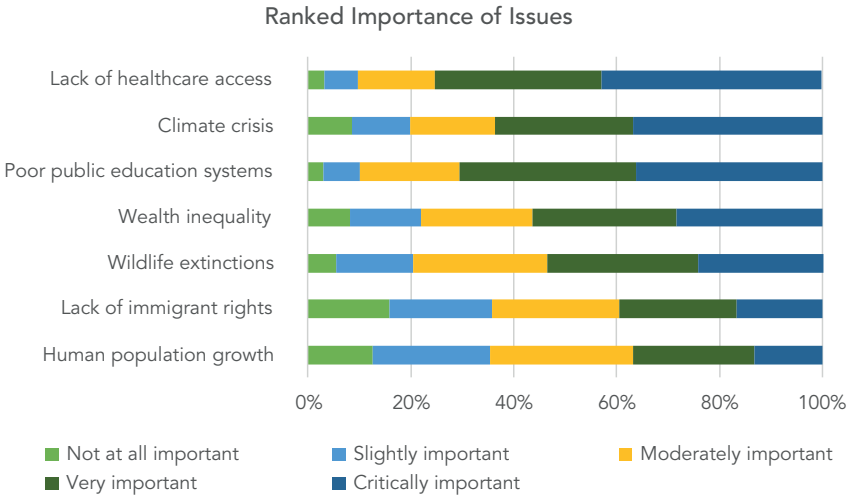


Figure 1: Attitudes: What do you think is primarily responsible for the rapid loss of species biodiversity?

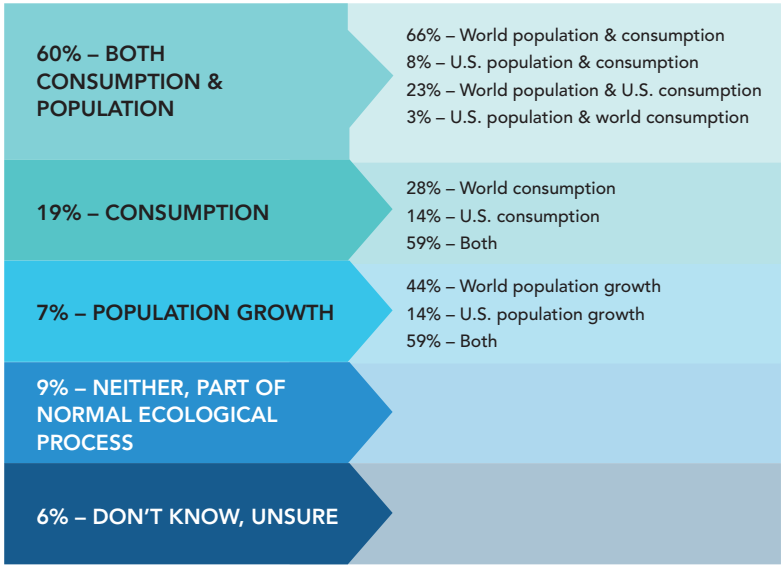


Figure 1 summarises the main question: what is responsible for the rapid loss of species biodiversity? Sixty per cent of respondents said both population growth and consumption levels are responsible for the rapid loss of species biodiversity. Using the responses from this question, there were additional Survey Monkey logic based sub-questions. Of this sixty per cent, 66 per cent believed the world's population and consumption are at fault. Of the seven per cent that believed population to be the only issue, 44 per cent believed world population growth is the primary cause, twelve per cent believed US population growth is the main cause, and 44 per cent believed it is both world and US population growth.

Some of the questions were duplicative of survey questions used in 2013. Each of these questions showed large statistically significant changes in attitudes from 2013 to 2019. As shown in charts 3, 4 and 5, nearly three-quarters of respondents (73 per cent) thought the world's population is growing too fast which is a 23 per cent increase over 2013 survey results. The same number (73 per cent) somewhat agreed or strongly agreed that human population growth is driving other animal species to extinction, a thirteen per cent increase over 2013 survey results. Finally, two out of three respondents (67 per cent) somewhat agreed or strongly agreed that stabilising population growth will help protect the environment, a thirteen per cent increase over 2013 survey results.

Chart 3: Attitudes: In 2018 the world population reached 7.6 billion. The world's population is projected to reach 11 billion by the end of the century. Do you think the world's population is growing

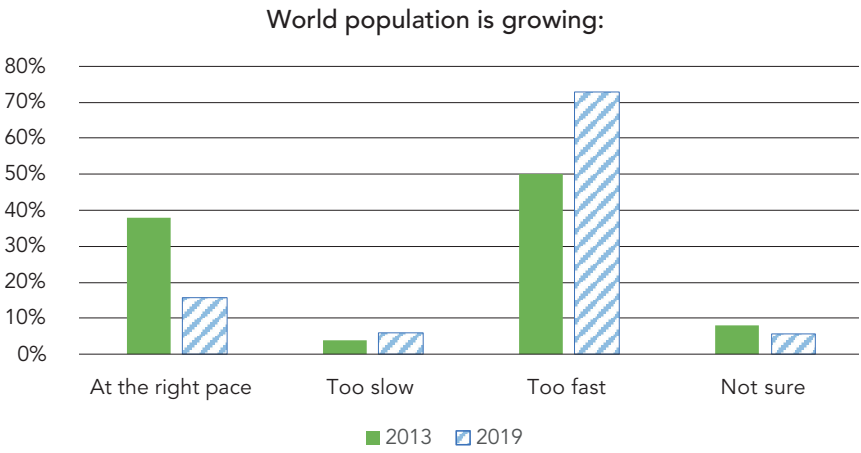


Chart 4: Attitudes: Rate whether you agree or disagree with the statement 'Human population growth is driving other animal species to extinction'.

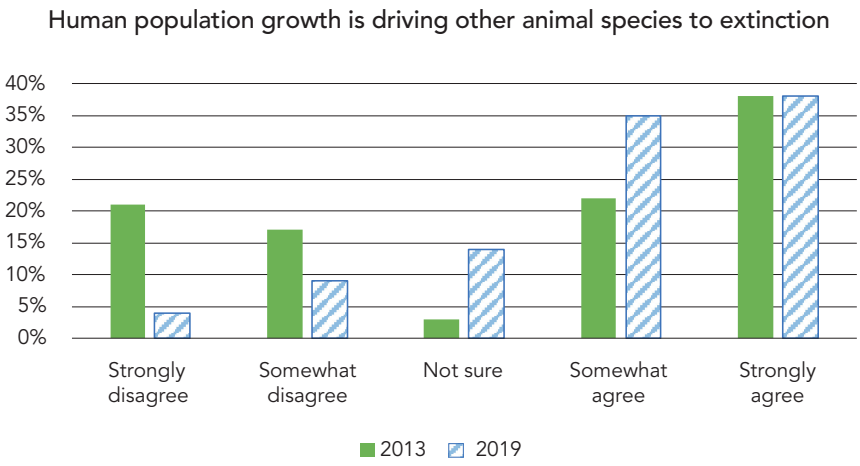
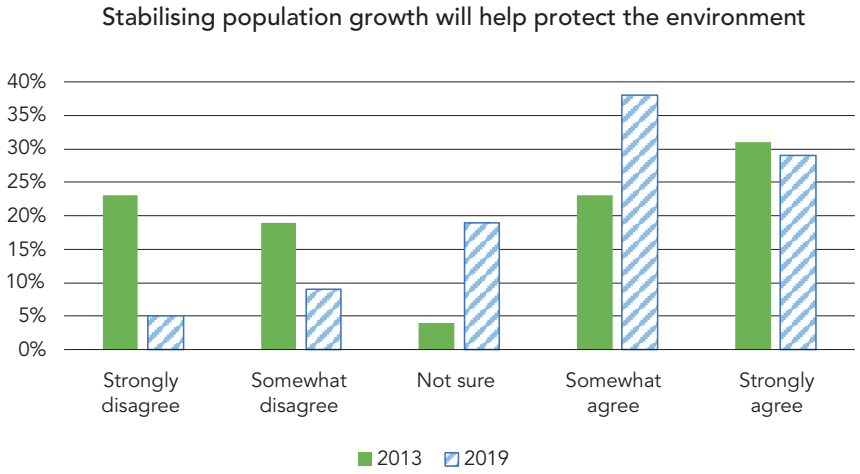


Chart 5: Attitudes: Rate whether you agree or disagree with the statement 'Stabilising population growth will help protect the environment'.



Norms/Morality: The vast majority (85 per cent) of respondents felt a moral responsibility to prevent wildlife extinctions and, using this question, the following crosstabs were calculated. As noted in Table 1, of the 85 per cent that believed society has a moral responsibility to prevent wildlife extinctions:

- Two out of three (65 per cent) indicated both population and consumption are primarily responsible for the rapid loss of species biodiversity. This was a five per cent increase over responses from the total sample.

- Two-thirds (67 per cent) felt no challenge discussing the topic of population growth with others. This was a ten per cent increase over responses from the total sample.

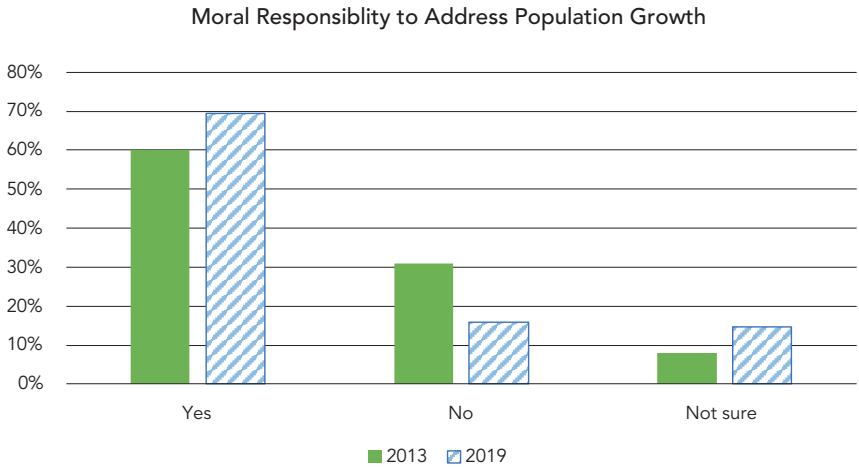
- One-third (34 per cent) voted for policymakers who acknowledge that population pressures impact the environment. This was a three per cent increase over responses from the total sample.

Table 1: Norms/Morality Crosstab Results

Of the 85% that believed society has a moral responsibility to prevent wildlife extinctions:	**Per cent**	**Per cent increase over responses from total sample**
Indicated both population and consumption are primarily responsible for the rapid loss of species biodiversity.	65%	5%
Felt no challenge discussing the topic of population growth with others.	67%	10%
Voted for policymakers who acknowledge that population pressures impact the environment.	34%	3%

As noted in Chart 6, more than two thirds (69 per cent) of respondents said that, if widespread wildlife extinctions are unavoidable without slowing human population growth, our society has a moral responsibility to address population growth. This was a nine per cent increase over 2013 survey results – the lowest positive change among the questions that were asked in both the 2013 and 2019 surveys. Among those who felt a moral responsibility to address population growth, 72 per cent felt no challenge discussing the topic with others and 33 per cent were more likely to vote for policymakers who acknowledge that population pressures affect the environment. Those who felt a moral responsibility to address population growth were 27 per cent more likely to vote for policymakers who support reproductive rights.

Chart 6: Norms/Morality: If widespread wildlife extinctions are unavoidable without slowing human population growth, do you think our society has a moral responsibility to address population growth?



Actions: The survey included many behavioural questions on both behavioural intention and actions already taken, some of which are noted by the Overpopulation Project (The Overpopulation Project, n.d.), and ranged from easy-to-do to harder-to-do. Generally, one-third of respondents said they were willing to act if they had more information on how to act. The population-specific actions offered in the survey and summarised below and in Chart 7 are:

1. Educate myself about population growth

2. Write population issue opinion pieces for local news media and

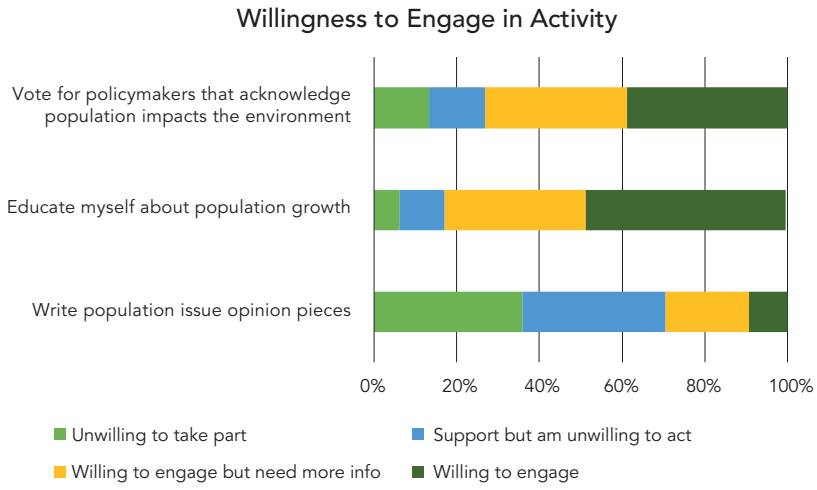
3. Vote for policymakers that acknowledge that population pressures impact the environment.

1. Educate myself about population growth.
According to survey respondents, 48 per cent were willing to educate themselves about population growth, and 34 per cent were willing to but needed more information. Nearly half (48 per cent) said they had done this in the past. However, only nineteen per cent of respondents had both educated themselves on population growth and could correctly answer the number of people added to the planet since 1970. So past education is not necessarily a reliable indication of knowledge.

2. Write population issue opinion pieces for local news media.
This activity was the lowest-scoring action. Only nine per cent of respondents were willing to write population issue opinion pieces for the local news media. The number jumped to twenty per cent who said they were willing to but needed more information. Only three per cent of respondents said they had done this in the past. Predictably, those who wrote opinion pieces were more likely to say they felt no challenge discussing the topic of population growth (92 per cent versus 66 per cent among overall respondents). It is important to note that only 32 respondents, or 3.5 per cent of the sample, stated they wrote population opinion pieces. Thus, any conclusions drawn from this small sample size must be stated with caution.

3. Vote for policymakers who acknowledge that population pressures impact the environment.
The final behaviour asked in the population section was about voting. Thirty-nine per cent were willing to vote for policymakers who acknowledge that population pressures affect the environment, and 34 per cent were willing to but needed more information. One in 3 (31 per cent) said they have done this in the past.

Chart 7: Actions: Respondents' willingness to take population-related actions



According to the survey, two thirds (66 per cent) of respondents felt no challenge discussing the topic of population growth with others. For the 34 per cent who preferred not to discuss it, the top barrier was that they felt it was too complicated. Other barriers are listed below in Table 2.

Table 2: Rationale for not wanting to discuss population growth with others

Survey response options	Per cent
I feel the topic of population growth is too complicated for me to confidently discuss with others.	28%
I feel the political climate today makes population growth too challenging to discuss with others.	16%
I feel my peers would not appreciate discussing population growth with me.	13%
The topic of population growth is not important enough to me to discuss.	12%
I feel the topic of population growth is too personal to discuss with others.	11%

Survey response options	Per cent
I feel the topic of population growth is difficult to discuss because I have concerns about its potential impact on immigrants, people of color or other marginalised communities.	9%
I hesitate to discuss the topic of population growth because others may think I am prejudiced against immigrants, people of color or other marginalised communities.	7%
Other: Write-in responses included: 'Difficult to discuss with those who want larger families', 'I am in favour of more people', and 'Should not be discussed at all.'	4%

These results are not the same across various demographic views. The following highlights statistically different results for age, gender, income and race/ethnicity.

Age: Survey respondents of typical reproductive age (men and women under age 45) were more concerned with the climate crisis, lack of immigrant rights and wealth inequality than those who are older. They were eleven per cent more likely to say that human population growth is making climate change worse. However, compared to their elders, they were more likely to say the topic of population growth is difficult to discuss because they have concerns about its potential impact on immigrants, people of colour or other marginalised communities. These challenges, however, did not stop them from educating themselves about population growth. Those aged 44 and younger self-reported that they had educated themselves about population growth – thirteen per cent more than older survey respondents.

Gender: There also appeared to be a gender gap related to the level of concern about population growth, as only forty per cent of women educated themselves about the topic, compared to 55 per cent of men, though only 23 per cent of these men knew the correct number of people added to the planet since 1970. Women were more likely than men to highly rank lack of healthcare access as a critically important issue (47 per cent vs 39 per cent).

Income: People making under $50,000 a year placed greater importance on lack of healthcare access than those making over $50,000.

Race/Ethnicity: Racial and ethnic differences are evident throughout the survey data. Black respondents were eighteen per cent less likely to believe the world's population is growing too fast. Also, Black respondents were five per cent more likely – and Latinx respondents ten per cent more likely – to say they preferred not to discuss population growth with others because they felt their peers would not appreciate discussing it. Finally, Black respondents felt lack of healthcare access was twenty per cent more critically important than other topics, and Latinx respondents felt poor education systems were fourteen per cent more critically important than other topics.

Discussion

This survey is not without its limitations. For one, as mentioned above, a stratified voluntary response sampling method through Amazon's MTurk was used. Random sampling methods are preferred when conducting surveys. Despite this, we deployed measures to ensure geographic (state level) representativeness. Furthermore, our racial and ethnic sample composition roughly approximated that of the US population as a whole. As such, we believe we have quality data from which to draw meaningful conclusions. Future research could include analysing the data per US state and overlaying that with conservation maps and family planning access data, conducting message testing to understand what resonates, facilitating social listening to learn about influencers and/or conducting focus groups to collaboratively design a campaign.

These survey results are informing a theory of change with the goal of altering attitudes and getting more people to act and advocate for rights-based solutions to population growth. One hurdle in this work is the need to destigmatise conversations around population, sex and family planning. The results show that respondents are located throughout the change cycle. For example, only a third understand the exponential growth of human population, indicating that an increase in awareness is still needed.

In relationship to norms, the result that nearly three out of four respondents understood that human population is driving the extinction crisis is a strong social norm that could be used in intervention messaging to show positive attitudinal momentum. The result that seventy per cent of respondents thought we have a moral responsibility to prevent wildlife extinctions, if they are unavoidable without slowing human population growth, can be similarly used.

Behavioural intention for some actions is high, but for other actions is low. For example, over eighty per cent of respondents were willing to educate themselves about population growth, and 73 per cent were willing to vote for policymakers who acknowledge that population pressure impacts the environment. But 34 per cent preferred not to discuss population growth, and the main reason (28 per cent) was that the topic was too complicated. For actions that are low, addressing the barriers discussed in the background section can increase willingness to take action.

It's important to acknowledge that the rights and dignity of women and Black, Indigenous and other people of colour were, and continue to be, violated in the name of population control, causing long-term harm and reproductive oppression. These violations include China's one-child policy (Phillips, 2015), testing the first birth control pill on Puerto Rican women living in public housing projects in the 1950s and 1960s (Vargas, 2017), the 25–50 per cent of Native American women sterilised in the 1970s (Blakemore, 2016), the nearly 150 female inmates sterilised in California prisons between 2006 to 2010 (Ko, 2016) and, recently, forced hysterectomies in ICE detention centres (Narea, 2020). These atrocities underscore the importance of supporting reproductive rights and justice allies and ensuring any population-related advocacy and solutions are equitable and fair.

Although this history can be hard to face, when it is swept under the rug or avoided it allows the topic to be co-opted by extremists. By addressing population in a respectful, rights-focused way, advocates of slowing human population growth can make it clear that xenophobia and prejudice should play no role in policymaking. Because population, consumption and extraction/production are global issues that transcend national borders, US immigration policies should recognise that immigration is a human right and rooted in human dignity. Regardless, the rights of immigrants should not be compromised, and equitable treatment for all should be a goal.

Conclusion

Center for Biological Diversity projects, informed by this research, aim to help people talk sensitively and sensibly about the systemic barriers to reproductive and environmental justice that hurt people and the planet and the solutions that lie in voluntary family planning, comprehensive sex education, gender empowerment and racial, ethnic and religious equity.

The differential results of this survey suggest that future campaigns regarding population growth need to be adapted to various demographics and identities and built in cooperation with impacted communities. The findings show overlapping support for systemic changes to healthcare and education systems across demographics. Advocates of curbing population growth can achieve their goal – with popular support – through advocating for greater sexual and reproductive health and comprehensive sexual education for everyone.

This survey data helps unravel the binary thinking that environmental degradation is solely caused by either population momentum or consumption, along with either/or thinking that individual actions are not part of systems change. Much of the data was segmented by demographics, allowing us to better understand current and future audiences. These results will support creating culturally sensitive, inclusive and effective campaign messages, tactics and strategies that highlight education and reproductive healthcare for all. They also support a draft theory of change that includes increasing awareness of these interconnected issues, altering attitudes and perceptions around the topics, increasing behavioural intention – which leads to action – and advocating for, and ultimately changing, social norms.

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COMMENT

A Wager on Global Food Prices 2001–2020: Who Won and What Does it Mean?

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Abstract

This paper presents the results of a 2011 wager between Stan Becker and David Lam about the trajectory of world food prices for the period 2011–2020 versus the period 2002–2010. The wager was a response to Lam's 2011 presidential address to the Population Association of America, which showed that many health and socio-demographic indicators had improved over the previous fifty years, in spite of the addition of four billion people to the world's population. Lam lost the wager, with the Food and Agriculture Organization's price index for five food groups averaging about twenty per cent higher for 2011–2020 than for 2001–2010. Becker and Lam discuss the background of the wager, give their differing interpretations of the outcome and discuss future trends in population, food production and food prices. Lam gives a more optimistic perspective on future trends, while Becker raises concerns about rapid degradation of planetary ecosystems, species loss and global warming.

Keywords: food prices; population; wager; economics; ecology

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Introduction

Predicting the future is always risky. Food prices are a case in point. David Lam, an economist and President of the Population Association of America in 2011, in his presidential address showed that many health and socio-demographic indicators had improved over the previous fifty years despite the dire predictions of neo-Malthusian Paul Ehrlich (Lam, 2011). He reviewed the bet between Paul Ehrlich and Julian Simon, an economist, regarding the trend in prices of five metals over the decade 1980–1990. Ehrlich lost the bet. Lam then challenged anyone in the audience who might want to wager on indicators for the future. Stan Becker, a demographer with some knowledge of ecological concerns (Becker, 2013), accepted the challenge and the two worked out details for a wager on food prices for the period 2011–2020 relative to their levels for 2001–2010 (Population Assoc. of America, 2012). The FAO Food Price Index (FPI) of the five FAO food groups was used as the metric (Cluff and Mustafa, 2020).

The results are now available (FAO, 2021). Overall, the FPI for the 2011–2020 period was nineteen per cent higher than in the 2001–2010 period, with higher prices in each of the five food groups.

Obviously many factors influence food prices – the weather, trade restrictions, etc. Demographers point to the increase in population of seventy to eighty million persons per year (up to 2020 anyway) as exerting continuous pressure on food availability. Under many of the IPCC climate scenarios, food security going forward is threatened by global warming (IPCC, 2021). The overall FPI for August 2021 is higher than any yearly value since 2011 (FAO, 2021). On the other hand, food production has continued to grow faster than population in all major regions, and the FPI declined for most of the 2011–2020 decade.

In this paper we discuss our differing interpretations of these trends in food prices, explain the origins of our wager and provide our perspectives on the wager's outcome. We also discuss the links to global population change and discuss our predictions about future food prices.

1. What was your wager about?

In 2011 David Lam gave the Presidential address at the Population Association of America Annual Meeting (Lam 2011). In it he reviewed the bet between Paul Ehrlich (biologist) and Julian Simon (economist) on whether prices of five metals

would increase or decrease over the decade 1980–1990. Ehrlich bet prices would increase as supply is limited while demand is increasing with a growing world population. Simon bet the opposite and won the bet in 1990.

Lam also presented data on many indicators that have improved since 1960. He noted that the price of food, like most other commodities, had tended to decline between 1960 and 2000, but had increased significantly between 2000 and 2010. He said he expected that food prices would return to their downward trend in the future. During his address he challenged anyone in the large audience who wanted to bet him about future food prices. Stan Becker, a demographer in the audience who believes limits on food production are being reached, took up the challenge. The wager was on food prices over the decade 2011–2020 compared to food prices in the decade 2001–2010. Lam believed that food prices would go down despite continued population growth. Becker believed that resource constraints (limits on fresh water, oil and arable land) would lead to price increases. Becker's critiques of Lam's arguments were summarised in Becker (2013), with Lam responding in Lam (2013).

Lam and Becker agreed to use the Food and Agriculture Organization (FAO) world food price index as the source of data. FAO collects data on five food groups: meat, dairy, cereal, oil and sugar. We considered the cost of a food basket with the average prices over the decade 2011–2020 compared to those over the decade 2001–2010. For the wager, $200 was set for each food group. So if the price increased for example, by fifteen per cent for each food, then Lam would owe Becker $200*0.15*5 = $150. Similarly, if prices declined by fifteen per cent Becker would owe Lam $150. We used the real price index, which adjusts for inflation, as the basis for the wager.

2. Why was it important to you?

LAM: In making the wager I was expressing my optimism that the world would continue to experience many of the positive outcomes of the previous fifty years, as indicated by rising food production per capita, falling poverty rates and a general trend of falling prices for food and most other commodities, all in spite of the addition of four billion people between 1960 and 2011. In particular, it seemed unlikely that the sharp increase in the price of food and other commodities that was observed during the ten years before my presidential address was likely to continue. I expected that the fact that food production continued to grow faster

than population would cause food prices to return to the declining trend that characterised the 1960–2000 period.

BECKER: The wager was important to me because, while Lam's presentation of positive trends for many indicators since 1960 was correct (e.g. declining mortality and fertility, higher percentages with schooling and declining malnutrition), he minimised the looming threats and barely considered trends in ecosystem indicators. Specifically, there are major threats to the planet's ecosystems that have come from the vast expansion of human population between 1960 (three billion) and 2010 (seven billion) and many scientists before 2011 had given quite dire forecasts for the future unless humanity acted decisively on CO_2 emissions and biodiversity, to name two critical areas (e.g. Rockstrom et al. 2009; Ehrlich and Pringle, 2008). More specifically with regard to food production:

a) Virtually all the best agricultural land is already under cultivation (Frona, Szenderk and Harangi-Rakos, 2019).

b) 34 per cent of fish stocks are fished at unsustainable levels already (FAO, 2020).

c) Tropical forests are being destroyed at an alarming rate (averaging about ten million hectares per year) to make room for the production of more soy, palm oil, livestock, with the latter to feed an increasingly meat-eating world. (FAO and UNEP, 2020).

d) Drawing water from aquifers to irrigate crops in China, India, the USA and elsewhere is depleting these aquifers very rapidly (Bierkens and Wada, 2019).

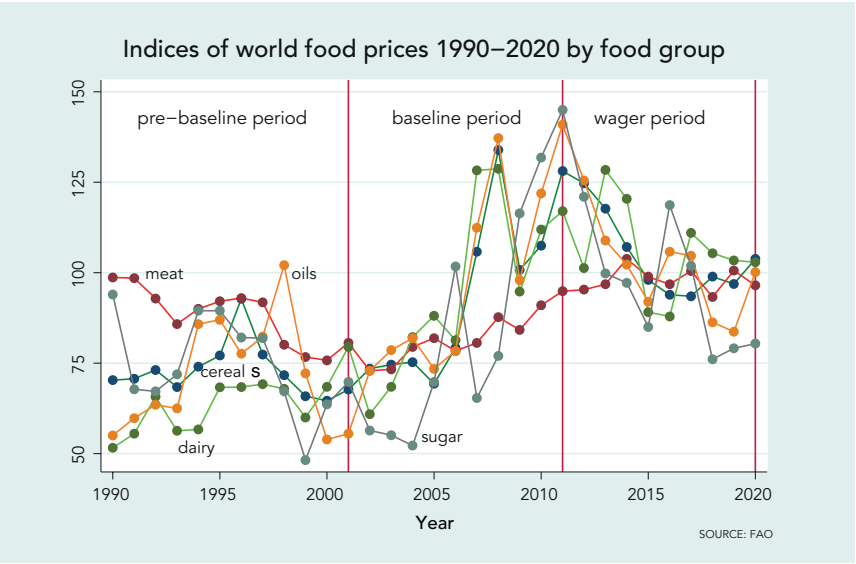
e) In parallel with these problems, the diminution of natural habitats due to the expansion of humans and crop production into virtually all areas of the globe has brought on a massive extinction of other species. For example, more than half of primate species are endangered and four of the seven large primate species are critically endangered (IUCN, 2021).

f) It is estimated that 23 per cent of total anthropogenic greenhouse gas emissions derive from agriculture, forestry and other land use (IPCC, 2019) and most of this (fifteen per cent) is from the livestock sector (Gerber et al., 2013).

3. How does the FAO collect data on food prices?

The Food Price Index is based on international agricultural commodity markets for five food groups. These include the following 23 commodities: wheat, maize, sorghum, barley and rice for the cereals group; butter, whole milk powder, skimmed milk powder and cheese for the dairy group; poultry, pig, bovine and ovine for the meat group; and sugar is the fourth group. The fifth or oils group consists of price quotations for soybean, sunflower, rapeseed, groundnut, cotton seed, copra, palm kernel, palm, linseed and castor oils (FAO, 2021).

Figure 1

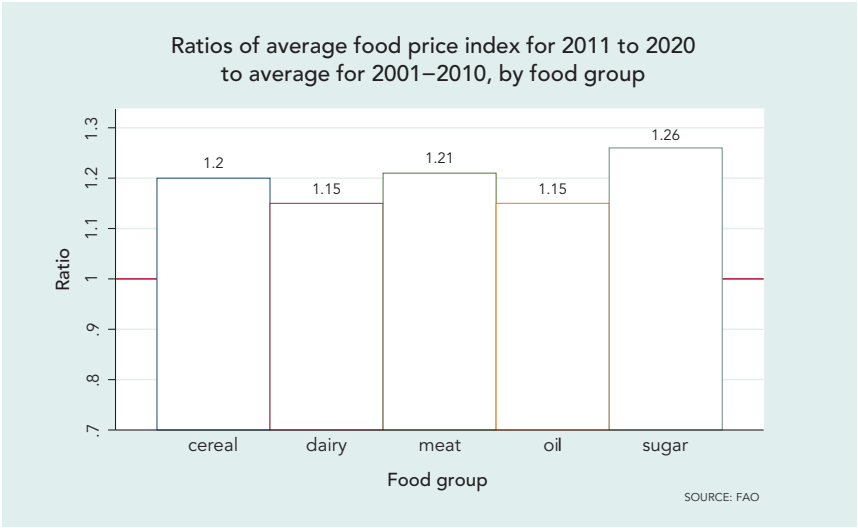


4. What was the outcome of the wager?

Figure 1 shows the inflation-adjusted yearly values of the food price indexes from FAO from the beginning of its series in 1990 to 2020. As seen in the figure, prices tended to decline from 1990 to 2000, rose sharply from 2000 to around

2011 (the date of Lam's presidential address), and have tended to decline after 2011. The decline in prices after 2011 is slower than the increase from 2001–2010, however, with the result that the average prices for the 2011–2020 period are higher than the average prices for the 2001–2010 period for all five food groups. This comparison was the basis for the wager, so Becker won. Figure 2 shows the relevant ratios for the wager, by food group. Doing the mathematics reveals that Lam owes Becker $194.

Figure 2



5. How are these prices related to food production and population growth?

LAM: One fundamental fact in considering the links between food prices and population is that food production has increased faster than population in every region in the world in the past several decades. Population growth is one of the most important drivers of increased demand for food. Rising incomes and changing consumption patterns can also increase demand for food, but demand for food does not increase much from rising incomes alone. The fact that food production is growing faster than population creates downward pressure on food prices. This downward pressure can be offset by many other factors in the short

run, including weather-induced crop failure on the supply side, rising incomes on the demand side, and problems in markets due to disruptions in international trade, rising transport costs, and speculative trading in commodity markets. These factors tend to create short-run volatility, but in the long run they do not offset the simple fact that food production is growing faster than population. Of course, this could all change if food production declines due to climate change or other factors, and there is good reason to worry about those problems. My prediction in 2011 was that food production would continue to grow faster than population, as it had in the previous fifty years, and that this would push food prices down. Food production did continue to grow faster than population, as I predicted, and food prices did begin to fall after 2011. Food prices tended to fall steadily from 2011 to 2020; however, prices after 2011 did not fall fast enough to go below prices for the early part of the decade 2001–2010. Because of this, the average price for 2011–2020 was higher than the average price for 2001–2010. Since these average prices for the two decades were the basis of the wager, I lost the wager.

BECKER: There is continuous pressure to increase food production in order to keep apace with population growth. Since food production per capita has actually increased, the relationship with prices is unclear. However, because meat consumption per capita has also increased, a larger portion of the cereal production is going into animal feed currently than was the case in previous decades. This does not bode well for CO_2 emissions or for preservation of the global ecosystem.

6. What do you think prices will do in the future?

LAM: One thing we can be sure of is that food prices will be volatile, as they have always been, with periods of both increases and decreases due to weather shocks, fuel price volatility, international trade disruptions and speculative behaviour in futures markets. In the long run, however, I think we will not see any significant trends either up or down, a continuation of the trends of the last sixty years. The inflation-adjusted price of food in 2020 was very similar to the price in 1960, in spite of all the changes in population, technology, income, climate and other factors over that period. Agricultural production is highly responsive to prices, so increasing prices tend to be offset by rising production, while falling prices lead to decreased production. The net result is relatively stable prices in the long run, combined with lots of volatility in the short run.

BECKER: A quote from Abraham Lincoln seems appropriate here: 'The most reliable way to predict the future is to create it.' If population growth continues, consumption levels remain at high levels in developed countries and increasing levels in developing countries (including the trend of greater consumption of meat), and switching to renewable sources of energy only proceeds slowly, then global temperatures will continue to rise and agriculture and fisheries will be adversely affected. This would lead to food shortages and the resultant price increases in future years. Only if the global community can work together to drastically reduce emissions, change dietary habits, and reduce population growth to zero, will there be stabilisation of food prices in future years. I wonder if any economist would take a wager today about future food prices?

7. What is learned from the results of the wager and what is the take-home message for readers?

LAM: Although I clearly lost the bet, there is a sense in which we both won. Food prices have in fact declined in almost every year since my presidential address, falling from the unusually high prices that existed after the steep rise of the 2001–2010 period. On the other hand, prices have not fallen enough to go below the average prices for the 2001–2010 period, with the result that food is still more expensive now than it was in the early 2000s. Food production continues to increase faster than population in all regions of the world, including Sub-Saharan Africa, a continuing reason for optimism about the world's ability to feed the additional billions that will be added in this century. Food prices, l ike all commodity prices, are quite volatile for many reasons. Short-run movements in food prices, even over several years, are not a good indicator of what is happening to overall supply and demand. In the long run we see food production more than keeping up with population growth, with food prices today being lower than they were in the 1960s, in spite of the world having almost five billion more people.

BECKER: There are many variables which affect food prices, and population growth is only one, but it does exert a steady pressure, i.e. feeding an added seventy to eighty million persons each year is a continual challenge. However, as we have seen, food prices peaked around 2010 and then declined while world population in 2020 was 838 million larger than the population in 2010 (UNDESA, 2021). Also, food prices are quite variable, which is similar to the case of the metals in the Ehrlich-Simon bet (Kiel, Matheson and Golembiewski, 2010).

If we need to continue increasing agricultural and fishery production in order to keep up with population growth, that will almost certainly mean continued deforestation, depletion of aquifers and fish catches beyond sustainable limits. Reducing population growth will ease the pressure on the already fragile ecosystems that we inhabit. More economists need to work on models which do not depend on continual growth of either population or consumption!

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PEER-REVIEWED ARTICLE

A Graphical Presentation of the Steady-state Economy Model

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Abstract

There are several theories claiming that their policies can save the planet from environmental catastrophe. This paper claims that it is only the Steady-State Economy model on which such reasonably effective expectations can be based. This is so for two reasons. First, the SSE is based on a clearly defined economic model which is presented graphically and briefly analysed. Second, it includes a policy proposal for reducing the size of global population. This is now approaching eight billion people and is expected to exceed nine billion in the next thirty years. The logic of the SSE suggests that stabilising population is not sufficient. The global population should actually be reduced if environmental balance is to be restored.

Keywords: steady-state economy; population; environment

1. Introduction

Over the last fifty years, the increasing intensity of environmental problems faced by the global community has led to the development of several important ideas and proposals regarding systemic changes to reverse existing environmental tendencies. Most prominent among them are the Steady-State Economy (Daly,

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1972, 1996), the Green Growth Economy or Green Economy (OECD, 2011, 2015; UN, 2012), the ideas of Degrowth (Kallis, 2011; Kallis, Kerschner and Martinez-Alier, 2012; Hickel and Kallis, 2020), Ecosocialism (Kovel and Löwy, 1991; Angus et al., 2009; Löwy, 2018), and Ecomodernism (Asafu-Adjaye et al., 2015). These ideas and proposals are sometimes referred to as theories. Strictly speaking, a theory is a statement that can be tested, and in that sense these ideas are not theories. However, we can continue to call them theories as long as we understand that in essence they are simply ideas or proposals. Although these theories share the same objectives – i.e. ecological equilibrium and distributional justice – their analyses and policy suggestions differ widely.

A convenient way for seeing the basic differences between these proposals is provided by the Impact Equation (Ehrlich and Holdren, 1971) commonly presented as

$$I = PAT$$

where I = impact, P = population size, A = affluence defined as consumption per capita and T = technology.

In this equation, technology (embodied and disembodied) can be thought of as a factor that transforms total production into environmental impact, however measured, and therefore it can be seen as representing efficiency in the use of resources.

In terms of the impact equation, the Green Growth and Eco-modernist positions see the solution to environmental problems in technological progress that will reduce the value of T, making possible absolute or relative decoupling, thus enabling economic growth to continue whilst reducing impact.

By contrast, the ideas of Degrowth centre on a reduction of production and consumption per capita (A) suggesting at the same time a non-violent and democratic transition beyond capitalism, without specifying the nature and the institutions of the post-capitalism system. For eco-socialists, environmental problems signify a crisis of the capitalist system itself and suggest that the health of the environment and distributional justice will coincide with the socialist

transformation of society. Thus, for eco-socialists, the impact equation says little as it does not discriminate among systems of social organisation, although critics have suggested that it is not clear how the variables of the equation will behave in a socialist society, especially given the failures of environmental policy in the former Soviet Union and other state socialist countries.

Given that environmental problems result from the amount of total production undertaken for human consumption, it is interesting, and at the same time surprising, that these theories totally ignore the size of world population. It is only the steady-state economy (SSE) model that recognises the importance of the per capita consumption (A) and the size of population (P).

The purpose of this paper is to discuss briefly the steady-state economy and to give a graphical exposition in order to make clear that, unlike the other theories mentioned above, it is based on a well-defined basic macroeconomic model.

2. The Steady-State Economy

The first descriptions of a steady-state economy are to be found in Plato's *Laws* and in Aristotle's *Politics,* both written in fourth century BC (Plato, 1926; Aristotle, 1932). Both models have the same basic elements, namely land limited in extent and a standard of living which is comfortable but not luxurious. These two elements determine the size of population of the city-state. The Aristotelian model is much more elaborate (Lianos, 2016), but both models are based on the recognition of the scarcity of resources, which at that time was synonymous with limited productive land, and on the idea that the good life of citizens, to the extent that it depends on the availability of material goods, necessitates restrictions on the size of population.

In chapter VI of his *Principles of Political Economy* Mill (1970 [1848]) briefly discusses the steady state, which he calls the stationary state and characterises it as 'a very considerable improvement on our present condition' (1970 [1848]: 113). He defines the optimum population as 'the density of population necessary to enable the mankind to obtain, in the greater degree, all the advantages both of co-operation and of social intercourse' (Mill, 1970 [1848]: 115). Mill was against population increase for two reasons. First, he argued, a strict restraint on population is indispensable for a better distribution of income and, second,

independently of the supplies of food and clothing 'it is not good for man to be kept perforce at all times in the presence of his species' which may happen in an overcrowded world (Mill, 1970 [1848]: 115).

Writing in 1930, Keynes (1963 [1930]) made the prediction that stability of population and peace would solve the economic problem – i.e. the problem of satisfying unlimited wants with limited resources.

> I draw the conclusion that, assuming no important wars and no important increase in population, the economic problem may be solved, or be at least within sight of solution, within a 100 years. This means that the economic problem is not – if we look into the future – the permanent problem of the human race (4).

Given that Keynes' optimistic vision was penned nearly a century ago, the present state of affairs is particularly disappointing and sad.

More recently, the idea of a steady-state economy is present in Boulding's spaceship Earth (Boulding, 1966), implied in Ehrlich's Population Bomb (Ehrlich, 1971), and more developed in *The Limits to Growth* (Meadows et al., 1974). However, Herman Daly (1972, 1991, 1996, 2008, 2010, 2019) is perhaps the most significant developer of the concept. A steady-state economy is defined by Daly as:

> an economy with constant population and constant stock of capital, maintained by a low rate of throughput that is within the regenerative and assimilative capacities of the ecosystem. This means low birth equal to low death rates, and low production equal to low depreciation rates … Alternatively, and more operationally, we might define the SSE in terms of a constant flow of throughput at a sustainable (low) level, with population and capital stock free to adjust to whatever size can be maintained by the constant throughput that begins with depletion of low-entropy resources and ends with pollution by high-entropy wastes. (Daly, 2008: 6).

It should be noted that, in the above quotation, Daly actually gives two definitions of the SSE. In the first, population and capital are constant. In the second, it is

the flow of throughput which is constant at a sustainable level and population and capital are free to change. The two definitions imply different consequences for the standard of living people can enjoy. If population is kept constant, improvements in productivity will allow higher per capita income whereas the constant flow of throughput may allow a bigger population size with a constant per capita income. However, in both cases, *stability of population and stability of resource consumption are key features.*

O'Neal et al. (2010: 11), expand the content of the SSE to include the following objectives: (a) sustainable scale, i.e. a size that is kept within the capacity of the global ecosystem to provide resources and absorb the wastes created by production and consumption; (b) efficient allocation of resources; (c) fair distribution in the sense of people having equal opportunities and by putting limits to excessive inequality of income; and (d) high quality of life in the sense of giving best global practice for health services, wellbeing, leisure time, economic stability, etc.

It is evident from the above that in the steady-state economy the role of government is important. It can change tax rates, intervene in markets to improve efficiency, impose restrictions on the use of resources when it seems necessary and keep population size constant, among other things. Daly (2017) suggests major changes in the monetary system, the most important of which is to abolish the fractional reserve banking system and establish a 100 per cent reserve requirement, but in my view this is not a required element for the steady-state economy (Lianos, 2018).

3. The Long-run Equilibrium in the Basic Model of the SSE

The basic elements of the SSE model are the following:

(1) A well-behaved production function which connects total product with inputs.

(2) Constant capital stock which implies that net investment is zero or that gross investment is equal to depreciation.

(3) Population is constant, which implies that births plus immigration are equal to deaths plus emigration and therefore the supply of labour is constant. Of course, in a worldwide context, migration will not be a factor in the stability of population because emigration from one country will be immigration to other countries.

(4) The quantity of output produced with given capital, labour and technology should not exceed the size that creates dangers for the sustainability of the system. Thus, the availability of resources and the ability of the system to absorb wastes determine maximum output. Sustainability is achieved and maintained if the difference between biocapacity (BC) and ecological footprint (EF) is zero or positive, i.e. BC – EF = 0 or greater.

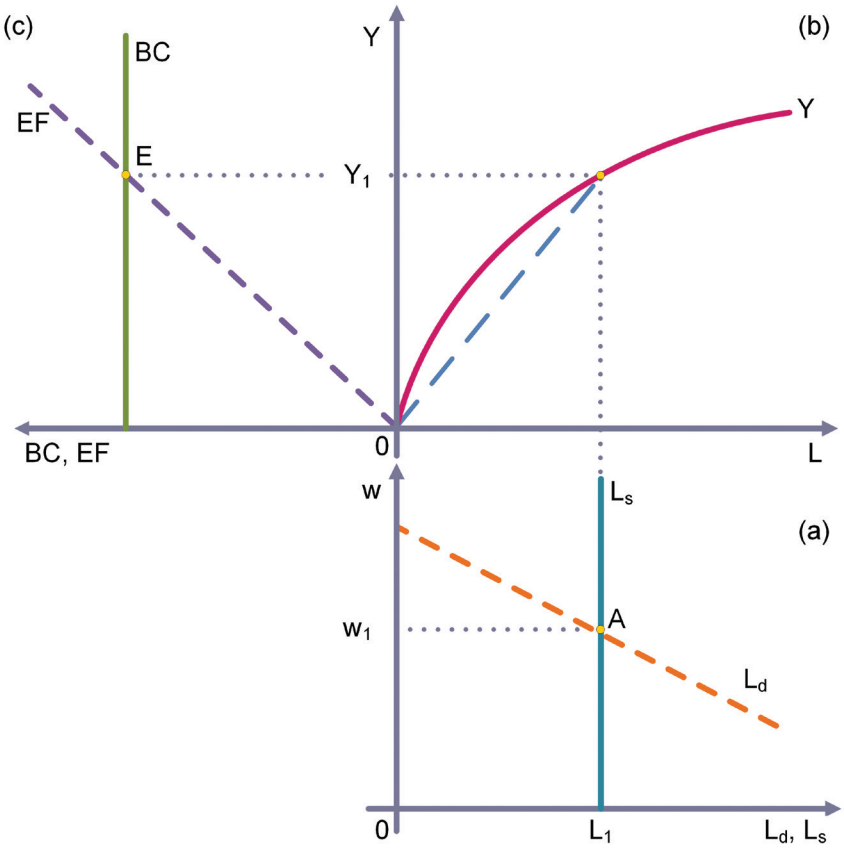
(5) The government has the authority and the ability to follow policies that eliminate discrepancies and coordinate markets so that equilibrium in one market is consistent with equilibrium in other markets. Prices are free to fluctuate for purposes of allocative efficiency.

Long-run equilibrium in a SSE is reached when the level of employment is such that, given the production function and the available technology, total production is at a level where the ecological footprint is equal to biocapacity (or less), as shown in Figure 1. Part (a) shows the labour market with the usual downward sloping demand for labour (L_d) and a constant supply of labour (L_s) which is a fraction of the constant population. Part (b) shows the production function which connects labour employment with total product (Y). Part (c) shows the ecological footprint (EF) and biocapacity (BC). Biocapacity is drawn as a straight line for simplicity. The ecological footprint is linearly and positively related to total product. Product per capita is shown by the slope of the dotted line in part (b). The functional distribution of income is shown in part (a) where labour's share is the area $0L_1Aw_1$ and capital's share the triangle wAw_1.

The equilibrium position shown in Figure 1 is unique because there is only one level of total product which corresponds to equality of EF (ecological footprint) with BC (biocapacity). It may be argued that, with respect to sustainability, any level of total product can be at equilibrium as long as EF is less than BC.

Of course there is nothing in the SSE to guarantee that per capita product would be sufficient for a high standard of living because biocapacity is exogenous and the standard of living depends on the population size. Given that the production function is subject to diminishing returns, a reduction of population (and labour supply) will reduce total output, but will raise per capita product, raise wages, reduce total profits and reduce the ecological footprint. An increase in population will have opposite effects.

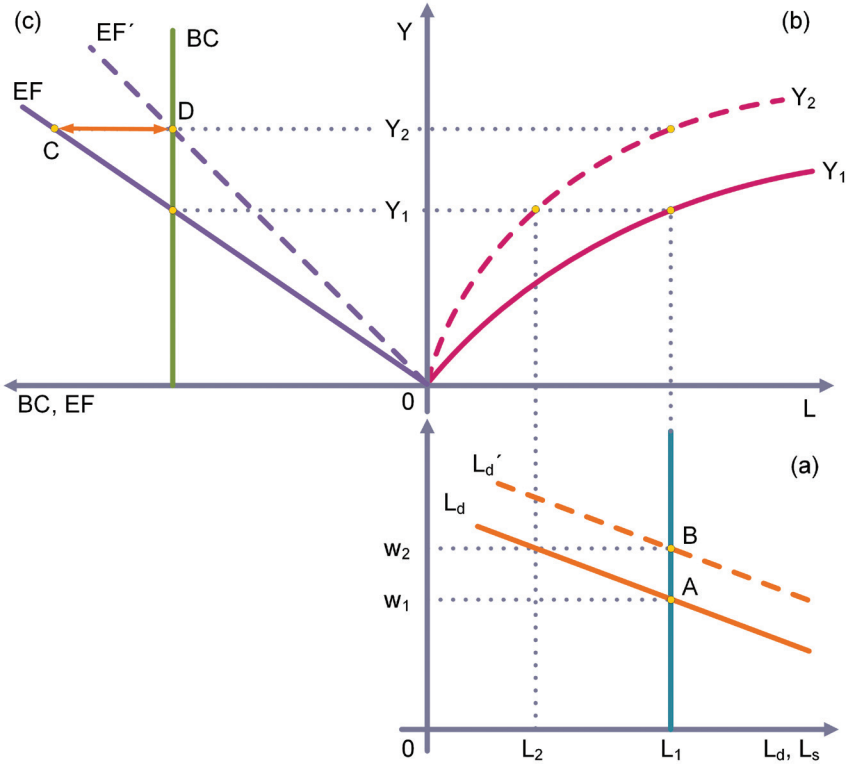
Figure 1: A steady state economy in long-run equilibrium



4. The Effects of Technological Change

The role of technological change in SSE is important because it raises productivity and per capita product. However, at the same time, it may raise the use of limited resources and the ecological footprint unless new techniques of production allow absolute decoupling so that total product increases while the ecological footprint stays constant or declines. Figure 2 shows the effect of a technological change that increases productivity of labour and shifts the production function to Y_2.

Figure 2: Increase of ecological deficit following an improvement in technology



With production at level Y_2 and with constant population, the ecological footprint becomes greater than biocapacity and an ecological deficit appears as shown by the distance CD in part (c). This deficit can be eliminated by following policies to reduce total production, e.g. by reducing the length of the working day and thus reducing the labour supply at point L_2. In this case, what is lost in potentially higher output is gained in leisure time. Also, the ecological deficit may be eliminated if the new technology reduces the waste of production and the line EF rotates to the right and becomes EF'.

5. The Size of Population

The main objective of the SSE is a sustainable level of total product – i.e. a constant flow of throughput at a sustainable level. According to Daly, once this level is determined, population and the stock of capital are free to adjust to whatever size can be maintained by the constant throughput (Daly, 2008: 4). This definition leaves the size of population undefined for two reasons. First, there may be more than one way of combining labour and capital to produce the sustainable quantity of output. Second, given that the least cost combination will be chosen, there is no way to guarantee that the resulting per capita product will be enough for an acceptable standard of living. In other words, the sustainable level of output can be produced by many different quantities of labour supplies and thus it is likely for the SSE to coexist with a population size that corresponds to a low standard of living. Incidentally, this is what would happen if degrowth policies are followed.

In the steady-state economy model, the size of population is of central importance in the sense that it affects the equilibrium values of the other variables, with the exception of biocapacity. It is therefore crucial to determine its optimal size. It needs to be remembered that the question of optimal size is different from that of how many people the Earth can support in the sense that it requires the adoption of a criterion on the basis of which optimality is determined. I believe that most people will agree that a high quality of life, however defined, is the relevant criterion. Twenty-four centuries ago Aristotle used the term 'best life' to refer to high quality of life and defined it as follows:

> For the present let us take it as established that the best life, whether separately for an individual or collectively for states, is the life conjoined with virtue furnished with sufficient means for taking part in virtuous action. (1932: 1323b40–1324a2)

More recently, Daily et al. (1994) wrote of a decent life for everyone, by which the authors meant that all should have access to sufficient food, education to whatever level they are capable, best-in-class health care, sanitary living conditions, and – more difficult to define – equal economic opportunities. Cohen (2017) goes further in arguing that:

> The real crux of the population question is the quality of people's lives: the ability of people to participate in what it means to be human; to work, play, and die with dignity; and to have some sense that one's own life has meaning and is connected with other people's lives. (42)

Given that resources are limited, the level of output consistent with a high quality of life cannot be determined independently of the size of population. The existence of an upper limit implies a trade-off between population and living standards. Every country, and by extension the world, can be said to operate under a budget constraint determined by the upper limit of available productive resources. It follows that there is an optimal population size that corresponds to a per capita product which is sufficient for providing the means for a high quality of life.

Thus, it appears that the steady-state economy model requires not just a constant population but a constant population of a given size and this in turn involves social choices regarding the desired standard of living. In terms of Figure 1, the size of population that corresponds to L_1 is compatible with a sustainable level of production, but it may not provide sufficient means for a high quality of life for everyone. A reduction of population and a corresponding reduction in the supply of labour will increase per capita income – the straight line in section (b) will rotate to the left – and at the same time will reduce the ecological footprint.

6. The Institutional Framework

With respect to the institutional framework within which the SSE can function, the question has been raised of whether the SSE implies a capitalist or a socialist system of social organisation. It is argued by some authors (e.g. Smith, 2010; Binswanger, 2009), that a steady-state economy is not compatible with capitalism because capitalism implies growth since the basic motive behind its functioning is profit. Daly's answer to this question is that the SSE economy 'is something different from capitalism and socialism' (2010). However, I argue that the SSE is compatible with both systems (Lianos, 2021).

7. Discussion

Theoretically, in a SSE the size of population must be constant or with small deviations that do not threaten the stability of the environment. However, the

SSE model needs to include not just constant population size but an optimum size consistent with sustainability. At the present time, world production is not sustainable as the ecological footprint exceeds biocapacity by approximately seventy per cent. Therefore, from a policy point of view, supporters of SSE should argue not for *constant* but for *declining* population. When Herman Daly first spoke of the need for keeping population constant, its size was about three billion, less than forty per cent of its present size. At the present time, a policy proposal for constant population is not relevant to the existing state of affairs.

Despite the undeniable detrimental effects of overpopulation and the predicted growth of world population in the next fifty years, it seems unrealistic to expect, at present, a worldwide agreement to undertake effective measures for stabilising and reducing the world population to a level that would be consistent with a sustainable level of world production. Rather, one should expect a deterioration of the economic and ecological state of affairs to be followed by extensive social unrest in many parts of the planet. (Acemoglu et al., 2017)

Although the effects of overpopulation are obvious, it is not likely that population reduction policies will be adopted. Governments, religious leaders and representatives of organised economic interests are pro-natalists for obvious reasons. Also, in many countries, economic conditions and the existing institutional framework favour the social norm of a large family. Even in overpopulated countries, with the exception of China, overpopulation is a taboo subject.

It is sometimes suggested that there is a close theoretical proximity between the SSE and Degrowth and also that the SSE is the end-state of Degrowth. However, the theoretical differences between the two, as well as the expected results of the corresponding suggested policies, are vast. First, Degrowth is mainly a political agenda without clearly defined objectives and without a well-specified economic model, whereas SSE has a well-defined economic model as shown in figures of section 3. For example, the size of population which is a crucial variable in the SSE is almost never mentioned in the Degrowth literature and when it is mentioned (Kallis, Kerschner and Martinez-Alier, 2012), it is left to be decided within the framework of ecofeminism, suggesting that the creation of coming generations is a female responsibility alone. It is implied that female empowerment and rejection of societal and family coercion will be enough to reduce birth rates.

Second, the policy implications are vastly different. Degrowth to sustainable level without population reduction would have catastrophic results. The present level of world production is 1.7 times that compatible with ecological equilibrium (Earth overshoot day was 22 August in 2020). Given that the 2020 world GDP was 84.54 trillion, the sustainable level of world production is approximately 49.7 trillion current US$. Capital depreciation is about fifteen per cent of GDP and therefore the net product would be about 42.4 trillion. With the present size of world population of 7.9 billion, this amount corresponds to 5,367 US$ per capita. Third, Degrowth theorists expect degrowth policies to be associated with a political movement that would lead to social transformation (political transition) that would make the suggested policies possible, which is not implied by SSE.

Obviously, the main policy suggestion that follows for the version of SSE presented here is a decline in population size. This will be followed by a gradual decline in total product to environmentally sustainable levels, but this would not bring poverty and social unrest because population also declines and, thus, per capita product may be constant or more likely increase. The Appendix presents some results from the Japanese economy which in the last ten years has experienced a decline in population size. Also, as mentioned above, a SSE is compatible with capitalism and socialism or any other democratic socio-economic system. It should be self-evident that, given the limited space and resources of the Earth, there is *no* system of social organisation that could offer a respectable level of wellbeing without significant reduction of the world population size. Of course, it is not suggested that population reduction will automatically solve all economic problems of the world, but it is claimed that it will make solutions much easier.

In a recent study, O'Neal et al. (2018) have examined the possibility of a good life for all within planetary boundaries assuming a population of seven billion. They conclude that some basic physical needs (i.e. nutrition, sanitation, access to energy, elimination of extreme poverty) can be satisfied by using resources at a level that does not overstep planetary boundaries but, for more qualitative goals (i.e. life satisfaction, healthy life expectancy, secondary education, democratic quality, social support, and equality), it would be necessary for the provisioning systems that mediate between resource use and social outcomes to become two to six times more efficient. The overall conclusion of this is that 'if people are to lead a good life within planetary boundaries, then the level of resource use

associated with meeting basic needs must be dramatically reduced' (O'Neal et al., 2018: 6). Also, Hickel (2018) asks if it is possible to achieve a good life for all within planetary boundaries and his answer is in the affirmative on the condition that the rich countries enter into a period of degrowth and thus resources are freed to be used for growth in the poor countries. The probability that this condition can be met in the present state of affairs in the world is practically zero.

Both these studies refer to the role of population reduction, but they do not make it a central factor. It seems, therefore, that the only common ground between SSE and Degrowth and other theories is that they all claim they can bring environmental equilibrium and save the planet.

8. Conclusion

Among the theories claiming that their policies can save the planet from environmental catastrophe, it is only the Steady-State Economy model on which such reasonably effective expectations can be based. This is so for two reasons. First, the SSE is based on a clearly defined economic model. Second, it includes a policy proposal for reducing the size of world population. Given that production and consumption take place for the sole reason of satisfying human needs, it is difficult to understand why some theories totally ignore the number of humans living on Earth.

The SSE needs to be supplemented by a clear definition of the optimum size of population and by a numerical value of that size. The existing estimates give an optimum size of about three billion people (Lianos and Pseiridis, 2015). Even with a large margin of error, the conclusion that the Earth is overpopulated cannot be avoided.

Appendix

Japan is a major industrial country with a population of 126 million and a GDP of 4.3 trillion in 2020 (in constant 2015 US$). In terms of current US$, Japan's GDP in 2020 was 4.98 trillion. Since 2009 Japan's population has been declining and therefore provides a real-world demonstration of the economic effects that may follow population decline. Table A.1 below presents data on population, Gross Domestic Product (GDP), GDP per capita, and trade balance for the 2010–2020 period.

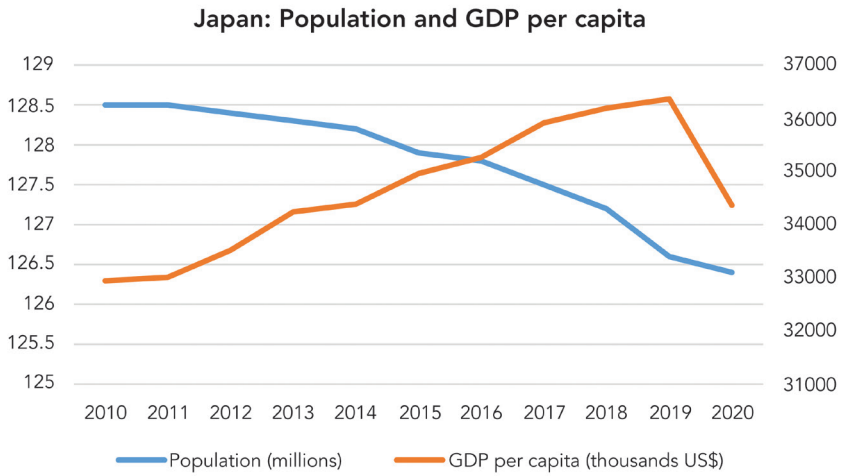
Population, GDP, GDP per capita and Trade Balance of Japan, 2010–2020 in constant 2015 USD. Sources: United Nations, World population prospects, and World Bank, National Accounts Data

Year	Population (millions)	GDP (trillions US$)	GDP per capita (thousands US$)	Trade balance (billions US$)
2010	128.5	4.219	32,942	83.25
2011	128.5	4.220	33,011	–33.4
2012	128.4	4.278	33,518	–95.9
2013	128.3	4.364	34,240	–119.4
2014	128.2	4.377	34,387	–119.6
2015	127.9	4.445	34,961	–18.4
2016	127.8	4.478	35,265	48.8
2017	127.5	4.553	35,914	45.3
2018	127.2	4.577	36,188	11.6
2019	126.6	4.591	36,362	8.7
2020	126.4	4.325	34,366	–

According to these data, in the ten-year period from 2010 to 2020, population has declined from 128.5 million to 126.4 million. In the same period, GDP increased from $4.22 trillion in 2010 to $4.59 trillion in 2019 with a fall to $4.33 trillion in 2020 as a consequence of the Covid pandemic. Thus, as a result of the increase of GDP and the decline of population, per capita GDP has increased. One might assume the growth of GDP to be attributed to an increase of total demand either because of an expansion of exports or a reduction of imports or both. The table shows that the trade balance has been positive and negative and therefore does not seem to have been directly connected with the growth of GDP.

Figure A.1 shows clearly that, during this period, population and GDP move in opposite directions. Population decline has not led the economy to a period of recession. Japan's experience cannot be generalised, but it does provide evidence in support of the SSE model prediction that population decline may result in higher per capita product.

Figure A1: Population and GDP of Japan, 2010–2020



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